Agricultural Geography

AGRICULTURAL GEOGRAPHY

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Preface

Agricultural Geography is a branch of geography that deals with areas of land cultivation and the effect of such cultivation on the physical landscape. About 45% of the world's population makes their living through agriculture.

"Agricultural Geography in its manifestations has acquired a significant and important place in geographical discipline . The diver field of study has been one of the methodological upheavals which encompasses traditional and practices of agriculture to the most modern methods and techniques viz., agricultural regionalization, agricultural type forming systems , systems and types, locational analysis, and quantified techniques of exacting agricultural practices like levels of agricultural development ,and scales of hierarchical orders.

Traditional agricultural geography focused on spatial patterns and varying agricultural systems, particularly from a basis in economic geography and/or land use. As time has gone on, some connections have become mostly via human-environment perspectives on natural resources, sustainability, health, and food systems. In addition to shifting broad social concerns affecting work related to agricultural geography, modern industrial agriculture has spread to other world regions.

Owing to globalization and liberalization, agriculture in India need to change and change for better than the best. Diversification of production is fast happening along with widespread dietary evolution. Commodity based production is giving way to system based production and there is a paradigm shift using farming system to production to consortium system of operation. Private sector participation is increasing. Agriculture is becoming more and more knowledge-intensive and market-driven. Hence for more innovative research, efficient policies and effective delivery of services, supplies and markets are imperative. Agriculture is no more closed and protected, but globalized and open.

Farm mechanization facilitates timeliness in operations, better placement of inputs, lower cost of production and reduction in drudgery of farm workers. It plays an important role in enhancing the productivity and profitability of agriculture by 20-30% reduction in cost of production and 5-20% higher cropping intensity. Mechanization involves development of tools, equipment and ensuring adequate power for carrying out the on-farm and off-farm agricultural activities.

Modern geographers initially focused on food as an economic activity, especially in terms of agricultural geography. It was not until recently that geographers have turned their attention to food in a wider sense: "The emergence of an agro-food geography that seeks to examine issues along the food chain or within systems of food provision derives, in part, from the strengthening of political economy approaches in the 1980s".

This book covers all the aspects of agriculture. It is hoped, the book will be found to be of immense value to the students of higher education, researchers and teachers.

—Dr. Udhav Eknath Chavan

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Agricultural Geography: An Outline

CONCEPT OF AGRICULTURE

Agriculture is the production, processing, marketing, and use of foods, fibres and byproducts from plant crops and animals. Agriculture was the key development that led to the rise of human civilization, with the husbandry of domesticated animals and plants (*i.e.* crops) creating food surpluses that enabled the development of more densely populated and stratified societies. The study of agriculture is known as agricultural science. Agriculture is also observed in certain species of ant and termite.

Agriculture encompasses a wide variety of specialties and techniques, including ways to expand the lands suitable for plant raising, by digging water-channels and other forms of irrigation. Cultivation of crops on arable land and the pastoral herding of livestock on rangeland remain at the foundation of agriculture. In the past century there has been increasing concern to identify and quantify various forms of agriculture. In the developed world the range usually extends between sustainable agriculture (*e.g.* permaculture or organic agriculture) and intensive farming (*e.g.* industrial agriculture).

Modern agronomy, plant breeding, pesticides and fertilizers, and technological improvements have sharply increased yields from cultivation, but at the same time have caused widespread ecological damage and negative human health effects. Selective breeding and modern practices in animal husbandry such as intensive pig farming (and similar practices applied to the chicken) have similarly increased the output of meat, but have raised concerns about animal cruelty and the health effects of the antibiotics, growth hormones, and other chemicals commonly used in industrial meat production.

The major agricultural products can be broadly grouped into foods, fibres, fuels, and raw materials. In the 21st century, plants have been used to grow biofuels, biopharmaceuticals, bioplastics, and pharmaceuticals. Specific foods include cereals, vegetables, fruits, and meat. Fibres include cotton, wool, hemp, silk and flax. Raw materials include lumber and bamboo. Other useful materials are produced by plants, such as resins. Biofuels include methane from biomass, ethanol, and bio diesel. Cut flowers, nursery plants, tropical fish and birds for the pet trade are some of the ornamental products.

In 2007, one third of the world's workers were employed in agriculture. The services sector has overtaken agriculture as the economic sector employing the most people worldwide.

Despite the size of its workforce, agricultural production accounts for less than five per cent of the gross world product (an aggregate of all gross domestic products).

Agriculture has played a key role in the development of human civilization. Until the Industrial Revolution, the vast majority of the human population labored in agriculture. Development of agricultural techniques has steadily increased agricultural productivity, and the widespread diffusion of these techniques during a time period is often called an agricultural revolution. A remarkable shift in agricultural practices has occurred over the past century in response to new technologies.

In particular, the Haber-Bosch method for synthesizing ammonium nitrate made the traditional practice of recycling nutrients with crop rotation and animal manure less necessary. Synthetic nitrogen, along with mined rock phosphate, pesticides and mechanization, have greatly increased crop yields in the early 20th century.

Increased supply of grains has led to cheaper livestock as well. Further, global yield increases were experienced later in the 20th century when high-yield varieties of common staple grains such as rice, wheat, and corn (maize) were introduced as a part of the Green Revolution. The Green Revolution exported the technologies (including pesticides and synthetic nitrogen) of the developed world to the developing world.

Thomas Malthus famously predicted that the Earth would not be able to support its growing population, but technologies such as the Green Revolution have allowed the world to produce a surplus of food. Many governments have subsidized agriculture to ensure an adequate food supply. These agricultural subsidies are often linked to the production of certain commodities such as wheat, corn (maize), rice, soybeans, and milk. These subsidies, especially when instituted by developed countries have been noted as protectionist, inefficient, and environmentally damaging.

In the past century agriculture has been characterized by enhanced productivity, the use of synthetic fertilizers and pesticides, selective breeding, mechanization, water contamination, and farm subsidies. Proponents of organic farming such as Sir Albert Howard argued in the early 20th century that the overuse of pesticides and synthetic fertilizers damages the long-term fertility of the soil. While this feeling lay dormant for decades, as environmental awareness has increased in the 21st century there has been a movement towards sustainable agriculture by some farmers, consumers, and policymakers.

In recent years there has been a backlash against perceived external environmental effects of mainstream agriculture, particularly regarding water pollution, resulting in the organic movement. One of the major forces behind this movement has been the European Union, which first certified organic food in 1991 and began reform of its Common Agricultural Policy (CAP) in 2005 to phase out commodity-linked farm subsidies, also known as decoupling.

The growth of organic farming has renewed research in alternative technologies such as integrated pest management and selective breeding. Recent mainstream technological developments include genetically modified food. In late 2007, several factors pushed up the price of grains consumed by humans as well as used to feed poultry and dairy cows and other cattle, causing higher prices of wheat (up 58%), soybean (up 32%), and maize (up 11%) over the year. Food riots took place in several countries across the world. Contributing factors included drought in Australia and elsewhere, increasing demand for grain-fed animal products from the growing middle classes of countries such as China and India, diversion of foodgrain to biofuel production and trade restrictions imposed by several countries.

An epidemic of stem rust on wheat caused by race Ug99 is currently spreading across Africa and into Asia and is causing major concern. Approximately 40% of the world's agricultural land is seriously degraded. In Africa, if current trends of soil degradation continue, the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa.

HISTORY OF AGRICULTURAL GEOGRAPY

Agricultural practices such as irrigation, crop rotation, fertilizers, and pesticides were developed long ago, but have made great strides in the past century. The history of agriculture has played a major role in human history, as agricultural progress has been a crucial factor in worldwide socio-economic change. Division of labour in agricultural societies made commonplace specializations rarely seen in hunter-gatherer cultures. So, too, are arts such as epic literature and monumental architecture, as well as codified legal systems. When farmers became capable of producing food beyond the needs of their own families, others in their society were freed to devote themselves to projects other than food acquisition. Historians and anthropologists have long argued that the development of agriculture made civilization possible.

Ancient Origins

The Fertile Crescent of Western Asia, Egypt, and India were sites of the earliest planned sowing and harvesting of plants that had previously been gathered in the wild. Independent development of agriculture occurred in northern and southern China, Africa's Sahel, New Guinea and several regions of the Americas. The eight so-called Neolithic founder crops of agriculture appear: first emmer wheat and einkorn wheat, then hulled barley, peas, lentils, bitter vetch, chick peas and flax.

By 7000 BC, small-scale agriculture reached Egypt. From at least 7000 BC the Indian subcontinent saw farming of wheat and barley, as attested by archaeological excavation at Mehrgarh in Balochistan in what is present day Pakistan. By 6000 BC, mid-scale farming was entrenched on the banks of the Nile. This, as irrigation had not yet matured sufficiently. About this time, agriculture was developed independently in the Far East, with rice, rather than wheat, as the primary crop. Chinese and Indonesian farmers went on to domesticate taro and beans including mung, soy and azuki. To complement these new sources of carbohydrates, highly organized net fishing of rivers, lakes and ocean shores in these areas brought in great volumes of essential protein. Collectively, these new methods of farming and fishing inaugurated a human population boom that dwarfed all previous expansions and continues today.

By 5000 BC, the Sumerians had developed core agricultural techniques including large-scale intensive cultivation of land, monocropping, organized irrigation, and the use of a specialized labour force, particularly along the waterway now known as the Shatt al-Arab, from its Persian Gulf delta to the confluence of the Tigris and Euphrates. Domestication of wild aurochs and mouflon into cattle and sheep, respectively, ushered in the large-scale use of animals for food/fibre and as beasts of burden. The shepherd joined the farmer as an essential provider for sedentary and seminomadic societies. Maize, manioc, and arrowroot were first domesticated in the Americas as far back as 5200 BC. The potato, tomato, pepper, squash, several varieties of bean, tobacco, and several other plants were also developed in the Americas, as was extensive terracing of steep hillsides in much of Andean South America. The Greeks and Romans built on techniques pioneered by the Sumerians, but made few fundamentally new advances. Southern Greeks struggled with very poor soils, yet managed to become a dominant society for years. The Romans were noted for an emphasis on the cultivation of crops for trade.

In the same region, a parallel agricultural revolution occurred, resulting in some of the most important crops grown today. In Mesoamerica wild teosinte was transformed through human selection into the ancestor of modern maize, more than 6000 years ago. It gradually spread across North America and was the major crop of Native Americans at the time of European exploration. Other Mesoamerican crops include hundreds of varieties of squash and beans.

Cocoa was also a major crop in domesticated Mexico and Central America. The turkey, one of the most important meat birds, was probably domesticated in Mexico or the U.S. Southwest. In the Andes region of South America the major domesticated crop was potatoes, domesticated perhaps 5000 years ago. Large varieties of beans were domesticated, in South America, as well as animals, including llamas, alpacas, and guinea pigs. Coca, still a major crop, was also domesticated in the Andes.

A minor center of domestication, the indigenous people of the Eastern U.S. appear to have domesticated numerous crops. Sunflowers, tobacco, varieties of squash and Chenopodium, as well as crops no longer grown, including marshelder and little barley were domesticated. Other wild foods may have undergone some selective cultivation, including wild rice and maple sugar. The most common varieties of strawberry were domesticated from Eastern North America. By 3500 BC, the simplest form of the plough was developed, called the ard. Before this period, simple digging sticks or hoes were used. These tools would have also been easier to transport, which was a benefit as people only stayed until the soil's nutrients were depleted. However, through excavations in Mexico it has been found that the continuous cultivating of smaller pieces of land would also have been a sustaining practice. Additional research in central Europe later revealed that agriculture was indeed practiced at this method. For this method, ards were thus much more efficient than digging sticks.

Middle Ages

During the Middle Ages, farmers in North Africa, the Near East, and Europe began making use of agricultural technologies including irrigation systems based on hydraulic and hydrostatic principles, machines such as norias, water-raising machines, dams, and reservoirs. This combined with the invention of a three-field system of crop rotation and the moldboard plow greatly improved agricultural efficiency. In the European medieval period, agriculture was considered part of the set of seven mechanical arts.

Modern Era

After 1492, a global exchange of previously local crops and livestock breeds occurred. Key crops involved in this exchange included the tomato, maize, potato, manioc, cocoa bean and tobacco going from the New World to the Old, and several varieties of wheat, spices, coffee, and sugar cane going from the Old World to the New. The most important animal exportation from the Old World to the New were those of the horse and dog (dogs were already present in the pre-Columbian Americas but not in the numbers and breeds suited to farm work). Although not usually food animals, the horse (including donkeys and ponies) and dog quickly filled essential production roles on western-hemisphere farms.

The potato became an important staple crop in northern Europe. Since being introduced by Portuguese in the 16th century, maize and manioc have replaced traditional African crops as the continent’s most important staple food crops. By the early 19th century, agricultural techniques, implements, seed stocks and cultivated plants selected and given a unique name because of its decorative or useful characteristics had so improved that yield per land unit was many times that seen in the Middle Ages. Although there is a vast and interesting history of crop cultivation before the dawn of the 20th century, there is little question that the work of Charles Darwin and Gregor Mendel created the scientific foundation for plant breeding that led to its explosive impact over the past 150 years.

With the rapid rise of mechanization in the late 19th century and the 20th century, particularly in the form of the tractor, farming tasks could be done with a speed and on a scale previously impossible. These advances have led to efficiencies enabling certain modern farms in the United States, Argentina, Israel, Germany, and a few other nations to output volumes of high-quality produce per land unit at what may be the practical limit.

The Haber-Bosch method for synthesizing ammonium nitrate represented a major breakthrough and allowed crop yields to overcome previous constraints. In the past century agriculture has been characterized by enhanced productivity, the substitution of labour for synthetic fertilizers and pesticides, water pollution, and farm subsidies. In recent years there has been a backlash against the external environmental effects of conventional agriculture, resulting in the organic movement.

The cereals rice, corn, and wheat provide 60% of human food supply. Between 1700 and 1980, "the total area of cultivated land worldwide increased 466%" and yields increased dramatically, particularly because of selectively bred high-yielding varieties, fertilizers, pesticides, irrigation, and machinery. For example, irrigation increased corn yields in eastern Colorado by 400 to 500% from 1940 to 1997.

However, concerns have been raised over the sustainability of intensive agriculture. Intensive agriculture has become associated with decreased soil quality in India and Asia, and there has been increased concern over the effects of fertilizers and pesticides on the environment, particularly as population increases and food demand expands. The monocultures typically used in intensive agriculture increase the number of pests, which are controlled through pesticides. Integrated pest management (IPM), which "has been promoted for decades and has had some notable successes" has not significantly affected the use of pesticides because policies encourage the use of pesticides and IPM is knowledge-intensive. Although the "Green Revolution" significantly increased rice yields in Asia, yield increases have not occurred in the past 15–20 years. The genetic "yield potential" has increased for wheat, but the yield potential for rice has not increased since 1966, and the yield potential for maize has "barely increased in 35 years". It takes a decade or two for herbicide-resistant weeds to emerge, and insects become resistant to insecticides within about a decade. Crop rotation helps to prevent resistances. Agricultural exploration expeditions, since the late 19th century, have been mounted to find new species and new agricultural practices in different areas of the world. Two early examples of expeditions include Frank N. Meyer's fruit- and nut-collecting trip to China and Japan from 1916-1918 and the Dorsett-Morse Oriental Agricultural Exploration Expedition to China, Japan, and Korea from 1929-1931 to collect soybean germplasm to support the rise in soybean agriculture in the United States.

In 2009, the agricultural output of China was the largest in the world, followed by the European Union, India and the United States, according to the International Monetary Fund. Economists measure the total factor productivity of agriculture and by this measure agriculture in the United States is roughly 2.6 times more productive than it was in 1948.

Six countries–the US, Canada, France, Australia, Argentina and Thailand–supply 90% of grain exports. The United States controls almost half of world grain exports. Water deficits, which are already spurring heavy grain imports in numerous middle-sized countries, including Algeria, Iran, Egypt, and Mexico, may soon do the same in larger countries, such as China or India.

CROP PRODUCTION SYSTEMS

Cropping systems vary among farms depending on the available resources and constraints; geography and climate of the farm; government policy; economic, social and political pressures; and the philosophy and culture of the farmer. Shifting cultivation (or slash and burn) is a system in which forests are burnt, releasing nutrients to support cultivation of annual and then perennial crops for a period of several years. Then the plot is left fallow to regrow forest, and the farmer moves to a new plot, returning after many more years (10-20).

This fallow period is shortened if population density grows, requiring the input of nutrients (fertilizer or manure) and some manual pest control. Annual cultivation is the next phase of intensity in which there is no fallow period. This requires even greater nutrient and pest control inputs.

Further industrialization lead to the use of monocultures, when one cultivar is planted on a large acreage. Because of the low biodiversity, nutrient use is uniform and pests tend to build up, necessitating the greater use of pesticides and fertilizers. Multiple cropping, in which several crops are grown sequentially in one year, and intercropping, when several crops are grown at the same time are other kinds of annual cropping systems known as polycultures. In tropical environments, all of these cropping systems are practiced. In subtropical and arid environments, the timing and extent of agriculture may be limited by rainfall, either not allowing multiple annual crops in a year, or requiring irrigation. In all of these environments perennial crops are grown (coffee, chocolate) and systems are practiced such as agroforestry. In temperate environments, where ecosystems were predominantly grassland or prairie, highly productive annual cropping is the dominant farming system.

The last century has seen the intensification, concentration and specialization of agriculture, relying upon new technologies of agricultural chemicals (fertilizers and pesticides), mechanization, and plant breeding (hybrids and GMO's). In the past few decades, a move towards sustainability in agriculture has also developed, integrating ideas of socio-economic justice and conservation of resources and the environment within a farming system. This has led to the development of many responses to the conventional agriculture approach, including organic agriculture, urban agriculture, community supported agriculture, ecological or biological agriculture, integrated farming and holistic management, as well as an increased trend towards agricultural diversification.

Crop Statistics

Important categories of crops include grains and pseudograins, pulses (legumes), forage, and fruits and vegetables. Specific crops are cultivated in distinct growing regions throughout the world. In millions of metric tons, based on FAO estimate.

Top Agricultural Products, by Crop Types (Million Metric Tons) 2004 Data

Cereals	2,263
Vegetables and melons	866
Roots and Tubers	715
Milk	619
Fruit	503
Meat	259
Oilcrops	133
Fish (2001 estimate)	130
Eggs	63
Pulses	60
Vegetable Fiber	30

Source:Food and Agriculture Organization (FAO)

Top agricultural products, by individual crops (million metric tons) 2004 data

Sugar Cane	1,324
Maize	721
Wheat	627
Rice	605
Potatoes	328
Sugar Beet	249
Soybean	204
Oil Palm Fruit	162
Barley	154
Tomato	120

Source:Food and Agriculture Organization (FAO)

AGRICULTURAL DEVELOPMENT IN SUSTAINABILITY

Agricultural development has three distinct but related dimensions: the physical-technical, the economic-financial, and the institution-human. The physical-technical dimension addresses land utilization, agricultural technologies, research and extension, agricultural inputs, farm-to-market access, productivity and production maximization, and so on. Agricultural development from the economic-financial perspective is concerned with costs, factors of production, terms if trade, pricing policies, subsidies, incentives, credit, return on investment, market mechanisms, and the like.

The institutional-human dimension looks at knowledge and skills, organization and management, training, implementation capacity, social relations, politics, communication, motivation, participation, local government, public-private sector linkages, culture and values, historical experience, and so on. Agricultural development, as with much of the development field, has tended to be the province of the technical and economic specialists. Their language and concerns have dominated the analysis of rural and agricultural sector issues, the specification of agricultural development objectives, and the design of programmes and projects to achieve those objectives. The institutional-human dimension has frequently been either completely ignored or treated as a source of problems or constraints to achieving technical and economic targets, a residual category for anything not defined as technical or economic.

For example, a World Bank staff member notes that, "between 1976 and 1980 the Bank invested U.S. $920 million in agricultural projects without funds in any one of them being allocated to the staff training needed for the new activities on which those projects depended".

Recent work by Ruttan represents one effort to build theoretical integration of the three dimensions. On the applied front, the USAID-supported farming systems approach to agricultural development is one example of an explicit attempt to integrate the three dimensions operationally.

Recognition of the importance of institutional and human factors in socio-economic development in general has increased substantially over the past 15 years or so, and is now a high priority area of attention by donor agencies and developing country governments alike. Being a social technology, institutional development does suffer in the eyes of crop scientists, agricultural economists, and macroeconomic analysts from a lack of specificity, predictability, and hard-and fast rules.

Despite its "softness," institutional development is a frequently espoused need of developing country officials and an aim often expressed by donor agencies. U.S. foreign assistance policy, for example, aims officially "to build and maintain the social and economic institutions necessary to achieving self-sustaining growth".

This goal of institutional development is nowhere more important than in the rural and agricultural sectors, which continue to be the source of most employment in developing countries. Except for emergency relief, where the delivery of food for consumption is unavoidable, donor policies stress that assistance for the countryside should be an investment, that it generate a flow of benefits that endures after the external funds run out.

The cumulative lessons of experience show that to have lasting impact, donor efforts to improve rural areas in the developing countries, and agriculture in particular, need to work with durable indigenous institutions both at the central and local levels. It is not surprising that, in the 1990s, institutional sustainability is emerging as one of the major problem areas for sectoral management, as well as for public administration of core government functions in developing nations.

This chapter introduces the topic of institutional sustainability, focusing in particular on the agricultural and rural sectors, though its observations apply equally to other parts of the economy. To set the stage for the rest of the book, we start by briefly exploring the meanings of the key terms "sustainability" and "institution." Then we review the latest quantitative studies of sustainability, putting them in a comparative perspective.

The broad topic of development "sustainability" is obviously not a new issue. The folklore of foreign aid is replete with tales of equipment that never worked in the field and was left to rust, of well-intended recommendations that local people disregarded, of organizations that succumbed to apathy — if they ever functioned in the first place.

Critics of development assistance have always complained about this sort of waste. It has often been easier to be clear about the failed and was not sustained than to search out what worked, what lasted, and why. In the mid- to late 1980s, however, sustainability has surfaced as a distinct and pressing concern of policy-makers in donor agencies and in the developing world.

As the last decade of the twentieth century gets underway, the expansion of cropped area and the adoption of modern farming techniques are putting new, perhaps irreversible, stress on the natural environment in developing countries, while soft international markets for agricultural commodities are forcing reappraisal of the possibilities for the Third World to increase its farm exports. Conventional development strategies seem more and more to have run their course, yet fresh approaches have been difficult to find.

"Aid weariness" among the donor countries and high levels of indebtedness among the recipients have constrained the search for creative solutions. Finding ways to yes both external and indigenous development resources more efficiently to achieve broader and more lasting impact has become, accordingly, more difficult and more imperative.

Each of the academic disciplines cuts into sustainability problems from a different angle. Three points of view stand out, each reflective of the three dimensions of agricultural development previously noted. Agricultural and natural scientists tend to frame the problem of sustainability in terms of the long-term impact of current farming practices on the global resource base.

The chemicals and intensive cultivation associated with green revolution technology can degrade the environment and waste energy resources; scientific breeding of seed may reduce the native genetic diversity of crops, making food supplies more vulnerable to plant disease and pests. Because of such problems, agriculturalists and naturalistst are increasingly concerned with identifying and promoting methods of cultivation that can protect and enhance nature's assets, while continuing to produce enough food to satisfy burgeoning populations.

Thus the blue-ribbon Bruntland Commission has defined sustainable development as "development that meets the needs of future generations without compromising the ability of future generations to meet their own needs". Countries such as Nepal and Haiti are living (or dying) examples of unsustainable development, and represent cautionary stories for those who would ignore the ecological costs of detrimental policies and practices.

A downward spiral of events can result, with deforestation and erosion leading to food insecurity, extremes of poverty, class warfare, and ultimately to societal breakdown. Sub-Saharan African nations also appear to be in danger of proceeding down this road.

Economists, by contrast, are somewhat less preoccupied with the ecological dimensions of sustainability per se, since the mining of natural resources can be justified from an economic point of view. Their concern is not conservation by itself, but the appropriate tradeoffs between economic growth and environmental preservation.

Accordingly, economists tend to be troubled by the manmade market distortions that curtail the growth of production and employment in the Third World. The most widespread examples of these distortions are the ill-considered of politically convenient price regimens that penalize the rural sector in many developing countries. There are extended economic costs to such policies.

As the World Bank notes: "Discrimination against agriculture on a sustained basis not only reallocates resources within agriculture but also draws them out of it. As labor and capital move out and technical progress slow, the longterm losses can be large."

Management experts tend to make the development project or the organization their unit of analysis, and to worry about sustainability in terms of how to meet recurrent costs or permanently improve capacity for implementation. Development project management has emphasized achieving planned targets within a specified time frame and budget, thus responding more to donor agency needs for accountability than to recipient country capacity-building requirements.

Donor-supported projects, with their autonomous implementation units, frequently experience a collapsing "balloon effect" when external funds and advisers are withdrawn.

Because they are often organizationally "quarantined" and protected, with special budget and staff, such projects may leave little lasting imprint on regular government agencies, and in many cases may actually weaken them by drawing off the best national talent.

The management perspective on sustainability, however, has evolved away from a narrow project focus, expanding to concentrate more on programmes integrated into developing country agencies and on the question of how to maintain an ongoing flow of goods and services to intended beneficiaries.

From the administrative point of view, sustainability means building organizational capacity to perform over an extended time period (longer than the life of-project horizon) and assuring the continuation of useful and valued outcomes for client groups.

Specialists concerned with nonagricultural sectors cut into sustainability issues in their own way. Health experts, for example, are usually more concerned with the clientele than the implementing agency; they see the problem in terms of promoting affordable preventative health measures, a opposed to curative care alone, measures that enable poor people to enhance their physical well-being over the long run.

But the fundamental problems of sustainability in health and other fields are closely parallel to those facing farmers and rural administrators. The thread that connects the agro-environmental, economic, and management perspective on sustainability is effective social institutions, which much be in place to deal with all the current challenges to development.

Overcoming the environmental damage of modern farming, for instance, is likely to require (among other things) that scientific organizations attack novel research problems, that private enterprise produce greater quantities of more sophisticated farm inputs, that farm advisory services disperse new knowledge, that local authorities mobilize farmers to change collective and individual behaviour, and that farmers' organizations collect and market unfamiliar crops.

Even something as seemingly straightforward as price as price reform requires considerable institutional capacity to analyze and monitor the impact of new prices, let alone to manage any political backlash.

The institutional dimension, for example, has emerged as critical to the success of the structural adjustment programmes and sector adjustment loans provided by the International Monetary Fund and the World Bank.

In virtually all problems of "development sustainability" the institutional dimension plays a key role. Unfortunately, many Third World countries lack the depth of institutions to carry through the complex and exacting duties likely to be needed to tackle the development tasks of the 1990s.

Rule-oriented Institution

What are institutions? The concept is subtle and thus subject to confusion. According to Huntington definition, they are stable, valued, recurring patterns of behaviour. Institutions thus include rules or procedures that shaped how people act, and roles or organizations that have attained special status or legitimacy. Their importance is now being rediscovered by the social sciences, including the development subfield.

An example of a rule-oriented institution is a system of land tenure; whereas a role oriented institution could be the legal authority established to adjudicate disputes arising out of the land-tenure system. Both rules and roles can be institutionalized, the former as codes of law or custom, the latter as concrete organizations.

It is useful to keep in mind the distinction between these two types of institutions.

Development assistance for agriculture and rural development is sometimes aimed at altering a village society's fundamental rules, for instance, by promoting tenure reform and land redistribution. When practitioners seek to build better institutions, however, the role-oriented, organizational definition is usually what they have in mind.

The USAID-sponsored institution-building literature of the 1960s, for instance, converged around organizations makes this matter of official policy, arguing that "because institutions become tangible only through the policies and actions of particular organizations, much of [our] institutional development effort will be focused on improving the policies and procedures of key organizations."

Most other donors and developing countries adhere to a similar definition, often narrowing it to mean formal collectives in the public sector, such as ministries, parastatals, agencies, or commissions. This book follows these conventions part way, by focusing on institutions in the organizational sense; however, our framework of analysis allows, indeed requires us, to simultaneously consider the effect on organizations of established codes of behaviour.

The development community's focus on role-oriented, organized activities unfortunately introduces another point of confusion, since "institutions" in this sense can be used loosely to refer to any formal or semi-formal collective entity. But not all organizations are institutions, any more than all institutions are organizations. As Perrow points out: "Some organizations are merely... rational tools in which there is little personal investment and which can be cast aside without regret.

Others become institutionalized. They take on a distinctive character; they become prized in and of themselves, not merely for the goods or services they grind out. People build their lives around them, identify with them, become dependent on them." Many rural organizations fail this test. When one refers to them as institutions it is often to speak hopefully about what they might become, and not realistically about what they, in fact, are.

A prime example of this failure is the experience of many developing countries with agricultural cooperatives, where the gap between what the coops were intended to be, and what they actually are, has been wide.

Our contributors concentrate on formally-constituted collectivities, but without prejudging whether they deserve the appellation "institution" in a strict sense. Further, the fact that the case studies tend to neglect informal modes of social organization, should not be interpreted as indicating that such institutions are less important in development. Nor should the focus of the case studies on discrete institutions be taken to mean that one may ignore the contextual factors within which organizations functions. To understand sustainability, it is important to keep this larger environment clearly in view.

GEOGRAPHY OF AGRICULTURE

Around ten to twelve thousand years ago, human began to domesticate plants and animals for food. Before this first agricultural revolution, people relied on hunting and gathering to obtain food supplies.

While there are still groups of hunters and gatherers in the world, most societies have switched to agriculture. The beginnings of agriculture did not just occur in one place but appeared almost simultaneously around the world, possibly through trail and error with different plants and animals or by long term experimentation. Between the first agricultural revolution thousands of years ago and the 17th century, agriculture remained pretty much the same.

In the seventeenth century, a second agricultural revolution took place which increased efficiency of production as well as distribution which allowed more people to move to the cities as the industrial revolution got under way. The eighteenth century's European colonies became sources of raw agricultural and mineral products for the industrializing nations.

Now, many of the countries which were once colonies of Europe, especially those in Central America, are still heavily involved in the same types of agricultural production as they were hundreds of years ago.

Farming in the twentieth century has become highly technological in more developed nations with geographical technologies like GIS, GPS, and remote sensing while less developed nations continue with practices which are similar to those developed after the first agricultural revolution, thousands of years ago. About 45% of the world's population makes their living through agriculture.

The proportion of the population involved in agriculture ranges from about 2% in the United States to about 80% in some parts of Asia and Africa. There are two types of agriculture, subsistence and commercial.

There are millions of subsistence farmers in the world, those who produce only enough crops to feed their families. Many subsistence farmers use the slash and burn or swidden agricultural method. Swidden is a technique used by about 150 to 200 million people, and is especially prevalent in Africa, Latin America, and Southeast Asia.

A portion of land is cleared and burned to provide at least one and up to three years of good crops for that portion of land. Once the land can no longer be utilized, a new patch of ground is slashed and burnt for another round of crops. Swidden is not a neat or well-organized method of agricultural production by it is effective for farmers who don't know much about irrigation, soil, and fertilization. The second type of agriculture is commercial agriculture, where the primary purpose is to sell one's product at market. This takes place throughout the world and includes major fruit plantations in Central America as well as huge agribusiness wheat farms in the Midwestern United States.Geographers commonly identify two major "belts" of crops in the U.S.

The wheat belt is identified as crossing the Dakotas, Nebraska, Kansas, and Oklahoma. Corn, which is primarily grown to feed livestock, reaches from southern Minnesota, across Iowa, Illinois, Indiana, and Ohio. J.H. Von Thunen developed a model in 1826 (which wasn't translated into English until 1966) for the agricultural use of land.

It has been utilized by geographers since that time. His theory stated that the more perishable and heavier products would be grown closer to urban areas. By looking at the crops grown within metropolitan areas in the U.S., we can see that his theory still holds true. It is very common for perishable vegetables and fruits to be grown within metropolitan areas while less-perishable grain is predominantly produced in non-metropolitan counties. Agriculture uses about a third of the land on the planet and occupies the lives of about two and a half billion people. It's important to understand where our food comes from.

2

Role of Irrigation and Horticulture

IRRIGATION WATER REQUIREMENTS

The assessment of the irrigation potential, based on soil and water resources, can only be done by simultaneously assessing the irrigation water requirements (IWR).

Net irrigation water requirement (NIWR) is the quantity of water necessary for crop growth. It is expressed in millimeters per year or in m^3/ha per year (1 mm = 10 m^3/ha). It depends on the cropping pattern and the climate. Information on irrigation efficiency is necessary to be able to transform NIWR into gross irrigation water requirement (GIWR), which is the quantity of water to be applied in reality, taking into account water losses. Multiplying GIWR by the area that is suitable for irrigation gives the total water requirement for that area. In this study water requirements are expressed in km^3/year.

Calculations of irrigation water requirements are done while preparing national water master plans or irrigation projects. Useful information was obtained from a number of country studies available from AQUASTAT, but the information was based on many different approaches. For the purpose of this study the need was felt to develop a method of computing irrigation water requirements for the whole continent in a systematic way. In order to be able to do this at the scale of the continent, assumptions have to be made on the definition of areas to be considered homogeneous in terms of rainfall, potential evapotranspiration, cropping pattern, cropping intensity and irrigation efficiency.

Methodology

For the calculation of irrigation water requirements the following steps have been followed:

- Delineation of major irrigation cropping pattern zones. These zones are considered homogeneous in terms of types of irrigated crops grown, crop calendar, cropping intensity and gross irrigation efficiency. Represented on the map of Africa, they should be viewed as regions where some homogeneity can be found in terms of irrigated crops. The cropping pattern proposed for the zone should be viewed as representative of an 'average' rather than a 'typical' irrigation scheme.
- Definition of the area of influence of the climate stations (in GIS) and quality check on the climate data.
- Combination of the irrigation cropping pattern zones with the climate stations' zones (in GIS) to obtain basic mapping units.
- Calculation of net and gross irrigation water requirements for different scenarios.
- Comparison with existing data and final adjustment.

Delineation of Irrigation Cropping Pattern Zones

The criteria used for the delineation of the irrigation cropping pattern zones were, in order of decreasing importance: distribution of irrigated crops, average rainfall trends and patterns, topographic gradients, presence of large river valleys (Nile, Niger, Senegal), presence of extensive wetlands (the Sudd in Sudan), population pressure, technological differences and crop calendar above and below the equator (Zaire).

The starting point was the type of irrigated crops currently grown in Africa. This resulted in 18 zones. From these zones, sub-zones showing a different cropping intensity or a different crop calendar were defied. This resulted in a total of 24 irrigation pattern zones, which are considered to be homogeneous for:

- crops currently grown;
- crop calendar;
- cropping intensity.

Only the main crops currently grown, those occupying at least 85% of the irrigated area, were considered. Land occupation of the remaining 15 % by secondary crops was assigned to the main crops.

An 'average' typical monthly crop calendar was assigned to each zone, based on work done by FAO's global information and early warning system, and on information from the reference library of FAO's agro-meteorology group, AQUASTAT and, for eastern Africa, from the IGADD crop production system zones inventory.

For each crop the actual cropping intensity was derived from national crop production and land use figures extracted from the FAO AGROSTAT and AQUASTAT databases. It ranges from 100 to 200%, according to the crop calendar. The cropping intensity to be used in this study of irrigation potential ('potential' scenario) was generally estimated by increasing current values by 10 to 20%, but it was assumed that because of market limitations the current high intensity (in relative terms) of vegetables in certain parts of the continent would not be found in the potential scenario. Therefore, intensities of cereal crops are higher in the potential scenario than in the actual situation.

Definition of the Climate Stations' Area of Influence

The climate data from the FAOCLIM cd-rom were used, as this was the most up to date climate database available. This data set includes long term average rainfall and reference potential evapotranspiration (ET_0) data for 1025 stations throughout Africa. ET_0 was calculated by the Penman-Monteith method .

To obtain a spatial coverage of climate data (P. ET_0) over the continent, each station was assigned an area of influence using the

Thiessen polygons method. This method assigns an area of 'nearest vicinity' to each climate station. Gives an indication of the density of the stations over the continent. As expected, the desert areas in northern and southern Africa are much less well covered than the rest of the continent. The rainfall data were compared with raster maps prepared by the Australian National University and corrected where necessary.

Combination of Cropping Pattern Zones with the Climate Stations

In ArcInfo, the 24 cropping pattern zones and the 1025 climate station data were merged. This resulted in 1437 basic map features, homogeneous in irrigation cropping characteristics and climate. All further calculations were carried out on these 1437 basic mapping units.

Calculation of Irrigation Water Requirements

Crop water requirements (CWR) for a given crop, i, are given by:

$$CWR_i = \sum_{t=0}^{T}\left(kc_{i_t} \cdot ET_{o_t} - P_{eff_t}\right) \text{unit: mm}$$

where kc_{i_t} is the crop coefficient of the given crop i during the growth stage t and where T is the final growth stage.

Each crop has its own water requirements. Net irrigation water requirements (NIWR) in a specific scheme for a given year are thus the sum of individual crop water requirements (CWR_i) calculated for each irrigated crop i. Multiple cropping (several cropping periods per year) is thus automatically taken into account by separately computing crop water requirements for each cropping period. By dividing by the area of the scheme (S. in ha), a value for irrigation water requirements is obtained and can be expressed in mm or in m^3/ha (1 mm = 10 m^3/ha).

$$NIWR = \frac{\sum_{i=1}^{n} CWR_i \cdot S_i}{S} \text{unit: mm}$$

where S_i is the area cultivated with the crop i in ha.

The cropping intensity of the scheme can be defined as:

$$\frac{\sum_{i=1}^{n} S_i}{S}$$

FAO's CROPWAT software (version 5.7) was used to compute NIWR for each of the 137 basic units described in chapter 2 . The model was run for three different scenarios:

- actual cropping intensity, effective rainfall;
- potential cropping intensity, effective rainfall;
- potential cropping intensity, dependable rainfall.

Gross irrigation water requirement (GIWR) is the amount of water to be extracted (by diversion, pumping) and applied to the irrigation scheme. It includes NIWR plus water losses:

$$GIWR = \frac{1}{E} \cdot NIWR_{unit.\ mm}$$

where E is the global efficiency of the irrigation system.

Limited objective information on irrigation efficiency was available and estimates were based on several criteria:

- figures found in literature;
- type of crops irrigated;
- the level of intensification of the irrigation techniques.

In this study the irrigation efficiencies for the 'potential' scenario range from 45 to 80%. Point observations were further generalized by hand to obtain zones of homogeneous irrigation water requirements (HIWR). A total of 84 HIWR zones were defined.

The methodology was tested and calibrated using a case study on the Egyptian Nile Valley and Delta where water requirements and availability could be computed with relative precision.

Results

Summarizes the figures for each of the 84 zones. NIWR and GIWR for the potential scenario with effective rainfall were further combined with the 136 basic units of this study to obtain individual NIWR and GIWR for each of these units through GIS.

The results have been compared with figures available from country studies (national water master plans, projects, etc.). The comparison shows that the methodology yields relatively accurate regional estimates of IWR that are suitable for the present study. Discrepancies with country studies find their origin mostly in the assumptions made on cropping pattern, cropping intensity and irrigation efficiency, and are discussed in details in Chapter 6.

The influence of *cropping pattern zones* on the quality of the output is of prime importance. Important differences in irrigation water requirements in adjacent zones is one of the consequences of this approach.

For instance, in Burkina Faso, areas located north of the 1000 mm annual rainfall line have a gross potential water requirement of 500 mm per year, while areas located just south of this line need more than 2800 mm per year.

This artificial break is due to the choice of the irrigated cropping pattern zones, where it was decided that no rice was cultivated under 1000 mm of rainfall per year. Within the cropping pattern zones, the boundaries of irrigation water requirement zones follow rainfall trends.

The estimates used for *cropping intensity* and *irrigation efficiencies*, to obtain the gross irrigation water requirements from the net figures, also have a direct influence on the results presented on the final maps.

The differences in irrigation water requirements between adjacent zones is directly related to the *density of the climate stations' network*. In low-density areas, such as the Sahara and southern Africa, differences in IWR between adjacent zones are high (up to 600 mm/year gross requirements) as the low station density does not allow the delineation of HIWR zones with smaller differences. A high density of the station network in the rest of the continent, in combination with rainfall raster maps, has resulted in differences of a maximum of 200 mm/year gross requirements between adjacent zones.

ENVIRONMENTAL IMPACT OF IRRIGATION

Environmental impacts of irrigation are the changes in quantity and quality of soil and water as a result of irrigation and the ensuing effects on natural and social conditions at the tail-end and downstream of the irrigation scheme.

The impacts stem from the changed hydrological conditions owing to the installation and operation of the scheme.

An irrigation scheme often draws water from the river and distributes it over the irrigated area. As a hydrological result it is found that:

- the downstream river discharge is reduced
- the evaporation in the scheme is increased
- the goundwater recharge in the scheme is increased
- the level of the water table rises
- the drainage flow is increased.

These may be Called Direct Effects

The effects thereof on soil and water quality are indirect and complex, Water logging and soil salination are part of these, whereas the subsequent impacts on natural, ecological and socio-enonomic conditions is very intricate.

Irrigation can also be done extracting groundwater by (tube) wells. As a hydrological result it is found that the level of the water descends. The effects may be water mining, land/soil subsidence, and, along the coast, saltwater intrusion.

Irrigation projects can have large benefits, but the negative side effects are often overlooked.

Reduced Downstream River Discharge

The reduced downstream river discharge may cause:

- reduced downstream flooding
- disappearance of ecologically and economically important wetlands or flood forests
- reduced availability of industrial, municipal, household, and drinking water

- reduced shipping routes. Water withdrawal poses a serious threat to the Ganges. In India, barrages control all of the tributaries to the Ganges and divert roughly 60 percent of river flow to irrigation
- reduced fishing opportunities. The Indus River in Pakistan faces scarcity due to over-extraction of water for agriculture. The Indus is inhabited by 25 amphibian species and 147 fish species of which 22 are found nowhere else in the world. It harbors the endangered Indus River dolphin, one of the world's rarest mammals. Fish populations, the main source of protein and overall life support systems for many communities, are also being threatened
- reduced discharge into the sea, which may have various consequences like coastal erosion (e.g. in Ghana) and salt water intrusion in delta's and estuaries (e.g. in Egypt, see Aswan dam). Current water withdrawal from the river Nile for irrigation is so high that, despite its size, in dry periods the river does not reach the sea . The Aral sea has suffered an "environmental catastrophe" due to the interception of river water for irrigation purposes.

Increased Groundwater Recharge, Waterlogging, Soil Salinity

This illustrates an environmental impact of upstream irrigation developments causing an increased flow of groundwater to this lower lying area leading to the adverse conditions

The increased groundwater recharge stems from the unavoidable deep percolation losses occurring in the irrigation scheme.

The lower the irrigation efficiency, the higher the losses. Although fairly high irrigation efficiencies of 70% or more (i.e. losses of 30% or less) can be obtained with sophisticated techniques like sprinkler irrigation and drip irrigation, or by precision land levelling for surface irrigation, in practice the losses are commonly in the order of 40 to 60%. This may cause:

- rising water tables,

- increased storage of groundwater that may be used for irrigation, municipal, household and drinking water by pumping from wells,
- waterlogging and drainage problems in villages, agricultural lands, and along roads with mostly negative consequences. The increased level of the water table can lead to reduced agricultural production.
- shallow water tables are a sign that the aquifer is unable to cope with the groundwater recharge stemming from the deep percolation losses,
- where water tables are shallow, the irrigation applications are reduced. As a result, the soil is no longer leached and soil salinity problems develop,
- stagnant water tables at the soil surface are known to increase the incidence of water borne diseases like malaria, filariasis, yellow fever, dengue, and schistosomiasis (Bilharzia) in many areas. Health costs, appraisals of health impacts and mitigation measures are rarely part of irrigation projects, if at all.
- to mitigate the adverse effects of shallow water tables and soil salinization, some form of watertable control, soil salinity control, drainage and drainage system is needed.
- As drainage water moves through the soil profile it may dissolve nutrients (either fertilizer based or naturally occurring) such as nitrates, leading to a built up of those nutrients in the ground water aquifer. High nitrate levels in drinking water can be harmful to humans particularly for infants under 6 months where it is linked to 'blue-baby syndrome' (see Methemoglobinemia).

Case Studies:

1. In India 2.189.400 ha have been reported to suffer from waterlogging in irrigation canal commands. Also 3.469.100 ha were reported to be seriously salt affected here
2. In the Indus Plains in Pakistan, more than 2 million hectares of land is waterlogged. The soil of 13.6 million hectares within the Gross Command Area was surveyed, which

revealed that 3.1 million hectares (23%) was saline. 23% of this was in Sindh and 13% in the Punjab. More than 3 million ha of water-logged lands have been provided with tube-wells and drains at the cost of billions of rupees, but the reclamation objectives were only partially achieved. The Asian Development Bank (ADB) states that 38% of the irrigated area is now waterlogged and 14% of the surface is too saline for use

3. In the Nile delta of Egypt, drainage is being installed in millions of hectares to combat the water-logging resulting from the introduction of massive perennial irrigation after completion of the High Dam at Assuan
4. In Mexico, 15% of the 3.000.000 ha if irrigable land is salinized and 10% is waterlogged
5. In Peru some 300.000 ha of the 1.050.000 ha of irrigable land suffers from this problem (see Irrigation in Peru).
6. Estimates indicate that roughly one-third of the irrigated land in the major irrigation countries is already badly affected by salinity or is expected to become so in the near future. Present estimates for Israel are 13% of the irrigated land,, Australia 20%, China 15%, Irak 50%, Egypt 30%. Irrigation-induced salinity occurs in large and small irrigation systems alike
7. FAO has estimated that by 1990 about 52 x 10^6 ha of irrigated land will need to have improved drainage systems installed, much of it subsurface drainage to control salinity.

Reduced Downstream Drainage and Groundwater Quality:

- The downstream drainage water quality may deteriorate owing to leaching of salts, nutrients, herbicides and pesticides. This may negatively affect the health of the population at the tail-end and downstream of the irrigation scheme, as well as the ecological balance. The Aral sea, for example, is seriously polluted by drainage water.
- The downstream quality of the groundwater may deteriorate in a similar way as the downstream drainage water and have similar consequences.

SURFACE IRRIGATION

Surface irrigation is defined as the group of application techniques where water is applied and distributed over the soil surface by gravity. It is by far the most common form of irrigation throughout the world and has been practiced in many areas virtually unchanged for thousands of years.

Surface irrigation is often referred to as flood irrigation, implying that the water distribution is uncontrolled and therefore, inherently inefficient. In reality, some of the irrigation practices grouped under this name involve a significant degree of management (for example surge irrigation). Surface irrigation comes in three major types; level basin, furrow and border strip.

The Process

The process of surface irrigation can be described using four phases. As water is applied to the top end of the field it will flow or advance over the field length. The advance phase refers to that length of time as water is applied to the top end of the field and flows or advances over the field length. After the water reaches the end of the field it will either run-off or start to pond. The period of time between the end of the advance phase and the shut-off of the inflow is termed the wetting, pending or storage phase. As the inflow ceases the water will continue to runoff and infiltrate until the entire field is drained. The depletion phase is that short period of time after cut-off when the length of the field is still submerged. The recession phase describes the time period while the water front is retreating towards the downstream end of the field. The depth of water applied to any point in the field is a function of the opportunity time, the length of time for which water is present on the soil surface.

Basin Irrigation

Level basin irrigation has historically been used in small areas having level surfaces that are surrounded by earth banks. The water is applied rapidly to the entire basin and is allowed to infiltrate. Basins may be linked sequentially so that drainage from one basin is diverted into the next once the desired soil water deficit is satisfied. A "closed" type basin is one where no water is drained from the basin. Basin irrigation is favoured in soils with relatively low infiltration rates (Walker and Skogerboe 1987). Fields are typically set up to follow the natural contours of the land but the introduction of laser levelling and land grading has permitted the construction of large rectangular basins that are more appropriate for mechanised broadacre cropping. Basin irrigation is commonly used in the production of crops such as rice and wheat.

Furrow Irrigation

Furrow irrigation is conducted by creating small parallel channels along the field length in the direction of predominant slope. Water is applied to the top end of each furrow and flows down the field under the influence of gravity. Water may be supplied using gated pipe, siphon and head ditch or bankless systems. The speed of water movement is determined by many factors such as slope, surface roughness and furrow shape but most importantly by the inflow rate and soil infiltration rate. The spacing between adjacent furrows is governed by the crop species, common spacings typically range from 0.75 to 2 metres. The crop is planted on the ridge between furrows which may contain a single row of plants or several rows in the case of a bed type system. Furrows may range anywhere from less than 100 m to 2000 m long depending on the soil type, location and crop type. Shorter furrows are commonly associated with higher uniformity of application but result in increasing potential for runoff losses. Furrow irrigation is particularly suited to broad-acre row crops such as cotton, maize and sugar cane. It is also practiced in various horticultural industries such as citrus, stone fruit and tomatoes.

The water can take a considerable period of time to reach the other end, meaning water has been infiltrating for a longer period of time at the top end of the field. This results in poor uniformity with high application at the top end with lower application at the bottom end. In most cases the performance of furrow irrigation can be improved through increasing the speed at which water moves along the field (the advance rate). This can be achieved through increasing flow rates or through the practice of surge irrigation. Increasing the advance rate not only improves the uniformity but also reduces the total volume of water required to complete the irrigation.

Surge Irrigation

Surge Irrigation is a variant of furrow irrigation where the water supply is pulsed on and off in planned time periods (e.g. on for ½ hour off for ½ hour). The wetting and drying cycles reduce infiltration rates resulting in faster advance rates and higher uniformities than continuous flow.

The reduction in infiltration is a result of surface consolidation, filling of cracks and micro pores and the disintegration of soil particles during rapid wetting and consequent surface sealing during each drying phase. The effectiveness of surge irrigation is soil type dependent, for example many clay soils experience a rapid sealing behaviour under continuous flow therefore surge offers little benefit.

Bay/Border Strip Irrigation

Border strip or bay irrigation could be considered as a hybrid of level basin and furrow irrigation. The borders of the irrigated strip are longer and the strips are narrower than for basin irrigation and are orientated to align lengthwise with the slope of the field.

The water is applied to the top end of the bay, which is usually constructed to facilitate free-flowing conditions at the downstream end. One common use of this technique includes the irrigation of pasture for dairy production.

Drainage after Harvest or in Rainy Season

Drainage of flooded banks or drainage of extremely wet soil during the rainy season may be done by ditches. Drainage by ditches may be done with crops that require the soil to be wet but not completely saturated (and sometimes, especially not at certain times of year). An example is blueberries. In the rainy season/winter, they require drier soil.

Issues Associated with Surface Irrigation

While surface irrigation can be practiced effectively using the right management under the right conditions, it is often associated with a number of issues undermining productivity and environmental sustainability

- Waterlogging - Can cause the plant to shut down delaying further growth until sufficient water drains from the rootzone. Waterlogging may be counteracted by drainage and watertable control.
- Deep drainage - Over irrigation may cause water to move below the root zone resulting in rising water tables. In regions with naturally occurring saline soil layers (for example salinity in south eastern Australia) or saline aqifers, these rising water tables may bring salt up into the root zone leading to problems of irrigation salinity.
- Salinization - Depending on water quality irrigation water may add significant volumes of salt to the soil profile. While this is a lesser issue for surface irrigation compared to other irrigation methods (due to the comparatively high leaching fraction), lack of subsurface drainage may restrict the leaching of salts from the soil. This can be remedied by drainage and soil salinity control.

Localized Irrigation

Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods.

Drip Irrigation

Drip irrigation, also known as trickle irrigation or micro irrigation, is an irrigation method which saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters.

History

Drip irrigation has been used since ancient times when buried clay pots were filled with water, which would gradually seep into the grass. Modern drip irrigation began its development in Afghanistan in 1866 when researchers began experimenting with irrigation using clay pipe to create combination irrigation and drainage systems. In 1913, E.B. House at Colorado State University succeeded in applying water to the root zone of plants without raising the water table. Perforated pipe was introduced in Germany in the 1920s and in 1934, O.E. Nobey experimented with irrigating through porous canvas hose at Michigan State University.

With the advent of modern plastics during and after World War II, major improvements in drip irrigation became possible. Plastic microtubing and various types of emitters began to be used in the greenhouses of Europe and the United States.

The modern technology of drip irrigation was invented in Israel by Simcha Blass and his son Yeshayahu. Instead of releasing water through tiny holes, blocked easily by tiny particles, water was released through larger and longer passageways by using velocity to slow water inside a plastic emitter. The first experimental system of this type was established in 1959 when Blass partnered with Kibbutz Hatzerim to create an irrigation company called Netafim. Together they developed and patented the first practical surface drip irrigation emitter. This method was very successful and subsequently spread to Australia, North America, and South America by the late 1960s.

In the United States, in the early 1960s, the first drip tape, called *Dew Hose*, was developed by Richard Chapin of Chapin Watermatics (first system established during 1964). In Pakistan it has been promoted by the Pakistan Atomic Energy Commission, the Agriculture Development Bank as well as successive governments. Beginning in 1989, Jain irrigation helped pioneer effective water-management through drip irrigation in India. Jain irrigation also introduced some drip irrigation marketing approaches to Indian agriculture such as 'Integrated System Approach', One-Stop-Shop for Farmers, 'Infrastructure Status to

Drip Irrigation & Farm as Industry.' The latest developments in the field involve even further reduction in drip rates being delivered and less tendency to clog. One of the prestigious names in the field of drip irrigation in India is Kisan Irrigations Limited. Although among the top names in the field of Pipes & Fittings in India, they were a late entrant in this field. However, they have made important strides with their innovative & futuristic products like Hydrozig & Flat ranges in driplines as well as semi-portable, portable & flexible Mini and Micro Sprinkler Irrigation Systems for farmers in India. Their systems have been widely accepted by farmers due to the lowest clogging rate in operational conditions mainly due to the efficient Filtration Unit used which are indigenously manufactured at Kisan.

Modern drip irrigation has arguably become the world's most valued innovation in agriculture since the invention of the impact sprinkler in the 1930s, which offered the first practical alternative to surface irrigation. Drip irrigation may also use devices called micro-spray heads, which spray water in a small area, instead of dripping emitters. These are generally used on tree and vine crops with wider root zones. Subsurface drip irrigation (SDI) uses permanently or temporarily buried dripperline or drip tape located at or below the plant roots. It is becoming popular for row crop irrigation, especially in areas where water supplies are limited or recycled water is used for irrigation. Careful study of all the relevant factors like land topography, soil, water, crop and agro-climatic conditions are needed to determine the most suitable drip irrigation system and components to be used in a specific installation.

Components and Operation

Components (listed in order from water source):

- Pump or pressurized water source
- Water Filter(s) - Filtration Systems: Sand Separator like Hydro-Cyclone, Screen filters, Media Filters
- Fertigation Systems (Venturi injector) and Chemigation Equipment (optional)

- Backwash Controller (Backflow Preventer)
- Pressure Control Valve (Pressure Regulator)
- Main Line (larger diameter Pipe and Pipe Fittings)
- Hand-operated, electronic, or hydraulic Control Valves and Safety Valves
- Smaller diameter polytube (often referred to as "laterals")
- Poly fittings and Accessories (to make connections)
- Emitting Devices at plants (ex. Emitter or Drippers, micro spray heads, on-line drippers, trickle rings)
- Note that in Drip irrigation systems Pump and valves may be manually or automatically operated by a controller.

Most large drip irrigation systems employ some type of filter to prevent clogging of the small emitter flow path by small waterborne particles. New technologies are now being offered that minimize clogging. Some residential systems are installed without additional filters since potable water is already filtered at the water treatment plant. Virtually all drip irrigation equipment manufacturers recommend that filters be employed and generally will not honour warranties unless this is done. Last line filters just before the final delivery pipe are strongly recommended in addition to any other filtration system due to fine particle settlement and accidental insertion of particles in the intermediate lines.

Drip and subsurface drip irrigation is used almost exclusively when using recycled municipal waste water. Regulations typically do not permit spraying water through the air that has not been fully treated to potable water standards.

Because of the way the water is applied in a drip system, traditional surface applications of timed-release fertilizer are sometimes ineffective, so drip systems often mix liquid fertilizer with the irrigation water. This is called fertigation; fertigation and chemigation (application of pesticides and other chemicals to periodically clean out the system, such as chlorine or sulfuric acid) use chemical injectors such as diaphragm pumps, piston pumps, or venturi pumps. The chemicals may be added constantly whenever the system is irrigating or at intervals. Fertilizer savings of up to 95% are being reported from recent university field tests using drip fertigation and slow water delivery as compared to timed-release and irrigation by micro spray heads.

If properly designed, installed, and managed, drip irrigation may help achieve water conservation by reducing evaporation and deep drainage when compared to other types of irrigation such as flood or overhead sprinklers since water can be more precisely applied to the plant roots. In addition, drip can eliminate many diseases that are spread through water contact with the foliage. Finally, in regions where water supplies are severely limited, there may be no actual water savings, but rather simply an increase in production while using the same amount of water as before. In very arid regions or on sandy soils, the preferred method is to apply the irrigation water as slowly as possible.

Pulsed irrigation is sometimes used to decrease the amount of water delivered to the plant at any one time, thus reducing runoff or deep percolation. Pulsed systems are typically expensive and require extensive maintenance. Therefore, the latest efforts by emitter manufacturers are focused toward developing new technologies that deliver irrigation water at ultra-low flow rates, i.e. less than 1.0 liter per hour. Slow and even delivery further improves water use efficiency without incurring the expense and complexity of pulsed delivery equipment.

IRRIGATION WATER QUALITY FOR GREENHOUSE PRODUCTION

Most greenhouse media contain 30 to 60 per cent peat moss alone or in combination with composted pine bark. Other materials are added for drainage and aeration. In terms of air/water relations in the root zone, the quality of the peat used is very important. Peat that has been milled too much has a smaller fibre size. Media settling may result in loss of plant-rooting volume. Also, aggregates such as vermiculite may or may not improve drainage and air space, depending on the size and shape of the particle. Fine-grade vermiculite particles may actually decrease media aeration. Only a portion of the water added to media is available for root uptake.

Available water-holding capacity is the amount of water held in the root zone and available to plants between irrigating and when the plant wilts. In a 6-inch pot, approximately 65 per cent of the pore space is filled with water after the pot has been saturated and allowed to drain.

Generally only about 70 per cent of that water is available; the rest is called unavailable water. The amount of available water depends on how tightly the water is held to the particles of materials that make up the media (matric tension). For example, peat has relatively higher unavailable water contents at a given matric tension compared to rock wool. This variability in the availability of water in different types of media components means no two media are exactly alike in terms of providing water to plants. This makes knowing when to water difficult. Another important characteristic of media components that influences watering practices is wettability, *i.e.*, the ability of dry media to rapidly absorb water when moistened. The choice of media should be influenced by irrigation systems and practices.

Media Column Height/Containers

Another factor relating media to air/water relations in the root zone is the size of the growing container. With media in containers, the amount of air and water held in a given media is a function of the height of the column of media. The taller the column, the smaller the ratio of water to air spaces. This is most important in plug production where the small cells drain very poorly or not at all, resulting in poor root zone aeration.

The dramatic effect of container height on air space is evident, which shows the change in per cent volume air space of a 1:1 peat:vermiculite media in various growing containers. In all containers, there will be a certain amount of saturated media at the bottom of the container after drainage. This is due to what is called a >perched water table. The saturation zone is a larger part of the total volume of the growing media in a very short container, such as a plug cell. A good way to illustrate the effect of container height is to use a sponge. A sponge of the dimensions 2@ x 4.25@ x 8.5@ (72.25 cubic inches or 1,184 milliliters) represents the media in a container. When fully saturated, the sponge holds 950 ml; that is, the total porosity is 80 per cent. Holding the sponge so it is 2 inches high results in about 50 ml water draining out, resulting in a volume air space of 4.2 per cent. If it then is held so it is 4.25 inches high, another 125 ml drains out, resulting in a volume air space of 14.8 per cent. If the sponge is then held so it is 8.5 inches high, another 375 ml drains out, resulting in a volume air space of 46.5 per cent. Starting with the same volume of media (sponge), the effect of container height (sponge height) on media air space is dramatic. We can conclude that the choice of containers is important in managing water/air relations in the root zone, especially of plugs.

Another issue is whether square or round plug cells are better. In general, square cells with their greater volume make crop management a little easier. As long as the height is the same, however, there is no difference in air space.

Media Handling

How media are handled can greatly influence their air and water characteristics. The major concern is to avoid compaction. Containers, including plug trays, should be lightly filled and the excess brushed off the top. Air space can be drastically reduced by compaction. At no time should any growing containers be stacked. The moisture content of the media prior to filling containers may also be important. Adding water to peat based mixes before filling plug trays causes the media to swell and helps create more aeration. Water added to about 100 per cent by weight of the media is sufficient for cell packs. Plug mixes should have about 200 per cent by weight water added before filling plug trays. Moistening of the media before filling larger containers does not have much benefit.

SAND CULTURE

This term may be used in a general way to refer to cultures in sand, fine gravel or cinders, but here it applies specifically to cultures of plants in sand, using nutrient solutions to supply the mineral elements required for plant growth. Sand is adapted ibr such use where free drainage is possible, as in the constant-drip and flush or "slop" techniques. In small installations, coarser grades of sand may be used with sub-irrigation, which see. In larger installations, it is not suitable for the subirrigation method because of slow drainage, but it can be used in a greenhouse bench with free drainage and the surface application of the nutrient solution. The best type of sand is a quartz sand of the grade used for making concrete. It should be washed clean. This can be done by placing the sand in a pail or tub and forcing water up through it by delivering the water through a hose at the bottom of the receptacle so the flooding will carry out clay and silt particles. Washing is especially important if the sand is fine. If the sand is too coarse, it will require more nutrient solution to maintain the proper moisture relation.

If the only source of sand available is a limestone sand, it may be advisable' to use cinders, for the lime sand contains much calcium which, in excess, will cause plant foliage to turn yellow. However, by using a more acid nutrient solution, or by running the nutrient solution daily through the limestone sand for two weeks before placing the plants in the medium, the sand grains can be given a coating of phosphates and be made safe for growing plants.

Growing Seedlings in Sand

Seedlings can be raised by sand culture either to be transferred to cultures for chemical gardening or for use in the outdoor garden. By this method seedlings with very fine root systems can be produced; if handled properly they will transplant into soil readily and, given proper care, start to grow promptly. In addition, losses from damping-off are minimized, while another advantage is that if the seedlings are not too crowded, they can remain in the sand if supplied with nutrient solution in the proper concentration.

A good way to handle them is to construct a box not less than 4 in. Deep on the inside with openings in the bottom so excess solution can drain out. These spaces between the bottom boards or small drainage holes can be covered with cheesecloth, burlap, or glass wool to prevent the sand from sifting through. Fill the box with clean sand and flush it well with water to settle the sand thoroughly. Then flush with nutrient solution diluted with five times as much water. The seeds may be sown in drills or rows or broadcast; if in rows, make the furrows barely deep enough so that the seeds can be covered after being sown thinly. If the broadcast method is used, spread the seeds uniformly and not too thickly over the surface, and cover with about one-fourth inch of sand. In either case, firm or compact the sand, then apply the dilute nutrient solution until the sand is saturated.

Cover the box with newspaper to reduce evaporation and place in the proper temperature for the kind of seed sown. Since it would be fatal to the embryo of the seed if the surface should become dry, the sand must be kept moist. The dilute nutrient solutions should be applied as a fine spray, to prevent disturbing the surface; a rubber bulb syringe with a fine rose nozzle is excellent for this purpose.

As soon as the seeds have germinated and the shoots appeared above the surface, remove the newspaper covering. When the seedlings have grown to suitable size, they may be transplanted to a permanent location or to other vessels where they can be more widely spaced.

If it is desired to leave them in the flat, thin them out to a proper spacing. They are now able to manufacture food in their leaves, and the nutrient solution should be applied in a stronger concentration – one part of nutrient solution to one part of water. Should it be desired or necessary to remove the seedlings from the sand medium, flood it with nutrient solution and gently pull the plants out one by one, assisting the removal with sonic instrument thrust under the root. A label, spatula, or case knife will be suitable.

"Sand culture is one of the most efficient and cost-effective methods of soilless culture, and is widely used in the dry arid regions of the Middle East. Although it is not used in Australia on a commercial scale, it has proved popular among some growers for crop trials. Its simplicity and low capital cost makes it an attractive alternative to existing growing methods." Sand culture is one of the most efficient and cost-effective methods of soilless culture, and is widely used in the dry arid regions of the Middle East. Although it is not used in Australia on a commercial scale, it has proved popular among some growers for crop trials. Its simplicity and low capital cost makes it an attractive alternative to existing growing methods." by Leo Wright History records that Aztec Indians were among the first to use sand culture techniques.

During the 12th century the Aztecs developed extraordinary irrigation systems in the Mexican basin, with swamp reclamation their most significant achievement, even including the colonisation of surrounding lakes. The Aztecs grew beans and squash on primitive rafts covered with sand removed from shallow lake beds. The plant roots grew through the sand down into the nutrient-rich water of the lake. A few of these so-called 'floating gardens' can still be seen on the lakes surrounding Mexico City today. In modern times, sand culture re-emerged during the 1960s, ironically in Puerto Penasco, Mexico, where successful trials led to commercial operations in Mexico, the U.S. Southwest and in the Middle East. Using coarse beach sand, leached free of excess salts, vegetables were either sown directly in the sand or planted as seedlings.

The Advantages

The sand culture system has many advantages over traditional hydroponic techniques. The fact that it is an 'open' ('run-to-waste') system, whereby the nutrient solution is not recycled, greatly reduces the likelihood of diseases such as Fusarium and Verticillium spreading in the medium. It also means there is no nutrient imbalance since plants are fed with fresh nutrient solution at each irrigation cycle. Another advantage is the excellent capillary action of sand, which results in lateral movement of nutrients so that there is an even distribution of nutrients throughout the root zone. Additionally, water retention is high owing to the smallness of the sand particles, allowing fewer irrigation cycles during the course of the day. Unlike other systems, particularly NFT (Nutrient Film Technique, in which there is no medium), in the event of a fractured pipe, power or mechanical failure, there is more time available to repair the system before plants consume existing water in the medium and begin to experience stress due to dehydration.

Practical advantages of sand culture include lower construction costs, simplicity of operation, and easy maintenance and service.

The Disadvantages

The disadvantages of sand culture are few, and in some cases are in common with other hydroponic techniques. A major disadvantage is the need to use chemical or steam sterilisation between crops in order to destroy media-borne pathogens. Such methods are thorough, although somewhat time- consuming. Like all drip irrigation systems, feed lines can become blocked with fine nutrient particles, grit or sand. This can be overcome by using in-line mesh filters which can be easily cleaned. Perhaps the overriding factor which makes sand culture unattractive to end-users is the seemingly high consumption rate of nutrients because of the need to run to waste.

However, with careful management, the waste should account for no more than 8 per cent to 10 per cent of the total nutrient solution added. Salt build-up is another common problem, but this can be corrected by flushing the medium periodically with fresh water. Again, regular and careful monitoring of the drainage water for evidence of salt accumulation is important to prevent excess salt problems.

Sand Culture Systems There are basically two proven methods of utilising sand as a growing medium. The first is to use plastic-lined beds in above ground troughs; the other is to spread sand over the entire floor of the growing area. Both methods use a sand depth of between 300 and 400 mm. Sand beds can be easily constructed with wooden sides, or with concrete reinforcement wire, cut and bent to form an above ground trough and lined with thick, black plastic film. The bed must be watertight as leaks mean wasted nutrients. Polyethylene film (6-20micron), or swimming pool liner are ideal. If using black polyethylene film, it should be doubled over for maximum strength – a single layer of polyethylene will stretch and tend to mould around sharp objects once sand is shovelled into the bed, which may cause it to rupture. The bottom of the trough should have a 1:400 incline (150mm drop per 60 metres), so that it can be drained or leached when required. A drain pipe should be set along the entire length of each sand bed, which in turn should be connected to a main pipe at one end to collect waste water from all beds and to conduct it away from the greenhouse or growing area.

For sand beds deeper than 400mm, 50mm agricultural pipe, covered with blue metal, can be used to channel excess nutrients away. For a standard sand bed, 70mm pressure pipe can be used and this should be seated on a shallow layer of blue metal. The pipe should have drainage holes, cut across the pipe with a saw every 450mm, with the holes positioned on the undersurface of the pipe to discourage plant roots entering the pipe.

For greenhouse operations, the floor should have a gradient of 150mm per 30 metres, (1:200 incline), and should be covered with 6 micron black plastic film. Generally, two layers of black film are used to overlap and cover the entire floor.

A 30mm-50mm diameter drainage pipe, cut in the manner described earlier, is placed on top of the plastic at a uniform spacing of 1-2 metres between pipes, depending upon the grade of sand in use.

The finer the sand, the closer the pipes should be spaced. Drain pipes must run parallel with the slope of the floor. At the low end of the greenhouse a connecting pipe is installed to conduct excess nutrients away from the greenhouse where it can be used for outside irrigation. Once the pipes are in place, the entire greenhouse floor is covered with sand to a depth of 300mm. A simple home system can be designed along the same lines as commercial units, but on a much smaller scale. It should consist of a bed or growing tray, nutrient reservoir and a trickle feeding system operated by a pump that is controlled by a timer. The growing tray can have small holes in the bottom of the plastic liner or a perforated plastic pipe can be used for drainage.

One of the oldest and still popular hydroponic methods is to use a wick system. This consists of a double pot, one containing the sand and plant, and the other the nutrient solution. A fibrous wick is set into the growing pot about one-third of the way with the other end suspended in the nutrient solution. As the sand dries out, capillary action draws more solution through the wick to the plant root zone. Ideal Sand Aggregate Research shows that beach sand is usually too fine and causes puddling, indicated by water coming to the surface upon vibration of the sand.

Examples of puddling can often be seen in footsteps while walking along wet beach sand. It is caused by the high percentage of silt and fine sand. The ideal sand aggregate is river sand, washed free of fine silt and clay. The sand particle size should be between 0.6mm and 2mm in diameter, which allows the aggregate to drain freely and not puddle after an application of water. Cuming recommends a mixture of grades (30-40 per cent of 0.5mm, 40-60 per cent of 0.2mm to 0.5mm, and 5-15 per cent of 0.2mm). Drip irrigation System A drip irrigation system must be used with sand culture. In a greenhouse situation piping should be capable of delivering 6-10 litres per minute for each 100 square metres, or 30-45 litres per minute for each 500 square metres of growing area. However, the rate and length of irrigation cycle will depend upon the crop, its maturity, weather conditions and time of day.

The volume of water can be regulated using a flow control valve for each sand bed. The valve is adjusted for each bed according to plant requirements. In this way several plant types can be grown. The flow valve should be positioned upstream from the solenoid valve which automatically controls the irrigation cycle. Where several beds are cultivated, there is no need to water them simultaneously. The water arrangement can be set so that individual beds are watered separately, thus ensuring mains pressure is not reduced. For small sand beds, a single 13mm black polyethylene pipe can be run down the length of the bed with spaghetti lines inserted every 300mm. Larger beds will require 13mm poly pipe run along the inside of each plant row. Emitters can be used to deliver nutrients to plants, adjusted to deliver 4-6 litres per hour. Alternatively, spaghetti tubing can be inserted into the main 13mm feed line. A short length (50mm) of 13mm poly tube can be attached to the end of each spaghetti line to channel nutrients out to each side of the irrigation point. Emitters, above ground pipes and fittings should be black to prevent algae growth inside the piping system.

Watering

If a timer is used, it should be programmed to deliver nutrients two to five times daily, depending on the maturity of plants, weather and seasonal factors. The water is added to each cycle to allow 8 per cent-10 per cent drain off. Twice a week a sample of the drain off should be taken and tested for total dissolved salts. If the dissolved salts reach 2000 parts per million (ppm), then the entire sand bed should be leached free of salts using fresh water.

The Nutrient Tank

The nutrient tank should be large enough to meet feeding requirements for at least one week. And if several crops are grown which have different nutrient requirements, then two tanks should be used, each with its own specific nutrient formulation. In this event, independent irrigation systems must be connected to each nutrient tank. Since sand culture is an open system, there is no need to change the nutrient solution regularly. However, the tank should be drained and cleaned periodically of any sludge or sediment which may accumulate owing to inert carriers in the fertilizer salts. Sand culture beds can be constructed on any surface, including hard bedrock or stony ground with a minimum of fuss. That, combined with low installation costs, simplicity of operation and retention of moisture, even in hot weather, makes it an ideal system for Australian conditions. It is particularly well-suited to rain shadow areas. Perhaps the only significant disadvantage is that it is likely to become waterlogged during heavy rain periods in those systems exposed to the elements.

HORTICULTURE

Horticulture is the science and art of producing, improving, marketing, and using fruits, vegetables, flowers, and ornamental plants. It differs from botany and other plant sciences in that horticulture incorporates both science and aesthetics.

Prodtuction and consumption of high quality fruits and vegetables allows us to maintain a healthy, balanced daily diet. Flowers and ornamental plants enrich our homes and communities, and contribute to our sense of well-being. Horticulture impacts our lives on a daily basis by providing nutritious fruits and vegetables, offering visual enjoyment, and promoting recreational activities.

Methods

Plant propagation is primarily done by conventional methods, which include sexual and asexual methods. However, in the recent past plant propagation through biotechnological applications have made great contributions towards mass scale production of plants.

The conventional and the recent biotechnological approaches in fruit plant propagation.Sexual Method of Propagation: In this method the plants are raised from seeds.

Advantages: For evolution of new varieties through breeding, the hybrids are raised from seed:

- In some fruit plants like papaya, this is the most popular method of propagation.
- Seed propagated rootstocks are hardy and develop better root system.
- Viruses don't transmit through seeds, thus mostly the seedlings are free from virus diseases.
- Occurrence of polyembryony (more than one embryo in seed) in citrus and mango leads to the development of uniform seedlings as in asexual method.

Disadvantages:

- Seedlings have a long juvenile period and come into bearing later ascompared to asexually raised plants.
- Due to segregation of characters, the progeny is not true-to-type.——
- It is not economical to handle larger trees, as less number of trees can be accommodated per unit area and the cultural operations are difficult.

Asexual Method of Propagation

In this method of propagation the plants are obtained from a vegetative portion of the mother plant instead of seeds.

Advantages:

- In some fruit plants like banana, which do not bear seeds, this is the only method of propagation.
- The plants are generally true-to-type, uniform in growth, yielding capacity and fruit quality.
- Have short juvenile phase, thus come into bearing earlier than seedling plants.
- The advantages of rootstocks can be obtained by budding or grafting susceptible varieties on resistant/ tolerant rootstocks.
- Plants have restricted growth, thus cultural practices and harvesting are easy.

Disadvantages:

- New variety cannot be evolved by this method.
- Such plants are not so vigorous and long-lived as the seedling trees.
- Germplasm conservation requires lot of space and is expensive as compared to storage of seeds.

GROWTH OF HORTICULTURE

The horticulture scenario of the country is rapidly changing. The production and productivity of horticultural crops have increased manifold. Production of fruits and vegetables has tripled in the last 50 years. The productivity has gone up by three times in banana and by 2.5 times in potato. Today horticultural crops cover about 25 per cent of total agricultural exports of the country. The corporate sector is also showing greater interest in horticulture. A major shift in consumption pattern of fresh and processed fruits and vegetables is expected in the coming century. There will be greater technology adoption both in traditional horticultural enterprise as well as in commercial horticulture sectors. Diversification and value addition will be the key words in the Indian horticulture in the 21st Century.

Horticulture research in India is about four decades old. Systematic research on fruit, vegetable and ornamental crops began in 1954 with the initiation of independent institutions and programmes. The research agenda is designed relevant to national plans and priorities for the horticulture development. Today, eight ICAR institutes with 27 regional stations, 1 project directorate, 10 national research centres, 16 all India coordinated research projects (AICRPS) with 223 research stations, 1 full-fledged university of horticulture, 25 state agricultural universities and 7 multi-disciplinary institutes of the ICAR are engaged in horticulture research. In addition, a few R&D establishments of crop/commodity boards and private sectors are providing research support to Indian horticulture. Research system in horticulture is now geared to provide necessary technological support to the expanding horticultural industry. The research efforts in the past were mainly concentrated on crop improvement, propagation of seed/planting material, agrotechniques, crop protection and post harvest management.

Varietal Development

Among the fruit crops, improved high yielding mango varieties, Mallika, Amrapali, Ratna, Sindhu, Arka Aruna, Arka Puneet, Dashehari-51 and hybrids namely CISH-M-1 and CISH-M-2 have been developed. Mallika is coming up in southern states like Karnataka and Amrapali is performing well in eastern India. Dashehari-51, a regular bearing cultivar with about 38 per cent higher productivity than the normal Dashehari, has been identified after 14 years of rigorous selection. In guava, three selections, namely Lalit, CISH-G-1 and CISH-G-2 have been developed for domestic and export markets.

The fruits of Lalit are of medium size weighing about 150 g each and suitable for both table and processing purposes. In banana, high yielding hybrids like FHIA-01 and FHIA-03 are promising for replacing varieties, Panchananda and Bluggoe, respectively. Cultivar, Saba is found promising under sodic soils. In addition, high yielding varieties like Col, Hl and H2 have been developed. In grape, superior and high yielding varieties have been developed *e.g.* Beauty Seedless and Pusa Seedless and early ripening variety, Perlette for cultivation under North Indian conditions and Anabe-Shahi, Dilkhush, Thompson Seedless, Tas-A-Ganesh, Sonaka, Bangalore Blue and Pachadraksha for south Indian conditions.

In citrus, high yielding and cluster bearing varieties of acid lime have been developed. *e.g.*, Rough Lemon, Rangpur Lime, Pramaini, Vikram PKM-1. Trifoliate oranges, namely Flying Dragon and Rich 16-6 are dwarfing types. In papaya, high yielding superior varieties both for table purpose and papain production have been developed. *e.g.*, Co-1 to Co-7, Coorg Honey Dew, Pusa Delicious, Pusa Majesty, Pusa Giant and Pusa Nanha. In apple, superior hybrids have been developed. *e.g.*, Lal Ambari, Sunehari. Red Spur, Star Crimson, Golden Spur, Red Chief, Oregon Spur, Skyline Supreme and Vance Delicious have been identified. Tissue culture protocols for micro-propagation of two commercial varieties have been developed.

Among the vegetable crops, more than 130 open pollinated varieties, 36 hybrids, 3 synthetics and 29 resistant varieties of 20 vegetable crops have been developed and released for cultivation in different agro-climatic regions. These include 40 in tomato, 45 in brinjal, 13 in cauliflower, 12 in chillies, 20 in pea, 9 in musk melon, 16 in onion and 44 in other crops.

In potato, 33 high yielding varieties have been developed indigenously for large scale cultivation in different regions. Kufri Ashoka and Kufri Pukhraj mature in 75 days. Kufri Jawahar and Kufri Satluj are field resistant to late blight. Kufri Jawahar has most ideal plant type for inter-cropping. Kufri Chipsona-1 and Kufri Chipsona-2 have been developed with excellent processing attributes, comparable to exotic varieties. Kufri Swarna resistant to golden nematode is ideal for Nilgiri Hills.

In tuber crops, improved varieties of different tuber crops have been recommended/released for commercial cultivation. These includes 9 varieties of cassava, 15 varieties of sweet potato, 6 varieties of colocasia, 3 varieties each of greater yam and lesser yam, 1 each of *Amorphophallus,* taro and yambean. Cassava varieties, Sree Visakham and Sree Prakash are popular in Kerala. Triploid clone, Sree Harsha with high dry matter and starch content is suitable for industrial belt of Tamil Nadu. Two early maturing varieties Sree Jaya and Sree Vijya have been released for culinary purposes. Elephant foot yam variety, Am-15 has been released with high yield potential of 41 t/ha.

Among the plantation and spice crops, India is the first country to exploit hybrid vigour in coconut. Twelve hybrids involving tall and dwarf parents and 4 varieties have been released for commercial cultivation. These varieties yield 21 to 89 per cent more than the local cultivars. Some of the released varieties like Chandra Kalpa and Pratap (Banawali Green Round) are receiving wide acceptance of farmers. Chowghat Green Dwarf variety is good for tender coconut purpose. In arecanut, 4 high yielding varieties, namely, Mangala, Sumangala, Sreemangala and Mohitnagar have been developed, giving about 30 per cent higher yield than the local cultivars.

In oil palm, first efforts for improvement were made by producing Tenera hybrids using Pisifera pollen imported from Nigeria. Dura x Pisifera hybrids are field tested in East and West Godavari districts, Khammam and Krishna districts of Andhra Pradesh, with yield potential of 20-25 tonnes/ha of FFB from the fifth year. In cashew, 22 region specific selections and 12 hybrids with yield potential of 1.5-2 tonnes of raw nuts/ha have been produced and released for commercial cultivation.

The present standards fixed for cashew varieties include export grade kernels of W-210 to W-240 and at least one tonne per ha yield with 30 per cent shelling. In black pepper, 6 varieties, namely, Sreekara, Subhakara, Palode-2, Panniyur-2, Panniyur-4, Panchami and Pournami, and 2 hybrids *viz.* Panniyur-1 and Panniyur-4 have been developed. In cardamom, a number of improved varieties have been developed and released for commercial cultivation *e.g.,* CCS-1, Mudigere-1, PV-1, ICRI-1 and ICRI-2. In ginger, varieties like Suprabha, Suruchi, Suravi and Varada have been developed. In turmeric, several varieties *viz.*, Co-1, Krishna, Sugandham, BSR-1, Suvarna, Roma, Suroma, Rajendra Sonia, Sugana, Sudarshana, Ranga, Rasmi, Prabha, Prathiba, Mega Turmeric and RCT-1 have been developed with yield potential of up to 44 tonnes of fresh rhizomes per ha. Three high yielding cinnamon lines, namely, Navashree, Nithyashree and Konkan Tej have been released for cultivation.

Agrotechniques

In fruit crops, improved agrotechniques developed have helped the farmers in improving the productivity and quality of produce. Soil application of paclobutrazol (4 g/tree) increase flowering and fruiting in mango on commercial scale in coastal Maharashtra. It also controls irregular bearing in cultivar Dashehari. Spray of NAA @ 200 ppm in October is recommended for control of malformation. Heavy fruit drop at maturity in cultivar Langra can be controlled by spraying NAA (20 ppm). In guava, double spray of 10 and 20 per cent urea on cultivars, Allahabad Safeda and Sardar twice at bloom eliminate poor quality rainy season crop and increases winter season yield by 3 and 4 times, respectively. Application of neem coated urea (800 g/plants) yields 98 kg fruits/ plant in variety, Sardar compared to 37 kg from untreated plants. In banana, high density planting (4550 plants/ha) yield up to 174 t/ha.

Adoption of improved technology in Maharashtra has resulted in fruit yield increase up to 52 t/ha. In citrus, two grafting methods using inverted 'T' cut and apical triangle cut have been developed with overall success of around 36 per cent using either method.

For accelerating the survival of growth, shoot tip grafts, the successful grafts are double grafted (side grafted) on vigorous greenhouse grown Rough Lemon and Rangpur Lime seedlings. Rangpur Lime rootstock is found superior for sweet oranges and mandarins. In papaya, closer spacing of 1.4 x 1.4 m is recommended for high yield. Drip irrigation techniques have been standardized. In banana, it has resulted in production gain (60-70 per cent) and early harvesting (40-50 days), besides improved water efficiency. Likewise, in grapes higher yields have been obtained with better water use efficiency (11 per cent).

In vegetable crops, improved production technology has been developed for major crops. Drip irrigation is economical in tomato and brinjal. In cucumber, replenishment of evaporation loss through irrigation resulted in maximization of yield of quality fruits. Drip irrigation in watermelon provided 33 per cent higher yield with a water saving of 40 per cent. Nutrient requirements and fertilizer schedules have been worked out crop-wise and recommended for different agro-climatic regions. In leguminous vegetables, high N depresses nodulation. The VAM fungi increases P availability to plants.

In all leguminous vegetables, inoculation of the VAM fungi along with *Rhizobium* culture is beneficial. Production technologies for *kharif* onion in northern India and long day type onions for high altitudes have been standardized. Pendimethalin (Stomp) has been found effective in controlling weeds in tomato, brinjal, chilli, bell pepper and okra. In potato, a number of potato-based multiple and inter cropping systems have been developed for different potato growing regions. Intercrop combinations with sugarcane in Maharashtra, wheat in Chhota Nagpur area and linseed in central Uttar Pradesh are found remunerative. A suitable method of urea application has also been worked out.

In tuber crops, short duration legumes *viz.*, groundnut and French bean and cowpea can be successfully inter-cropped with cassava. Short-duration cassava, Sree Prakash is ideal in double cropped rice fields. Studies on cassava-based multiple cropping systems involving banana, coconut, *Leucaena* and Eucalyptus, have shown banana-cassava combination to give maximum root yield. Banana and coconut combination reduces soil loss and surface run-off considerably. *Dioscorea* and elephant foot yam with banana, Nendran can generate an additional income of Rs 20,000/- over the sole crop of banana. For Inter-cropping *Dioscorea* in coconut garden, the ideal planting density is 9000 plants/ha. When *Amorphophallus* is raised as an inter-crop in coconut garden, one third dose of recommended fertilizers is sufficient. Inoculation with VAM fungi in cassava give about 15-20 per cent increase in yield.

Among the plantation and spice crops, density of 175 coconut palms/ha (7.5 m x 7.5 m spacing) is found ideal. In general, NPK application of 500:320:1200 g/palm/year is found optimum. A multi-storied cropping system involving black pepper trained on coconut trees, and cocoa in between the rows of coconut and pineapple in the ground floor has been found ideal for exploiting light, soil and air spaces. In arecanut, application of NPK (100:40:140 g) and green leaf (14 kg) per palm per year is recommended for coastal regions of Kerala and Karnataka and for plains of West Bengal, Karnataka and Assam.

In oil palm, application of NPK (1200:600:1200 g/palm) is found to give 17.1 tonne of FFB per ha. In black pepper, rapid methods for production of rooted cuttings of pepper have been developed and a commercial protocol has been standardised for micropropagation of black pepper. Ginger yield could be increased up to 33 percent by application of neem cake at the rate of two tonnes per ha and the fertilizer schedule of 75 kg each of N, P_20_5 and K_20. Technology for storage of ginger seed rhizome is standardised and recommended.

Protection Technologies

For major fruit crops, plant protection schedules have been developed for the control of significant insect-pests for wider adoption. In the recent years, research efforts are directed to devise eco-friendly, economical and long lasting control measures. Success has been achieved in biological control of mealy bugs in mango and guava. The *Beauveria bassiana* has been found killing mango mealy bug and hopper. In grapes, integrated management of *Spodoptera* caterpillar involving light and pheromone traps, NPV and neem based insecticides and biological control of mealy bug by the beetle *Cryptolaemus montrouzieri* have been standardized. Studies on pesticide residues have resulted in working out of safe-waiting periods for harvesting and consumption of fruits.

In vegetable crops, about 50 improved measures for efficient management of diseases and 23 for insect-pests have been worked out and popularized in different agro-climatic regions in the country. Integrated pest management (IPM) for controlling diamond back moth on cabbage through a trap crop like mustard has been demonstrated. Fruit borer *(H. armigera)* on tomato can be controlled by the release of *Trichogramma pretiosum* alone and in combination with HaNPV. In potato, integrated management schedules for control of bacterial wilt and tuber moth have been developed. A late blight forecasting system has been developed for the hills.

Among the tuber crops, the major diseases affecting tuber crops are cassava mosaic and brown leaf spot in cassava, *Phytophthora* leaf blight in colocasia, *Fusarium* wilt in elephant yam and virus diseases of sweet potato.

Foliar sprays of Bavistin (0.1 per cent) combined with disodium and dipotassium phosphates (100 ppm) and calcium sulphate at 15-day interval was found to check foliar diseases in sweet potato. The major pests include spider mites, scale insects and white fly on cassava, weevil on sweet potato, defoliators, aphids and mites on colocasia, and scales and mealy bugs on yams and elephant yam. Cultural methods for weevil control include clean cultivation, destruction of alternate hosts and timely harvest. An effective IPM package using synthetic sex pheromone has been developed. Control measures involving insecticides have been evolved for the control of pests of other tuber crops. Among the plantation and spice crops, bud rot of coconut caused by *Phytophthora palmivora* can be effectively controlled by spraying Bordeaux mixture. Calyxin root feeding and drenching of soil with 1 per cent Bordeaux mixture along with neem cake application @ 5 kg per palm per year is recommended for controlling Thanjavur wilt disease reported in Tamil Nadu, Andhra Pradesh and Karnataka.

A package of practices has been developed for managing mycoplasma like organisms (MLOs) in root wilt affected coconut palms in Kerala and Thatipaka disease affected palms in Andhra Pradesh.

Eradication of all root wilt affected palms is recommended. In cashew, tea mosquito bug (TMB) can be effectively controlled through a schedule of spray coinciding with flushing, flowering and fruiting. For effective control of stem and root borer infestation, constant monitoring and adoption of strict sanitation in the plantations coupled with prophylactic application of coal tar and kerosene in the ratio of 1:2 on trunks are recommended. In black pepper, spraying Bordeaux mixture (1 per cent) and drenching the soil with copper oxychloride (0.2 per cent) is found effective in managing *Phytophthora* foot rot.

Seed/planting Material Propagation

In most of the fruit crops, vegetative propagation techniques have been standardized. Soft wood grafting has been standardized for mango, sapota, custard-apple and jackfruit. Other vegetative propagation techniques have been developed for*ber, aonla,* jackfruit, custard-apple and *bael*. In mango, veneer grafting and stone-grafting is practised commercially. Mango variety, Vellaikolumban is suitable semi-dwarfing rootstock for Alphonso. Old unproductive mango trees can be rejuvenated successfully by pruning the 4th order branches during December-January. Flowering and fruiting are regular in pruned trees. For mandarin orange, Rangpur lime is a drought hardy rootstock. In grapes, Dogridge and Salt Creek (Ramsey) are suitable for minimizing adverse effects of soil salinity on Thompson Seedless.

A tissue culture technique for mass multiplication of Dogridge has been standardised. In banana, sword suckers of 700-1000 g are optimum. Rhizomes with active lateral buds and dead central buds are preferred for distant transportation in western India. Double paring and shade drying followed by dipping in Monocrotophos (0.5 per cent) and Bavistin (0.2 per cent) is recommended to disinfect nematodes and soil borne fungi. Tissue cultured banana plants are now commercially adopted for their uniformity in flowering and produce. Shoot-tip grafting technique in citrus has been considerably advanced.

In vegetable crops, seed production of over 120 open pollinated high yielding varieties of different vegetables has been well established in the country. Hybrid seed production has become easier with the development of male sterile lines in tomato, self incompatible lines in cauliflower and gynoecious lines in cucumber and muskmelon. In brinjal, functional male sterility controlled by a single recessive gene has been identified.

Temperature barrier in cole crops (cabbage and cauliflower) has been overcome by developing heat tolerant hybrids. It is now possible to cultivate cabbage and cauliflower in southern India.

Development of tomato varieties resistant to bacterial wilt has made their cultivation successful in non-traditional areas. Onion seed production technology for cultivation in kharif season has been developed for north Indian states especially, Haryana, Punjab and western Uttar Pradesh. Seed Plot Technique has been developed for production of disease-free potato seed in plains. It is widely adopted by farmers.

A new technology for raising commercial crop of potato using 'True Potato Seed' (TPS) has been developed and standardized as supplementary technology to the traditional tuber grown crop. Two TPS populations, TPS-C-3 and HPS-113 are recommended for commercial production in Bihar, Gujarat, Tripura and West Bengal. Micropropagation protocols have been developed in banana, oil palm, cashew, black pepper, ginger, *etc*. Seed gardens of Tall (T) x Dwarf (D) and D x T hybrids have been established for production of coconut hybrids.

Post Harvest Management Technologies

The post harvest handling of fruits and vegetables accounts for 20-30 per cent of losses at different stages of storage, grading, packing, transport and finally at marketing as a fresh produce or in processed form. A number of improved technologies have been developed for commercial exploitation. An on-farm, low cost, environment friendly cool chamber, Zero Energy Cool Chamber has been developed using locally available material.

The principle of evaporative cooling reduces the inside temperature by as much as 17-18^{o}C and keeps the relative humidity above 90 per cent during peak summer. The chamber increases the shelf life and reduces PLW of banana, mango, orange lime, grape fruit, tomato and potato in different situations in India. Maturity standards for mango, guava, grape, litchi and *ber* and chemical treatments for regulation of ripening in mango, sapota and banana have been standardised.

Optimum storage temperatures worked out for several fruits, vegetables and tuber crops. A mango harvester, fruit peeler, hand and pedal operator cassava chipping machines, harvesting tools

(5-14 times efficient), coconut dehusking machine, implements for mechanisation of potato cultivation and other crops have been developed. A number of improved technologies have been developed for commercial exploitation *viz.*, tent type foldable solar dryer, packaging boxes for distant transportation of apple, mango, citrus and plum, production of value added products-pectin from peel and flour from mango fruit kernel, production of fruit post carbonated beverages *etc*.

Production Constraints

In spite of great strides made, the productivity of horticultural crops, in general, is still quite low and the post harvest losses particularly of perishable commodities, are considerable. Improvement in quality standards of the produce and their marketing are essential to increase our share in the global market. The research agenda in horticulture is by design relevant to national plans and priorities and research programmes are normally formulated keeping in view the thrust areas in development. The major technology related constraints contributing to low productivity of horticultural crops and inferior quality of produce are:

- Vast majority of holdings are small and un-irrigated.
- Large tracts of low and unproductive plantations needing replacement/rejuvenation.
- Low productivity of crops due to inferior genetic stocks and poor management.
- Inadequate supply of quality planting materials of improved varieties.
- High incidence of pests and diseases.
- Heavy post harvest losses and low utilisation in processing sector.

For addressing the above constraints, research institutions are engaged in both basic and applied research. While formulating research strategies some of the inherent weaknesses associated with perennial tree crops and certain perpetual problems in Indian horticulture must be kept in mind. They are:

- Long period required for development of improved genotypes. Application of biotechnological tools/methods in horticultural crops is still in its early stage of development in the country.
- Chronic production problems due to major disorders like alternate bearing, malformation and spongy tissue in mango, guava wilt, citrus decline, root wilt in coconut, viral disease in vegetables, *Phytophthora* diseases in large number of crops *etc*. remained largely unresolved.
- Lack of advanced technologies for post harvest handling, processing and marketing of produce.

Losses caused by biotic stresses are very high and due to pesticide residue problems development of eco-friendly IPM strategy is more relevant in horticulture. There is a threat for loss of valuable genetic resources, if measures are not taken for their conservation.

Wastelands and hilly terrains being the potential future expansion areas, matching technologies for dry land and hill horticulture need to be developed. Counter seasonal advantages from diverse agro-climatic situations provide strength for extended availability of horticultural crops round the year and such potentials can be harnessed only with relevant research support.

HORTICULTURE AND ANTHROPOLOGY

The origins of horticulture lie in the transition of human communities from nomadic hunter gatherers to sedentary or semi-sedentary horticultural communities, cultivating a variety of crops on a small scale around their dwellings or in specialized plots at some remove (such as the "milpa" or maize field of mesoamerican cultures). In forest areas such horticulture is often carried out in swiddens ("slash and burn" areas). A characteristic of horticultural communities is that useful trees are often to be found planted around communities or specially retained from the natural ecosytem.

Horticultural communities may be distinguished from agricultural ones by:

(1) the small scale of the cultivation, using small plots of mixed crops rather than large field of single crops

(2) the use of a variety of crops, often including fruit trees

(3) the encouragement of useful native plants alongside direct cultivation

(4) continued use of other forms of livelihood.

In pre-contact North America the semi-sedentary horticultural communities of the eastern woodlands (growing maize, squash and sunflower) contrasted markedly with the mobile hunter gatherer communities of the Plains people.

In central America, Mayan horticulture involved augmentation of the forest with useful trees such as papaya, avocado, cacao, ceiba and sapodilla. In the cornfields, multiple crops were grown such as beans (using cornstalks as supports), squash, pumpkins and chili peppers, in some cultures tended mainly or exclusively by women.

Pests and Diseases of Roses

Roses Rosa sp. are susceptible to a number of pests, diseases and disorders. A large number of the problems affecting roses are seasonal and climatic. Certain varieties of roses are naturally more resistant or immune than others to certain pests and diseases.

Cultivation requirements of individual rose species and cultivars, when observed, often assist in the prevention of certain pests, diseases and disorders.

Pests

Pests are often considered to be the insects that affect roses:

- *Aphids (Greenfly) (Order Hemiptera: Family Aphididae) Macrosiphum Rosae:* Likely to be found on new shoots and buds, aphids are soft bodied insects 1-2mm long. Often green but occasionally light-brown, and sometimes with wings, they may cover (in a colony) the complete growing tip of the plant. Aphids are most active in spring and summer and multiply at a prodigeous rate feeding on the sap of the plant by piercing the plant cells via a proboscis. In large quantities they may seriously retard the growth of the plant and ruin buds. They are particularly damaging to the new shoots with subsequent damage to the emerging leaves which become malformed with much the same appearance as leaf-curl in peaches.

- *Two-spotted Mite (Spider-mites or Red spider mite) (Order Acari: Family Tetranychidae) Tetranychus Urticae:* Previously known as red-spider mite these arachnids prefer the underside of leaves and are difficult to see with an unaided eye. Evidence of their presence is silvering of leaves where the mites have destroyed individual leaf cells. Fine webbing and eggs on the undersides of leaves is further evidence of the presence of Tetranychus urticae.
- *Thrips (Order Thysanoptera):* Thrips are slim-winged insects 1mm in length, resembling fine black slivers of wood. Preferring light-coloured blooms and often appearing in plague numbers flowers are often left looking bruised and lustreless.
- *Caterpillars (Order Lepidoptera) See also List of Lepidoptera which Feed on Roses:* The tortryx (tortrix) moth Lozotaenia forsterana is a prominent pest of roses, although not the sole pest. The caterpillars are green, up to 15mm long, and can be found boring into buds or within curled leaves. When disturbed the caterpillars move swiftly, dropping to the ground on a fine thread. Damage is chewn leaves and flowers and buds with "shot holes".

Cottony Cushion Scale (Order Hemiptera : Family Coccoidea) Icerya purchasi

This scale infests twigs and branches. The mature female is oval in shape, reddish-brown with black hairs, 5 mm long. When mature the insect remains stationary and produces an egg sac in grooves, by extrusion, in the body which encases hundreds of red eggs. The insect causes little damage but produces copious honeydew (frass) that can cause damaging sooty mould.

California Red Scale (Order Hemiptera : Family Coccoidea) Aonidiella Aurantii

A hard scale, orange to orange-pink, the female covering being less than 1.5mm across. Often in plague numbers this scale infests upper surfaces of foliage causing yellowing, leaf fall, and twig and branch dieback. Serious infestations can cause plant death.

Rose Scale (Order Hemiptera : Family Coccoidea) Aulacaspis rosae

Mainly found on the stems and branches of the plant, lack of control will allow the pest to spread to flower stalks and petioles. At this point the plant would be stunted, spindly and with a white, flaky crust of scales on the bark. Female Aulacaspis rosaemay live for 1 year and may lay 80 eggs each with several overlapping generations living within milliimetres of the original parent.

- *Leaf cutting bee (Order Hymenoptera : Family Megachilidae) Megachile spp.*

Leafcutter bees are 6-16mm long and mostly black with bands of light-coloured hair. They chew pieces from the edges of leaves. The pieces are regular in shape, circular or oval. Damage is not often significant.

- *Nematodes (Eelworms)(Order Tylenchida: Family Heteroderidae)*

Root-knot nematode Meloidogyne spp.

Root-knot nematode - symptoms of Meloidogyne infestation in roses is stunting, slow-growth, pale green leaves and wilting in mild weather.

- *Metallic flea-beetles (Order Coleoptera: Family Chrysomelidae) Altica spp.*

The small, shiny and metallic Altica beetles have thickened hindlegs adapted to jumping, similar to fleas. The insects are 3mm long and chew holes of irregular shapes in young leaves and buds. As the leaves enlarge so do the holes.

Diseases

Fungal, bacterial and viral diseases affect roses:

Fungal Disease

- *Black Spot (Class Leotiomycetes: Family Helotiales) Marssonina rosae syn. Diplocarpon rosae :* Marssonina rosae causes black spots on leaves. The spots, which may be as much as 12mm across, are generally circular and have an irregular edge often with a yellow halo. Leaves frequently turn yellow and fall early. Sometimes new leaves are produced, and these may also become affected.

Continual defoliation will cause weakness, die-back or death of the plant. Some very susceptible species may have stems affected with a considerable reduction in plant vigour.

- *Powdery Mildew Oidium sp. :* Oidium produces a very fine, powdery coating on the surface of buds and leaves. Significant cases have stems and particularly thorns, infected. Attacks on young leaves and buds will cause deformity with retardation of growth. Infected buds will fail to open. The disease is likely in hot, humid weather, with fungal spores overwintering on the stems and fallen leaves.
- *Downy mildew (Class Oomycetes : Family Peronosporaceae) Peronospora sparsa :* Peronospora causes purple-red to dark-brown spots on the leaves with irregular margins, however, often angular. Stems, petioles and flower stalks can split and spotted with purple marks. Buds, sepals, petals and calyces can be affected and will present purple spots. New growth affected will be deformed. The disease is spread by wind.
- *Rust Phragmidium mucronatum :* Rose rust appears as yellow patches on the surface of leaves, with orange pustules of spores underneath the leaf. The fungus is spread by wind. Affected leaves fall prior to healthy ones and plants may be defoliated in serious infections.
- *Anthracnose Sphaceloma rosarum :* Spots caused by this fungus originate from a point where leaves are watersoaked, ususally unnoticeable at first, until they turn black with a very distinct defined edge. As the spots enlarge

the centre becomes gray and may fall out resulting in a shot-hole appearance. Defoliation may occur but is often not serious.

- *Grey mould (Class Leotiomycetes: Family Sclerotiniceae) Botrytis cineria:* On roses grey mould is prmiarily a disease of the flowers and buds, leaves are infrequently attacked. Infected buds rot on the stem and infection may progress down the stem. On petals botrytis cineria produces pink rings.
- *Verticillium wilt (Class Incertae sedis: Family Verticillium) Verticillium dahliae*
- *Sooty moulds Alternaria spp. :* Sooty mould appears as black, dry powder on leaves similar to chimney soot. Many sooty moulds grow on the honeydew (frass) produced by sap-sucking insect such as aphids and soft scales. Alternaria does no direct damage to plants but surface cover of leaves will reduce the plants capacity to photosynthesise and may create an unsatisfactory plant appearance.
- *Canker Leptosphaeria coniothyrium and Cryptosporella umbrina :* Cankers present as small yellowish or reddish spots on bark slowly increasing in size. Leptosphaeria coniothyrium turns brown, increases in size, and may eventually girdle the stem. The tissue within the infection begins to dry out and shrink, presenting a shrivelled appearance. If the disease infects only part of the stem, growth above the canker will continue. If it girdles the stem, however, growth will cease and the stem will die.

Viral Disease

- *Rose Mosaic :* This diesase is caused by a complex or viruses and is charaterised by yello patterns on the leaves. The patterns vary considerably, ranging between all-over fine blotches to patterns of lines in waves. The patterns may appear on a few or many leaves. Plants are infected by this virus at propagation using infected plant material.
- *Rose Wilt* : Rose wilt is a complex of viruses and is referred to as dieback in some areas. The disease can be spread by

vectors such as aphids. Symptoms are variable and range from stunted growth to curled young leaves. The soft tissue symptoms are more evident in spring and new leaves will reflex towards their own petioles. The affected leaves are brittle and easily fall from the plant. Fully formed leaves will 'wilt' as if the plant were water stressed.

Bacterial Disease

- *Crown gall rot (Class Alpha Proteobacteria: Family Rhizobiaceae) Agrobacterium rhizogenes :* This disease is characterised by large lumps at the base of the plant stem or on roots. Galls may appear higher on stems as the disease progresses. Galls are soft compared to surrounding plant tissues. The pathogenic bacteria enter the plant via a wound. If the disease affects the plant whilst it is young the plant may be affected to the degree where it will not produce blooms. All affected plants wilt readily and grow poorly.

Environmental Disorders

- *Frost* : Frost will destroy fresh growth causing stems and leaves to wilt, turn black and fall away from the plant. Timing pruning to promote growth after the threat of frost is a means to avoid frost damage.
- *Salinity* : Salinity will present in roses as limp and light brown leaves with dry leaf margins. Soil may require testing to determine salinity levels. Symptoms will present if salinity is greater than 1200 parts per million.
- *Herbicide Damage* : Overspray or soil leaching of herbicidal sprays can present with several symptoms: Prolonged exposure to overspray of glyphosatewill cause yellow leaves and new leaves will be small and elongated.

Hormone weedsprays (*e.g.* 24-D & 245-T) may cause grotesque new growth with thin twisted leaves and distorted buds. Plants may die in severe cases.

Pre-emergent herbicides contacting the plants' rootsystem via the soil will cause yellowing foliage. Effects of soil borne herbicide may take several years to clear.

CONTRIBUTIONS OF MOLECULAR BIOLOGY IN HORTICULTURE

More and more pathologists are using molecular probes for early detection of diseases. However, the main contributions of modern biotechnology remain probably in the hands of the plant breeders. Indeed, molecular markers are of great use in detecting desirable new genes, or to identify important QTL. This marker-assisted selection is very useful for many vegetable plants. Other applications are DNA - fingerprinting and genetic engineering. This recent technology aims to insert and to express new specific genes into a selected plants.

Marker-assisted Selection

Molecular markers and genome mapping will reach a large extension in the next breeding programmes of tomatoes, peas, cabbages, melons, potatoes,... It will be possible to improve the speed and the incorporation efficiency of desirable new genes by utilizing of closely linked selectable molecular markers genes by utilizing of closely linked selectable molecular markers. The number of backcross will be reduced. Tanksley *et al.* (1981) show that only with 12 markers, one on each tomato chromosome, the composition of the recurrent parent genome is similar to that observed in the absence of selection after the third backcross two years later. Therefore, it's easy to understand the high improvement that we can get with the 700 tomato markers already known in 1990 for this crop.

The utilization of molecular markers could also identify important quantitative trait loci (QTL). Recently Foolad and Chen (1998) have identified 13 RAPD markers at eight genomic regions, that were associated with QTLs affecting salt tolerance during germination in tomato.

DNA Fingerprinting

The DNA polymorphism observed by RFLP, AFLP, or RAPD, allows cultivar identification of fruit trees, apple, citrus,... or other vegetatively propagated plants. Although some mutants, as coloured fruits, escape these identification techniques, some people would evaluate the genetic uniformity of regenerated plants in this way.

Genetic Engineering

Genetic engineering consists of introducing a foreign gene into a plant genome to create a new function. Or at the contrary, it could be to reduce or suppress an existing gene function, as in the antisense strategy.

1. *Historic:* In this field, progress were very rapid. In 1974 the pathogenicity of Agrobacterium tumefaciens, due to a large plasmid called Ti, was demonstrated. In 1977, Chilton *et al.* demonstrate a stable incorporation of plasmid Ti-DNA into higher plant cells. In 1983, the team of Van Montagu and Schell in Gent succeeded in producing a transgenic plant, and eleven years later the first transgenic cultivars were available in the market.
2. *Transgenic Plants with New Agronomic Traits:* Two different techniques are commonly used to introduce genetic information (DNA) inside cells, protected by pectocellulosic walls. A particle bombardment process, called biolistic, is used with success for monocots gynmosperm, squash, peas,...Today, this technique allows the bombardment of meristems and avoids the difficulties of regeneration. But the mediation of Agrobacterium remains till now the most routinely system to transform dicotyledonous plants.

   The main agronomic traits introduced in horticultural plants and already commercialised are Bt toxin and herbicide resistance. Other studies concern virus resistance, male sterility...
3. *Antisense Strategy:* Calgene created in 1994 the first commercial transgenic plant, a long shelf life tomato, by the suppression of polygalacturonase activity due to an antisense gene. However, t activity due to an antisense gene. However, this Flavr Savr tomato variety was removed from the trade 3 years later, because of its disease susceptibility and its lack of productivity !

Later, other tomato varieties with long storage qualities were obtained by the utilization of an antisense RNA inhibition of ACC synthase or ACC oxydase, two ethylene precursors.

The antisense technique was also used to reduce the lignification of woody plants, by blocking the enzymes involved in the precursor of lignin biosynthesis. Another interesting application was the induction of white flowers in petunia and in different other ornamental plants by the suppression of chalcone synthase activity.

4. *Transmission of the New Traits:* These traits induced by the transferred DNA are transmitted to the progeny as a dominant Mendelian character. Nevertheless in some cases, transgenic plants with a strong gene expression can generate progenies with only a faint no gene expression. This problem is not clearly elucidate.
5. *Marker, Reporter, Promotor and Expression Genes:* To select the transformed cells, some marker genes, very often resistant to antibiotics or to herbicides, are attached to the coding sequence, as a promoter or an expression gene. Those allow the new gene to express in the whole plant or in a specific plant tissue.

   Some reporter genes are used to follow the evolution one.

   Some reporter genes are used to follow the evolution of the transformed cells. The most frequent reporter genes are the gene "gus" or the gene lux (luciferase).
6. *Horticultural Transgenic Crops already released in USA:* The Flavr Savr tomato was the first genetically engineered whole food approved for commercial sale in 1994. Four other transgenic tomatoes with a delayed ripening were approved later (1995 and 1996).

In 1995, potatoes with Bt genes and a squash cultivar resistant to two viruses were released. Two years later, another squash cultivar resistant to 3 viruses and a papaya line also resistant to viruses were approved. Two other horticultural crops are waiting the authorities approval: red hearted cichory (Radicchio) with male sterility and resistance to herbicide, and a tomato with Bt toxin.

It there are so few commercial transgenic plants in horticulture, it's probably due to the relatively low acreage of these horticultural crops in comparison with other agricultural crops. In 1997, in the world 5 million ha were planted with glyphosate resistant soybeans released by Monsanto alone.

Nowadays, it's true also that many transgenic plants exist in research laboratories, awaiting authorization for field testing, as they are very interesting model plants for learning physiology: lettuce with less nitrate by increasing nitrate reductase gene active with less nitrate by increasing nitrate reductase gene activity, a yeast ribonuclease gene to reduce viroid infection on potato, modification of lignin synthesis in plant to produce trees adapted to paper industry, or timber, or biomases production, regulation genes to control tree architecture,....

Situation of Biotechnologies in the World: Development and Risks

Situation in the Young Countries or in Developing Countries: A general use of *in vitro* micropropagation in the developing countries is now a reality, as it was predicted by Albert Sasson (1993). African countries for instance are producing potatoe, banana, cassava...

Even the production of transgenic plants is no longer a prerogative of the Northern countries. Different experiments are now starting in the South, specially in the international laboratories from CGIAR. Although CGIAR's expenditures on biotechnology for 1997 raise only 24.2 million US$ on an annual budget of 345 million US$ this Consultative Group on International Agricultural Research plays a very important role as contributor to agricultural research for developing countries. The large international research centres IITA (Ibadan, Nigeria), CIP (Lima, Peru), CIAT (Cali, Columbia),... belong to the CGIAR. Their roles and NGO's are primordial. The genetic transformation their roles and NGO's are primordial. The genetic transformation of cassava is an excellent example. Its tuberous roots provide food for over 500 million people, mostly small-scale farmers. Unfortunately, till recently this integral plant for food security in developing countries has been recalcitrant to transformation approaches. However, thanks to the participation of international institutes located in cassava growing countries, CIAT and IITA with the help of four development associations from Swiss, UK, The Netherlands and USA, were able to initiate procotols for cassava transformation and regeneration.

Other networks, like the Cassava Biotechnology Network (CBN) previously described, exist. REDBIO, a technical cooperation network on plant biotechnology, is supported by FAO to promote a best use of scarce manpower, equipment and other resources in Latin America.

On the other hand, more and more private laboratories exist in the developing countries which have a high scientific and technical level (China, Singapore, Taiwan, India, Brasil, Mexico, Chile,...). In these countries, European, American or Japanese agrochemical companies are investing. Also these countries will have their chance to develop their own technologies, and to export to the Northern markets.

Meanwhile, genetic engineering techniques are being applied mainly to crops which are important for g applied mainly to crops which are important for the industrialized world, not crops on which the world's hungry depend. Therefore, it is unrealistic when Monsanto writes "the experts said that biotechnological innovation will increase the crop productivity without occupation of new lands, saving tropical forest of best quality and animal habitat". However, the World Bank was promising in a 1997 publication Bioengineering of crops that" transgenic crops could improve food yield by up to 25 per cent in the developing countries and could help to feed an estimated additional three billion people over the next 30 years".

But, not all people are confident in this prospective. To the contrary, some are afraid that the poorest countries, where more than 700 million people are chronically undernourished will miss the biotechnological revolution.

Nevertheless, there is some hope to transfer to the developing countries high technology, which don't undermine the environmental and social network. So, the Agricultural Biotechnology for Sustainable Productivity Project (ABSP project) is managed by Michigan University. Four American universities, two research centres from France and USA, and two American private companies are also involved in this project. The ABSP's objectives are the reduction of losses due to pathogens and the reduction of losses due to pathogens and pests by using transgenic plants (sweet potatoes, potatoes, cucurbits, tomatoes) and by cloning commercial value-plants (bananas, pineapple, coffee).

Situation in the Northern Countries

1. *Mass Propagation:* In 1988, Pierik (1991) predicted a European *in vitro* propagation of 212 million plantlets/ year. He was also predicting an important development of this activity for the future. Following Pierik this quantity accounted for only 5 per cent of the plants able to be propagated by vegetative means. However a few years later Pierik's prediction was not confirmed. The world production was estimated at 600 million. In USA, Zimmerman (1997) was recording a production of 121 million plantlets for a total of 110 laboratories, half produced in 11 laboratories, and 6 labs were propagating each more than 6 million plants per year.

   In Europe, only the Dutch production of micropropagated plants is precisely known. In 1990 the total production was 95.5 million. In 1995, the Dutch in country production reached only 53,7 million, whereas importations increased 77,3 million. (37 million from Poland and 17,1 million from India) (Pierik, data unpublished). These laboratory relocations to low-cost manpower countries are commonly observed, and put the question of the quality management.

2. *Transgenics:* The GMOs invade progressively all the US lands: 1.6 per cent in 1996, 15 per cent in 1997, 50 per cent in 2000..... It will represent an estimated market of 3,9 million US$ in 2003 ! The largestt agrochemical companies

are merging to become giants of agrobusiness such as Novartis, Monsanto, Zeneca,...

Following Monsanto in 1996, about 950 T insecticides were saved by introduction of resistant cotton, id est a net savings of 81 US$/ha for the grower. Glyphosate-resistant soybeans (4 million ha in 1997) allow a savomgs of 44 to 49 US$/ha. (Information from cultivar, suppl. n 436, Feb. 16, pp. 24-37, 1998).

3. *Perspectives, Limitations and Environmental Risks*: Ecological impact related with the introduction of GMOs is always an open debate.

   The application to agriculture of these new technologies certainly opens interesting perspectives, but also raises potential problems. The risk of crop transgene spreading has been demonstrated. A researcher of Clemson University in South Carolina reported "that in a population of wild strawberries growing within 50 meters of a strawberry field, more than 50 per cent of the wild plants contained marker genes from the cultivated strawberries".

A Danish team have shown a possible rapid spread of genes from oilseed rape to the weedy relative *Brassica campestris*.

There are other risks. *Brassica campestris*. There are other risks. The introduction of Bt gene allows a drastic reduction in the use of toxic chemicals for crop protection. But a poorly controlled use of Bt-technology can destroy more effectively the predators than the pests.

Or when" many crop plants are transformed with similar effective traits, in such situation, many polyphagous pest species, which by nature are more flexible evolutionarily than those that have a narrower diet, are likely to overcome Bt resistance very quickly". Therefore, before releasing a transgenic plant, any risk has to be weighed against the benefit of the transgenic crops. We must not forget that annually in the world 500.000 acute pesticide poisonings, with 5000 deaths, are observed.

3

Employment in the Agricultural Sector

EMPLOYMENT IN AGRICULTURE

Though share of agriculture in economy has declined during planned development of the country; it still assumes pivotal role in the rural economy. The employment growth in agriculture in rural sector has been abysmally low (0.06 per centviii), and insignificant during the '90s, thoughthe growth was significant (1.18 per cent) during the '80s. Whereas the growth in agriculturalincome during the '90s has been marginally higher (0.02 per cent) than the '80s. This trend in fact suggests job-less growth in agriculture; proper understanding about the reasons behind this trendwarrants studying the structure of agricultural growth.

Agricultural income as per the CSO annual series consists of income from crop outputs (field and plantation crops), livestocks, fisheries and forestry. Information on agriculture and livestock outputs are available at specific disaggregate level. This table presents triennium average, percent share of commodity aggregates during beginning of a decade and also annual compound growth rate (ACGR) in these aggregates during the decade. There has been continuous decline in the shareof cereals, pulses, oilseeds and fibres; fibre is essentially aggregates of cotton, jute and mesta.Some commodities for which share in value of output remained almost stagnant are sugar, drugs and narcotics; tea, coffee and tobacco together constitute the group drug and narcotics. Thecommodities whose share has increased in the value of agricultural output are fruits andvegetables, condiments and spices.

If we collate these trends in commodity aggregates with their trend in India's agriculture export-import basket, it is evident that the share of exportable commodities has increased while that of the importable commodities has declined in the value of output. The share of thecommodities in which India has been a traditional exporter remained stagnant during the reference period. This further suggests that the commodities in which country has emerged exporter in recent decades are the one for which share has increased in the recent period. As amatter of fact exports generally increase relative price of the commodity and hence the relativeshare of commodity in the aggregate value. In other words increase in the share of horticultural products and spices in agricultural output may not result in significant increase of employment inthat commodity aggregate.

A consistent increase in exports of a commodity also increases itsproduction. There is also a possibility of increase in the production of exportable commodities by substituting it for importable commodities; this substitution will not necessarily increase employment at the aggregate level. Information related to livestock output is presented separately for milk, egg, wool; these items have bearing for bovines, poultry and ovine rearing, while meat group includes flesh of all these livestock and birds. The historical trend growth in these items suggests that milch animalsand poultry are emerging important.

The share of output from bee and silk-worm (api and sericulture) even though small (1.3%) has increased; while that of wool and hair obtained fromgoat and sheep has decreased during the reference period (1971-2003). The share of meat has stagnated; meat and meat products barring poultry meat is the joint product.

A decreasing trendin the share of meat products, in combination with the decline in the share of wool and hair suggests that ovine rearing is getting discouraged; as a matter of fact ovine rearing is highlylabour intensive. Again stagnation in the share of meat in light of the structural changes in bovine populationx, suggests that cattle rearing is being transformed from subsistence to commercial level. This kind of transformation unless integrated properly with the processing may not increaseemployment in the livestock sector. Non-Agriculture Employment The ACGR of employment in non-agricultural sector unlike agriculture has been positiveand significant during the'90s; this has been so for both the sectors: rural and urban.

The annualcompound growth rate of employment in non-agriculture sector during (1994-00) has been less than the previous reference period (1983-1994). The non-agriculture industrial categories where employment growth during the '90s was positive and also higher than the previous referenceperiod were manufacturing, construction, trades, transports and business services. This trend inemployment growth was slightly different at the sectoral level; in urban sector manufacturing, trade, transport and business services were the industries where employment growth was higher than the previous reference period while in rural sector it is construction, transport and business services.In manufacturing employment growth was similar in rural and urban sector during the'80s; the disparity in the rate of growth between sectors has surfaced in the '90s.

The possiblereasons for disparity in rural and urban rate of growth of employment in manufacturing are;

(a) growing disparity in rural and urban infrastructure facilities with regard to power and telecommunications;

(b) greater focus on cost-competitiveness, scale economies in the '90s has discouraged rural manufacturing which is generally at small scale;

(c) uncertain policy environment in relation to small-scale industry;

(d) with trade liberalization and growing clout of media relative importance of goods produced in metropolitan factories have increased.

A detailed study of manufacturing activities under organized and unorganized sector has found that the growth of employment, value-addition and capital in the organized manufacturing sector has grown in the initial period of reform (1984-95), and declined subsequently. Growth in the unorganized sector presents different trend, this has peaked up in the initial phase of partial liberalization (1984-90), flattened during the reform period (1989-95); subsequently unorganizedsegments not necessarily rural unorganised surged forward following adoption of promotionalpoliciesxiitowards small-scale industries. This growth has been particularly high for the organic as compared to the inorganic manufacturing unitsxiii(Unni et al 2001 and Rani and Unni 2004). The employment growth in construction peaked up during the '90s; though it was high (1.75%) even in the '80s.

Construction activity is related with the economic prosperity, demographic pressure also influences construction activities; this will be corroborated with the state-wise analysis of data. Certain economic policiesxivhave also encouraged constructionactivities in the '90s. In urban sector construction activity has peaked up early (in the '80s) whilein the rural India this has peaked up during the '90s. The extension of basic infrastructure likeroad in rural India might have encouraged employment in construction during the '90s. In transport-storage-communication(TSC),finance-insurance-realestate-business (FIREB) services employment increased in both the sectors, rural and urban. Employment in TSC is more influenced with the investment in infrastructure, in recent years infrastructure is getting high priority, investment is increasing so the employment in this category.

Increase ininfrastructure has almost direct affect on employment in the real estate; this appears to havesome spread effect on the business services. Again with the Government in with-drawl mode, asis apparent with the downsizing of public sectors; employment in utilities, community-social-personal (CSP) services have declined while employment in finance, insurance and business services have increased.In the '90s employment growth was negative in mining and quarrying, utilities andcommunity services. These industries largely fall under the domain of public sector. Since there isalready an effort to downsize the role of public sector, decline of employment in these industrial categories are obvious. In mining decline in employment could also have accentuated because ofstrict environmental regulations and increased focus towards clean technologies. Strict environmental regulations have in fact, caused closure of many mining units. Again focus towards cleaner technology, which essentially means use of more gas and oil-based technology rather than coal, has discouraged production of coal while encouraged production of oil and gas. As amatter of fact coal is labour intensive while gas and oil is capital intensive; so this substitution could also have caused decline of employment in mining. Employment Elasticity A broad trend of employment across industries and possible reasons for particular trendwas explained; this sub-section discusses comparative performance of employment and incomein various industries.

The mining and utilities are however exceptions; these are also the industrial categories for which employment growthwas negative. The other industrial category for which employment growth was negative was community services, the income growth for this category was positive; this is not unusualconsidering the fact that income in this category is primarily aggregation of salary of its employees and it is ironical that in spite of all the austerity measures, salaries in the Government sector has not reduced in the country. The employment elasticity is the ratio of growth in employment to the growth in income inthe specific industry. Since employment growth has been negative in mining, utilities andbusiness services employment elasticity has also been negative. In the present table this is beingrepresented as zero.

It is interesting to note that employment elasticity in industries other than theabove three, increased over the previous reference period. Employment elasticity indicates intensity of labour in that industry, though heterogeneity within the industry at this level of aggregation restricts us to arrive at some solid inference about it. Based on the above trend inemployment elasticity it can be argued that intensity of labour in most of the industries has increased during the reference period.

In manufacturing increase in elasticity was only notional.Increase in employment elasticity has been very high in transport and business services; but then heterogeneity in these industries are too large to arrive at some meaningful inferences about trend of employment intensity in specific activity of this industry. In construction and trade there was small increase in employment elasticity. This increase of employment in construction can be taken seriously since heterogeneity in theseindustries is not large as compared to other industries.

There are in fact studies that suggest thatsome of the non-agriculture industries in recent years are emerging as residuals. Trade especially retail trade presents one such case; with increase in literacy especially rural literacy young peoplewants to be identified as shopkeepers rather than farmers, rural artisans. Similarly agricultural labourers probably liked to be identified more as construction worker. Rural Employment Across States The above analysis pertains to comparative account of employment for major industries at the aggregate level. Certain trends, which were evident at the aggregate level, may emerge robustwith the help of state level information. Again some of the industries were focused more towards the rural sector; a detailed analysis of these industries may suggest some measures for increasing rural employment in India.

It is apparent from table that in a span of 17years share of agriculture in rural employment has declined by only 2 per cent at the aggregatelevel. There are mixed trends from states; percent share of agriculture has not declined in the state of Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Maharashtra. and Orissa. The reasons for non-decline of rural employment in agriculture could be different amongst thesestates. In certain states like Bihar, Orissa, dearth of opportunity in non-agricultural sector could have pushed rural workers towards agriculture whereas in states like Maharashtra pull factor could have attracted employment in agriculture. These issues need further probing. In non-agriculture employment categories manufacturing is the most important; this accounts for more than 7 per cent of rural employment in the country. With increase indemographic pressure on land, one would expect manufacturing to become more important in the rural sector; however there is only marginal increase in its share during the reference period.

Theshare of manufacturing sector has in fact declined in some states like Andhra Pradesh, Bihar, Goa, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa and Punjab. In Assam, Delhi, Gujarat, Haryana, Tamilnadu and West Bengal share of manufacturing has increased during thereference period. Though reasons behind these trends are different for different states; the changes ininfrastructures to large extent explain different trends. In the later group of states ruralinfrastructure has increased significantly during the reference period.

This does not necessarilymean that rural infrastructure in the earlier group of states is poor; as a matter of fact significant increase of rural infrastructure in these states might not have happened during the period. Thereis evidence at least from Punjab to suggest that even with a relatively better rural infrastructure manufacturing is shifting away from the rural sector; here rural sector is based on the censusclassification rather than the revenue records. A greater urbanization and rural urban disparity in infrastructure like assured electricity could also have lead to this situation.

The state of Delhi presents a different situation, where rural manufacturing has increased significantly. Arguments generally put forth in developed world tojustify manufacturing in rural sector like low cost of living etc, holds good in Delhi. The differencein rural and urban infrastructure from the view -point of manufacturing activity is not significantly different in Delhi. Nevertheless, manufacturing units in rural sector are exempted from some of the strict environmental and fiscal regulations.

The utilities (consisting of electricity, water), mining and quarrying are the employmentcategories not very important from rural perspective. Both these categories register negative growth during '90s at the aggregate level; the share of mining in rural employment has however increased at the aggregate level. Whereas share of utilities in rural employment like its share atthe aggregate level has declined. Construction has emerged as an important engine for growth in rural employment; its share in most of the states barring Karnataka, Madhya Pradesh and Maharashtra has increased.

The states of Bihar and Orissa doing not so good otherwise have done well in construction. It appears that population pressure in these states accompanied with a favourable policyenvironment for building construction material during the reference period has encouragedconstruction activity. There can be other reasons such as increase in per capita income forimproved construction activity in the country. Trade is another industry groups where rural employment has increased at the aggregate level and also for most of the states. The state of Andhra Pradesh, Orissa and Tamil Nadu were exceptions. The share of transport in rural employment has increased for all the reference states.

The reason is obvious, rural infrastructure is on rise and with increase of basic infrastructure likeroad in rural sector, transport activity and also employment in this industrial category has increased. The services are of two categories; community social and personal (CSP) services arelargely under the domain of the public sector while finance insurance real estate and business (FIREB) services are under private sector. The share of CSP services in rural employment has also declined in the country, though Assam was an exception. It may be noted that in recent decade there has been greater focus on the Northeastern states including Assam so increase inthe share of CSP services is obvious. The share of CSP services in rural employment also might have declined on account of rural urban classification in census. There is possibility that with increase of rural employment in community social and personal services in a place, populationaround that place increases and with increase of population beyond 5000, village (rural) gets reclassified as town (urban) sector.

The share of FIREB services in rural employment increased marginally at the aggregatelevel; though this has been one of the best performer for some states such as Andhra Pradesh,Bihar, Gujarat, Haryana, Kerala, Maharashtra, Rajasthan. The share of

FIREB services has in fact declined in many states like Delhi, Goa, Karnataka, Orissa and West Bengal. There could bevarieties of reasons varying across states for this decline in the share of FIREB services. Unlike other industrial categories the FIREB services require different kind of skill and infrastructure. This definitely requires better literacy.

The FIREB services also require more communication related infrastructures; basic infrastructure like road is also important. With these illustrations about nature and pattern of rural employment across states, it isevident that there are various independent factors which influences employment in differentindustrial categories. For instance, demography or population pressure influences constructionactivity, while employment in trade and transport is more influenced with the basic infrastructurelike road. The expansion of rural road appears to have been acting either ways; road is increasingrural employment in trade and transport, there is also instance of road discouraging rural butincreasing urban employment in manufacturing and business services.

The skilled workers formrural area travel to perform their job in a unit located in the urban sector while they live in ruralsector as cost of living is low in the area. In spite of it, infrastructure as such is important foremployment in most of the industrial categories; the kind of infrastructure however varies across industries; for instance, employment in manufacturing requires more of assured power /electricity; while employment in transport and trade requires basic infrastructure like road; employment in finance-insurance-real estate-business services however require more of communication relatedinfrastructures.Gender aspects of Rural Employment In all major industrial categories male dominates rural employment; share of female intotal rural employment has however not been insignificant (around 30 per cent).

Bulk of femaleworkers is concentrated in agriculture, manufacturing and community services; Table 4 presents gender-wise proportion of rural workers in these industrial categories for important states of India. Like previous comparisons, this state-wise information is also for the year 1983 and 1999-00.

Industrial category-wise gender proportion indicates that females are more concentrated in agriculture followed by manufacturing and business services. The proportion offemales in these industrial categories has increased significantly; more than 2 per cent in agriculture and community services while less than 2 per cent for manufacturing at the aggregatelevel. Trend in gender-wise employment in many states is different than that of the country. In agriculture for instance proportion of female has declined in Bihar, MadhyaPradesh and West Bengal. Amongst these states, Bihar and Madhya Pradesh are the states where proportion of rural employment in agriculture did not decrease during the reference period; this suggests that the pressure on agriculture for rural employment is quite high and in this kind of situation male are generally preferred over females for employment.

This reason however does not hold good for West Bengal; as this has experienced spurt in agricultural growth. Participation of females is more in specific agricultural operations and activities; any changes in the structureof agriculture and allied activity in a state can also lead to changes in the woman's participation inan industrial category. In community social and personal services though share of female in rural employment has increased at the aggregate level.

The corresponding share has not increased in the state of Assam, Haryana, Orissa and Rajasthan. These states barring Assam and Rajasthan have registered sharp decline in the share of CSP services in rural employment. The CSP services are considered better than many other employment categories for workers of similar qualification. In this situation competition for getting employed in this category increases and probably male dominates female in this competition since difference between gender in human development related statistics like literacy is more sharp in these states.

In manufacturing over all decline in the share of male was observed, the correspondingshare for female however declined in the state of Delhi, Goa, Haryana, Punjab, Gujarat, Maharashtra, Karnataka and Himachal Pradesh. Many of these states have good roadinfrastructure, there is a possibility that manufacturing units are doing well in their urban centers and rural sector is providing cheap labour to these manufacturing units; and male has somedistinct advantages over females in commuting. The share of female in total rural employment has increased marginally during the reference period. Many states in fact report decline in the share of female in total ruralemployment. Some of these states are Bihar, Madhya Pradesh, Rajasthan, Delhi, Goa, Haryanaand Kerala. Profile of these states present different reasons for decline in the share of female; first group of states suggest penuries as possible reasons for decline in the share of femalewhereas later group of states suggest urbanization and high mobility of work force as possiblereasons for decreasing share of female in rural employment.

The share of female in ruralemployment has increased in relatively well-off states. It must be noted that the proportion of female in total rural employment has increased (0.52%) marginally; the corresponding share has increased significantly in agriculture,manufacturing and community services; difference in this rate necessarily implies that share of females in other industrial categories has not increased. Trend from states varies widely; thereare in fact many states where proportion of female in rural employment has declined for of course wide and varied reasons.

Quality of Employment The quality is as important as the quantity of employment and in the rural sectordisguised unemployment is the most important issue while analyzing quality of rural employment. The NSS data presents a comparative account of usually employed persons and personsemployed on the basis of current daily status (CDS) during a year; this difference reveals disguised unemployment in the rural sector.

This information is available separately for males andfemales in rural and urban sectors of India. Under employment here means that persons though employed on the basis of usualstatus is not getting sufficient employment in man days to be termed employed on the basis ofCDS. A comparison of underemployment across categories of workers suggests that underemployment is the highest for rural females. A relatively high disguised unemployment is awell-recognized problem of Indian agriculture; employment of women is often specific to particularagricultural operations like harvesting, their employment is less frequent as compared to male, a high disguised unemployment for female is therefore obvious.

This table indicates income aspect of employment quality. The category of employment, self-employed, regular and casual also explains quality of employment. Present study assumes that with increase in the proportion of casual workers intotal workers quality of employment decreases since India lacks effective social securitymeasures for casual workers; otherwise also safety nets for poor are too poor in the country.

It is evident from table that in the rural sector a largeproportion of male (54.4%) is self-employed, casual workers are distant second while regularemployed workers account for only small proportion (9%) of total workers. The urban sector presents a contrasting picture, regular employed are the most dominant class of worker closelyfollowed by the self-employed workers; casual workers are the least important in terms ofnumbers. Again across gender problem of casualisation is more acute for females, especiallyrural female. A temporal comparison of employment categories suggests that casualisation, that is, percent of casual to regular employed workers, is on rise.

In this regard it must be noted that trade union or association is less relevant for casualand self-employed workers, which dominate the rural workforce. Existence of trade unions and its membership provides enough bargaining power to workers and is definitely important to adjudge quality of rural employment.

Table 6 further shows that proportion of self-employed workers in rural sector has declined while its share in the urban sector has increased during the reference period. This is quite an interesting finding and requires further probing as to why proportion of self employed workers has declined in the rural sector. It must be noted that self-employed workers are more associated with the own account enterprises; and in this context the above trend is important. The quality of employment is also related to the type and scale of enterprises.

An enterprise employing more than 20 workers is covered under the Factories Act, and this act to some extent protects interest of workers even though it is casual worker. The proportion of salaried workers also increases with the size of enterprises. Trends in Enterprises There can be different ways of classifying enterprises; on the basis of number of personshired, enterprises are own account enterprises (OAEs) and establishments. The establishments on the basis of number of people hired are Directory and Non-directory enterprises; theseenterprises vary on the basis of type of regulations. Enterprises can also be classified on the basis of its location: rural and urban; type of activities being performed: agricultural and non-agricultural enterprises. Present study discusses trend in enterprises on the basis of above criteria. Enterprise level information is obtained from the Economic Census, and is available forthe year 1980, 1990 and 1998.

The Economic Census does not include enterprises engaged incrop production and plantations. Table 7 presents distribution of agriculture and non-agricultural establishments by sizeclass of employment at the aggregate level. Table suggests that even in the rural sector non-agricultural enterprises in terms of number of units and persons employed are many times (12-18times) higher than the agricultural enterprises. In urban sector this difference between agriculture and non-agricultural enterprises is even higher. As far as distribution of enterprises according tothe size-class of employment is concerned, difference between the distribution of agriculture andnon-agriculture enterprises is less in the rural as well as the urban sector. The difference between agricultural and non-agricultural enterprises is significant when distribution of employment is taken into account. In non-agricultural enterprises concentration of employment is higher (33.6%) towards larger establishments; this trend is more pronounced in case of urban sector.

The percent share of non-agricultural enterprises and its trend during last three economicsurvey 1980, 1990, and 1998 suggests trend almost similar to that of employment; in rural enterprises per cent share of construction, trade, transport and business services has increased. The share of manufacturing enterprises has declined in both rural andurban sector. This trend is different than that of the employment in manufacturing; there arechances that in the regime of trade liberalization, importance of economies of scale have beenrealized by the manufacturers and they are trying to consolidate the smaller units into the bigger units. Again not-so-favorable business environment for small-scale industries especially during the early '90s might also have led to closures of many small-scale units.

The total numbers of enterprises are not growing proportionately; construction, trade, transport and services are on rise, increase in these units might also have reduced the share of manufacturing in total enterprises. Even though numbers of enterprises are on rise, for the sake of quality of employment one would expect that average size of enterprises should grow; data from Economic Census however do not clearly support this; trends are different across enterprises and sectors. The results from survey of enterprises as reported by different issues of theEconomic Census by and large reinforces employment results from the NSSO QuinquennialSurveys; this does not suggest any significant improvement on the quality aspect of ruralemployment in the country.

EMPLOYMENT DIVERSIFICATION WITHIN AGRICULTURE

We can succinctly see the continuance of rural workers' excessive dependence on field crop production sector. In 1983-84, except for Jammu-Kashmir, Kerala and Punjab, in each of the other fourteen states, agricultural employment was very highly concentrated in crop production sector, ranging from 81.0 per cent in Rajasthan and West Bengal to 97.3 per cent in Madhya Pradesh; in fact, in as many as 8 of these fourteen states, employment in crop production accounted for as high as 87-88 per cent. The situation changed during the next decade, although the fact of excessive dependence on the crop production sector did not change. In fact, Jammu-Kashmir and Punjab increased their dependence on crop production sector by a fairly sizeable margin; Kerala alone remained the exception. So did Bihar, Karnataka, Maharashtra, Uttar Pradesh and West Bengal. Some of these states joined, albeit on a moderate scale, the green revolution club during the eighties, and consequently, their production and employment priorities shifted towards the field crops that had duly demonstrated their higher commercial content in the seventies. Again, although the excessive dependence on field crop production sector continued right till the end of the nineties, yet, considerable restructuring of agricultural employment overtook a number of states, induced partly by shifts in domestic demand and partly by the opportunities thrown upon by the open economic regime.

For example, in Kerala, there was a formidable shift of employment from plantations to field crop production; this lends itself to diverse interpretations. The drastic reduction could be the consequence of rubber plantations going into deep trouble in the post-reform years, and the consequent retrenchment of workers, who, in the absence of better opportunities, might have gone into the field crop sector; perhaps, the traditional segment of coconut too has not been able to sustain itself. It could as well be possible that the traditional field crop sector has started growing fruit (most notably banana and casava) and vegetables, which are more labour- intensive. All these conjectures need to be validated through further research.

Then, in Punjab, Gujarat, and Himachal Pradesh, livestock added a substantial weight to agricultural employment; Assam, Jammu- Kashmir, and to a limited extent Maharashtra, looked to plantations; Karnataka's post-reform strategy seems to have favoured new crops (e.g. fruit, vegetables, flowers, etc) in the field crop production sector; Himachal Pradesh foresaw its relative employment advantage through expansion of livestock activities and curtailment of conventional field crops such as wheat, maize and paddy; fishing seems to have been losing its verve in many of the states, most notably in Assam, Kerala, Orissa and West Bengal, and so on. In total terms, different states seem to have responded to the package of economic reforms according to their respective resource endowments and the opportunities that could be availed of.

Although, the overbearing importance of the field crop production sector faced no major diminution during the post-reform years, practically in each part of Indian agriculture, yet some re-shuffling of individual segments caused a moderate level of employment restructuring within agriculture.

The pattern of employment restructuring described above for rural workers as a whole applies, mutatis mutandis, to male as well as female workers. A few qualitative contrasts need nevertheless be underlined. While it is true that, during the post-reforms period, the proportion of employment in the field crop sector declined or increased, and the reverse happened for the non-crop segment, simultaneously for male and female workers, in some states, the change went in the opposite directions. Jammu-Kashmir is a typical case where female employment in field crop sector, as a proportion of total agricultural employment, increased from 39.41 per cent in 1993-94 to as high as 62.26 per cent in 1999-2000 while its counterpart for males declined from 94.59 per cent to 81.18 per cent, during the same period.

In Punjab, the corresponding employment decline in the field crop sector was from 25.48 per cent to 11.84 per cent for rural females, against no visible change for rural males. In West Bengal, female employment in the field crop sector rose from 75.76 per cent in 1993-94 to as high as 92.89 per cent in 1999-2000. In total terms, except for Jammu-Kashmir, Karnataka, Kerala, Orissa and West Bengal, where the proportion of agricultural employment in the noncrop segment declined, by varying proportions, during 1993-94/1999-2000, in all other states, it registered an increase. The increase was formidable indeed in Bihar, (from 0.64 per cent to 11.03 per cent), Gujarat (from 17.16 per cent to 27.54 per cent), Himachal Pradesh (from 13.87 per cent to 27.75 per cent), and Punjab (from 74.54 per cent to 88.16 per cent).

The moot point is that, except in Jammu-Kashmir, the recent employment restructuring within agriculture has been responsible for narrowing the male: female differences in field crop and non-crop employment shares; in 1999-2000, for rural females, the share of non-crop activities in total agricultural employment stood higher than or equal to that for their male counterparts, in sixteen of the seventeen states. In plain terms, the proverbial 'assigned work domains' of rural females (most notably fishing) are breaking down; they are now penetrating into areas where they were almost conspicuous by their absence some two decades back (e.g. agricultural services). For a host of socio-economic and cultural reasons, livestock has, however, continued to be their forte outside the field crop sector.

Livestock accounts for 88.94 per cent of female agricultural employment in Punjab, 51.04 per cent in Haryana, 31.38 per cent in Rajasthan, 30.55 per cent in Kerala, 25.42 per cent in Himachal Pradesh, 24.19 per cent in Gujarat, and so on. It is interesting to see that in the green revolution states of Punjab, Haryana, and (Western) Uttar Pradesh), and a few others, female employment in this segment of total agricultural employment witnessed, during the post-reform years, an increase almost exactly equal to what they lost in the field crop sector; the male workers' involvement in livestock did not increase nor did it decline in the field crop sector, in any of these states. In sum, the rural female workers are not a static entity; they too seem to respond to the post-reform labour market compulsions, and to participate in employment restructuring that has been going on inside (as well as outside) agriculture.

DEVELOPMENT OF EMPLOYMENT

There were fears that employment growth would decline significantly after liberalisation. However, subsequently rural employment growth declined from 2% in 1987-8 to 1993-4 to 0.7% p.a. during 1993-4 to 1999-2000. Similarly, urban employment growth declined from 3% to 1% during the same period. The reasons for this decline in the growth of employment are not very clear. Rural non-agricultural employment increased from about 18% in 24% of total rural employment over the whole period (Table 4)1. Job creation was particularly strong in sectors like construction, trade, hotels and restaurants, transport, storage, communications. Diversification has been much slower for females compared to males: 85% of females still work in agriculture.

The stagnation in rural non-farm employment during the period 1987-8 to 1993-4 has been attributed to economic liberalisation in the country. Sen (1998) indicates that public expenditure in rural areas seem to be an important factor in raising rural non-farm employment till 1987-8. Due to stabilisation and structural adjustment, public expenditure declined in the early 1990s and this could be one reason for the stagnation. High employment growth RNFS sub-sectors are given in Table 5. Of these high growth sub-sectors, construction, public administration, land transport and mining started from a significant employment base in 1977-8 and are therefore clearly important for rural employment. The data in Table 5 indicate a significant growth in rural employment in agricultural processing (jute, hemp and mesa products); real estate, business and legal services; land transport; and construction. In 1987-93, employment growth rates were static or lower in all the sub-sectors except in real estate and business, jute, hemp and mesa products. However, most of the sub-sectors, except electrical, construction, chemical and public administration, showed more than 3% growth even during this period.

Elasticity of Employment with respect to GDP

As Bhalla (1998) noted, elasticities that approach unity are not desirable: high elasticities may imply very low productivity and therefore wage rates. He maintains that under Indian conditions, elasticity of the order of 0.5 to 0.6 at the aggregate level is sufficient. The overall elasticity of employment has recovered in the 1990s, after a significant fall in the 1980s. But at 0.47 it is still not ideal for India according to Balla's parameters. Agriculture and services led the recovery of elasticities. The elasticity of manufacturing has persisted at about the same low level as established in the 1980s. The big swing in elasticity for construction is a result of the 1987-8 drought, which made many workers from agriculture move to construction and then move back again once the drought was over.

The rate of growth in employment has been positive over time, although more modest than economic growth. It actually declined between 1994-2000, at a time when rates of economic growth were increasing in most sectors except utilities. Within the rural sector, RNFS employment has increased as a proportion of total employment, although women are still more concentrated in agriculture and allied activities. Construction, public administration, transport and mining are the largest employers that have experienced high employment growth. Growth in these sectors deteriorated 1987-93 due to a combination of drought in 1987 and ongoing cuts in public administration as part of the economic reform and liberalisation programme, but continued at least 3% p.a. As long as economic growth continues at current levels, the prospects for rural job creation remain strong as both agriculture and most of the big employers have reasonable employment elasticities. But note that agriculture is the biggest employer but has the weakest economic growth: there will need to be significant job creation in the RNFS sector to compensate for this.

RELATIONS OF PRODUCTION

In India, 90% of the workforce is in informal sector. In this Section, we explore what we know about changes in relations of production in this sector, using as a proxy changes in numbers of workers and of self-employed in informal manufacturing and trade (as these two sectors are the largest rural employers after agriculture and dominate the rural informal sector). NSS and CSO collect information on 3 categories of informal sector enterprises:

(i) own account enterprises (owned and operated without the help of any regularly employed or hired workers) (OAE);

(ii) non-directory establishments (enterprises which employ 5 workers or fewer, of which at least one is a regularly employed hired worker (NDE);

(iii) directory establishments (which employ 6 or more workers, of which at least one is hired) (DE).

Own account enterprises form the clear majority in terms of units and workers, with non-directory establishments constituting the second largest group. Bhalla (2000) examined the trends in number of units and workers for the period late 1970s to early 1990s and drew the following conclusions:

In the rural informal manufacturing sector, both the number of units and workers more than doubled between 1978-9 and 1984-5. However, between 1984-5 and 1994-5, both the number of units and employment declined: more than 4 million informal manufacturing jobs were lost and just over 4 million units were closed down.

In rural areas, where more than 80% of all informal sector manufacturing units are located, own account enterprises accounted for the overwhelming majority of job losses.

Two significant changes in non-farm informal sector workforce structure seem to be taking place in India: a shift of non-farm jobs from rural areas to urban areas. In the rural informal sector, manufacturing is losing more jobs than trade. Further, within both manufacturing and trade, job losses are concentrated among the self employed in family operated enterprises.

Female Participation

Women form an important component of the rural informal manufacturing sector workforce, both as workers and self-employed in own account enterprise: just under 40% of the total, and up until recently over 50% in "traditional" primary processing activities such as beverages, cotton and jute. Most recently, their share in these traditional activities has fallen in favour of more modern sub-sectors such as chemicals, electricity, transport, textiles.

The number of rural manufacturing and trade units and jobs declined very significantly between 1984- 1994, particularly in manufacturing and particularly in family-operated (own account) enterprises, due to a movement of these units to urban areas.

This will have had a marked effect on rural women, because they find it hard to move out of agriculture, as we saw in the previous Section, and have not traditionally worked in the high employment growth sectors (construction, mining, transport and public administration). Instead, they have relied on working in the informal manufacturing sector.

ACCESS TO EMPLOYMENT

Education

Education is important for workers in order to get good quality employment and is one of the key factors determining the success of rural diversification. Literacy alone is at best only one indicator. Literacy definition covers anyone who can write their name and this means many people may be classified as literate although they may not understand simple written instructions. Unless we have these abilities for workers, the efficiency of the labour force in many occupations is likely to remain low. Illiteracy has declined over time. However, even in 1999-2000, 68% of rural males and 91% of rural females are either illiterate or have been educated only up to primary level.

Migration

Census and NSS capture permanent and semi-permanent migration. These data sources indicate that national level decadal or intercensal migration declined relative to population from 12% to 10% between 1981-91. Of the 226 million persons who changed places of residence within the country as per the 1991 Census, only 9% persons moved for employment reasons and 2% moved for business reasons. While inter-state migration accounted for 12% of all migrants, it accounted for 29% of those who migrated for employment or business reasons. Among those migrating for employment, the ruralurban stream is important but it does not constitute the dominant stream, accounting for 45% of all such migrants. Both the Censuses and NSS ignore or severely underestimate short duration (circular) migrants and commuting labour. The National Commission on Rural Labour (NCRL) estimates more than 10 million circular migrants in the rural areas alone.

These include an estimated 4.5 million inter-state migrants and 6 million intra-state migrants. The Commission notes that there are large numbers of seasonally migrant workers in agriculture and plantations, brick-kilns, quarries, construction sites and fish processing. In addition, large numbers of seasonal migrants work in the urban informal manufacturing, construction, services or transport sectors - as casual labourers, head-loaders, coolies, rickshaw-pullers, hawkers and so on. Information is not available on the trends in circulation of labour over time but the few studies on migration over several decades that exist suggest a growth in labour circulation (e.g. Breman, 1996).

Some studies have examined the impact of labour migration in the source and destination areas. Srivastava's study (1998) shows that in the source areas, increased labour mobility has contributed to breaking down the isolated nature of rural labour markets and a greater integration between rural and urban labour markets. The overall impact of labour outmigration in the recent period has been to put an upward pressure on wages and accelerate changes in production relations. Remittances to rural areas are quite sizeable in many areas (e.g. U.P. Hills). On the other hand, in the destination areas, labour migration is principally to the rural and urban informal sectors.

Migrant labour in these areas operates in a setting in which there is segmentation and fragmentation in the labour market and enables the employers to lower wage costs, and exercise greater control over the labour process. Micro-studies suggest an increase in labour mobility via seasonal migration and commuting. A micro study in Uttar Pradesh indicates a diversification in employment from agriculture to non-agriculture. An important component of non-agricultural employment opportunities is non-local, linked to migration, both on an individual and household basis. In many study areas, non-agriculture has emerged as a major source of employment.

A study by de Haan (1999) on the role of migration in promoting livelihoods indicates that it may not be possible to generalise about the characteristics of migrants, or about the effects of migration on broader development, inequality and poverty. For example, there is no one-to-one relationship between status of migrants and land ownership. In some places, landless workers dominate migrants while in other places there is a positive relationship between landholding and migration.

The very low education levels in rural areas limits access to better-paid employment, leaving rural workers with low skill, low productivity (therefore probably low wage) jobs in construction, mining and transport. These are also sectors that have not traditionally attracted women. Low education levels could be one of the reasons informal sector manufacturing and trade units are moving to urban areas: as they move from traditional agricultural processing to more "modern" activities, requiring a more educated workforce. Migration seems to have benefited the source areas in improving rural livelihoods while in the destination areas migrant labour are being exploited. However, a very small proportion of total migration is for work reasons, the majority of this being intra-state and circular migration and not predominantly rural - urban. Permanent migration appears to have declined over time, whilst seasonal migration and commuting has increased. The available evidence does not indicate the reasons for low migration and the extent that it forms a barrier to accessing work. Other factors - particularly lack of education - may act as a constraint to rural workers to seeking paid work away from home.

TRENDS IN POVERTY

Whilst poverty among rural and urban workers has declined over time, it is still substantial. Poverty among urban workers declined faster than for rural workers. Most recently, the rate of decline has slowed. Nearly 80% of the poor are concentrated in agriculture and this has not changed significantly in recent years. Most of these are agricultural labourers rather than cultivators - although the proportion of labourers below the poverty line appears to have declined slightly since liberalization. Construction workers are the other rural group with significant numbers below the poverty line. Thus, for agricultural labourers, shifting to any other sector seems to be a better option. On the other hand, if cultivators shift to manufacturing or construction, they would be worse off.

Trends in Growth and Employment

The overall rate of growth in GDP in India was higher in the 1990s compared to the 1980s. The growth rate in agriculture declined marginally in the 1990s while there was marginal increase in industry and construction. Within industry, manufacturing sector's growth rate increased in the 1990s while those of mining and quarrying and electricity and water declined. Significant growth occurred in services particularly in trade, hotels, restaurants and community and personal services. Employment trends in rural areas are consistent with these growth trends. The data on rural employment show that there has been diversification from agriculture to nonagriculture, although diversification has been much slower for females as compared to males. Construction, transport and mining4 are sectors employing large numbers of people that show high employment growth rates and thus increasing employment shares over the period. Construction and transport have high employment elasticities, which bodes well for continued job creation in these sectors. However, even with these high elasticities, they will provide only a fraction of the total jobs traditionally provided by agriculture, and the construction sector is notable for a high incidence of poverty.

Furthermore, there has been a worrying decline in the number of rural manufacturing and trade units and jobs, which have traditionally accounted for about 11% of rural jobs - the next most significant source of work after agriculture. These units appear to be moving to urban areas. One could hypothesise that this is partly due to the very low literacy levels in rural areas: we presented evidence that rural manufacturing and trade have been diversifying from traditional agro-processing to modern sector activities, in which case the prevailing education level of rural labour may no longer be sufficient. The fact that the majority of rural manufacturing and trade units are family operated enterprises, but most of the new rural jobs are casual, is one factor contributing to the increasing casualisation of the rural labour force or - in the case of women - a withdrawal from the labour market (there is evidence that women withdraw from the labour market rather than register as unemployed). The decline in rural manufacturing and trade units particularly affects women, who are not moving out of agriculture as much as men and are not major participants in the current high employment growth sectors. Perhaps the prevailing mode of self-employed cottage-industry style rural manufacturing fits better with women's domestic obligations than does going out to work in construction, mining or transport. How are women going to cope, now that manufacturing and trade are moving to urban areas?

And public administration, but data was incomplete for this sector so we have not attempted to consider it further in our analysis.

Construction, transport and mining are not mobile in the same way as manufacturing and trade, so jobs in these sectors can be expected to stay put. This is good for poor rural job-seekers as these sectors have relatively high employment generation potential for (presumably) relatively unskilled work, although providing only a fraction of the number of jobs traditionally provided by agriculture. However, the construction and transport sectors are very dependent on stimuli from overall economic growth and can be expected to decline exponentially in times of economic downturn - not a solid base on which to build rural diversification. In addition, labour productivity is below average in both agriculture and all the high employment growth RNFS sectors (except mining). This implies that wage rates will not be high, and is borne out by the high incidence of poverty in agriculture and construction. Neither are the new high employment growth sectors particularly accessible to women. Overall although there has been an overall decline in unemployment, this has been accompanied by an increase in casualisation of jobs and underemployment. And the poorest segments of the population continue to rely on wage labour in agriculture, which as an economic sector is growing only slowly and does not have high employment generation potential (employment elasticities), in addition to being subject to low wages.

More needs to be found out about why rural manufacturing and trade is moving to urban areas, as these have been significant employers in rural areas traditionally, have experienced good economic growth and wage rates, and are accessible to women (although manufacturing in particular does not show high employment elasticities).

Rural Diversification and Poverty Alleviation

Recent economic growth in India has been accompanied by marked diversification in rural areas. What appears to have caused this, and what effect has it had on employment opportunities for the poor? Various studies have identified several 'push' and 'pull' factors that determine growth in rural nonfarm employment. Among them are agricultural growth, unemployment, commercialisation of agriculture, urbanisation, real wages, and public expenditure5 There has been a debate whether the diversification has been due to 'pull factors' or 'push factors'. It is generally believed that if the diversification is due to higher agricultural growth, pull factors may be operating in the economy. On the other hand, if it is distress-related diversification, for example due to unemployment, push factors seem to be more important and the rural non-farm sector may be acting as a residual sector (for more on this, see Vaidyanathn (1986) and (1994)). In the 1980s, this residual sector argument was refuted because real wages were rising in rural areas.

Also it has been noted that non-agricultural wages are higher than that for agricultural workers in rural areas (Papola, 1991). Although the fact that on average non-agricultural workers are better-off than agricultural workers does weaken the case for the 'residual sector' hypothesis, matters are more complicated (see Sen, 1998). Chandrasekhar (1993) suggest much more complex non-linear relationships between agricultural prosperity and rural non-agricultural employment: increasing when villages manage to escape a stage of involution but have yet to enter a phase of sustained agricultural growth, and decreasing as they go through a phase of sustained irrigation-induced expansion in agricultural output, and increasing again in the mature green revolution phase when growth of land productivity tapers off and mechanisation reduces the demand for agricultural labour. There are also problems with the argument that if wages rates are higher in non-agriculture than in agriculture, then the former cannot be a 'residual sector'. The problem is that any wage differential must be caused either by some barrier to entry into higher wage sectors due to skill, location, contacts leading to job access or some other specificity; or be a compensation for harder work or higher expenses such as commuting. Due to all the above reasons, movements out of agriculture may not always be likely to improve the overall quality of employment.

Policy Implications

In India unemployment rates are not high. The rate is around 6%. This is because unemployment rates are based on time criterion. Poor people are too poor to be unemployed for a long time. Instead, we have the concept of 'working poor'. In other words many people are working at low wages and low working conditions in agriculture and the informal sector. Therefore, the challenge is to shift these workers to higher productivity (therefore higher wage) sectors and also create new jobs in the nonagriculture sector. Thus, the real nature of the unemployment problem is not that people are not 'employed' in some activity but that large number of those classified as employed are engaged in low quality employment, which does not provide adequate income to keep a family above the poverty line. The employment strategy we need therefore is not a strategy that ensures an adequate growth in the volume of employment, but one that ensures a sufficient growth in quality employment opportunities. Allowing the poor to contribute to and benefit from increased growth rates will pose particular challenges, as employment in India is largely unorganised, rural and non-industrial in nature. It will be necessary to ensure that government policy and programmes recognise the perceptions and priorities of the poor, improve productivity and create diversified opportunities to earn income. We discuss options for employment creation and diversification in different sectors6.

EMPLOYMENT GROWTH RATES: ALL INDIA SCENARIO

The NSS data for the nineties clearly throw up a mixture of gains and losses for rural and urban employment growth rates; growth rates are estimated for two sub-periods: 1983/1993-94 and 1993-94/1999-2000. As said earlier, for notional convenience, we take these as pre- and post-reform periods. Although Table 8 gives a disparate picture across different production sectors, between male and female workers, and between rural and urban areas, yet, in overall terms, one tends to gather the impression that all has not been well on the employment front, during the post-reform years. On the one hand, the rate of growth of employment has witnessed a varying degree of decline, in many sectors, both in rural and urban areas, and for male and female workers. On the other, in some sectors, the post-reform employment growth rate has been higher, compared with what it was during the pre-reform years. On balance, the improved employment growth rates do not compensate for the declining rates firstly because the number of such sectors is small and secondly because these are not the major absorbers of rural workforce. In brief, the setbacks are more widely spread and more grievous in magnitude; post-reform concern for employment has, therefore, its own empirical validity. Let us look into the details of Table 8. The overall rate of growth of employment for rural workers declined from 1.75 per cent per annum during 1983/1993-94 to a low of 0.66 per cent per annum during the postreform years, for rural males, it declined from 1.94 per cent to 0.94 per cent and for rural females, it declined from 1.41 per cent to an abysmally low of 0.15 per cent. All this is hardly a reflection of an employment- friendly scenario. A varying degree of decline was witnessed for urban areas also; from 3.22 per cent to 2.61 per cent for urban males, from 3.44 per cent to 0.94 per cent for females, and from 3.27 per cent to 2.27 for urban persons. Thus, an employment setback has fallen on every section of the Indian work- force. In relative terms, the most grievous setback is suffered by rural females, followed by rural males, urban females and urban males, in that order.

But then, it is rather important to underline that the rate of growth of urban employment, continued to be much higher than that in the rural areas, especially when the rural- urban comparison is made for workers belonging to the same sex. In sum, it is pretty much clear that the rosy employment- friendly picture, that was believed by some reform protagonists to follow, has not yet come off; in fact, it is the contrary that seems to have happened, during the 6-7 years of economic reforms. That the overall employment growth rate suffered a varying degree of setback, during the post- compared with the prereform years, for every section of the work- force, most visibly in the rural areas, lends support to the thesis of a negative fallout of economic reforms as far as the overall employment growth rate is concerned. We must, however, look into the post-reform employment scenario in individual sectors before framing a final view. Highly disparate trends are discernible for employment growth, during 1993-94/1999- 2000 over 1983/ 1993-94, in various sectors of the rural (and urban) economy. For example, for rural workers, transport-storage-communications, construction and agro-based manufacturing were clearly the cheering spots, while agriculture, mining, utilities, trade (especially the whole-sale trade), finance- insurance-real estate, and community-socialpersonal services, showed negative growth or slow-downs in employment. The benefit of improved employment growth during the post-reform years was not available to both sections of the rural work force. While employment for rule male workers in the transport-storagecommunications sector increased sizably from 4.51 per cent per annum during the pre-reform years to as high as 7.45 per cent during the post-reform period, for their female counterparts, it witnessed a steep decline from 8.30 per cent to 0.15 per cent only.

The fast pace of expansion that this sector has witnessed in recent years has generally been more conducive to male job seekers, partly because of the physical labour involved and partly because of the shifting locale of the underlying activities. On the other hand, the benefits of improved employment growth rate in the construction sector are duly shared, albeit unevenly, by male and female workers, primarily because of the convenient locale of the construction activities. Another feature of the post-reform employment scenario which, in our view, is more redeeming and less disappointing, is that the pace of employment growth in the manufacturing sector slackened but only marginally, from 2.10 per cent to 1.79 per cent for rural males, and from 2.21 per cent to 1.75 per cent for rural females; summarily, the same story unfolds itself for urban manufacturing also.

It may be a sheer coincidence that, during the post-reform years, the rate of growth of employment in this sector was nearly the same for rural male and female workers but it does connote a positive development for the latter in as much as it is generally feared that, under the new economic regime, entry of rural female job seekers in the manufacturing sector becomes particularly difficult. Perhaps, only a more detailed sub-sector break-up would throw bare the branches of manufacturing where the rural females are gaining advantages over their male counterparts, and vice versa. The fact that the rural economy stands well enmeshed with the rest of the economy, or the rural job aspirants can no more operate outside the precincts of the national labour market is authenticated, albeit indirectly and meekly, by a pattern of employment growth commonly shared by rural and urban workers.

It cannot be a coincidence that employment growth rates in transport-storage-communications, construction, and agro-based manufacturing sectors, improved during the post-reform years, both for rural and urban workers; likewise, the decline or slow-down in the mining, utilities, finance-insurance-real estates, and community-socialpersonal services, were the common fate of both the groups. It is only for trade that, during the post-reform years, the urban workers surged much ahead of their rural counterparts when the retail trade activity gained additional momentum under the informal sector of the urban economy, in addition to a high pace of employment expansion in the hotel-restaurant segment. Let us peep inside the major sectors. For agriculture, we may better concentrate on rural workers alone. Practically, each sub-sector in the primary sector suffered a varying degree of setback; the worst sufferers are fishing, plantations, and forestry-logging. The employment growth rate in the livestock segment did improve but it was not able to switch over from a negative to a positive rate. Some important male-female differences may nonetheless be underlined. The employment setbacks in field crop production, fishing, livestock, and agricultural services were shared, in varying degree, by both groups of workers; the setback in plantations and forestry- logging fell largely to the share of rural male workers only.

On the whole, for a host of reasons, most ostensibly the declining land: man ratio in general, and increasing marginalization of holdings in particular, the rising pace of mechanization, cropping pattern adjustments not necessarily attuned to labour-absorbing crop enterprises, the general preference of the young entrants to the labour market in favour of non- farm jobs, etc., agriculture and its constituent sub-sectors could not take on people at the same rate as they did during the pre-reform years. But then, as we see below, the pace of nonfarm employment expansion has not compensated for the sluggish labour absorptive capacity of agriculture. A mingle of improved and shrunken employment growth rates was the fate of the manufacturing sector. Employment growth rates for rural workers witnessed a varying degree of improvement during the post-reform years in textile products, wood and wood products, leather and leather products, chemicals and chemical products, non-metallic mineral products, basic metal industries, metal products, and agro- industries. The opposite was true for food products, beverages, cotton and wool products, paper and paper products, rubber and rubber products, machine tools and electrical machinery, other manufacturing, repair services, and non-agro industries. Improved employment expansion was particularly striking for textile products, leather and leather products, basic metal products, and metal products, while the squeeze in the pace of employment growth was substantially high for cotton and wool products, other manufacturing and repair services.

The mixed picture observed for the total of rural workers is discernible, in varying degree and form, for the rural male and female workers. The combined effect of these developments is that for the total of manufacturing, employment growth rate did not witness a big decline; in our view, the mild decline from 2.14 per cent during the pre-reform period to 1.78 per cent in the post-reform years is reflective of the adjustment process that the rural industry in India was involved in during the 6-7 years of the post-reform years.

Perhaps, in the next phase, some product lines, especially those which fared well during the period 1993-94/1999-2000, may further consolidate their production base and throw up augmented avenues of employment; our hope stems from the fact that industries such as textile products, leather and leather products, chemicals and chemical products, basic metal products and metal products, have already demonstrated their remarkable employment-expanding capabilities, during 1993-94/1999-2000 contrasted to their dismal performance during 1983/1993-94, even while many other branches, including the conventional agro-based segments, lost their verve during the post- 1993 years. The employment setbacks reported in community-social-personal services, are fairly widely spread across individual segments. For example, for rural workers, employment growth suffered severe setbacks in sanitary services, community services, recreational and cultural services, and personal services; it is only in respect of education and scientific personnel that a mild improvement from 2.90 per cent to 3.01 per cent in employment growth rate occurred in the post-1993 years, compared with the pre-1993 period.

The above pattern is shared, in varying degree and form, both by rural male and female workers. The all-round setback in this sector is a matter of worry, firstly because, among the non-farm segment of the rural economy, it provides a major share of employment, and secondly because, employment in segments such as sanitary services, medical and health, community services, and recreational and cultural services is largely sustained by the pace and pattern of public expenditure which, as we see later, came under seize during the post-reform years. The fact that the employment setback in this sector has assumed the same shape in urban areas also lends credence to our contention on the all-round post-reform public expenditure seize. In overall terms, the rural work force has been at a disadvantage; it gained relatively less in work-place increments and lost relatively more in work-place decrements. Perhaps, this tendency might intensify itself in the years ahead inasmuch as the low levels of educational, training and skill capabilities of rural job seekers would push them back in the fiercely competitive labour market. In plain terms, the quality of work force is not the same between the rural and urban areas.

Increasing Casualization in Rural Employment

It is at once clear that in rural India, the incidence of self-employment has been consistently on a relative decline, both for male and female workers; for rural males, it declined from around 66 per cent in 1972-73 to 55.0 per cent in 1999-2000 and for rural females, it dropped from 65 per cent to 57 per cent. In urban India, it has been hovering around 40.0 per cent for male workers; for urban females, it faced a sizeable decline only during the nineties. Second, regular salaried jobs have unmistakably been on the decline, both for rural male and female, especially the former, and urban male workers; for urban female workers, it remains more or less the same till we enter the 1990s thereafter it started increasing although sluggishly from 27.5 per cent in 1987-88 to 28.6 in 1993-94 and further on to 33.3 per cent in 1999-2000.

Third, and quite strikingly, employment under casual labour basis has increased for all the four categories of workers. The increase has been fairly steep in the case of rural male workers, a little less so in the case of rural females, and somewhat moderate in the case of urban male and female workers. The point of economic substance is that in rural India, the casual wage-employment is steadily rising at the cost of self-employment, while in urban India, it is the regular salaried jobs which are gradually yielding to casual wage labour. For rural areas, the switch-over is a more worrisome matter since the declining incidence of selfemployment may be throwing some people out of self-cultivation only to swell the ranks of the land- less agricultural labourers. In fact, for rural India, independent information through population census does confirm the rising proportion of the land- less agricultural labourers from about 17.0 per cent in 1961 to as high as 32.0 per cent in 1991 (Haan, 1980, Part II: 2; Census of India, Paper-3 of 1991: 193). It is as well possible that many among the self-employed sub-marginal and marginal cultivators, whose proportion among the cultivating households has been continuously rising during the 1960s, 1970s and 1980s, temporarily give up agriculture and seek work as nonagricultural labourers, on casual basis. That the temporary 'switch-over' or seasonal supplementation is a real possibility, and, by implication, is behind the increasing casualization of wage labour, has its support from the much higher increase in casually employed males compared with their female counterparts. The extremely high incidence of casualization for rural female workers, and its rise over time, especially during the nineties, is discernible through the rough index of casualization.

This index shows the number of casual wage earners for every one-hundred of regular salaried employees. The male- female contrasts in the rural areas are too striking to invite a special emphasis. But then, the real contrast is between the rural females and their urban counterparts, or for that matter, between rural and urban workers as a whole. The ridiculously low share in regular salaried jobs for rural workers (e.g., in 1999-2000, 8.8 per cent only against 36 per cent under casual labour for rural males, and 3.0 per cent only against 40.0 per cent under casual labour for rural females) tells the story of their relative disadvantage in the most blatant manner. The marked rural-urban differences in terms of the proportion of workers engaged as casual wage earners at once confirm numerous disadvantages (e.g. low wage rates, irregularity and uncertainty in employment, uncongenial work conditions) of rural workers, most visibly the females among them. The quickened pace of casualisation, and a more visible decline in the proportion of self-employed workers, during the nineties, much more markedly among the rural workers, lends some credence to the theory of increasing segmentation in the Indian labour market, in general, and increasing marginalization of rural job aspirants, in particular. Interestingly, in most recent years, casualisation has not been discernible for urban workers; in fact, it has declined for urban females during 1993-94/1999-2000.

This is plainly so because of the marked improvement in the educational and training capabilities of urban female job seekers, almost at tandem with urban males; the future cadres of the urban female job aspirants are likely to be equipped with educational, training and skill accomplishments not much different from their male counterparts, and would thus be able to compete effectively in the information-, technology-, and management- intensive urban labour market. The prospective rural female job seekers do not seem to have a very bright chance on such job frontiers. In plain terms, for a preponderant majority of rural workers, coming as they do from the landless labour, marginal and small cultivating households, self-employment on own or leased- in land and casual wage employment on others' farms or in one or the other non-farm activity are the only two choices; regular salaried jobs do not accommodate more than a handful of them, nearly to the total exclusion of the female job aspirants. It bears some conjecture, therefore, that in terms of quality of employment, rural job seekers have undoubtedly a long gap to cover.

State-wise Evidence on Casualization

In as many as twelve of the seventeen states, the proportion of rural workers employed as casual wage labourers registered a varying degree of increase during the post-1993 years. The increase was rather strong in Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, and West Bengal. It is equally clear that the process of increasing casualisation of wage labour encompassed workers of both sexes, in most of the states. For rural male workers, the increasing casualization of wage labour is clearly accompanied by a decline in the share of self-employment; the latter is true of as many as fourteen states while the former holds for no less than thirteen states. Again for male workers, the proportion of regular salaried employees did not witness a noticeable diminution except in Jammu-Kashmir and West Bengal; on the contrary, each of the remaining fifteen states had a slight improvement to report for the post-reform years. In any case, the proportion of regular salaried male employees continued to be fairly small, in most of the states, except in Assam, Haryana, Punjab and Tamil Nadu. In overall terms, in most of the states, self-employment for men has been steadily declining while casua lisation of wage labour has been on an increase.

For female workers, there is no clear, much less an inverse, relationship between selfemployment and casual wage labour, as is discernible for their male counterparts. For some states, the former increased while the latter decreased, in the post-reform years, while the opposite also happened for other states. No significant change occurred, during the post-1993 years, in the proportion of regular salaried female employees; as a matter of fact, for rural females, this source of employment has all along been extremely small for most of the states, except in Assam and Kerala, ranging from 0.8 per cent in Jammu-Kashmir to just 5.3 per cent in West Bengal in 1983, from 0.9 per cent in Rajasthan to 7.3 per cent in West Bengal in 1993-94, and, from 1.0 per cent in Rajasthan to only 6.9 per cent in Tamil Nadu in 1999- 2000.

Clearly, in most of the states, the choice for them has been only between selfemployment and casual wage labour. The fact that, in their case, the index of casualisation has consistently been higher, in some cases many times higher, than that for their male counterparts, in most of the states, testifies to their low standing in the rural labour market. However, in the post-reforms years, the index of casualisation for them did not increase in more than four of the seventeen states while, for male workers, it increased in as many as eight states. In some sense, therefore, during the past few years, the overall composition of employment did not worsen as much for the rural female workers as it did for their male counterparts

Growth of Employment

The proponents of economic reforms would make us believe that employment was expected to pick up primarily because the output growth was likely to pick up after economic reforms took roots. Dwelling more on the labour-displacing effects of these reforms, the critics would, however, believe that employment would not grow in the same proportion in which output would grow, given the compulsion of installing a more capital-intensive technology in many branches of production. Since technological changes of the above type are likely to come about only in selected production sectors, and labour- intensive technologies are likely to dominate in many others, a mixed overall picture on employment growth was likely to emerge for some years after the arrival of the reforms. This is what seems to be happening currently in the Indian economy in general, and rural areas in particular.

Educational Background of Rural Workers

It is abundantly clear that, with one or two stray exceptions, in all parts of rural India, and, for both categories of rural workers, there has been a gradual decline, first between 1983 and 1993-94, and then between 1993-94 and 1999-2000, in the proportion of illiterate workers and a gradual increase in the proportion of educated ones; following the usual convention, we take secondary or higher secondary level of schooling and other higher qualifications as the dividing line between educated and uneducated workforce. It is as much evident that the proportion of semi-educated rural workers (those with primary and/or middle level schooling) has also witnessed a steady increase over time, practically in all parts of rural India. These are welcome developments, in their own right. But then, we cannot hide the fact that, at the national level, as late as 1999-2000, only 11.7 per cent of rural male workers and just 5.0 per cent of their female counterparts constituted the 'educated workforce'.

For the former group of workers, this percentage ranged from as low as 7.4 per cent in Madhya Pradesh to about 21.0 per cent in Kerala and Himachal Pradesh; for the latter, it ranged from an extremely low level of 2.0-3.0 per cent in Rajasthan, Bihar and Madhya Pradesh to 18.8 per cent in Kerala. Looking at the other extreme, it is rather frightening to see that in spite of the phenomenal expansion of educational facilities during the five decades of India's economic development, India's rural economy has still to contend with no fewer than 41.2 per cent of illiterate male and no fewer than 61.5 per cent of illiterate female workers. The situation is far worse in some of the states. For example, in 1999-2000, the proportion of illiterate male workers was as high as 54.4 in Bihar, 49.1 in Andhra Pradesh, 44.8 each in Madhya Pradesh and Rajasthan, and Uttar Pradesh, and so on.

The only soothing pockets are Kerala (15.2 per cent), and to a lesser extent, Himachal Pradesh (26.9 per cent). The situation is rather appalling in respect of rural female workers. For example, again in 1999-2000, the proportion of illiterate female workers was as high as 76.3 in Bihar, 76.0 in Rajasthan, 69.3 in Uttar Pradesh, 68.3 in Madhya Pradesh, 66.5 in Andhra Pradesh, 62.9 in Orissa, 60.7 in Karnataka, and so on. For this category of workers, Kerala is the only pleasing spot (21.3 per cent). Even Himachal Pradesh which has done remarkably well in the matter of rural education does not seem to have rid itself of the male bias.

First, a fairly high proportion of the educated rural persons are involved in agriculture, primarily because agriculture is the mainstay of the rural economy, and it is not possible for all educated job aspirants to get into one or the other type of non-agricultural jobs. In a sense, it is redeeming to see that the proportion of educated rural persons choosing to stay back in agriculture has been increasing steadily from 44.38 per cent in 1983 to 50.18 in 1993-94 and to 52.26 per cent in 1999-2000; the corresponding figures for rural males have been 45.45, 51.53 and 52.79, and for rural females 26.93, 34.32 and 46.86, respectively (Cols.3 and 4). While for the rural males, the influx of educated persons into agriculture has been much faster during the pre- compared with the post-reform phase, for their female counterparts, it has been the other way round.

The most promising segment in which the educated female, and to a lesser extent male, job seekers seem to have gone to is agricultural services where the rate of growth of employment has been remarkably high during the pre- as well as post-reform years, both for males and females. To the extent that 'new agriculture' too demands higher levels of educational and training pre-requisites, 'modern agriculture', especially that linked with the world outside, is becoming an attractive career to the educated job seekers. Second, a fairly substantial proportion of the educated incremental workforce, both males and females, has been accommodated by agriculture, during the pre- as well as post-reform years. It clearly points to the inability of many an educated rural job seeker to gain an entry into the non-agricultural sectors, most ostensibly because the number of such jobs is far too limited and the number of claimants far too large, even if the painful reality of low content of rural education is kept aside.

Since the competition for nonagricultural jobs became more intense in the post-reform phase, largely because of the expanding demand-supply hiatus on the labour market, and the rural female job aspirants being the weakest in the chain of competitors, more than 63 per cent of the incremental educated female workers staying back in agriculture should cause no surprise; during 1993-94/1999-2000, only 36.70 per cent of them could get into non-agricultural jobs while during the pre-reform decade, no fewer than 61.83 per cent of them could go to such jobs.

Third, it is extremely gratifying to see that the rate of growth of employment among the educated rural work seekers has been many times higher than that among the job seekers as a whole, irrespective of the sector in which they are ultimately absorbed. It is once again a confirmation of our earlier contention that many among the educated rural female job seekers could not get into the non-agricultural sector, more expressly during the post-reform phase, considering that the rate of growth of employment in this sector dropped for them from 9.76 per cent during the pre-reform phase to 6.11 per cent during the post-reform years, against its increase from 13.60 per cent to 15.87 per cent, respectively, in agriculture.

For the total of the rural economy, employment growth rates for the educated job claimants declined both for rural males and females, yet these were many times as high as those for the job aspirants in general. The crucial role of education, whether towards creation of additional avenues of self-employment in and outside agriculture, or for getting into wage paid jobs in non-agricultural activities, is thus more than evident. Finally, a note of caution is a must. In spite of the high growth rate of employment for educated persons, inside and outside agriculture, for rural males and females, and, during and before the reform years, the fact still remains that the proportion of such educated persons is very low, and a majority of the rural workers, both in the farm and non- farm sectors, do not have much to claim on the educational front.

It is a pity that as late as 1999-2000, not more than 12.17 per cent of rural males, and a ridiculously low of 2.17 per cent of rural females engaged in agriculture constituted the 'educated workforce'. With the proportion of educated males and females, engaged in non-agricultural activities during 1999- 2000, being 26.69 and 13.06, respectively, the situation is hardly pleasing outside agriculture either. Although these proportions have been increasing steadily over time, yet the low levels in the base year (1983) wo uld not let even an extraordinary expansion improve the situation beyond a point.

That is how, the share of educated rural male workers engaged in agriculture, starting from 4.91 per cent in 1983, could not go beyond 8.96 per cent in 1993-94, and to 12.17 per cent in 1999-2000; for their female counterparts, the share could travel from 0.32 per cent to 1.04 per cent, and finally to 2.15 per cent only.

The upward journey in the nonagricultural sector commenced from 19.99 per cent in 1983, reached 23.38 per cent in 1993- 94, and terminated at 26.69 per cent only, in the case of rural males; for rural females, the three flag points were 5.43, 11.37 and 13.06 per cent only. The vulnerability of rural workers surfaces most blatantly when we go to technical/professional education, although the expanding network of technical/ professional educational facilities is often glibly claimed as a solid achievement of the post-Independence India.

A detailed field survey of tiny and small rural industrial enterprises in the three states of Maharashtra, Haryana and West Bengal, conducted by the author during April-June 2000, shows that on-the job training was reported by as many as 82.0 per cent of the rural and 86.0 per cent of the urban workers; just about 7.0 per cent of them in rural, and 9.0 per cent of them in urban areas, received training through government agencies (Chadha, 2001b:157).

The most distressing picture is discernible on the front of technical education. For example, only 8 per cent of rural and 10.5 per cent of urban workers engaged in such industries have had the benefit of technical education; a substantial proportion (65.0 per cent of rural and 48.0 per cent of urban workers) of them nonetheless stopped at the ITI or polytechnic level; rural workers with management degrees (e.g. MBA) were nearly conspicuous by their absence.

RIGHT TO WORK AND THE RURAL EMPLOYMENT GUARANTEE ACT

The 1991 reforms resulted in a reduction in public works programs and employment generating activities, rising input costs while the prices and support of the government declined. This affected rural India badly and lead to a falling agricultural production, and thus a reduced per capita availability of food grains, as well as a decrease in purchasing power. Employment in general is a problem as the labour force has grown faster than the growth of employment. In addition, there is a growing discrimination of women in rural labour with lower wager and a faster overall decline in women's employment. Thus, with high unemployment rates, increased poverty, starvation deaths, and peasant suicides, rural India suffers a severe crisis

Background to the Problem

Over the past decades, the number of malnourished people in India has increased instead of decreasing. Particularly communities in rural areas face a difficult situation, which is aggravated by an environmental crisis resulting from the green revolution. While the green revolution attempted to feed millions of citizens it had grave long-term consequences ; falling water tables, dried up rivers, increased soil erosion, reduced lifespan of dams, which lead to a major crisis of drinking water in many areas.

To improve the situation and move towards sustainable environmental regeneration, a substantial boost in public investment is required since they go beyond the capacities of individual small farmers. Those investments would start of a chain of events. First of all, to put to use these investments effectively, massive employment programs could be started. This would offer many unskilled people a job paid in grains or cash and thus would help improve their standard of living. Second, public investment in environmental regeneration would improve the environment and water situation while increasing the agricultural productivity of small and marginal farmers.

Possible Scenario That May Pose Solutions

One way to enforce the crucial public investment is to legislate the right to work. The National Rural Employment Guarantee Act (NREGA) is one attempt in this direction.

The original act was based on the principles of universality and self-selection, which allowed all households to apply and an extension of the Act to the whole of rural India within a five-year period. The NREGA promises to provide legal guarantee for at least one hundred days of employment, to begin with on asset-creating work programs every year at minimum wages.

It was open to adult members of every rural household who would volunteer to do casual manual work. Under the act there should be no gender discrimination in the "provision of employment or the payment of wages". Every applicant should be offered employment within 15 days of registration. If this were not the case an unemployment allowance would be paid.

Limitations to This Scenario

The reality of the NREG bill of 2004 shows a slightly different picture: every rural household became every poor rural household whereas poor was defined as households below the poverty line. Yet, this identification leaves out millions of the near poor and those that have only fragile and precarious livelihoods. In addition, the new bill does not guarantee a time-bound extension to the whole of rural Indian but, instead, allows the government to withdraw it at any time while the bill can also be restricted to certain areas.

Furthermore, wages are not linked to any norms and seem to be arbitrary, without any fixed minimum common figure. Also, the way "work" has been defined it limits the scope of employment guarantee. Finally, the exclusion of women is not adequately addressed.

Consequently, the National Rural Employment Guarantee Bill of 2004 tabled in the Parliament will not be able to fulfill the purpose of the original draft without the benevolence of the state. However, the intention of creating an NREG was to empower disadvantaged rural households and improve the living standards of hundreds of million people without any restriction. While this is a noble attempt, the limitations of the actual bill suggest that the reality will be different.

India, the country with the second largest population, faces severe difficulties with a labour force growing faster then employment opportunities. This results in a circle of problems starting with high unemployment rates, growing discrimination of women, and increased poverty and can lead to starvation death and peasant suicides. Particularly households in rural areas are affected by these dramatic outcomes. The national employment guarantee act addresses this crisis with an option that could be beneficial for millions. The bill that passed the Indian parliament, however, varies from the original proposal and thus puts limitations on the number of, and ways, people can benefit from it.

Advocacy and Communication Strategies

To address the changes in the current proposal of the national employment guarantee scheme from the original act and including the resulting implications, Pipal Tree will publicize articles in newspapers and journals. It will also provide extensive documentation and communication on background information and future changes, as well as the status of implementation. To enhance communication and start a dialogue among key actors, Pipal Tree will use a list-serve to reach its network partners and key actors.

As the difference between the original and current proposal will have a great impact on millions of people it is important to find a consensus that leads to maximal benefits for the poor. Pipal Tree will play a mediator and help find such a consensus through lobbying with government official, business representatives, NGOs, and pressure groups.

Mediation

Our conference will set off discussions and an ongoing dialogue among key actors and those interested in the national rural employment guarantee act and its implementation. These workshops and discussion will focus on the problems arising from the modified proposal and the resulting impact on the rural population. The aim is to find possible solutions to allow a majority of the poor to benefit from the NREGA.

During our conference we will call key civil society leaders, trade unionists, and others, to dialogue on this issue.

Steps to be taken to arrive at workable solutions

(1) Build coalitions of NGO's, intellectuals, media and other civil society leaders that can suggest sustainable

development plans in the districts selected. Prevent the programme from degenerating into an unplanned relief effort.

(2) Increase media coverage and ensure coverage to those people who will be effected.

(3) Form new pressure groups.

(4) Increase cooperation between NGOs, people's organization, and pressure groups working towards the implementation of the original act.

(5) Monitor the government's actions towards it's implementation and try to enforce further actions, especially at the 150 districts where is being implement, check corruption (such as bogus muster rolls), and so on.

Key Actors

Among key actors who deal with the NREGA are :

- Government officials, political leaders, policymakers ;
- NGOs promoting employment and income generating activities especially in the unorganised sector, womens' empowerment, and rural development ;
- Journalists and mediapersons ;
- Researchers and workers' rights activists ;
- Pressure Groups and Social Movements ;
- Business and Corporate Houses ;
- Pressure groups and social movements supporting the original NREGA.

Employment generation is one of the major priorities drawing the attention of the governments and economic planners all over the world. India is no exception.

The approach to tackling unemployment problem have varied from time to time. In the initial years of planning no attempt was made to define an independent employment strategy. The focus on economic growth was viewed as essential for improving the employment situation. Thus, in the Five Year Plans, the generation of employment was viewed as part of the process of development.

It was, however, observed that the rate of growth of employment was generally much lower than the GDP rate of growth of the economy. Seasons of severe drought and failure of monsoons exposed large sections of population to extensive deprivations and compounded the situation. Successive plan strategies, policies and programmes were, therefore, re-designed to bring about a special focus on employment generation as a specific objective. The seventies and eighties saw the emergence of special schemes like NREP, RLEGP to provide wage employment through public works programmes and schemes to promote self-employment and entrepreneurship to the unemployed and the poor. Employment levels expanded steadily during the seventies and eighties but the rate of growth of employment continued to lag behind that of the labour force. Unemployment among the educated showed a rising trend.

In 1998-99, various poverty alleviation and employment generation programmes were re-grouped under two broad categories of self-employment schemes and wage employment schemes. Funding and organizational patterns were also rationalized for better results.

Workforce

India's labour force is growing at a rate of 2.5 percent annually, but employment is growing at only 2.3 per cent. Thus, the country is faced with the challenge of not only absorbing new entrants to the job market (estimated at seven million people every year), but also clearing the backlog.

More than 90 per cent of the 37 crore strong labour force is employed in the "unorganised sector" and are largely bereft of social security and other benefits of employment available in the "organised sector".Sixty per cent of India's workforce is self-employed, many of them remain very poor. Nearly 30 per cent are casual workers who are only seasonally employed. In the rural areas, agricultural workers form the bulk of the unorganised sector.

Unorganised sector is also made up of jobs in which the Minimum Wage Act is either not, or only marginally, implemented.

The absence of unions in the unorganized sector does not provide any opportunity for collective bargaining.

The bane of India's labour force is that over 70 per cent of workers are either illiterate or educated below the primary level.

With the opening of Indian economy and linking it to global economies, the rate of growth of employment declined sharply in 1990s as compared to 1980s. The decline in employment growth has been seen in conjunction with the decline in the labour force growth rate.

There is also a wide variation in unemployment rates across the states. Measured on Current Daily Status basis, unemployment ranges from a low of around 3 percent in Himachal Pradesh and Rajasthan to a high of 21 percent in Kerala.

While there may be divergence of opinion on the extent of under employment and unemployment, there is convergence of views on the need to expand employment. In order to achieve this goal, the economists have emphasized that any programme for this purpose must focus on growth, labour productivity and relative price of labour and capital. They have further suggested that micro economic policy framework must be such as to facilitate accelerated growth rate of 9 percent on a sustained basis. According to the noted economist Dr. C. Rangarajan a sustained growth of 9 percent per annum will totally eliminate unemployment by 2012.

Sector specific policies are required which would acclerate the growth of labour intensive sectors. These include among others agriculture, food processing and small-scale units in various sectors.

NREGA

One of the most significant interventions by the government to generate employment has been the launch of the National Rural Employment Guarantee Act (NREGA) in February 2006 in two hundred most backward districts of the country. Consequently, the scheme was extended to another 130 districts and from April 2008 it would be operative in all districts. For the current financial year, a budget provision of Rs.12, 000 crores was made for implementation of the Act. NREGA being demand driven, so far, nearly 2.12 crore house holds have been provided with employment. Under NREGA, 6.399.55 lakh person days works have been taken up for creating village assets that would in turn enrich rural and women has considerably gone up in this wage employment programme economy. The participation of weaker sections of the society, such as SC/STs.

Skill Development

Skill development of labour force is fundamental both to employment generation and improving productivity of labour. India has one of the largest labour forces in the world but the least number of skilled workers constituting only 5 percent compared to South Korea's 95 percent.

Almost 44 percent of labour force in 1999-2000 was illiterate and 33 percent had schooling up to secondary education level only. The other bane of our work force is that while their educational attainment is very low on the one hand, 61% of those educated up to secondary level and beyond, on the other hand, are without any professional skills. This is because our general education system is not oriented towards attaining vocational skills. The mid term appraisal of the 10th Plan points out, "our education system is not generating sufficient supply of trained people especially those trained in skills that are in demand." This has created a miss-match between the supply and demand of skills.

Increasing pace of globalization and technological change provides both challenges and growing opportunities for economic expansion and job creation. "In a rapidly changing environment, new ways and means of ensuring that people who work, possess the necessary knowledge, skills and attitude are criteria for seizing the opportunities inherent in globalisation and technical progress while reducing their unwanted consequences", reports International Labour Organisation.

The Prime Minister Dr. Manmohan Singh addressing the Indian Labour Conference in early 2007 said that the country would have to meet the challenge of increasing the skilled work force from the present 5% to about 50%, which is the norm in developed countries. He said, "To make our working people employable, we must create adequate infrastructure for skill training and certification and for imparting training. Industrial Training Institutes must keep pace with the technological demands of modern industry and the expanding universe of technical knowledge".

Responding to meet the challenge of the present and future needs of skill development, the Ministry of Labour and Employment has initiated a massive skill development programme. It has embarked on an initiative to impart skills to country's half of the labour force within next five years. Under this initiative vocational training will be provided to one million persons in 5 years and subsequently to one million people each year in close collaboration with State Governments, Industries, Trade Associations and other training providers. A provision of Rs. 555 crore has been made so far for this purpose.

Modernisation of ITIs

The Ministry has also embarked on upgrading Industrial Training Institutes (ITIs) for meeting the emerging market needs. During the 10th Plan 500 ITIs have been taken up for upgradation through public-private partnership. In addition 1396 ITIs are being upgraded during the 11th Plan beginning with 300 ITIs each year from the current financial year. The upgraded ITIs to be known as 'Centres of Excellence' will produce workers with world-class skills to enable them to compete in the global labour markets. The important aspects of the modernizations are multi entry and multi exit options to workers to upgrade their skills through multi skilled courses and the public-private partnership, which is being ensured through greater involvement of industry in all aspects of training.

One significant factor in the employment situation in the country is that the bulk of employment is in the unorganised sector. There has to be an endeavour to shift as much of labour force as possible from the unorganised to the organised sector. This would give workers a better deal in terms of wages. This is possible only if the rigidities in the labour market are relaxed and wage determination begins to reflect the resource endowment in the country. This would encourage establishments to adopt labour intensive technologies.

There has been a welcome and widespread social acceptance of the imperative need of the Indian economy to achieve higher growth rate of GDP in a sustained manner. The country recently achieved 9 percent GDP growth, which it not only plans to sustain but take it to a double-digit growth during the 11th plan.

It may not be difficult to meet the formidable challenge of providing job opportunities to eight million people every year. For this the growth rate of economy has to be accelerated, special emphasis to be given to labour intensive sectors, improving labour skills and functioning of the labour market.

ACCENT ON EMPOWERING THE SMALL FARMERS

Contributions of small holders in securing food for growing population have increased considerably even though they are most insecure and vulnerable group in the society. The off-farm and non-farm employment opportunities can play an important role. Against expectation under the liberalized scenario, the non-agricultural employment in rural areas has not improved. Greater emphasis needs to be placed on non-farm employment and appropriate budgetary allocations and rural credit through banking systems should be in place to promote appropriate rural enterprises. Specific human resource and skill development programmes to train them will make them better decision-makers and highly productive. Human resource development for increasing productivity of these small holders should get high priority. Thus, knowledge and skill development of rural people both in agriculture and non-agriculture sectors is essential for achieving economic and social goals. A careful balance will therefore need to be maintained between the agricultural and non-agricultural employment and farm and non-farm economy, as the two sectors are closely inter-connected. Raising agricultural productivity requires continuing investments in human resource development, agricultural research and development, improved information and extension, market, roads and related infrastructure development and efficient small-scale, farmer-controlled irrigation technologies, and custom hiring services. Such investments would give small farmers the options and flexibility to adjust and respond to market conditions.

For poor farm-households whose major endowment is its labour force, economic growth with equity will give increased entitlement by offering favourable markets for its products and more employment opportunities.

Economic growth if not managed suitably, can lead to growing inequalities. Agrarian reforms to alleviate unequal access to land, compounded by unequal access to water, credit, knowledge and markets, have not only rectified income distribution but also resulted in sharp increases in productivity and hence need to be adopted widely. Further, targeted measures that not only address the immediate food and health care requirements of disadvantaged groups, but also provide them with developmental means, like access to inputs, infrastructure, services and most important, education should be taken.

Identification of need-based productive programs is very critical, which can be explored through characterisation of production environment. We have to develop demand-driven and location-specific programs to meet the requirements of different regions to meet the nutritional security of most vulnerable population in the rural areas. Improved agricultural technology, irrigation, livestock sector and literacy will be most important instruments for improving the nutritional security of the farm-households.

Watershed development and water saving techniques will have far reaching implications in increasing agricultural production and raising calorie intake in the rainfed areas. Livestock sector should receive high priority with multiple objectives of diversifying agriculture, raising income and meeting the nutritional security of the poor farm households. Need based and location-specific community programs, which promise to raise nutritional security, should be identified and effectively implemented. Expansion of micro credit programmes for income-generation activities, innovative approaches to promote family planning and providing primary health services to people and livestock and education should enhance labour productivity and adoption of new technologies. Development of the post-harvest sector, cooperatives, roads, education, and research and development should be an investment priority. A congenial policy environment is needed to enable smaller holders to take the advantage of available techniques of production, which can generate more incomes and employment in villages. For this poor farmer needs the support of necessary services in the form of backward and forward linkages. Small-mechanised tools, which minimise drudgery and do not reduce employment, but only add value to the working hours are needed to enhance labour productivity. Special safety nets should be designed and implemented for them. Can agricultural cooperatives internalise and galvanize these marginal and excluded people? Off-farm employment provided through cooperatives will go a long way in pulling them out of the state where poverty breeds poverty. Therefore, investment in the empowerment of the small landholders will pay off handsomely.

Let us create rural centres of production and processing by masses through cooperatives or empowerment of Gram Panchayats to promote cooperatives. This will improve efficiency of input and output marketing and give higher income. There is need to disseminate widely post-harvest handling and agro-processing and value addition technologies not only to reduce the heavy post-harvest losses but also improve quality through proper storage, packaging, handling and transport. Panchayati Raj institutions and cooperatives can play significant role in all these directions. Giving them power over the administration, as contemplated under the 73rd and 74th Amendment of the Constitution has not been implemented seriously so far in any of the states.

TRENDS IN THE AGRICULTURE SECTOR

There were three distinct periods in the evolution of Indian agriculture and agricultural policy after Independence. The first period was before the Green Revolution up to the mid-1960s (Phase 1). The second period was the Green Revolution from the mid-1960s till the late 1980s (Phase 2). The third phase continues from then to the present day (Phase 3).

The first period saw the government focusing policy on the following:

- irrigation,
- land reforms,
- community development, and
- restructuring of rural credit institutions.

Land reforms involved abolition of intermediaries, tenancy reforms, acquisition of surplus land through ceilings on holdings and redistribution and consolidation of holdings; success varied across states. Land reforms quite successfully altered agrarian structures in states like Kerala, West Bengal and Karnataka, but failed to do so in states such as Bihar, Orissa and Rajasthan. Changes in agrarian structures occurred in Punjab, Haryana, Western Uttar Pradesh, Tamil Nadu and Andhra Pradesh.

A Community Development Programme was started in 1952, for integrated village development by coordinating the development of agriculture, animal husbandry, infrastructure and extension at the block level. Also in 1952 the National Extension Programme was spliced into the Community Development Programme, incorporating provision of technical inputs. The Intensive Agricultural District Programme (IADP), started in selected potential districts in 1960 and 1961, aimed to provide a package of high-yielding inputs (seed, fertilizers, plant protection measures, etc.) to farmers. The Intensive Agricultural Area Programme (IAAP), started in selected potential blocks in 1964 and 1965 aimed to provide technological inputs for identified crops.

Whether these changes were successful or not depends upon how one benchmarks success. Compared to the low or negative growth in the period immediately preceding Independence, they were successful. Both productivity and output increased during most of the period. However, progress in productivity improvements was not commensurate with the requirements even during good monsoon years. There were institutional constraints in providing inputs like high-yielding varieties, fertilizers and irrigation, coupled with a switch during the Second Plan (1956–1961), with reduced investments in agriculture as fallout. In other words, the government was unable to inject the required financial resources, or develop adequate institutional back-up to enable widespread and sustained implementation. Moreover, the government was also unable to effect improvements in technology and the usage of improved seeds, inputs and methods did not occur until much later.

On the positive side the first phase did succeed in other aspects that facilitated later changes. Land reforms (although limited to some states and discussed elsewhere), assigning ownership rights to tenants, consolidation of holdings, among others, were important measures that started during this period and have continued to a varying extent to the present day. The establishment of many agricultural technology institutions and the birth of a widespread extension services system also transpired during this time (although it is now ineffective in many states). Most importantly, administrative systems were developed during this period with the capacity to take on the challenge of the Green Revolution when the technologies finally became available.

The mid-1960s witnessed a succession of exogenous negative shocks that had a major impact on agricultural output: a war with China in 1962, a war with Pakistan in 1965 and successive monsoon failures in 1965 to 1966 and 1966 to 1967. India had to resort to large-scale imports of food.

The Green Revolution package was based on increased availability/access to:

- high-yielding varieties (HYV) of seeds,
- fertilizers,
- irrigation,
- biochemicals,

- extension services,
- availability of credit,
- establishment of marketing and price-support mechanisms for farmers.

This was spliced with a price-support policy. The government's role in ensuring the availability of complementary inputs for HYV seeds was quite significant. Ahluwalia summarizes it well, " it required a comprehensive strategy for agricultural change requiring active Government intervention in many dimensions…".

A sustained effort was needed to expand irrigation with a shift from major to medium and minor irrigation projects. It was necessary to move the banking system into rural areas to provide credit for the purchase of biochemical inputs needed for HYVs. Nationalized banks were given the task of upgrading their rural operations and they succeeded to a large extent. Primary agriculture markets were regulated and some of the usurious practices of traders stopped. Extension services were set up and backed by numerous agricultural research establishments. Development of appropriate varieties was critical given the heterogeneity in agroclimatic conditions. The ability of the government to effect adequate coordinating mechanisms was also quite important. Provision of credit was facilitated through the nationalization of banks. Fertilizer availability and accessibility was expanded through subsidies and was juxtaposed by public and private sector expansion in manufacturing. Moreover price support was instituted at remunerative prices. This coordination role cannot be understated. While subsidized inputs were becoming available and productivity increases were rapid and concentrated, the price-support mechanism ensured that incomes for farmers increased. The three key characteristics of the mandate were: simultaneous handling of constraints in supply and marketing, a coordinated approach and recognition of heterogeneity in agroclimatic conditions. This approach can be assigned most of the credit for the success of the Green Revolution. The growth rates in area, production and productivity of major crop groups. The asterisks in the table indicate the major contributing factors behind increase in production during that period. From 1949–1950 to 1964–1965, non-foodgrain was the major component of crop production and for both foodgrain and non-foodgrain, production growth primarily transpired through area expansion. This was reversed from 1967–1968 to 1980–1981. During this period, expansion of production for both foodgrain and non-foodgrain occurred through productivity increases, area expansion having slowed down. This trend continued from 1979–1980 to 1989–1990, with productivity increases becoming sharper and the area under foodgrain actually declining. However, in the last few years, productivity growth has slackened, and so has growth in production, particularly of foodgrain.

However the Green Revolution had several positive aspects: (1) As foodgrain production increased faster than the population growth rate, per capita availability of food increased. Per capita net availability of cereals and pulses was 394.9 grams in 1951, 468.7 grams in 1961, 468.8 grams in 1971, 454.8 grams in 1981, 510.1 grams in 1991 and 416.2 grams in 2001 (GOI 2004–2005). (2) Per capita income generation in agriculture increased. (3) Agriculture was better protected from the ravages of drought. (4) There was greater commercialization and diversification, with cropping patterns changing in favour of commercial crops and moving away from coarse cereals, even for small and marginal farmers. (5) Capital accumulation rose, including investments from the private sector. (6) While there may have been some reservations about the initial distributional impact of the Green Revolution package, the benefits became more broad-based in subsequent years.

Many holdings are marginal (less than 1 ha) or small (between 1 and 2 ha). Barring pulses and coarse cereals, all other crops seem to have benefited from the new technologies. In addition, there was a paradigm shift from foodgrain towards commercial crops and even fruits and vegetables, this diversification being at the expense of pulses and coarse cereals. Although a large percentage of small and marginal farmers is still dependent on foodgrain, there was some diversification among small and marginal farmers. For instance, the share of cereals in area cultivated by small and marginal farmers declined from 71.44 percent in 1970 to 1971 to 70.57 percent in 1980 to 1981 and 66.22 percent in 1990 to 1991; the share of fruit and vegetables increased in area from 2.43 percent in 1970 to 1971 to 3.25 percent in 1980 to 1981 and 3.71 percent in 1990 to 1991 (Despande *et al.* 2004). Thus it can be argued that there has been a degree of commercialization and diversification among small and marginal farmers but this could have been greater.

However there are some qualifiers. The first is that the coordinated approach did not lead to the spread of the benefits of the new technologies across India. Only a few areas benefited. It is difficult for a central government to introduce measures and mechanisms that are fine-tuned to the requirements of each state and district. , Success was based on the term "provision" — *inter alia* provision of credit, HYVs, subsidized fertilizers and extension services. These had a negative long-term impact on the development of market-backed services and commodities. Lastly, the new technologies were biased towards high usage of water for irrigation. As many parts of the country were not irrigated, power-operated motorized tubewells sprung up across the country. Crops such as rice in Punjab and sugar cane in Maharashtra have become quite important even though surface water is limited in some of these areas. The result has been a rapid fall in water levels.

In the 1980s, when the balance between demand and supply of cereals (foodgrain) was in sight, the overall goal of agricultural strategy/policy shifted from "maximization of production of foodgrain" to "evolution of a production pattern in line with the demand pattern". The implication of this shift is that the emphasis of the policy shifted from foodgrain to other agricultural commodities like oilseed, fruit and vegetables. The shift helped to increase the output of non-cereal food items.

Diversification has been occurring in India since Phase 1, however, it became more prominent in the 1980s (but waned in the 1990s). There is little agreement on how much of this was due to the government efforts and how much transpired because of changing economic conditions. It would be fair to argue for oilseed that the shift from coarse cereals to oilseed in rain-fed areas was aided by (i) a protective trade environment; (ii) favourable price policy; and (iii) the connecting of the Technology Mission on Oilseeds. At the same time diversification was not merely attributable to greater area under high-value commodities; the improvements in yield also would have been generated by government-aided supply and technology-related factors.

The improvements in both production and yield for the crop sector. There were significant improvements for livestock in the 1980s — the value of the livestock sector in total agricultural output value increased from about 18 percent in the triennium ending (TE) 1980 to 1981 to 23 percent in TE 1990 to 1991 (although it remained stagnant at that level by TE 1997 to 1998. Almost 70 percent of the livestock sector's production (in value terms) is accounted for by the milk and products subsector; the role of "Operation Flood" cannot be understated.

The value of the fisheries subsector swelled by about 50 percent during the 1990s, although as a share of the total it declined from 1.3 to 1.0 percent of the total agriculture sector value during the period. There were significant and coordinated government efforts to increase fish production. The central government's outlays towards the fishery sector as a share of the total agriculture sector outlays were more than doubled from 2 to 3 percent in the 1970s to about 5.5 percent in the 1980s and 1990s. Production and development programmes were instituted in both marine and inland areas. Farmers' development agencies were established both for fresh and brackish water areas. These programmes included technology upgrading components, encouragement and involvement of the private sector in activities such as seed, feed and other inputs and also creation of suitable infrastructure for storage, transport, marketing and credit. By 1998/1999 more than 50 seed hatcheries at the national level had been established, fishery industrial estates had been created and 30 minor fishing harbours and 130 fish-landing centres had evolved.

Diversification in favour of high-value commodities is considered by some to have only partly benefited through government efforts. Both econometric and GIS-based studies also suggest that the presence of infrastructure aided diversification.

Rao *et al.* (2004) found that in their sample, the areas close to large urban centres (and as a result with better connectivity to urban centres) could diversify more to high-value commodities. They concluded that urbanization is a strong demand driver for high-value commodities. In an earlier econometric study, Joshi *et al.* came to a similar conclusion — that diversification into high-value commodities was demand driven, unlike the supply driven Green Revolution.

Between 1990–1991 and 1998–1999, the annual average increase in yields was only 1.79 percent and 1.31 percent for wheat and rice, respectively. Despite the successes of the Green Revolution, there continue to be concerns with agricultural performance during Phase 3, the present phase of globalization and diversification, initiated in the 1990s, and some macro issues emerge.

The first macro point is the one already alluded to indirectly. Compared to the 1980s, there was deceleration of agricultural growth in the 1990s. The cuts across all crops and both production and yields. The quality of the system for collecting agricultural statistics and the extent of deceleration can be debated, but the conclusion that growth in the crop sector decelerated in the 1990s is fairly obvious. In any case, deficiencies in the quality of statistics are constant factors and cannot explain the deceleration. Indeed, growth in non-food and non-crop output was also faster in the 1980s than in the 1990s and growth in animal husbandry, poultry, dairy, horticulture and fisheries also slowed down. This deceleration happened despite the reversal of historical discrimination against agriculture. In the 1990s, the terms of trade moved in favour of agriculture and this was independent of the terms of trade measures used. There were several reasons for this reversal of trend. There were higher prices for rice and wheat through support/procurement policies and prices of other crops also increased. There is a positive correlation between procurement prices, open market prices and higher prices in the PDS (public distribution system). Simultaneously, because protection granted to manufacturing declined, the relative prices of manufactured products also declined. *A priori*, one should therefore have expected a positive supply response and increased capital accumulation.

However farm profitability declined in the 1990s. Not all farmers had access to higher support prices for rice, wheat or sugar cane, there was a deceleration in yields and real input prices also increased, thanks to prices for fertilizers, power and diesel that were closer to market-determined prices. Higher cereal prices also contributed to increases in wage costs.

Consequent to per capita income growth, NSS data show changes in consumption patterns, with a decline in consumption of cereals in both rural and urban India, despite cereals still being important in the food basket. There has been a shift from consumption of coarse cereals to rice and wheat and also a shift towards consumption of fruit and vegetables and even fish and eggs. Some of these changes. Consumption patterns are changing, even for the bottom 30 percent of the population and the shares of non-cereal food (fruit and vegetables) and non-food items have been increasing in consumption baskets. Increased cereal prices and lower rural incomes may have depressed demand for both cereal and non-cereal food, but there is no denying that preferences are also changing.

The Reason for Deceleration

Why did deceleration occur? More importantly, why did deceleration occur when better technologies were more readily available? In answering this question, it is important to distinguish between generic problems that continue to constrain agriculture and issues that became constraints in the reform decade of the 1990s. The former constitutes part of the agricultural cum rural reform agenda, the latter is more specific. First, one confronts a diminishing returns argument, with total factor productivity declining, as opposed to an argument based on increases in input costs or a slower increase in output prices. This argument is usually applied to Punjab, Haryana and the western parts of Uttar Pradesh where agriculture has become overcapitalized. In these traditional Green Revolution areas, there are also questions about unsustainable practices like excessive use of water and imbalanced use of fertilizers. Land has become degraded. These are traditional arguments associated with the Green Revolution and concern reduction in soil fertility, excessive use of fertilizers and imbalance of nutrient content in the soil, problems related to biomass availability, genetic erosion, waterlogging and salinization, depletion of groundwater tables, imbalances in nutrient availability because of changes in cropping patterns and contamination of waterbodies and soil by pesticides and fertilizers. Then there is the issue related to lowering of farm profitability in the 1990s. While these are important topics, they are not very convincing in explaining the 1990s deceleration, unless one plugs in a regional dimension. In the 1980s, availability of power, irrigation and infrastructure helped the spread of the Green Revolution to the Eastern Region, particularly for paddy rice. Owing to power shortages, among other factors, this osmosis was less evident in the 1990s.

Another explanation for the 1990s deceleration is reduced public investments, especially in irrigation; this is directly reflected in the reduced share of capital formation in agriculture in the overall GDP. Moreover, in the 1990s, the quality of public sector agricultural research, technology development and extension services deteriorated.

While public investments in agriculture have declined, especially investments in research, private investments have not been able to compensate for the decline in public sector investments. Thus the burden of fiscal reform has been borne by agricultural investments, especially at the state level, including expenditure on R&D. More specifically, expenditure on research stagnated, while that on extension declined. The state withdrew from spending on agriculture, without establishing alternative institutional mechanisms. State governments lack resources, a problem that was aggravated in the 1990s, and adversely affected the development of agricultural infrastructure.

This can be juxtaposed with the failure of risk mitigation instruments to develop and general regulatory failure. There were no coordinated policies or crop adjustment programmes to enable the move from rice and wheat towards pulses, oilseed or other crops. Diversification led to risk and uncertainty and in the absence of institutions, this was difficult to handle. Within public sector institutions, there was deterioration in management and monitoring norms. Hence, there were instances of adulterated fertilizers and seeds that were substandard. Whether extension departments of state governments are the best agencies for quality checks and inspections of inputs like fertilizers, insecticides, pesticides, feed and seeds is debatable. However, the quality of these extension services deteriorated in the 1990s.

While only tangentially related to the slowdown of the 1990s, there is the question of the form public investments in agriculture should take. The Steering Group on Agriculture and Allied Sectors (SGAAS) does not question this, but the Approach Paper to the Tenth Five Year Plan (APTFYP) does, "The policy approach to agriculture, particularly in the 1990s, has been to secure increased production through subsidies in inputs such as power, water and fertilizer, and by increasing the minimum support price rather than through building new capital assets in irrigation, power and rural infrastructure. This strategy has run into serious difficulties." The statement further identifies that the deterioration in state finances and the financial non-viability of the State Electricity Boards have meant that crowding out has occurred in public agricultural investment/expenditures for:

- roads,
- irrigation,
- expenditure on technological upgrading,
- maintenance of canals and roads,
- expansion of power supply to rural areas not covered,
- improvement in quality of rural power.

Moreover the combination of dependence on subsurface water and free/subsidized power is not only environmentally harmful but has also led to:

- excessive use of water that produced waterlogging in many areas,
- falling water tables.

At the same time, there is no evidence of any improvement in income distribution. Last, it is also increasingly being noticed that despite the best intensions of the policy there is a significant imbalance between usage of N, P and K fertilizers. Moreover, financial constraints are increasing both for the state governments and their State Electricity Boards (SEBs).

These problems are particularly severe in the poorer states. The equity, efficiency and sustainability of this approach are questionable. The subsidies have grown in size and are now financially unsustainable. Power continues to be supplied free for farmers in many states and is otherwise highly subsidized given the high cost of production of SEBs. According to one estimate energy subsidies (of which power is one component) accounted for about 10 percent of all the subsidies in the late 1990s. This figure is likely to increase subsequently.

Moreover, the small and marginal farmers have been less able to access credit despite the existence of a large rural credit system. Poor land records are endemic across rural India. Also much of the agriculture sector is in the unorganized segment. But the financial system is largely in the organized sector and requires credible land ownership records, systematic record keeping and formal contracts. This has contributed to a situation where the bulk of the small and marginal farmers cannot access formal credit institutions. In the 1990s, availability of credit for large farmers may have risen, but declined for small farmers. Moreover, although 18 percent of priority sector lending is supposed to be for agriculture, agriculture's share in net bank credit has been more like 12 percent.

In summary, there is unarguable stagnation in Indian agriculture and more so in the foodgrain sector. This is due to a combination of factors ranging from overdependence on the government in some areas/sectors, falling ability of the various government entities to subsidize and/or directly provide various inputs and services and overuse of resources. The "mission mode" that was so successful in tackling the problems of low production cannot be a vehicle to take on this set of problems. This requires efficient functioning of the price mechanism, smooth transactions between the various stakeholders, the alignment of incentives at the microlevel and fine-tuning of technology to the needs of the farmer. There are arguments for and against the current system of minimum support price (MSP) and subsidized inputs.

DEVELOPMENT OF INDIAN AGRICULTURAL SECTORS

An appreciable pace of research has taken place in all sectors of agriculture including crops, horticulture, natural resource management, livestock, fisheries and agricultural engineering. The technology-led developments in agriculture have made India self-sufficient in foodgrains and a leading producer of several commodities in the world. The green revolution in crops, yellow revolution in oilseeds, white revolution in milk production, blue revolution in fish production and a golden revolution in horticulture bear an ample testimony to the contributions of agricultural research and development efforts undertaken in the country.

India has received worldwide acclaim in the field of agricultural research and education. The National Agricultural Research System (NARS), with the Indian Council of Agricultural Research (ICAR) as an apex body, has been striving for a holistic development of agriculture at the national level by planning, promoting, conducting and co-ordinating research, extension and education on all aspects of agriculture including animal sciences and fisheries for ensuring the optimal utilization of land, water, plant and animal genetic resources for sustainable agricultural development.

The Council undertakes research on fundamental and applied aspects in traditional and frontier areas to offer solutions to problems relating to conservation and management of resources, productivity improvement and health management of crops, animals and fisheries, post-harvest technology and value addition. This helps in developing new technologies in agriculture and allied sectors. The Council with its headquarters at New Delhi has a vast network of institutes all over the country consisting of 49 institutes including 5 National Institutes with 4 having Deemed University status, 5 National Bureaux, 33 National Research Centres, 11 Project Directorates and 78 All-India Co-ordinated

Research Projects. Besides, it coordinates agricultural education in the country through a network of 34 State Agricultural Universities, 1 Central Agricultural University, 3 Academic Universities and 5 Deemed Universities. All activities under the transfer of technology programme of the Council have been integrated with Krishi Vigyan Kendras (KVKs) and the mandate enlarged to perform the function of on-farm testing and research, long-term vocational training, in-service training of grass-root level functionaries and frontline demonstrations. A network of 344 KVKs has so far been established in our country. A strong back-up support is provided through 8 Trainers' Training Centres to these KVKs by updating knowledge of the KVK trainers in the advancements made in research.

To strengthen research extension efforts, implementation of Institution-Village Linkage Programme (IVLP) at 70 centres in the country, establishment of 40 Agricultural Technology Information Centres (ATIC), strengthening of 53 Zonal Agricultural Research Stations (ZARS) to take up the additional functions of KVK, and Strengthening of Directorate of Extension of State Agricultural Universities and Zonal Units have been recently undertaken under the National Agricultural Technology Project (NATP).

The Council aids, promotes and coordinates agricultural education programmes at the national level. The educational programmes are carried out through its network of universities. In addition to these, 4 National Institutes of the Council, *viz.*, Indian Agricultural Research Institute (IARI), Indian Veterinary Research Institute (IVRI), National Dairy Research Institute (NDRI), and Central Institute of Fisheries Education (CIFE) have been granted the status of deemed university. These institutes offer post-graduate degree programmes besides undertaking research in their respective areas.

Achievements

The agriculture research system has significantly contributed to productivity growth in almost all the sectors of agriculture. For instance with reference to 1950, the productivity gains are nearly 3.3 times in foodgrains, 1.6 times in fruits, 2.1 times in vegetables, 5.6 times in fish (aquaculture), 1.8 times in milk and 6.4 times in eggs. Development of about 3200 high yielding improved varieties of different crops and their production technologies and preservation of 2.2 lakh germplasm accessions of agri-horticultural crops and their wild relatives for future use in breeding programmes, are some remarkable achievements of the National Agricultural Research System. It is also revealing to note that the modern technologies have contributed to saving of the area, other resources and in increasing revenues and exports. For instance, modern varieties of rice saved nearly 39 million hectare and the wheat varieties 37 million hectare area.

Research in livestock and poultry sector has provided more options for increased income generation. The fisheries sector is also growing at an incremental pace, with an annual production of 5.9 million tonnes. Along with the livestock and poultry sector, it also contributes significantly to domestic nutritional security and rural development.

Research for development of farming implements has helped to make agricultural operations modern and less labour-intensive apart from saving the operational cost.

The programme on frontline demonstrations of improved production technologies, on-farm demonstrations of integrated nutrient and pest management, and a variety of training programmes involving farmers have shown encouraging results by successfully demonstrating the potential of new and improved technologies.

Keeping India Vision 2020 in view, each ICAR institution has formulated its Perspective Plan document, 2020. Adopting a bottom up approach, ICAR has also formulated its Vision 2020 document which has laid a broad road map for the next 20 years. ICAR scientists and peers have strived hard to set up a demand-driven research and development agenda. The gains from green revolution were not only consolidated but also several new grounds were broken for attaining new gains. Technological improvements were made in several non-traditional crops like soyabean, new crop seasons were explored in rabi maize, rabi sorghum, summer groundnut and summer pearl millet. Hybrid breeding approach was extended to rice, safflower, castor, pigeon pea and mustard.

Increased yields and stability were achieved through shifting away from kharif season production to rabi season production. Diversification covering fruits and vegetables, flowers, animal enterprises, poultry, fish and agro-forestry are also emphasised aiming at golden revolution. All these efforts added to defending the gains of green revolution, extending the gains to new areas and making new gains in several important areas contributing to accelerated agricultural transformation.

TECHNOLOGY LED-PROSPECTIVE AGRICULTURAL GROWTH

Indian agriculture is passing through many challenges following increasing demands of foodgrains, growing competition among nations for export of value-added quality produce, rising cost of production and dwindling sources of water. But they offer new opportunities for quality improvement, value-added products development, processing and enhancing the shelf life of agri-products through which India can compete with the rest of the world. New technologies like biotechnology, hybrid technology and bio-informatics will have their imprint on our success for meeting the challenges of food security and sustainability.

The six new initiatives of the Department of Agricultural Research and Education during the Xth Plan, are – Network Project on organic farming, Impact of Climate Change on Agricultural Productivity, Networking on Transgenics, National Bureau of Indian Veterinary Type Culture, Network on Biosystematics of Insects and National Research Centre for Agricultural Extension. Rainbow revolution encompassing an all-round growth in the production of foodgrains, edible oils, fruits, vegetables and animal and fish products and evergreen revolution in agriculture through diversified agriculture, precision farming, resource conservation and value addition to provide in real sense, the required food, nutrition and environmental security are the hopes of the future.

FUTURE EXPECTATIONS

Because of deceleration in the 1990s, expanding population and rapid economic growth, food security concerns have been raised. Food security at the national level need not be equated with 100 percent self-sufficiency in foodgrain production. Adequate foreign exchange reserves should instead be the issue. The mindset is largely a reflection of the food import scare India confronted before the Green Revolution. Future demand projections are contingent on assumptions made about population, per capita income growth, the time frame and hunger removal. The time frame tends to be 2020. Population projections for 2020 vary with 1.315 billion being closer to the mark now.

Consider the basic trends first. With economic growth, population increases and changing age distributions, food requirements will be higher. How they match up with expected production given current trends, and what implications this has for international markets.

Population

India's population in 2001 was 1.02 billion according to the Census of India, making it the second most populous country in the world after China (with a population of 1.28 billion). It has been estimated that in the next 15 years, the population will increase by about 23 percent to 1.24 billion persons. But estimates vary, some being as high as 1.4 billion. High growth rates can be ascribed to death rates being lower than birth rates. Between 2001 and 2010, almost 150 million more people need to be provided with adequate nutrition and between 2010 and 2015, another 83 million people need to be covered. Most GOI estimates do not go beyond 2015, but trends till 2020 are not likely to be any different.

Incomes and Expenditures

According to India's national accounts, total GDP in 2003 to 2004 was about US$600 billion (per capita GDP of US$540). Of this, personal disposable income was in the range of US$512 billion and 24.6 percent of this income was directed into savings by the household sector. During the postliberalization decade, from 1993–1994 to 2003–2004 the average annualized growth rate of India's GDP has been around 6.2 percent and this has been accelerating in the early 2000s.

The poverty has declined significantly, and is expected to continue to fall. The poverty line is defined by the GOI as the cost of a package of commodities (about 80 percent food items and 20 percent other essentials such as clothing) that can provide about 2 400 calories and 2 100 calories to an average Indian citizen living in rural and urban areas, respectively. The HCR (head count ratio) in India had fallen to about 26 percent in 1999 to 2000 from 39 percent in 1987 to 1988. Our own estimates are that if the GDP growth is sustained, it will fall to about 14 percent by 2010 and then to 8 percent by 2015. These are not very different from other estimates. Two further points need to be mentioned in this connection. First, income distributions are typically log normal and as the thick part of the distribution passes through the poverty line, it is possible for sharp reductions in HCRs to occur. Second, when the Indian poverty line evolved in India in the early 1960s, the presumption was that health and education would be merit goods, if not public goods. In either event, they would be provided by the government and need not be ingredients in private consumption expenditure. Hence, these are not included in defining or computing the poverty line. The 1990s, however, witnessed a switch from public expenditure to private expenditure in both health and education. It is thus possible that the Indian poverty line might be redefined at some time in the future. Notwithstanding this possibility, the proposition about decline in HCRs, assuming an unchanged poverty line, remains valid.

Both rural and urban areas have a very similar poverty scenario. However, India has a long way to go before the whole population has the means to consume the minimum required calories per day. During 1999 to 2000, more than one-fourth of India's population was below the poverty line and this amounted to about 260 million people at that time. If the rapid rate decline in poverty after 1991 were to continue, not only the percentage, but also the actual number of people below the poverty line is expected to be lower. The net impact on the demand for greater nutrition is obvious.

The Changing Food Basket

As incomes, and as a consequence expenditures, increase, not only are expenditures on food and agricultural commodities as a whole likely to increase, but the consumption basket characteristics are also likely to change. In both rural and urban areas, dairy products, meat, fruit and vegetables are likely to have a greater share of the additional demand being generated.

This is the standard picture across different countries, and is also reflected in the differing elasticities observed by various studies both for India as well as other countries. The income elasticities for five different income groups (quintiles 1–5) in urban and rural areas of India.

The food requirement is dependent on the consumption behaviour, which in turn is a direct outcome of income. With development, incomes are expected to rise and would thus impact consumption behaviour. The income elasticities are a measure of the future demand of various food items.

Quintile one (Q1) denotes the poorest 20 percent of the population and Q5 denotes the richest 20 percent. Income elasticities across all commodities, as well as quintiles, are higher for the rural areas as compared to urban areas. The elasticities also fall as income rises, both within urban and rural quintiles.

Wheat shows an elasticity of 0.50 and 0.32 for rural and urban areas respectively, in Q1. However, the elasticity decreases to 0.47 and 0.04 for the same areas in the case of Q5. Similarly, the income elasticity of rice in rural areas drops from 0.72 to a negative 0.21 as we move up from Q1 to Q5. A similar pattern is observed in the urban areas as well. The elasticities of milk and milk products, along with eggs, show very high values of greater than 1 for the lower quintiles, implying that the proportionate change in consumption demand is greater than the proportionate change in income. However, these elasticities also follow the general decreasing trend as we ascend to higher income groups. Elasticities for chicken and other meat are lower than those of milk and eggs. For rural areas, income elasticities for meat are greater than 1 across all income groups (1.25 for Q5), while they are less than 1 for all income groups falling in urban areas. Meat eating is common across India, however a significant share of the population is vegetarian. Even among those who consume meat, at certain times of the year a largely vegetarian diet is followed. Consequently, the income elasticities of meat products may not be as high as in other countries.

In both rural and urban areas, the own price elasticity declines in absolute terms as we move from the very poor to the non-poor section of the population.

For cereals in rural areas, elasticity declines from 0.7 to 0.1, while it changes from 0.5 to 0.1 for the urban areas. Milk, edible oils and meat show similar trends in both urban and rural areas, although demand for milk shows a higher sensitivity to price changes. Price elasticity of demand for sugar in rural areas increases marginally from 0.7 to 0.8, before declining to 0.6 for the non-poor. In urban areas, however, the elasticity shows a gradual decline as we move to higher income groups.

The demand for pulses is extremely sensitive to price changes in rural areas, with the elasticity being as high as 2.4 for the very poor in rural areas, but falls to 1.2 for the non-poor. For the non-poor section in urban areas too, the price elasticity is 0.9.

Consumption of agricultural products

Others have estimated the growth in food consumption and most have similar insights. Milk and milk products will see the largest increase up to 2020.

Fruit and vegetables, sugar and meat and fish consumption will also increase significantly. The reasons are obvious in light. Income increases matched by the high income responsiveness of these commodities will be the driving force. Among cereals, the highest percentage growth will be in wheat, followed by rice. Coarse grains are not likely to grow as much.

The demand for rice is projected to grow from 78.3 million tonnes/year in 2000 to 118.9 million tonnes/year in 2020, showing a compounded annual growth rate of 2.1 percent. The main factor driving this demand will be the increase in population. Wheat demand rises from 54.2 million tonnes in 2000 to 72.1 and 92.4 million tonnes in 2010 and 2020 respectively, with a growth rate of 2.7 percent. The responsible factors will be the rising population and positive income elasticity for wheat. The demand for other cereals will grow by 0.9 percent, primarily on account of change in preferences as incomes grow. On the whole, consumption demand for all cereals will show a growth of 76 million tonnes from 2000 to 2020 at the rate of 2.1 percent, which is marginally higher than the projected growth rate of the population.

Demand for food items such as milk products, meat and fruit is expected to grow at much higher levels of 3 to 5 percent in the next few years.

This is a natural result of growth in incomes following economic development. The estimated demand for foodgrain in 2020 is 240.6 million tonnes/year, growing from 155.6 tonnes/year in 2000 at the rate of 2.2 percent *per annum.* The income effect will manifest itself to raise the demand for milk and milk products to 166 tonnes, edible oils to 11 tonnes, meat and fish to 11 tonnes and sugar and gur (jaggery) to 25 tonnes/year.

Production of agricultural commodities

India has one of the largest land masses of any country of the world, and a high proportion of its land mass is arable. Although most of the land depends upon the monsoons for irrigation, irrigated areas have been increasing and comprise about 40 percent of the gross cropped area. However, yields in India are among the lowest in the world, and therefore there is significant scope for increases in the coming future.

A yield comparison across countries shows how India's crop production fares *vis àvis* international benchmarks. India's figures are contrasted with crop yields in the United States, China and an average for the world. While these can be compared for a number of different crops, the results are remarkably similar, with a few exceptions. For cereals, coarse grains and pulses, both the United States and China are well above the world average. India has extremely low yields, even by developing country standards. For oil crops and primary fibre crops as well, India has yield levels below the United States, China and aggregate world levels. Across different product segments, a similar picture emerges.

While the static picture of India's crop production is not encouraging, the indicators for the future provide grounds for optimism.

The potential improvements made possible by improvements in technology, organizational expertise and policy redirection have lifted the yield levels of many of India's crops. From 1961 to 2004, commodities with the largest increases in yield were wheat, maize and jute, and rice to a lesser extent. Pulses, oil crops and primary fibre crops have had muted increases in yield.

On an even more cautionary note, in the last ten years, improvements in yield have plateaued for Green Revolution heavyweights like wheat and cereals. From 2001 to 2004, several crops even experienced an absolute decline in their yields.

Given these indications, prospects for the future of Indian agriculture production are mixed. While yield levels seem to have plateaued, they are still significantly below competitive levels for most crops. While countries at the peak of the agricultural technology curve must pour funds into R&D to invent new ways to increase production, countries on the other side of the curve stand to benefit from implementing those methods that have already been pioneered. Catching up is always easier and for this reason alone, India should be able to realize fast and significant gains in the near future.

Price competitiveness

Currently, there are some estimates of price competitiveness, the results often being functions of whether an importable or an exportable hypothesis assumption is used and whether one uses the nominal protection coefficient (NPC), the effective protection coefficient (EPC), the effective subsidy coefficient (ESC) or the domestic resource cost (DRC). A widely referred to study by Bhalla (2004) revealed that:

- Most crops except oilseed, some coarse cereals and sugar are internationally competitive;
- More crops would be competitive if developed countries withdrew domestic support to agriculture;

- However, import competitiveness becomes reduced overtime because:
  - — Successive price hikes have led to very high prices for many agricultural commodities. For example major crops such as rice and wheat became non-competitive during recent years because of a fall in their international price combined with a major increase in their domestic price owing to increase in MSP.
  - — Productivity growth has decelerated, moreover production efficiency is being affected by lack of implementation of technological innovations.
  - — A major thrust is needed in infrastructure investment in general and investment in science and technology in particular for India to maintain and enhance its competitiveness.

PRODUCTION, CONSUMPTION AND SURPLUSES

The GTAP model has been used to predict India's trade with the rest of the world including India's own production and consumption. India's GDP is expected to grow at more than 7 percent for much of the period under consideration.

Moreover, the growth rate is expected to increase for the coming decade. As population growth has been falling owing to falling birth rates for the past two decades, the growth in labour supply would decline over the next decade and a half. Irrigated area is expected to grow, although not too significantly, as further increases will require significant public investments that show no signs of accelerating.

Private efforts are likely to be the main driving force behind the 1 percent annual increase in irrigated area. Skilled and highly educated labour is expected to rise much faster than unskilled labour; this reflects the latest improvements in the educational achievements of a large segment of the population. The capital stock would have to grow rapidly as well, and is expected to increase as labour supply growth tapers off to sustain the high growth rates of 8 percent.

These GDP forecasts need to be qualified. The GDP forecasts, with acceleration from 6.73 to 8 percent are actually a worst-case scenario, although one must mention that the BRIC (Brazil, Russia, India, China) report, generated by Goldman Sachs, involves real GDP growth of slightly less than 6 percent. A more likely scenario is GDP growth of 7.5 percent, accelerating to 8.5 percent and a third scenario would involve 7.5 percent accelerating to 9 percent. Long-term GDP forecasts are rare. In the short term, the Tenth Five Year Plan (2002 2007) talks about 8 percent real GDP growth during the Plan, while the National Common Minimum Programme (NCMP) of the UPA government considers 7 to 8 percent.

Although long-term projections are rare, when they are made, most experts expect real GDP growth of 7 to 8 percent for India in the period leading up to 2020. Notwithstanding reservations about the speed of economic reforms, consequent to debates about liberalization in a democratic policy, these estimates of 6, 7 or 8 percent are probably underestimates, even if one ignores the exchange rate aspect.

There are different ways to argue this out and all of these trends reinforce one another. Looking forward to 2015, an average savings rate of 30 percent is certainly plausible given the current rate of 28.1 percent rising. Foreign capital inflows are also increasing. There is no reason why the average investment rate should not therefore be 32 percent. The present incremental capital/output ratio (ICOR) is around 4 (though estimates vary between 3.5 and 4.6). Whatever the figure, there is no reason why this should increase significantly in the near future. Indeed, with reforms, competition and resultant efficiency improvements, the ICOR should decline. But even with an ICOR of 4, there is growth of 8 percent.

It is obvious that these quantitative forecasts have not considered the possibilities of future environmental degradation, unforeseen changes in economic and trade policy and of course technological changes. The growth in rice is going to be in the order of 1 percent *per annum* till 2010, for both production and consumption. For wheat however, the rise in incomes is going to create a marginally higher growth in consumption than expected production increases. For both oilseed and processed foods, consumption increases will outstrip production increases. Given current conditions and trends, similarly, for forestry products, as well as other foods, consumption increases are going to be far higher than likely production increases.

Overall, the patterns are quite unambiguous. Although production levels are likely to increase significantly, they are not going to be able to match the increases in consumption, at current and expected overall economic growth. This does not imply a fall in export earnings, as overall expected price increases due to the opening of international markets, as well as reduction of subsidies will tend to have a positive impact on prices. This is regardless of the temporary impasse at WTO on agricultural liberalization, which hopefully, will be temporary. The net export earnings for rice, wheat, sugar and other grains.

India is likely to maintain the status of an exporting country for rice and wheat. However for oilseed, India is likely to be a significant importing country in another decade and a half. It will also remain as a marginal exporter of sugar and coarse grains.

Despite being an exporter of jute and cotton, India will be a net importer of plant-based fibre. Moreover, it will also start to become a net importer of other horticultural crops. Although overall milk production is expected to increase rapidly, consumption increases will prevent India from becoming a large dairy product exporter. Cattle and red meat exports are likely to increase, although other animal products, such as leather, are likely to see a net increase in imports.

Expectations for India

Overall, India will remain a marginal exporter of wheat, coarse grains, sugar, cattle and red meat, fish and other foods. However, it will become a significant importer of oilseed, forestry products, other animal products and plant fibre. For products such as plant fibre and animal products, its position as a net exporter of manufactured items will be facilitated by larger imports of raw materials. For the other segments, rising domestic consumption not matched by domestic supply increases, will be the driving principle.

Forestry products are likely to be a significant import item, the bulk being related to wood. Industrial and furniture requirements are the important components that will drive forestry product shortfalls. Although India has large forest cover, commercial forestry is insignificant and is unlikely to expand in a big way given its current environmental protection laws. The statistics for forestry products have large gaps (much more than is usual for India). According to some FAO estimates, production in India for industrial roundwood has been falling (it was about 1.6 billion m^3 in 2000), while fuelwood has stagnated at about 2.9 million m^3 . Pulp and matchwood have also been showing a negative trend. On the whole, it is expected that India will be substituting imports for domestic production more and more in the near future.

The overall position is quite unambiguous. For Indian policy-makers, the most worrying aspects are stagnating yields. This in itself is not surprising, given the low investments in agriculture, as well as the constraints on agricultural trade. If India is to become a significant exporter of other agricultural products apart from rice, emphasis will have to be placed on improving yields. Investments in rural areas are therefore essential.

How would these estimates change if growth assumptions were different? India would continue to be a large importer of forestry products whether economic growth is 6 or 8 percent. Although the quantum may differ. Similarly, its position as a significant textile and garment producer may require it to import plant-based fibre, in spite of plus or minus 1 percent variation in growth. (What the numbers in this case are more sensitive too is the productivity assumption. Yields are currently quite low in large parts of India and the introduction of new varieties, BT cotton being one example, may lead to a rapid increase in cotton production in coming years.) India's low production of oilseed and high requirements will also drive its oilseed imports. But this needs to be qualified. Given its land area, it is conceivable that productivity enhancements could lead to a lower shortfall in oilseed and pulses. However, current trends indicate this to be a remote possibility. Now rice remains. Compared to the past, rice is not a preferred cereal; income elasticity measures also indicate that at the middle and upper income levels, the parameters are lower. In other words, estimates of rice surpluses are not as sensitive to economic growth assumptions.

How would these surpluses affect India's trade partners? This requires an examination of which countries could potentially be India's major trade partners in agricultural commodities.

4

Land Reforms, Land Use Policy and Planning

LAND REFORMS

Despite attempts at land reforms over successive Plan periods, the basic character of the agrarian economy has not undergone any structural change. The pattern of land distribution is highly skewed, with a high concentration of land in the hands of a few land owners on the one hand and the growing number of marginal and sub-marginal farmers on the other. Fragmentation of land holdings continues on a large scale and only a few States like Punjab, Haryana, Uttar Pradesh and parts of Maharashtra have been able to successfully undertake a programme of consolidation of holdings.

Agricultural tenancy, which was abolished in most of the States by various enactments in the post-Independence era, continues unabated though it is largely concealed. In the wake of liberalisation, several State Governments have modified their land ceiling laws so as to exempt orchards, fish ponds etc., from the purview of land ceilings. There is also a move to make suitable changes in tenancy regulations to attract private corporate investment in agriculture. Hence, it is necessary to reconsider the issue of land reforms, particularly from the point of view of the poor, as access to land is still a major source of livelihood in rural India. In fact, it has been argued that the need for poverty alleviation programmes has arisen because the land reforms have not been implemented in a systematic way. The experience of several countries in East Asia shows that land reforms, leading to structural equity in the distribution of land, are an essential prerequisite for economic development through agricultural transformation. In addition, the efficiency of land use and land management, and protection of the land rights of the tribals and women have assumed great significance in the context of the changes that are taking place in rural India.

The continued importance of land reforms was recognised in the Eighth Plan, with the abolition of intermediaries, redistribution of ceiling surplus land, tenancy reforms providing security of tenure to tenants and share croppers, consolidation of holdings and updating of land records as the main objectives of the land reform policy. However, only limited success was achieved with respect to these objectives in the Eighth Plan. Given that land reforms is a State subject, the Central Government can only draw the attention of the State Governments to the pressing needs for land reforms, which are central to any strategy of poverty alleviation.

At the end of the Seventh Plan, out of the 72.2 lakh acres of land declared surplus, only 46.5 lakh acres had been distributed. At the end of the Eighth Plan, out of the total 74.94 lakh acres declared surplus, 52.13 lakh acres had been distributed. In other words, during the Eighth Plan only 6-7 lakh acres were redistributed. Further, 12.4 lakh acres were under disputes pending in courts and 19.59 lakh acres were not available for distribution because they were unfit for cultivation or reserved for public purposes or for other miscellaneous reasons. In fact, only 59,000 acres were available for redistribution. Of the Bhoodan land donated, 53 per cent was distributed, accounting for 24.52 lakh acres. In addition, 142.87 lakh acres of wastelands were distributed among 88.5 lakh beneficiaries. But, there is still considerable scope for redistributing Government wastelands, common lands, ceiling surplus land and Bhoodan land.

Similarly, in the area of tenancy reforms very little progress has been made, after the initial abolition of 'zamindari' and the transfer of title to owner-cultivators in the immediate post-

Independence period. The successful implementation of tenancy laws has been confined to West Bengal, Karnataka and Kerala. In fact, in the Eighth Plan there was no progress in respect of conferment of rights on tenants and therefore the issue of tenancy reforms is still illusory, but requires tackling.

Consolidation of holdings has taken place in very few States. While 15 States had enacted appropriate legislation, Andhra Pradesh, Tamil Nadu, Kerala, Pondicherry and the North-Eastern States do not have any laws for consolidations of holdings. Several States like Bihar, Maharashtra and Rajasthan have suspended the programme. In fact, only in Uttar Pradesh, 900-1000 villages are being covered annually.

There is evidence of considerable alienation of tribals from their land. As per the latest available estimates, 4.6 lakh cases of tribal land alienation covering 9.2 lakh acres have been registered. Of these 2.7 lakh cases covering 6.3 lakh acres have been disposed of in favour of tribals but physically an estimated 4.7 lakh acres had been restored to them. In other cases, reconciliations are being effected.

It cannot be gainsaid that the essential prerequisite of any land reform measure is the recording of land rights and their updating. In recognition of this, a Centrally Sponsored Scheme for Strengthening of Revenue Administration and Updating of Land Records was introduced during the later half of the Seventh Plan and against an outlay of Rs.20.8 crore, Rs.14 crore were spent. In the Eighth Plan a provision of Rs.175 crore was made against which Rs.98 crore were released and Rs.66.7 crore utilised.

But, given that the funds are shared in the ratio of 50:50 between Centre and States, several States have not been able to provide their share and hence, the utilisation has been low. Several other States have not availed of this scheme at all. In 1995-96, funds were released only to Bihar, Kerala, Maharashtra, Madhya Pradesh, Rajasthan, Tamil Nadu and West Bengal aggregating to only Rs.18.8 crore.

The States have been requested repeatedly to expedite expenditure and to adopt new technologies for survey and settlement operations, preparation of maps etc. Funds for infrastructure development were also sanctioned to meet the training needs of the revenue functionaries. Some States have developed new training institutions, while a few have upgraded the existing ones. In 1988-89, 8 pilot projects were taken up for computerisation of land records with 100 per cent Central assistance. Since inception, 323 projects have been sanctioned and funds to the tune of Rs.64.43 crore have been released. However, the utilisation was only to the extent of 20 per cent. This shows the tardy progress made in the implementation of this scheme on the ground.

LAND REFORMS IN NINTH PLAN

In the Ninth Plan the issue of agrarian restructuring will continue to receive the top most priority in the expectation that the States would be able to facilitate changes that would make for more efficient agriculture, leading to increases in both output and employment. This process will, in turn, contribute to the achievement of a higher rate of economic growth with social justice.

The main components of the land reform policy are the detection of ceiling surplus land and the distribution of the existing surplus land, besides tenancy reform, consolidation of holdings, providing access to the poor on common lands and wastelands, preventing the alienation of tribal lands and providing land rights to women. However, for the successful implementation of land reforms, updating of the land records, both by traditional methods and through computerisation, is an essential prerequisite. Let us elaborate.

Ceiling on Land Holdings: With the introduction of the Land Ceilings Act in 1972, the ceiling on land holdings was introduced in almost all the States with the exception of some North-Eastern States, though the ceiling limit varied depending on the quality of the land. The ceiling surplus land was to be distributed among the landless poor. In this way, land ceiling was considered an important instrument for reducing disparities in the ownership of land and as a way of increasing productivity through greater utilisation of labour. However, in practice, the extent of land declared surplus was very limited. The total area declared surplus is estimated at less than 2 per cent of the total cultivated area. Further, distribution of surplus land has been limited in several States because of institutional and legal rigidities. There are other reasons too which have led to the poor performance with regard to land ceiling. Most importantly, the ceiling surplus land continues to exist in a concealed way particularly in areas which have been covered by irrigation in the post-1972 era. Further evidence suggests that there are areas where land owners have land in excess of ceiling limits which can be mopped up if the programme for unearthing it is pursued vigorously. Also, in order to circumvent the ceiling laws, benami and furzi transfers are effected which need to be identified. There is clearly a need to detect the land falling within the ceiling limits and redistribute it. But detection and distribution of ceiling surplus land require tremendous political and administrative will.

In the wake of the economic liberalisation in certain States like Karnataka, the industry and the large farmers are being given exemption from ceiling laws without seeking the permission of the Government of India. This would certainly go against the interest of the poor as it would increase landlessness and depress agricultural wages. Hence, this issue requires close examination, before such exemptions are given.

Small farms are efficient in terms of yields and returns per unit of area. However, they are often not able to generate adequate income to sustain further investment. Therefore, there is a need for both horizontal and vertical diversification of small farms. An analysis of Indian Council of Agricultural Research (ICAR's) data of national demonstrations shows that there are large technological/ yield gaps, particularly in the backward regions, which, if fully exploited, would enable the marginal and small farmers to generate incomes well above the sustenance level, subject to crop rotation, cropping pattern, yield responses of technological adoption, etc. In fact, in irrigated areas, the small and marginal farmers are viable because of their capacity to produce two or three crops a year. In the case of rainfed agriculture, a breakthrough in dryland farming is required with respect to the traditional cereal crop that can grow in these areas.

Alternatively, there is a possibility of shifting to other high-value crops like fruits, vegetables, mulberry, etc. Other support systems would have to be appropriately developed to provide facilities for credit, marketing, storage and transportation of the perishable high-value crops. In fact, a change in the cropping pattern away from cereals to some high-value crops, would certainly make the small and marginal farmers viable. Also, given the increasing market demand for certain products, sericulture, horticulture and aquaculture have a great potential. In Maharashtra and West Bengal a small piece of land yields adequate returns from horticulture and acquaculture respectively. This provides further justification for ensuring that ceilings are strictly enforced as small farms can be perfectly viable in the given context.

As observed in the UNDP Human Development Report 1996, as land is redistributed from big to small farms, not only the family labour per hectare can increase sharply, so, can hired labour also. For both the reasons, the employment situation improves even for those, who remain landless after the land reform.

The main conclusion from this is that an agricultural strategy centered on small farms, rather than large, simultaneously increases the social efficiency of resource use in agriculture and improves social equity through employment creation and more equal income distribution, that small farms generate.

While there appears to be a rationale for reducing the existing ceiling limits further with a view to alleviating poverty of the growing number of rural landless poor, this is unlikely to have the support of the State Governments. Therefore, a pragmatic approach would be to strictly enforce the existing ceiling limit without permitting any attempt to circumvent it. Given the employment elasticity of agriculture in areas, which are agriculturally backward, land reforms would ensure both agricultural growth and greater employment for the rural poor. It would also provide a social status to the large number of poor. A greater transparency in the method of distribution of surplus land is possible with a greater involvement of panchayats, local communities and NGOs.

Tenancy Reforms: The policy with regard to tenancy clearly provided for conferment of ownership rights on tenants or for acquisition of ownership rights by them on payment of a reasonable compensation to the landlords. The tenancy laws of most States abolished tenancies so as to vest ownership of land with the actual tiller. Despite the legal provisions to abolish tenancy, it has continued to flourish with the existence of a large number of tenants and sub-tenants without any protection against eviction leading to insecurity among them. The continued existence of oral and concealed tenancies has led to low investments and low productivity in agriculture in several States where the implementation of tenancy reforms has been tardy. In contrast, in West Bengal, Karnataka, and Kerala, much success has been achieved in this respect. The success of 'Operation Barga' in West Bengal is well documented. This shows that conferring occupancy rights on the tenants has led to better investments in land and consequently, a higher rate of return. Hence, it is desirable that States which have a high incidence of concealed tenancy recognise this fact and record the rights of tenants. In addition, absentee landlordism has to be restrained. To the extent that large land owners leave their land fallow, either the State should take it over and lease it out on a long-term basis or the land owners should be required to lease it out on a long-term basis. Measures would have to be taken for the protection of tenants against displacement, eviction and other forms of exploitation.

A ban on tenancy was imposed in almost all the States to encourage owner cultivation and to give security of tenure to the sharecroppers and the tenants. In areas characterised by semi-feudal modes of production, where agricultural markets are not well developed, this ban is desirable with a view to protecting the tenants. It has been demonstrated that in 1972-73 in Purnea district of Bihar 40 per cent of the land was under sharecropping. This percentage has gone down and is probably around 25 per cent. The share of landholders is limited to 25 per cent of the gross produce but in practice this is perhaps illusory. Since the tenancies are oral and the sharecroppers are weak their hold on land is tenuous and they have to give to the landlord more than half of the produce. In this case, the tenants have no incentive to make long-term investments in land. The landlords also do not look upon it as a productive asset but a store of value and a reflection of their social status. Both the landlord and the sharecropper would gain if the sharecropper had the rights of cultivation in the land as he would make greater investments which would lead to higher returns. This shows that in areas where tenancy flourishes, reforms are required together with a proper implementation of laws.

On the other hand, in the "Green Revolution" areas where there is greater awareness and the markets work, freeing the lease market for land would contribute both to equity and efficiency. In these areas where the traditional arrangements exist, the tenants have been reduced to the status of an agricultural labourer with the landlord exercising considerable influence. In this case, the tenants as well as small and marginal farmers would be able to augment their operational holdings by leasing in land and, with a greater intensity of cultivation, it would lead to greater output. Clearly, agricultural tenancy should be opened up and leasing in of land permitted subject to the ceiling limits. This would activise the land market which would enhance the poor people's access to land.

Protection of Tribal Land: Despite the commitment that the tribal lands must remain with the tribals, alienation of the tribals from their land continues on a large scale due to various legal loopholes and administrative lapses. Hence, in the Ninth Plan legal provisions must be made for the prevention of alienation of tribal lands and for their restoration, not only in the notified scheduled tribe areas but also in the tribal lands in other areas. Also, the regulation of resale of the tribal lands should be made as stringent as possible. Given that alienation is basically a consequence of economic deprivation and social discrimination it is felt, that for the tribal communities, various development programmes must be dovetailed in order to improve the income level of these people and to provide them with a basis for sustained livelihood. Even in the case of acquisition of lands of the tribals by the Government for public purposes, it should be restricted to a minimum. Encroachment of land belonging to tribals should not be permitted. Even civil courts should have no jurisdiction in the proceedings involving transfer of land of persons belonging to scheduled tribes.

Consolidation of Holdings: As already stated, consolidation of holdings has been successful in a very few States though several States have enacted legislation in this regard. In some cases, there are genuine problems in the process of consolidation including proper valuation of land, fear of eviction of small and marginal farmers who are tenants, inadequate availability of staff and lack of updated land records. Despite these constraints, consolidation of holdings makes for efficient land use and water management, leading to higher productivity and, therefore, must be enforced wherever practicable. However, in so far as there is insecurity among the tenants and small and marginal farmers, the State must ensure that their interests are protected. Consolidation operations, whenever undertaken, should be integrated with survey and settlement operations in order to avoid duplication in work and harassment to the affected person. The involvement of the Panchayati Raj Institutions should facilitate this process through a greater participation of the village people.

Government Land and Common Property Resources: In rural areas every village has common lands as well as other common property resources. These are a source of sustenance to the landless. Evidence suggests that considerable area of the government land has been taken over both by the rural poor as well as by the rural elite for agricultural and housing purposes. Unluckily, due to negligence, unsustainable overuse and excessive pressure of population on land, the productive capacity of common lands has been diminishing. However, joint forest management and watershed development programmes are schemes which can be successful in the regeneration of these common lands.

Clearly, 'pattas' should be given to the rural poor in order to provide them access to a means of livelihood. There are several success stories, both in the area of joint forest management as well as watershed development by groups of people, especially women on common land, which could be replicated. These lands can also be used for providing grazing land, fodder and fuel to the poor. If the common property resources vest in the Gram Panchayat, access to it should be limited to the rural poor and the rural elite should not be allowed to encroach upon it. Similarly, the wastelands which are lying unutilised should be reclaimed and distributed among the marginal farmers and landless labourers of the area. This would provide them a source of income as also generate greater output from a variety of activities in the area of agriculture, horticulture, fodder, fuelwood and other agro-forestry. Given the paucity of 'cultivable' land, it is necessary to redistribute the wastelands and fallow land in order to provide productive employment to the poor.

In the case of land vested and in possession of the Government and/ or where a final decision is pending in a judicial court, it is suggested that such land should not be kept vacant but allotted to eligible rural poor on a short-term basis with a clear understanding that they would have to handover the land to the original landlord if the court so directs. However, legal opinion is being sought on the possibility of taking up this measure. Again in the case of Government wasteland and degraded forests, there is a growing opinion that such land should be allotted/leased to the corporate sector and for industrial and commercial purposes. As argued above, this too would adversely affect the rural poor. Access to such land should be restricted to the rural poor in order to provide them with employment.

Gender and Land Rights: So far, the strategy of land reforms has not given any cognizance to the existing gender inequalities in land inheritance laws and ceiling laws. In most regions of the country, women constitute a disproportionate number of poor. They are also more dependent on agriculture for a livelihood than men, as men shift to non-farm employment. Also, it is estimated that 20 per cent of the rural households are *de facto* female-headed. Yet, very few women have titles to land and even fewer control it. Hence, ensuring women's effective command over land will be one of the new priorities of the Ninth Plan.

Traditionally, it was accepted that agricultural land would be inherited by sons, even though in some States the inheritance law did not stipulate such a provision. Hence, it is necessary to implement the laws and also to record the rights of women, where it is legally claimed by them. Further, in so far as inheritance rights in tenancy laws are subject to specific land acts, the issues cannot be easily resolved. In some States the tenancy laws provide for devolution of tenancy to male descendants and only in their absence, women can inherit, but then also to a limited extent. Hence, it is recommended that States should amend their land and inheritance laws so as to bring agricultural land at par with other forms of property. There has been some progress in this direction in Southern and Central India.

Many of our States have improved women's access to land and landed property. States like Karnataka, Tamil Nadu and Andhra Pradesh have amended the Hindu Succession Act, 1956 to formalise issues related to women's right to property including land. Some, like Rajasthan and Madhya Pradesh have provided that issues related to property, including landed property, would be dealt with in accordance with the appropriate personal laws. However, serious anomalies continue to persist. A number of States like U.P. Haryana, J&K, Delhi and Punjab are apparently yet to take adequate steps to provide the Constitutional/legal safeguards to women with respect to their access to land. Additionally, it is necessary that when ceilings are fixed in relation to a "family unit", the definition of a family should be uniform across States and sons and daughters should be given equal consideration, both while assessing ceiling surplus land and in land distribution under various resettlement programmes. The pattas should be in the name of women to a larger extent. While joint pattas are better than no pattas, which do not provide the women control over it. In fact, groups of poor rural women should be given group pattas with usufructuary rights, but no right to sell individually. This group approach would enable the women to retain control over land. They could invest in the land collectively and cooperate in sharing both labour time and the returns. There are several instances of such joint management by groups of women which need to be replicated. However, to enable women to reap the benefits of land acquisition, greater access to information, credit, inputs, marketing and technologies must be provided to them.

In order to have a better data base, both the Agricultural Census and the National Sample Surveys should provide information on land ownership, land operated and land under tenancy by gender. So far, land-based statistics are recorded on a household basis. A pilot survey should be undertaken proceeding the next nationwide NSS data collection exercise.

Updating of Access to Land Records: Maintenance of up-to-date land records is crucial for effective implementation of land reforms. In recognition of this, during the Seventh Plan period, a Centrally Sponsored Scheme for Strengthening of Revenue Administration and Updating of Land Records was introduced with a view to strengthening survey and settlement organisations at the grassroots level through training, equipment, staff etc. Hence, it is imperative that States should give special emphasis to resurveys and adopt appropriate modern technologies for this, including aerial survey, photogrametic systems, global positioning system, use of scanners, digital computerised maps etc.

Further, a special drive for recording land rights of tenants and sharecroppers, as in West Bengal, must be undertaken by other States. As recommended by the Conference of Revenue Ministers held in 1997 all the existing tenancy reform legislations should be examined and a model legislation prepared. Another Centrally Sponsored Scheme for Computerisation of Land Records was started during 1988-89 as a pilot project. But the scheme has made little progress. In fact, several factors including power shortage, lack of trained staff and bureaucratic procedures involved at various stages, have constrained the progress of computerisation of land records. Despite these problems, computerisation must be given a high priority and solutions found for the operational problems.

The updating of land records can be expedited even without computerisation through the involvement of panchayat institutions and the local revenue functionaries. The village-level revenue functionaries should be placed under the control of the Gram Panchayats, though the appellate jurisdiction should continue with the tehsildar. At the district level, the land revenue system must work under the Zilla Parishad. The 30 per cent representation for women in PRIs should help the cause of women in so far as recording of rights of women in land is concerned.

Moreover, steps have to be taken to bring about greater transparency in the administration of land records, with access to information regarding land holdings on demand by any individual. Copies of land records, including record of rights, field books/ field map, Land Pass Books as also mutation statements, status of land and jamabandi register should be accessible and copies provided on payment of a fee.

FARM EQUIPMENT

The equipment of a farm is a matter that has a close relation to the possible profits from operating it. The farmer must have sufficient work stock and machinery for operating the place easily and well. He must also have suitable buildings for storing his produce. Chapter III suggests a proportion for the investment of capital which will give satisfactory results in the general organization of the farm. The individual farmer, however, must study the problems which confront him, and erect buildings or buy machinery only as it can be shown that they will add to the profit form his farm, or lessen the labour of himself or the family, or add to the comforts and pleasures of the home. Some farmers will need corn cultivators, others need potato diggers, while still others need grain binders, hay loaders, or manure spreaders. Even in the same community, there is a great difference in the needs of the individual farmers for equipment or buildings.

Buildings, an Expense to the Farm

Few buildings return a direct profit on the money invested in them. It is necessary for the farmer to have a house for his family to live in, but it really does not add to the production from the farm. It is rather a bill of expense. The depreciation and upkeep will amount to five per cent or more on the investment.

So far as securing profits from the operation of the farm is concerned, therefore, it is to the farmer's interest to invest as little as possible in the house. A good house undoubtedly adds to the value of a farm as a home and increases its selling value, but does not in any way increase the production from the farm. The desire for comfort and the personal satisfaction of living in a good home must be weighed against the possibilities of paying the bills from the earnings of the farm.

The average sized farm in the United States is 138.1 acres. In Minnesota it is 177 acres. Few of the Minnesota farms under the present system of farming can afford to pay interest on an investment in a house for the farmer and his family of more than $2,000 to $2,500.

If a house costing more than that amount is erected the additional investment should be charged as a personal expense to the individual, and not as an operating expense against the farm. On many small farms a house costing $1,000 to $1,200 would adequately care for the labour necessary to operate the farm. In other states and particularly in the South, the dwellings will cost less than the amount indicated. The practice should be to charge against the operating expense of the farm only such dwellings as are used to shelter the working force of the farm, or in some way add to the farm income. In cases where a tenant house is provided to house and feed the farm labour, the owner's house should not be charged to the operating expense of the farm, but as a personal expense to the farmer.

Barns and other building likewise, must be made to add to the income of the farm by sheltering productive live stock; by protecting feed or market products from deterioration; or by affording shelter to productive labour. If they do not, they become a bill of expense to the farm. There should be a well demonstrated need for a building before its erection is undertaken.

What Machinery to Buy

The farmer is often confronted with the question of what machinery to buy, what size would be most economical and how to care for it so as to get the greatest use from it and make it last. As a rule, the American farmer is inclined to overstock with machinery. New inventions have been numerous and manufacturers are good advertisers. As a result, the farmers are led to try many machines before their value has been established or their wearing qualities determined.

The consequence is, that many must soon be discarded as poorly adapted to the work to be done. It is best not to be too hasty in buying new inventions. Experiment Stations and wealthy farm owners should do the experimenting. Farmers who have to pay for their machinery from the earnings of their farm, should stick to the "standard" machines.

Calculate when to Buy Machinery

Investments in machinery should be made only after carefully calculating the probabilities of being able to make the machine pay interest on the investment. This can be done by considering, (1) The quality of the work that can be done with and without the machine. (2) The cost of the work, with and without. (The cost includes interest, depreciation, cost of care, storage, insurance, risk, and repairs.) (3) The returns form the same capital invested in live stock, labour, or other enterprise. (4) The gain or loss in quality of product, with and without the machine. (5) The saving of man or horse labour. Other factors such as greater amount of time for recreation, or for other more agreeable work, should also be considered, though they do not necessarily affect the profits.

The original or first cost of the machine under consideration, should not be made the sole factor in the question. The cost per acre or per unit of product, should be made the basis of machinery cost and investment. The total cost for a year including interest on investment, repairs, depreciation, oil, and shelter, divided by the number of acres handled, will give the cost per acre for the machine. Calculations of the cost per acre of doing the same work without the machine should be made also and a method reached that will give the greatest possible gain.

Size of Machinery to Buy

Machines are made in various sizes. In buying a new machine, a farmer should consider at least two things. First, the amount of work to be done; second, the motive power available. It is a mistake to buy too small a machine and just as great a mistake to buy a machine so large that the motive power cannot adequately propel the machine. In determining what size to buy the capacity must be considered. The following example will illustrate. A farmer has ten cows, each giving 5,000 pounds of milk yearly. The aggregate amount of milk will be 50,000 pounds a year. Which will be most economical to buy for separating the milk, a separator with a capacity of 450 pounds per hour costing $100, or one with a capacity of 600 pounds per hour, for $125? In separating 50,000 pounds of milk with the 450 pound separator, 111 hours will be required, which at 14 cents per hour, will cost $15.54. With the 600-pound machine, 83 hours will be required costing $11.62. there will be again in labour saved, therefore, of $3.92. This, however, is not all profit. There is an additional investment in the machine of $25.00, which at 6 per cent would bear $1.50 interest. The depreciation also must be considered on the additional cost of investment. It is estimated that the depreciation on milk separators is 5 per cent. Five per cent on $25.00 will be $1.25. This added to the interest on the additional investment, amounts to $2.75. Subtracting the additional interest and depreciation charge of $2.75 from $3.92 saved in labour, would leave a net gain of $1.17 per year in the use of the larger machine. Similar calculations can be made comparing the gain to be made from the purchase of a large or small drill; the purchase of small walking plows or a large gang plow; the use of large and small grain binders; and many other machines used about the farm.

Maintenance

There is a great difference in the rate at which different farmers wear out machinery and equipment. The good care-taker can do much to prolong the life of his machinery. Proper housing is essential to keeping machinery in good order, but good housing is expensive and adds to the machinery cost of the farm. Machines that stand outdoors, warp and twist badly, thus increasing the friction when they are put to use. Machines stored in poor machine sheds with leaky roofs and wet floors, often rust quite as badly as if they were standing outdoors. Attention should be given also to the care of machines while in the field. Few operators take the time and care to properly oil the bearings. bolts are allowed to become loose, thus letting the machine sag or get out of adjustment. The matter of adjustment of the bearings and cutting devices also, is a factor in determining the length of time the machine can be used. Attention to these small details will add very much to the usefulness and length of life of a machine.

It is a good practice to go over the farm machinery at least once each year, tightening up bolts, renewing worn portions and making sure that the bearings are in good order for operation. If a forge and some blacksmith or carpenter tools can be had, much of the ordinary repair work can be done by the farmer or his sons. The saving in the cost of the work will not be great perhaps, but the saving in time, in going to the shop in the village, may amount to considerable.

Much of this repair work can be done on rainy days or in winter when farm work is not pressing, and the machines can be put in good condition then for the busy days during the seeding and harvest seasons. The depreciation of farm machinery is illustrated which is taken from Bulletin No. 117 of the Minnesota Experiment Station. These figures cover the depreciation of machinery on a number of Minnesota farms where records were kept during the years from 1902 to 1907.

A large variation in the rate of depreciation on various machines. Manure spreaders, hay loaders, and threshing outfits depreciate quite rapidly in value. Hay tedders, fanning mills, and grain tanks or wagon boxes, depreciate comparatively slowly. The rate of depreciation will not be the same on all farms, but by inventorying the cost price, and making an arbitrary valuation of the machine each year, it will be possible by using the figures covering ten to fifteen years, to determine the rate of depreciation on any farm. Most farmers will not be in position to do this.

Where they do not apply, it will probably be safe to estimate the depreciation on machinery at 10 per cent.

Machinery Cost per Acre

It is a matter of interest to know the cost per acre for the various kinds of machinery used on the farm. It may be made a factor in determing [*sic*] the cost of producing crops. The cost per acre is determined by including all charges against each of the machines for the year, such as interest, depreciation, repairs, oil, and cost of housing. This cost for each machine divided by the number of acres handled, determines the cost per acre for the use of the machinery.

Duty of Machinery

The capacity of machinery is often determined by the motive power applied. A machine cannot be run at full capacity unless sufficient motive power is supplied. The efficiency or capacity of a machine is based on horse power or the speed at which it is driven. Few machines perform all of the labour of which they are capable, owing to the fact that the use of the machine is interrupted by the demand for the farmer's time in doing chores which keeps him from the field work. In other words, the machines are not used for the full length of time for which they are capable.

LAND TENURE: RELATION OF THE FARMER TO THE FARM

The use of land may be acquired in two ways: (1) by ownership; (2) by rental. The form of rental varies with localities and systems of farming, but may be either cash or share. Sometimes combination cash and share rental is followed. The question is always before the farmer as to whether it is best for him to own the land or rent it. If he rents the land, which system offers the greatest advantages? These questions cannot be answered to cover all conditions and localities. It has been generally assumed that ownership tended toward the best returns from the land. It is a fact, however, that the best farming in the world probably, is carried on under a rental system. Much of the high priced land of Great Britain and of France is tilled by renters. The farming is intensive and the returns are very high. The advantages to the tillers of the soil in these cases lie in their ability to rent at a low figure. The owners of the land are satisfied to take their returns in "added nobility," which comes from owning land in these countries and from receiving the speculative value accruing in the rise of land. Whether it is best to own or rent, can be determined approximately by careful calculations of the probable crops and products to be grown and comparing these figures with the probable cost of growing them, and with the receipts that may be obtained from the market at hand.

It has been generally assumed by the American farmer that he should own his land. Encouragement has been given to this idea by the fact that through the Homestead Act and others, looking toward the settlement of the land, he has been able to secure possession of the land at low cost. Land values have been rising rapidly and farmers have been anxious to gain the appreciation. Another reason why farmers have preferred to own their land in America lies in the difficulty of getting satisfactory leases for a long term of years. A five or ten year lease would encourage a tenant to grow crops which would nourish the soil and greater attention would be given to keeping out noxious weeds. Fertilizers and manures would be more freely used and the inclination to exploit the soil would be lessened. Short leases result in frequent moves on the part of the tenant, and moving is always attended by more or less loss. Under this system only the poorest farms have been available for renting, and returns have not been sufficient to attract good tenants. Abundance of free or cheap land has tended toward ownership rather than toward developing a satisfactory leasing system.

The Advantages of Ownership

There are several advantages arising from the ownership of land. (1) Ownership assures long tenure or permanent possession. This stimulates an interest in building up the place and making improvements. Land is likely to be better tilled and the fertility of the soil better conserved. Systematic rotation of crops is more likely to be followed, and an effort made to build up a permanent and lasting business. This leads to the erection of good buildings and the maintenance of a permanent home. The owner feels that his interests all lie in the community and he becomes a better citizen from the fact that he owns the land. (2) Ownership gives to the owner the possibility of profits on the appreciation in land value. In this way the occupant of the land gains all of the value resulting from good tillage and the improvement of the land, and he secures the returns from any special forms of improvements that may be added to the property. (3) Ownership of the land obviates vexatious questions of leases and contracts in dealing with landlords. It offers freedom from annoying inspection by the owner, who to protect his property and prevent the depletion of the soil, must insist on certain forms of cultivation, care and cropping.

Against these advantages must be considered the risk incurred, which must be carried by the owner, in a large investment. This risk must be carried whether the crops are good or poor. In poor crop years the money invested in the farm may be made to bear only a very low rate of interest, or the farm may be run at a loss. Buildings depreciate to a certain extent and the owner of the land must bear the depreciation. Land poorly tilled also depreciates in value in certain communities, and if one buys in a poor location and pays too much for the land, he is likely to meet loss from depreciation in land value. The taxes and insurance must be paid and repairs on buildings must be made. These items all add to the annual cost of upkeep and must be counted among the disadvantages of land ownership.

Advantages of Cash Rental

The advantages of cash rental to the renter lie in the reduction of the investment and in shifting the payment of taxes, depreciation and upkeep to the landlord. Where good farms can be rented for cash, this system often brings better results to the renter than ownership, though he loses the possibility of securing the appreciated value of the land. The advantages of cash rental over share rental are as follows: (1) The renter gets all of the advantages of superior tillage and management. If a long lease can be secured, quite as much encouragement is given toward building up good systems of farming as where the land is owned. (2) The renter is not subject to close supervision and inspection by the landlord, which in some cases becomes very objectionable. (3) A greater latitude is allowed on the cropping system and in the management of the farm.

It should be borne in mind, however, that in the case of cash rental, the renter bears all of the risk of crop failure, which in some localities is considerable, due to adverse climatic conditions or to a refractory soil. The advantages of cash rental over share rental to the owner are: (1) Freedom from responsibility in planting, cropping, and in the management of the farm; relief from the task of frequent supervision. (2) It lessens the risk to the owner from crop failure, provided the tenant is responsible. In cases where the tenant is not financially responsible and cannot meet the bills, the owner is forced to lose the rent.

Advantages of Share Rental

Renting land on shares lightens the investment of the renter materially and makes it possible for men to secure farms who have not the capital to buy their farms or rent for cash. In most cases of share rental the renter furnishes the live stock for work purposes, the machinery, and household equipment. The landlord furnishes the other essentials for working the place. The crop is divided on a share basis which lightens the burden of the renter in case of crop failure.

The disadvantage to the renter from share renting lies in the fact that he gets only a share from the increase due to superior cultivation. Often the increase from this cultivation does not pay for the work he is required to do. To illustrate, it may be that a renter will put a dollar's worth of extra work on an acre of land in putting in a wheat crop and increase the yield two bushels.

If wheat should sell at 84 cents, which is the average price for wheat for a ten-year period, and the crop is divided on a half and half basis, the operator would get only 84 per cent of the dollar's worth of work. The fact that the increase must be shared with the landlord and that there is a probability of getting only slightly larger returns on good tillage, results in share-rented farms being poorly tilled and unsystematically cropped.

Ownership, Cash or Share Rental

It is possible to calculate approximately the returns from the land under each system of land tenure, as the following figures will illustrate. On a farm of 160 acres in the Central West where farm records were made the figures under the ownership system were as follows:

In the land	...	$12,000.00
In buildings	...	4,000.00
In live stock	...	1,162.00
In tools and machinery	...	389.00
Making a total investment of	...	$17,551.00

This amount should bear at least 5 per cent interest. The expense of operating the farm under the ownership system was,

Interest on investment	...	$877.55
Building repairs and depreciation	...	160.00
Machinery purchased	...	331.00
Taxes	...	85.00
Insurance	...	15.00
Seed	...	80.00
Stock purchased	...	256.00
Feed and supplies purchased	...	62.00
Labour	...	33.00
Cash for incidental expenses	...	50.00
Total	...	$1,949.55
The receipts from the farm were,		
From crops	...	$1,278.00
From live stock products	...	105.00
From sales of live stock	...	290.00
Increase in inventory	...	800.00
Total	...	$2,473.00

This would leave a net income for labour of $523.45, after 5 per cent interest has been paid on the investment. Under the cash rental system the interest on the land, depreciation on buildings, taxes, and insurance would be shifted to the owner. The operator would have the following expense:

Interest on money invested in live stock,		
tools and machinery, at 5%	...	$77.55
Cash rent, 160 acres at $4.25	...	680.00
Machinery purchased	...	331.00
Personal taxes and insurance	...	15.00
Seed	...	80.00
Labour	...	33.00
Feed and supplies	...	62.00
Stock purchased	...	256.00
Cash for operating	...	50.00
Total	...	$1,584.55
The receipts would be as before,		
From crops	...	$1,278.00
From live stock products	...	105.00
From live stock sales	...	290.00
Increased inventory	...	800.00
Total	...	$2,473.00

This leaves a net balance or labour income to the renter of $888.45, a gain of $365.00 over the ownership system. It should be borne in mind, however, that this gain is offset by the fact that the renter does not gain the advantage of rise in land value. The land owner receives only $680.00 for the use of his farm which is only 2.5 per cent on its net value. It is the possible appreciation in land value that satisfies the owner with the low interest rate received. He is also free from the care and labour of managing the farm. Under the share-renting system on a lease where the tenant owns all the live stock, feeding them with his own feed, and where the crops and hay are equally divided and the landlord furnishes the seed, the results to the renter would be as follows:

Expense of Tenant

Interest on money invested in live stock, tools, and machinery at 5%	...	$77.55
Machinery purchased	...	331.00
Personal taxes and insurance	...	15.00
Labour	...	33.00
Feed and supplies	...	62.00
Stock purchased	...	256.00
Cash for operating	...	50.00
Total	...	$824.55
Receipts of Tenant		
One-half of crop sales	...	$639.00
Live stock products sold	...	105.00
Live stock sold	...	290.00
Increased inventory	...	593.00
Total	...	$1,627.00
Expense	...	824.55
Receipts less expense	...	802.45

The tenant would receive a labour income of $802.45 which is $86.00 less than he would have received under the cash renting system, but $279.00 more than he would have made in owning the farm himself. The reward for the loss of the $86.00 is in the freedom from responsibility for a large cash indebtedness and lessened risk from poor crops. The immediate returns from share renting would be greater than from owning the farm, but the one who rents sacrifices the possibility of gain from rises in land values. In localities where depreciated values are likely to be met, a share rental system would be preferable for the farm operator. The land owner would receive for his share $639.00 from sale of crops, less $80 for seed, or $559.00. He would also have one-half of the hay. To make as much under the share-renting system as under the cash renting, he would have to sell $121.00 worth of hay.

INTEGRATION OF AGRICULTURE IN URBAN LAND USE PLANNING

Urban agriculture is increasingly becoming an important activity in urban economies, both in the South and the North. It can contribute significantly to the well being of farmers and other citizens, if properly managed. The growth of human settlements creates a competition between the traditional urban land uses and urban agriculture. Whilst regional and urban planners have generally accepted the peri-urban zone as a mixed zone in terms of land use categories (including urban agriculture), the intra-urban zone in most cases remains a preserve for "traditional" urban uses.

As is argued in this book, urban agriculture, however, has the potential to prosper in modern cities because of its multiple functions and relations with city issues. Cities provide easy access to markets and a prevailing high demand for food. Other reasons for agriculture in the city are reduced transport costs for produce and an abundance of resources and opportunities (such as recycled waste, under-employment and the availability of urban labour). In fact urban agricultural practices have always been part of the city, but the integration into the urban economy is what is lacking in today's urban planning and policies.

Urban planning in most developing countries has tended to be characterised by long-range comprehensive planning, which adopt a blue-print approach. This type of planning is associated with rigidity and a lack of responsiveness to social issues, and has negatively affected the integration of urban agriculture. Planning departments are often ill-equipped, understaffed and the position of planners is not often at the level of real decision making. This means that their decisions are not always recognised and their plans are often shelved for lack of resources to implement them.

Most planners in developing countries have a view of the city which is based on old-fashioned European or American models and pertaining to countries in which most of them have been trained. In addition, land laws in their own countries are archaic, while laws on health and environment which are promulgated at the national level leave little room for urban councils to manoeuvre at the local level (Foeken, 2006).

The scenario described is not yet a reality, although promising examples are given in this book. Urban planners and other professionals often lack information and technical know-how to cope with urban agriculture and facilitate its integration into urban development. Despite the growing recognition of urban agriculture, there are still many city planners, local authorities, sectoral organisations and NGOs who associate agriculture with rural areas only and are unaware of its presence in the urban areas.

However, this situation is slowly changing with increasing recognition of the importance of urban agriculture in the overall functioning of the wider urban economy. Most governments and local authorities have now begun to support (peri-)urban agriculture and are seeking ways in which to facilitate sustainable, safe and profitable production. Latin American cities such as Rosario have adopted a facilitating environment for urban agriculture. New capital cities such as Dodoma in Tanzania have been designed to accommodate (peri-)urban agriculture, while agriculture has been incorporated into urban expansion plans for Dar-es-Salaam and Maputo (Mougeot, 2000).

Debates surrounding urban planning standards and the feasibility of implementing these in cities of the developing world have resulted in a change in approach by planners who have realised that long-range planning is often unable to respond to the fast-changing circumstances of rapidly urbanising areas. New planning tools and approaches that are more flexible, seek greater community participation, more responsive and move away from the blue-print approach are being experimented with. The role of an urban planner has changed from that of an expert, technical designer of the future urban form to a facilitator of community needs and aspirations, often pushed or pulled by policy makers through various declarations, for example the Quito Declaration, and the Harare Declaration.

Planners are often accused of posing the greatest challenge to urban agriculture as they have not integrated it into urban areas as a land use nor designed residential estates to allow the activity to be carried out on-plot. The central question here is how planners, urban managers and policy makers can facilitate or support urban agriculture. There is a need to understand what planning is all about and the constraints that planners face in trying to integrate urban agriculture into development plans.

URBAN LAND USE PLANNING

Urban, city or town planning is the discipline of land use planning which deals with the physical, social, and economic development of metropolitan regions, municipalities and neighbourhoods. Land use planning is the term used for a branch of public policy which encompasses various disciplines which seek to order and regulate the use of land in an efficient way (Chapin and Kaiser, 1979). Urban planners shape patterns of land use and the built environment in and around cities to solve and prevent challenges of urbanisation, including providing shelter, food and other basic needs of life, protecting and conserving the natural environment and assuring equitable and efficient distribution of community resources, including land. (Quon, 1999)

As a profession, urban planning lays claim to being comprehensive in scope, future oriented, public interest driven, and of wanting to enhance the liveability of human settlements. It is also distinguished by its focus on numerous functional systems that make up the community, including the study of their characteristics and interconnectedness (Faludi, 1973).

Land use Planning

An urban area is made up of complementing and conflicting uses and demands that have to be properly managed. This scenario is made worse by the fact that land is a finite resource and the demands on a particular piece of land are many and varied.

Land use planning is viewed as the process of organising the use of land and its resources to best meet the people's needs over time according to the land's capabilities. According to this definition every piece of land within an urban environment should have an appropriate use. The definition further relates to the concepts of sustainable development and use of resources.

Land use planning can also be viewed as the development of a plan for the *future* use of land, for instance, through zoning. Land use planning is not a haphazard event but should be a well thought out process. Thus, if a certain use of land, for instance urban agriculture, is not considered during the planning process, it would then be very difficult to properly include it in the implementation of the plan, and to achieve the maximum benefit.

Urban Planning and the Urban Food System

Land use, housing, transportation, the environment, the urban economy and recreation, amongst others, are issues that planners are heavily involved in. The food system, however, is notable by its absence from the writing of planning scholars, from the plans prepared by planners and from the lecture rooms in which planning students are taught. As opposed to other commercial or private activities in cities, urban food production has never been addressed properly by legal regulation and planning.

The food system is defined as the chain of activities connecting food production, processing, distribution, consumption and waste management, as well as the associated regulatory institutions and activities. There are conceptual and practical reasons why planners should devote more attention to the food system, since it is paramount in the improvement of human settlements to better serve the needs of the people, and in incorporating linkages between various aspects such as physical, natural, housing, transportation, land use, and economic empowerment.

Approaches to Urban Planning

As mentioned, urban planning is continuing to develop and in many cities planners are experimenting with new approaches and tools, based on different views or paradigms. There is little information available on what these different visions imply for urban agriculture, although issues of importance are mentioned in various texts. Participatory approaches are becoming more popular. Other approaches brought in by the donor community are also taking root. It is against this background that urban agriculture can be made much more visible than it currently is.

Urban agriculture could play an important role in urban planning by linking to environmental, social and economic issues. All of the different approaches to urban planning provide specific opportunities and linkages to facilitate and catalyse the integration of urban agriculture into urban planning.

The Ecological Model is most current among environmental health and transport planners. It applies a systems view, in which the city is seen as a system of interrelated parts akin to a biological system. Planning is used as an approach to make cities healthy and disease free. Open and green spaces are seen as lungs to purify pollutants from the environment. It is dominant in environmental planning and management approaches, as promoted by Local Agenda 21 (as developed after the Earth Summit in Rio de Janeiro,1992). Dar es Salaam-Tanzania and Lusaka-Zambia are cities where this approach has been applied.

The implications of the Ecological Model for urban agriculture are that:

- urban agriculture is considered as a tool for environmental management through nutrient and waste recycling;
- nutritional and health conditions of residents can be improved through urban agriculture;
- urban agriculture may constitute a good use of derelict and open spaces;
- city gardens help to beautify the city;
- potential health risks for consumers – use of waste water, soil erosion – need to be considered.

New Urbanism (design, engineering, architecture) propagates the idea of a compact city. The key feature of this model of city development is to reverse the trend of the urban sprawl by learning from traditional urban development patterns. It promotes small plot sizes and building up open spaces within the city, but also uses of recreation. The model is applied in many new cities like Lilongwe, Dodoma, and Abuja.

The implications of the New Urbanism approach for urban agriculture are that:

- economic imperatives in the new urbanism militate against urban agriculture;
- it has been criticised by those that see home space as multi-functional production areas, and not just as a place to sleep;
- the model follows the recommendations of some aid agencies like the World Bank that have been advocating for the reduction of urban residential plots, leaving very little space for urban agriculture.

The Collaborative or Communicative Model is a procedural theory of how planning should be done. It acknowledges the divergent social-political and at times ethnic groups in the city, and encourages a process of consensus building in addressing problems and developing a vision for the city. The assumption is that with negotiation, problems in the city can be resolved. The model emphasises the role of the planner and the leadership she provides. It promotes multi-stakeholder processes, in which the planner should bring consensus among stakeholders and should not impose his own blue-print as in the new urbanism model. It assumes an even distribution of power among stakeholders. The implications of the Collaborative Model for urban agriculture are that:

- the mainstreaming of multi-stakeholder processes may give a voice to urban producers and place emphasis on urban agriculture being demand driven;
- there is a need to pay attention to issues of who has power and influence among stakeholders and on how a common position on urban agriculture can be negotiated;
- urban agriculture should emerge as a community need and be expressed as such; if it is a community need, it can find its place in urban development.

The contemporary Just City Perspective is characterised by democratic radicalism. It calls for a radical form of participation that goes beyond stakeholder involvement. It places emphasis on governance by the civil society, and making explicit the differences in power and the need for the "excluded" to fight for power and influence change. The implications of the Just City concept for urban agriculture are that:

- urban farmers need to organise themselves so that they can effectively lobby local authorities;
- the authorities need to be engaged in debates for the rights of urban farmers to earn a living out of a legitimate and honest means;
- negotiation is necessary for the use of any open land available for urban agriculture activities; this will also involve negotiating for the legalisation of informal settlements and informal sector activities.

The New Life Model argues that development institutions have realised that urban agriculture can facilitate the creation of new institutions. It links urban agriculture to different aspects of urban development such as poverty alleviation, urban nutrition and environmentalism, informal sector employment and gender, and argues for further enhancement of UA in these sectors. The implications of the New Life theory for urban agriculture are that:

- urban agriculture is a new field of development or perspective in sustainable city development and needs to be taken on board in the urban development discourse;
- emphasis is on the inter-linkages between urban agriculture and other urban development issues;
- urban agriculture may attract a lot of international development assistance if properly organised and well promoted;
- in city dynamics urban agriculture will adapt and develop itself to urban needs, until another main issue (new kid on the block) emerges and becomes in vogue.

The way different land uses and urban forms have emerged. These models are adhered to by urban authorities and NGOs and the visions espoused in the paradigms influence the way policies are developed. By clarifying the linkages and the potential role UA can and should have in urban development, it should be possible to integrate UA and articulate it clearly in urban development policies.

POLICY FORMULATION AND URBAN AGRICULTURE

Thus it is important to clarify potential roles and positive impacts of UA in the city and link these to current planning practices and perspectives. Urban planning is undertaken under existing national and municipal policies. Therefore analysing and influencing this process of policy formulation is paramount in seeking the integration of urban agriculture into sustainable urban development. The next sections highlight the status quo with regard to the integration of urban agriculture into urban development.

Municipalities in most countries are local planning authorities as promulgated by the various town and country planning acts. As local planning authorities, the municipalities have powers and functions to plan and implement local development plans, including enforcement of development control. Furthermore, municipalities have the power to specify or formulate development policies through by-laws. As policy-making bodies, municipalities therefore determine and shape the process of development at the local level. It is therefore within the ambit of municipalities to promote or prohibit urban agriculture. A policy framework for urban agriculture would encompass planning policies, legislation and regulations that guide or regulate land use planning and management. However, in most cities, urban agriculture is ignored, not addressed in national and municipal policies or is not acknowledged as a valid urban land use. And when regulations or by-laws on, or related to, urban agriculture exist, this is often not under an overall and clear policy, and the law may be interpreted differently by different actors (Foeken, 2006).

One could however question the need for a specific policy on urban agriculture, and argue that urban agriculture rather should relate to existing agricultural, land use or environmental policies

(Wolfgang, 2002). These policies however should then still set out objectives of equity entitlements to food and other urban area resources, principally land and water, so as to accommodate these for urban agriculture.

Whether urban agriculture is specific or not, in considering appropriate planning and policy measures, one needs to distinguish between profit-driven (and often capital-intensive) urban agriculture on the one hand and more subsistence, for-food, and largely informal urban agriculture on the other. The for-food urban agriculture tends to address the household food security aspects largely with very little emphasis on the economic aspects Policies on or related to urban agriculture should be aimed or related to the following issues:

- pro-poor poverty reduction;
- local economic development;
- environmental management;
- integration of disadvantaged groups;
- promotion of participatory governance and democratic cities.

The most relevant urban policy areas to urban agriculture are those on land use, public health, environment, social (& economic) development and food security.

Land Use

The key issues here, especially for informal urban agriculture, are the recognition of urban agriculture as an official urban land use, access to land and other resources, and security of tenure. Most municipalities either have city development structure plans, strategic plans or city development strategies, but most of these plans fail to take urban agriculture into account.

The policy instrument that can be used to achieve the objective of integrating urban agriculture into urban land use planning is urban land use zoning. Layout plans could indicate the areas within the city in which urban agriculture is allowed, including guidelines from planners on types of urban agriculture. In

Botswana, the City of Gaborone has set up poultry zones on land considered of low potential for development of other land uses.

Other policy options include the temporary use of vacant public and private land for urban agriculture. Municipalities could, for example, allow undeveloped land to be used for urban agriculture, subject to negotiation between the owner and the user. Further, municipalities have the option of promoting multifunctional land use. This could be done through encouraging community participation in the management of open spaces, where food can be grown in combination with other urban functions such as recreation and city greening. The case of Rosario (Lattuca et al., 2005) highlights this approach.

Health

Most cities have used the potential health risks of urban agriculture as a justification for prohibiting it. And indeed, urban agriculture, like any other industry, has potential risks for human health. But most of these potential negative effects can be minimised when urban agriculture is acknowledged and subsequently properly managed. Municipalities should develop and implement policies that minimise health risks without compromising the food production needs of the urban poor.

For instance, in Cuenca in Ecuador, the policy thrust has been to regulate use of chemical fertilisers and pesticides in urban areas, to promote training and exchange on ecological farming practices, to provide licenses and incentives (eg. tax reduction) to micro-enterprises that produce and supply ecologically-friendly inputs (compost, bio-pesticides, quality seeds etc.) and to promote secure hygienic conditions for crop handling, food processing and vending of food.

Environment

There are several positive effects of urban agriculture on the city environment, but as with health, proper management is necessary to mitigate potential.

In this chapter the example of linking to Environmental Management Plans (as in Dar Es Salaam) is given. Urban agriculture can also assist to reduce environmental pollution through the recycling of solid and liquid waste in the process of agricultural production. For example, the City of Harare irrigates pastures on three large-scale commercial farms, which support over 10,000 cows, using wastewater from its Crowborough and Firle sewer works. The water filters down and eventually finds its way back to the city reservoir after a natural purification process (Toriro, 2003).

Social Development

Urban agriculture is a sector that integrates the urban poor and unemployed into the urban economy. In so doing, it contributes immensely to feelings of higher self-esteem and safety among the urban poor. Urban agriculture has started receiving finances through regular municipal or state/national subsidies or financing mechanism. The mayor of Kampala has set aside a budget for urban agriculture, having realised its important social dimension (Makumbi, 2005)

Urban Food Security

As was stated in the introduction, most municipalities have no food policies, in spite of the increasing problem of urban food insecurity and growing urban poverty. Current trends regarding urban food insecurity in municipalities reveal that reliance on food produced in the rural areas is not sufficient, especially for the urban poor (FAO, 2001).

Despite food being a basic human need (and right), urban food security issues are low or not on the agenda of municipal policy makers and planners.

Putting urban agriculture on the agenda and integrating it into urban planning, should be done by giving attention to urban food systems (availability and origin of food and linking to the rural areas around cities). It is therefore recommended that municipalities should make urban food security a policy issue and develop plans to enhance food production in the urban and pen-urban zones. The Vancouver Food Policy Council is a good example.

INTERNATIONAL DEVELOPMENT PROGRAMMES

Apart from issues at local or municipal level, further linkages should also be sought with international perspectives and programmes, which can stimulate or facilitate attention for and integration of urban agriculture in urban development. By flagging important international support and institutions that are supportive of urban agriculture, local policy makers are more likely to be responsive to set up local programmes. This responsiveness can be consolidated through exchange programmes, collaborative research as well as cofunding of research and pilot projects. Some contemporary programmes are mentioned below.

The *Habitat Agenda* was first drafted in 1996 in Istanbul, Turkey. It constitutes a new social contract towards improving human settlements in the world. It is a reaffirmation of the commitment to better standards of living and improvement of quality of life in human settlements. It highlights the role and importance of local authorities and of a wide range of other interested parties in the struggle to improve human settlements. The Agenda makes specific references to urban agriculture and has several issues it can relate to.

The *Millennium Development Goals* inspire and motivate agencies and countries to work towards a common goal. They raise and maintain public awareness in rich countries, thus maintaining political pressure for aid spending and effectiveness. They can also enable citizens of partner countries to compare their progress with others. The MDGs provide an opportunity to link urban agriculture with world development goals.

The *Special Programme on Food Security (SPFS) of the United Nations Food and Agriculture Organisation (FAO)* is a multi-disciplinary programme aimed at promoting an integrated and participative approach to food security. In addition, the FAO committee on Agriculture recommended the development of an organisation-wide programme on urban agriculture, now one of the Priority Areas for Inter-disciplinary Action (PAIA), "Food for the Cities". Under this programme, FAO has started urban garden allotments in several cities.

The *United Nations Habitat NEPAD Cities Initiative* captures a strategic operational approach in addressing the urban challenge in Africa, by emphasising development and the environment. It is based on a broad participation of public, private and community groups, and concerned with inter-sectoral and inter-organisational aspects. It relies on bottom-up and demand-led responses and on local capacity building. Urban agriculture is listed as a relevant and immediate livelihood strategy in times of conflict and disaster.

The *Environmental Planning and Management Process* (EPM) is based on the premise that achieving sustainable development requires all actors to recognise the interconnectedness of the environment and development activities. It has been popularised by the United Nations Environment program UNEP in partnership with UN Habitat, and applied in their Sustainable Cities Programme.

It became a framework through which cities could implement the Local Agenda 21 and the Habitat Global Plan of Action. The Dar es Salaam Sustainable Cities programme has modelled its planning around the participatory approaches of the EPM process. The *Local Agenda 21* promotes development of action plans for sustainable development by local authorities jointly with stakeholders and citizens. It provides planning guidelines, incentive grants, training workshops, seminars, and promotes exchange of experiences in drafting local policies and action plans.

Poverty Reduction Strategy Papers (PSRPs) are prepared by member countries through a participatory process involving domestic stakeholders as well as external development partners, including the World Bank and the International Monetary Fund. A review of most of the PSRPs shows that they do not take into account urban agriculture as a strategy for poverty reduction (yet)!

HIV/AIDS and Urban Agriculture

HIV/AIDS and urban agricultureHIV/AIDS and urban agriculture HIV/AIDS has emerged as on of the foremost challenges for development and poverty alleviation. Sub-Saharan Africa is home to nearly 30 million of the world's 42 million people living with HIV and AIDS. Local governments have been called upon to address the HIV and AIDS problem seriously. Urban agriculture might provide an opportunity to do something positive for people infected and affected by HIV/AIDS. Governments should provide land and waste water resources that can be used to boost the nutritional status of sufferers and their dependants. Medicinal plants can be readily grown and harvested within the local environment. Self-employment in home and community gardens may strengthen self esteem.

Access to Land

Urban farming requires some land space, whether the farming system is soil based or not. Land is one of the most controversial issues associated with urban agriculture, referring to the issues of secure tenure and conflicts over use of scarce urban land, water and other resources. The emphasis here is on land. Land for urban agriculture is either not available, or when available it may not be accessible, and when accessible it may not be usable for a particular form of agriculture (Mushamba et al., 2003).

Availability

In most cities and towns there is a high demand for land for residential, commercial and industrial development, among others. The productive or potentially productive areas of the city that have not been paved over are not limited to communal farms and private gardens. In many cities such as Accra, Ghana, Setif in Algeria, Divo in Ivory Coast a lease for agricultural use of the land is only given for one year, because of claims for other uses. This makes availability of land, and other resources associated with land such as water, a great concern for the urban farmer.

Institutional land areas (belonging to hospitals, schools, and churches), riverbanks and roadsides, parks, lands under high-voltage electrical towers that cannot be used for buildings and those surrounding refuse dumps make up much of a municipality's territory. Planning the use and exploitation of these spaces requires mapping their location as a first step and then assessing their potential. It is important to assess the availability of land for urban agriculture in a given city in the short-, medium-or long-term period. Land may not be available due to rapid development of the built-up environment.

Accessibility

Land may be available but not accessible because of social or political reasons. Accessibility relates to the opportunity for the actual utilisation of available land by needy households or groups, taking into account administrative procedures and conflicts that may arise. Access may refer to the land itself or the use of the land. Often the ownership and tenure patterns are not known because of lack of records or frequent change of hands. Traditional forms of ownership as under customary law also exist. Land may also be far from where farmers live and public transportation and roads could be inadequate or not available. Available land may be too costly for farmers to rent. Farmers may not have the social or political connections necessary to learn about or gain access to the plots that are available. The poor and recent migrants in cities often lack access to land for urban agriculture. Planning policies and legislation that deem urban agriculture as an illegal activity can prevent farmers from accessing land. Discrimination by gender may prevent equal access by men and women.

Usability

The usability of available and accessible land is determined by factors such as topography, size of plot, soil texture and quality, availability of water and security of tenure. Also, services such as water for irrigation and inputs or market facilities, transportation infrastructure are factors that determine a plot's usability. In Rosario (Dubbelling, 2003) the following variables are used to define the suitability of the land: environmental quality; potential agronomic use; actual use (and previous use if the area has been used as a dump or for other hazardous activities); current regulations for land use; urban and city projects planned; water supply; ownership; and population groups interested in agriculture.

Incentives for producers to invest are compromised by the lack of security concerning land tenure and the fear of eviction. Why erect terraces, improve and fertilise the soil, or build irrigation reservoirs if the government does not guarantee that benefits can be reaped from those investments? Taxation rules and legal frameworks are therefore necessary to provide security and incentives for producers.

Land Tenure

Security of land tenure is very important, but hard to get for urban farmers, especially for those farming off-plot (on plots away from the homestead, like open areas in the city) or in peri-urban areas. Land tenure refers to the system of rights and institutions that governs access to and use of land and other resources on that land. It determines who can use what land and how. It derives from both statutory and customary law. Research on land tenure suggests that the most apparent qualitative linkage between tenure and food security is that increased security of tenure in productive resources enables more efficient and profitable production and hence greater access to food products.

Land tenure determines the level of investment that urban farmers themselves put into projects. The private sector is often not willing to advance loans to urban farmers as they lack legal rights to land and are therefore unable to use it as collateral. The tenure situation of women is even more precarious (MDP-FAO, 2001). Administrative arrangements for secure tenure are cumbersome and proper registration of plots and users is often nonexistent. However, (temporary) user permits have been successfully negotiated in some countries concerning leases for public and private land for specific periods of time with clear conditions as is highlighted in the cases.

5

Eradication of Hunger, Food Deficit and Food Surplus Regions

FIGHTING POVERTY AND HUNGER

Nearly one fourth of India's population, 251 million out of nearly one billion, is below the poverty line. One hundred seventy millions of the poor, 68 percent, are rural and the remaining 32 percent are urban. Number at the national level in rural area has decreased after 1983; the number of poor in the cities has been increasing. This is essentially due to migration of the destitute from villages to cities. There are serious implications of this trend on feeding the cities and food security of urban people, urban poverty and environment. A question may be asked as to whether the rural settings and opportunities could be improved for securing livelihood security and consequently rationalizing the migration to the cities.

An analysis of the incidence of rural poverty and hunger by farm size revealed that more than half of the landless people are poor. Poverty got significantly reduced from 54 percent in the landless group to 38 percent in the sub marginal group, suggesting that even a small piece of land, less than 1/2 hectare, can greatly reduce both poverty and hunger. The incidence of hunger and poverty gets reduced as one is able to meet even part of his/her dietary energy requirement through growing his/her own food.

Studies show that even a small plot of one's own helps women to escape extreme poverty and deprivation. Land is the main asset for livelihood security.

Although several factors affect the extent and depth of poverty and hunger, some of them have overwhelming impacts under the Indian setting. These include, irrigation, farming system and literacy. Generally, there is higher concentration of poor, and hungry people in rainfed areas as compared with those in irrigated zones. Even with 20 percent of the irrigation intensity, there is a sharp fall in the proportion of hunger and poverty and it remains there irrespective of further intensification of irrigation. Evidences suggest that extensive irrigation will prove much more effective than to adding more and more water, and often wasting it along with the associated degradation of the natural resources. Such a policy will not only reduce poverty and hunger, but will also promote equity and environmental protection and natural resource conservation. An effective water policy and institutional support is needed to ensure judicious and equitable allocation, distribution and exploitation of water and water resources.

Livestock has the highest effect on reducing poverty and hunger. In rural India, 43 percent of the people who do not own even a single livestock are malnourished. Addition of one cattle or one buffalo to their assets reduces the hunger prevalence by 16 and 25 percentage points, respectively. Only 14 percent of the people who owned one cattle and one buffalo were malnourished. In urban areas also, the addition of one cattle or one buffalo had significant impact on reduction of proportion of malnourished people. Livestock sector should also receive high priority with multiple objectives of diversifying agriculture, raising income and meeting the nutritional security of the poor farm households.

Literacy has a very high impact on poverty alleviation as well as on hunger reduction. The illiterate people, whether urban or rural, are the most poor and malnourished. In urban areas the impact of literacy on poverty is the highest. Education, even above primary level, is extremely effective in reducing both poverty and hunger. Graduate and technical education is, of course, the most important instrument for reducing both poverty and hunger. But its impact is most visible on poverty reduction. Therefore, the education policy of the country must be geared to remove illiteracy as soon as possible, as 50 percent of our people are still illiterate. Free education up to 8th standard coupled with mid day meal in the schools will go a long way in reducing both poverty and hunger and will thus help build a strong India. Further, this move will greatly reduce the violation of child labour laws and will offset some of the non tariff restrictions imposed by developed countries on exports from developing countries on the grounds of use of child labour.

UNIVERSAL DECLARATION ON THE ERADICATION OF HUNGER AND MALNUTRITION

Recognizing that :

(a) The grave food crisis that is afflicting the peoples of the developing countries where most of the world's hungry and ill-nourished live and where more than two thirds of the world's population produce about one third of the world's food-an imbalance which threatens to increase in the next 10 years-is not only fraught with grave economic and social implications, but also acutely jeopardizes the most fundamental principles and values associated with the right to life and human dignity as enshrined in the Universal Declaration of Human Rights;

(b) The elimination of hunger and malnutrition, included as one of the objectives in the United Nations Declaration on Social Progress and Development, and the elimination of the causes that determine this situation are the common objectives of all nations;

(c) The situation of the peoples afflicted by hunger and malnutrition arises from their historical circumstances, especially social inequalities, including in many cases alien and colonial domination, foreign occupation, racial discrimination, apartheid and neo-colonialism in all its forms, which continue to be among the greatest obstacles to the full emancipation and progress of the developing countries and all the peoples involved;

(d) This situation has been aggravated in recent years by a series of crises to which the world economy has been subjected, such as the deterioration in the international monetary system, the inflationary increase in import costs, the heavy burdens imposed by external debt on the balance of payments of many developing countries, a rising food demand partly due to demographic pressure, speculation, and a shortage of, and increased costs for, essential agricultural inputs;

(e) These phenomena should be considered within the framework of the on-going negotiations on the Charter of Economic Rights and Duties of States, and the General Assembly of the United Nations should be urged unanimously to agree upon, and to adopt, a Charter that will be an effective instrument for the establishment of new international economic relations based on principles of equity and justice;

(f) All countries, big or small, rich or poor, are equal. All countries have the full right to participate in the decisions on the food problem;

(g) The well-being of the peoples of the world largely depends on the adequate production and distribution of food as well as the establishment of a world food security system which would ensure adequate availability of, and reasonable prices for, food at all times, irrespective of periodic fluctuations and vagaries of weather and free of political and economic pressures, and should thus facilitate, amongst other things, the development process of developing countries;

(h) Peace and justice encompass an economic dimension helping the solution of the world economic problems, the liquidation of under-development, offering a lasting and definitive solution of the food problem for all peoples and guaranteeing to all countries the right to implement freely and effectively their development programmes. To this effect, it is necessary to eliminate threats and resort to force and to promote peaceful co-operation between States to the fullest extent possible, to apply the principles of non-interference in the internal affairs of other States, full equality of rights and respect of national independence and sovereignty, as well as to encourage the peaceful co-operation between all States, irrespective of their political, social and economic systems. The further improvement of international relations will create better conditions for international o-operation in all fields which should make possible large financial and material resources to be used, inter alia , for developing agricultural production and substantially improving world food security;

(i) For a lasting solution of the food problem all efforts should be made to eliminate the widening gaps which today separate developed and developing countries and to bring about a new international economic order. It should be possible for all countries to participate actively and effectively in the new international economic relations by the establishment of suitable international systems, where appropriate, capable of producing adequate action in order to establish just and equitable relations in international economic co-operation;

(j) Developing countries reaffirm their belief that the primary responsibility for ensuring their own rapid development rests with themselves. They declare, therefore, their readiness to continue to intensify their individual and collective efforts with a view to expanding their mutual co-operation in the field of agricultural development and food production, including the eradication of hunger and malnutrition;

(k) Since, for various reasons, many developing countries are not yet always able to meet their own food needs, urgent and effective international action should be taken to assist them, free of political pressures.

Consistent with the aims and objectives of the Declaration on the Establishment of a New International Economic Order and the

Programme of Action adopted by the General Assembly at its sixth special session,

The Conference consequently solemnly proclaims :

1. Every man, woman and child has the inalienable right to be free from hunger and malnutrition in order to develop fully and maintain their physical and mental faculties. Society today already possesses sufficient resources, organizational ability and technology and hence the competence to achieve this objective. Accordingly, the eradication of hunger is a common objective of all the countries of the international community, especially of the developed countries and others in a position to help.
2. It is a fundamental responsibility of Governments to work together for higher food production and a more equitable and efficient distribution of food between countries and within countries. Governments should initiate immediately a greater concerted attack on chronic malnutrition and deficiency diseases among the vulnerable and lower income groups. In order to ensure adequate nutrition for all, Governments should formulate appropriate food and nutrition policies integrated in overall socio-economic and agricultural development plans based on adequate knowledge of available as well as potential food resources. The importance of human milk in this connection should be stressed on nutritional grounds.
3. Food problems must be tackled during the preparation and implementation of national plans and programmes for economic and social development, with emphasis on their humanitarian aspects.
4. It is a responsibility of each State concerned, in accordance with its sovereign judgement and internal legislation, to remove the obstacles to food production and to provide proper incentives to agricultural producers. Of prime importance for the attainment of these objectives are effective measures of socio-economic transformation by agrarian, tax, credit and investment policy reform and the

reorganization of rural structures, such as the reform of the conditions of ownership, the encouragement of producer and consumer co-operatives, the mobilization of the full potential of human resources, both male and female, in the developing countries for an integrated rural development and the involvement of small farmers, fishermen and landless workers in attaining the required food production and employment targets. Moreover, it is necessary to recognize the key role of women in agricultural production and rural economy in many countries, and to ensure that appropriate education, extension programmes and financial facilities are made available to women on equal terms with men.

5. Marine and inland water resources are today becoming more important than ever as a source of food and economic prosperity. Accordingly, action should be taken to promote a rational exploitation of these resources, preferably for direct consumption, in order to contribute to meeting the food requirements of all peoples.
6. The efforts to increase food production should be complemented by every endeavour to prevent wastage of food in all its forms.
7. To give impetus to food production in developing countries and in particular in the least developed and most seriously affected among them, urgent and effective international action should be taken, by the developed countries and other countries in a position to do so, to provide them with sustained additional technical and financial assistance on favourable terms and in a volume sufficient to their needs on the basis of bilateral and multilateral arrangements. This assistance must be free of conditions inconsistent with the sovereignty of the receiving States.
8. All countries, and primarily the highly industrialized countries, should promote the advancement of food production technology and should make all efforts to promote the transfer, adaptation and dissemination of

appropriate food production technology for the benefit of the developing countries and, to that end, they should inter alia make all efforts to disseminate the results of their research work to Governments and scientific institutions of developing countries in order to enable them to promote a sustained agricultural development.

9. To assure the proper conservation of natural resources being utilized, or which might be utilized, for food production, all countries must collaborate in order to facilitate the preservation of the environment, including the marine environment.
10. All developed countries and others able to do so should collaborate technically and financially with the developing countries in their efforts to expand land and water resources for agricultural production and to assure a rapid increase in the availability, at fair costs, of agricultural inputs such as fertilizers and other chemicals, high-quality seeds, credit and technology. Co-operation among developing countries, in this connection, is also important.
11. All States should strive to the utmost to readjust, where appropriate, their agricultural policies to give priority to food production, recognizing in this connection the interrelationship between the world food problem and international trade. In the determination of attitudes towards farm support programmes for domestic food production, developed countries should take into account, as far as possible, the interest of the food-exporting developing countries, in order to avoid detrimental effect on their exports. Moreover, all countries should co-operate to devise effective steps to deal with the problem of stabilizing world markets and promoting equitable and remunerative prices, where appropriate through international arrangements, to improve access to markets through reduction or elimination of tariff and non-tariff barriers on the products of interest to the developing countries, to substantially increase the export earnings of these countries, to contribute to the diversification of their

exports, and apply to them, in the multilateral trade negotiations, the principles as agreed upon in the Tokyo Declaration, including the concept of non-reciprocity and more favourable treatment.

12. As it is the common responsibility of the entire international community to ensure the availability at all times of adequate world supplies of basic food-stuffs by way of appropriate reserves, including emergency reserves, all countries should co-operate in the establishment of an effective system of world food security by:

Participating in and supporting the operation of the Global Information and Early Warning System on Food and Agriculture;

Adhering to the objectives, policies and guidelines of the proposed International Undertaking on World Food Security as endorsed by the World Food Conference;

Earmarking, where possible, stocks or funds for meeting international emergency food requirements as envisaged in the proposed International Undertaking on World Food Security and developing international guidelines to provide for the co-ordination and the utilization of such stocks;

Co-operating in the provision of food aid for meeting emergency and nutritional needs as well as for stimulating rural employment through development projects.

All donor countries should accept and implement the concept of forward planning of food aid and make all efforts to provide commodities and/or financial assistance that will ensure adequate quantities of grains and other food commodities.

Time is short. Urgent and sustained action is vital. The Conference, therefore, calls upon all peoples expressing their will as individuals, and through their Governments, and non-governmental organizations, to work together to bring about the end of the age-old scourge of hunger.

The Conference affirms : The determination of the participating States to make full use of the United Nations system in the implementation of this Declaration and the other decisions adopted by the Conference.

LOW-INCOME FOOD-DEFICIT COUNTRY

The Food and Agriculture Organization of the United Nations (FAO) classifies countries as "low-income food-deficit" for analytical purposes on the basis of low income and food inadequacy, and when the country itself agrees with the status. The classification applies to countries that have a per capita income below the ceiling used by the World Bank to determine eligibility for International Development Association assistance and for 20-year terms from the International Bank for Reconstruction and Development, applied to countries included in World Bank categories I and II. The second criterion is based on the net (i.e. gross imports minus gross exports) food trade position of a country, averaged over the preceding 3 years. Trade volumes of a broad range of basic foodstuffs (e.g. cereals, roots and tubers, pulses, oilseeds and oils other than tree crop oils, meat and dairy products) are converted and aggregated by the calorie content of the individual commodities. The third criterion, which is self-exclusion, is applied when countries that meet the above two criteria specifically request to be excluded from the low-income food-deficit category. To avoid too-frequent changes of low-income food-deficit status, usually reflecting short-term exogenous shocks, an additional factor is taken into consideration. This factor, called "persistence of position", postpones the "exit" of a country from the list, even if it does not meet the low-income or food-deficit criteria, until the change in its status is verified for 3 consecutive years. In other words, the country is considered to be in a transitional phase during these 3 years. A country is taken off the list in the 4th year, after confirming a sustained improvement in its position.

What are the consequences and implications? The rationale behind the low-income food-deficit classification is that being both food deficit and having a low income at the same time means that the country lacks the resources not only to import food but also to produce sufficient amounts domestically. It is the combination of these two factors that makes these countries both food insecure and susceptible to domestic and external shocks, which could affect the nutritional status of vulnerable populations.

The low-income food-deficit list is intended to capture this aspect of the food problem.

In comparison with countries in other classifications commonly used for analytical and operational purposes, e.g. 'least-developed countries', the World Bank's 'low-income countries' and 'heavily indebted poor countries', countries that are low-income food-deficit have demonstrated better nutrition and health related outcomes.

FOOD SAFETY, LABELING AND REGULATION

Food security issues also coincide with food safety and food labeling concerns. Currently a global treaty, the Bio Safety Protocol, regulates the trade of GMOs. The EU currently requires all GMO foods to be labeled, whereas the US does not require transparent labeling of GMO foods. Since there are still questions regarding the safety and risks associated with GMO foods, some believe the public should have the freedom to choose and know what they are eating and require all GMO products to be labeled.

The Food and Agriculture Organization of the United Nations (FAO) leads international efforts to defeat hunger and provides a neutral forum where nations meet as equals to negotiate agreements and debate food policy and the regulation of agriculture.

According to Dr. Samuel Jutzi, director of FAO's animal production and health division, lobbying by "powerful" big food corporations has stopped reforms that would improve human health and the environment.

The "real, true issues are not being addressed by the political process because of the influence of lobbyists, of the true powerful entities," he said, speaking at the Compassion in World Farming annual forum. For example, recent proposals for a voluntary code of conduct for the livestock industry that would have provided incentives for improving standards for health, and environmental regulations, such as the number of animals an area of land can support without long-term damage, were successfully defeated due to large food company pressure.

Environmental impact

Agriculture imposes external costs upon society through pesticides, nutrient run-off, excessive water usage, and assorted other problems. A 2000 assessment of agriculture in the UK determined total external costs for 1996 of £2,343 million, or £208 per hectare. A 2005 analysis of these costs in the USA concluded that cropland imposes approximately $5 to 16 billion ($30 to $96 per hectare), while livestock production imposes $714 million. Both studies concluded that more should be done to internalize external costs, and neither included subsidies in their analysis, but noted that subsidies also influence the cost of agriculture to society. Both focused on purely fiscal impacts.

The 2000 review included reported pesticide poisonings but did not include speculative chronic effects of pesticides, and the 2004 review relied on a 1992 estimate of the total impact of pesticides. A key player who is credited to saving billions of lives because of his revolutionary work in developing new agricultural techniques is Norman Borlaug. His transformative work brought high-yield crop varieties to developing countries and earned him an unofficial title as the father of the Green Revolution.

Livestock Issues

A senior UN official and co-author of a UN report detailing this problem, Henning Steinfeld, said “Livestock are one of the most significant contributors to today’s most serious environmental problems”. Livestock production occupies 70% of all land used for agriculture, or 30% of the land surface of the planet. It is one of the largest sources of greenhouse gases, responsible for 18% of the world’s greenhouse gas emissions as measured in CO_2 equivalents.

By comparison, all transportation emits 13.5% of the CO_2. It produces 65% of human-related nitrous oxide (which has 296 times the global warming potential of $CO_{2,}$) and 37% of all human-induced methane (which is 23 times as warming as CO_2. It also generates 64% of the ammonia, which contributes to acid rain and acidification of ecosystems. Livestock expansion is cited as a key factor driving deforestation, in the Amazon basin

70% of previously forested area is now occupied by pastures and the remainder used for feed crops. Through deforestation and land degradation, livestock is also driving reductions in biodiversity.

Land Transformation and Degradation

Land transformation, the use of land to yield goods and services, is the most substantial way humans alter the Earth's ecosystems, and is considered the driving force in the loss of biodiversity. Estimates of the amount of land transformed by humans vary from 39–50%.Land degradation, the long-term decline in ecosystem function and productivity, is estimated to be occurring on 24% of land worldwide, with cropland overrepresented. The UN-FAO report cites land management as the driving factor behind degradation and reports that 1.5 billion people rely upon the degrading land. Degradation can be deforestation, desertification, soil erosion, mineral depletion, or chemical degradation (acidification and salinization).

Eutrophication

Eutrophication, excessive nutrients in aquatic ecosystems resulting in algal blooms and anoxia, leads to fish kills, loss of biodiversity, and renders water unfit for drinking and other industrial uses.

Excessive fertilization and manure application to cropland, as well as high livestock stocking densities cause nutrient (mainly nitrogen and phosphorus) run-off and leaching from agricultural land. These nutrients are major nonpoint pollutants contributing to eutrophication of aquatic ecosystems.

Pesticides

Pesticide use has increased since 1950 to 2.5 million tons annually worldwide, yet crop loss from pests has remained relatively constant. The World Health Organization estimated in 1992 that 3 million pesticide poisonings occur annually, causing 220,000 deaths. Pesticides select for pesticide resistance in the pest population, leading to a condition termed the 'pesticide treadmill' in which pest resistance warrants the development of a new pesticide.

An alternative argument is that the way to 'save the environment' and prevent famine is by using pesticides and intensive high yield farming, a view exemplified by a quote heading the Center for Global Food Issues website: 'Growing more per acre leaves more land for nature'. However, critics argue that a trade-off between the environment and a need for food is not inevitable, and that pesticides simply replace good agronomic practices such as crop rotation.

Climate Change

Climate change has the potential to affect agriculture through changes in temperature, rainfall (timing and quantity), CO_2, solar radiation and the interaction of these elements.Agriculture can both mitigate or worsen global warming.

Some of the increase in CO_2 in the atmosphere comes from the decomposition of organic matter in the soil, and much of the methane emitted into the atmosphere is caused by the decomposition of organic matter in wet soils such as rice paddies. Further, wet or anaerobic soils also lose nitrogen through denitrification, releasing the greenhouse gas nitric oxide. Changes in management can reduce the release of these greenhouse gases, and soil can further be used to sequester some of the CO_2 in the atmosphere.

International economics and agriculture

Differences in economic development, population density and culture mean that the farmers of the world operate under very different conditions. A US cotton farmer may receive US$230 in government subsidies per acre planted (in 2003), while farmers in Mali and other third-world countries do without. When prices decline, the heavily subsidized US farmer is not forced to reduce his output, making it difficult for cotton prices to rebound, but his Mali counterpart may go broke in the meantime. A livestock farmer in South Korea can calculate with a (highly subsidized) sales price of US$1300 for a calf produced.

A South American Mercosur country rancher calculates with a calf's sales price of US$120–200 (both 2008 figures). With the former, scarcity and high cost of land is compensated with public subsidies, the latter compensates absence of subsidies with economics of scale and low cost of land. In the Peoples Republic of China, a rural household's productive asset may be one hectare of farmland.

In Brazil, Paraguay and other countries where local legislature allows such purchases, international investors buy thousands of hectares of farmland or raw land at prices of a few hundred US$ per hectare.

FOOD SURPLUS AND WEATHER EVENTS

It would, therefore, be prudent to realise that food surpluses in India are marginal, too dependent on weather events.

In 2019-20, the production of pulses, sugar cane, milk, maize and oilseeds is likely to be lower than the previous year. In fact, India has been a net importer of maize for two years and the government may have to reduce duty on pulses. With global prices of edible oils rising, there is every likelihood of inflation there also.

The good news is that the outlook for Rabi crop is very good, as the high rainfall in the latter part of the monsoon had provided required soil moisture and it enabled reservoirs. Cold conditions in December and January in several parts of India will also help the Rabi crops. Area under wheat, gram, lentils and mustard is higher than the five-year average and the prices are likely to moderate when the harvest starts arriving in the markets in April.

Due to assured procurement, farmers in irrigated areas grow wheat and rice only. Pulses and oilseeds are not preferred as they don't give the same return to farmers. So, diversification from wheat and rice cycle is required not only for sustainability but also for checking inflation of various food items.

PM Kisan provides Rs 6000 per annum to all farmers, irrespective of any concern for the sustainability of crops. Thus, paddy continues to be the dominant Kharif crop in Punjab and Haryana. One way to address ecological sustainability is to provide direct incentive to farmers in water-stressed regions through PM Kisan. Farmers may then find it profitable to diversify from wheat and rice to other crops like maize and pulses.

The current challenge of food inflation will be solved by higher Rabi produce and easier imports. It is the long term task of meeting the demand for nutritious food for everyone which is more difficult and needs change in policies.

6

VonThunen's Theory of Agricultural Location and Its Recent Modifications

INTRODUCTION

The Von Thunen model of agricultural land use was created by farmer and amateur economist J.H. Von Thunen (1783-1850) in 1826 (but it wasn't translated into English until 1966). Von Thunen's model was created before industrialization and is based on the following limiting assumptions: The city is located centrally within an "Isolated State" which is self sufficient and has no external influences. The Isolated State is surrounded by an unoccupied wilderness. The land of the State is completely flat and has no rivers or mountains to interrupt the terrain. The soil quality and climate are consistent throughout the State. Farmers in the Isolated State transport their own goods to market via oxcart, across land, directly to the central city. Therefore, there are no roads. Farmers act to maximize profits.

LOCATION THEORY

Location theory, in economics and geography, theory concerned with the geographic location of economic activity; it has become an integral part of economic geography, regional science, and spatial economics. Location theory addresses the questions of what economic activities are located where and why. The location of economic activities can be determined on a broad level such as a region or metropolitan area, or on a narrow one such as a zone, neighbourhood, city block, or an individual site.

Johann Heinrich von Thünen, a Prussian landowner, introduced an early theory of agricultural location in Der isolierte Staat (1826) (The Isolated State). The Thünen model suggests that accessibility to the market (town) can create a complete system of agricultural land use. His model envisaged a single market surrounded by farmland, both situated on a plain of complete physical homogeneity. Transportation costs over the plain are related only to the distance traveled and the volume shipped. The model assumes that farmers surrounding the market will produce crops which have the highest market value (highest rent) that will give them the maximum net profit (the location, or land, rent). The determining factor in the location rent will be the transportation costs. When transportation costs are low, the location rent will be high, and vice versa. This situation produces a rent gradient along which the location rent decreases with distance from the market, eventually reaching zero. The Thünen model also addressed the location of intensive versus extensive agriculture in relation to the same market. Intensive agriculture will possess a steep gradient and will locate closer to the market than extensive agriculture. Different crops will possess different rent gradients. Perishable crops (vegetables and dairy products) will possess steep gradients while less perishable crops (grains) will possess less steep gradients.

In 1909 the German location economist Alfred Weber formulated a theory of industrial location in his book entitled Über den Standort der Industrien (Theory of the Location of Industries, 1929). Weber's theory, called the location triangle, sought the optimum location for the production of a good based on the fixed locations of the market and two raw material sources, which geographically form a triangle. He sought to determine the least-cost production location within the triangle by figuring the total costs of transporting raw material from both sites to the production site and product from the production site to the market. The weight of the raw materials and the final commodity are important determinants of the transport costs and the location of production.

Commodities that lose mass during production can be transported less expensively from the production site to the market than from the raw material site to the production site. The production site, therefore, will be located near the raw material sources. Where there is no great loss of mass during production, total transportation costs will be lower when located near the market.

Once a least-transport-cost location had been established within the triangle, Weber attempted to determine a cheap-labour alternate location. First he plotted the variation of transportation costs against the least-transport-cost location. Next he identified sites around the triangle that had lower labour costs than did the least-transport-cost location. If the transport costs were lower than the labour costs, then a cheap-labour alternative location was determined.

Another major contribution to location theory was Walter Christaller's formulation of the central place theory, which offered geometric explanations as to how settlements and places are located in relation to one another and why settlements function as hamlets, villages, towns, or cities.

William Alonso (Location and Land Use: Toward a General Theory of Land Rent, 1964) built upon the Thünen model to account for intra-urban variations in land use. He attempted to apply accessibility requirements to the city centre for various types of land use (housing, commercial, and industry). According to his theory, each land use type has its own rent gradient or bid rent curve. The curve sets the maximum amount of rent any land use type will yield for a specific location. Households, commercial establishments, and industries compete for locations according to each individual bid rent curve and their requirements for access to the city centre. All households will attempt to occupy as much land as possible while staying within their accessibility requirements. Since land is cheaper at the fringe of the city, households with less need for city centre accessibility will locate near the fringe; these will usually be wealthy households. Poor households require greater accessibility to the city centre and therefore will locate near the centre, competing with commercial and industrial establishments. This will tend to create a segregated land use system, because households will not pay commercial and industrial land prices for central locations.

The Thünen, Weber, Alonso, and Christaller models are not the sole contributors to location theory, but they are its foundation. These theories have been expanded upon and refined by geographers, economists, and regional scientists.

VON THUNEN'S LOCATION THEORY

The analysis of land use patterns has long been one of geography's basic concerns. At first, it might appear as if agricultural land use is little affected by relative location, once the factor of a suitable market has been acknowledged. Indeed, the farmer does adapt his land use to site conditions, climate, land forms, and soils.

However, the effects of the market situation cannot be disposed of as easily as all that. Johann Heinrich von Thunen (1983-1850), a German economist and estate owner of the early 19th century, developed a theory of agricultural location that is still worth considering.

This model is based on an econometric analysis of his estates in Mecklenburg, near Rostock in Germany. Most of the data used in explaining his theory were obtained by him through practical experience. He attempted to construct a theoretical model of land use pattern, giving a particular arrangement of towns and villages in a situation experienced in Mecklenburg.

The main aim of von Thunen's analysis was to show how and why agricul-tural land use varies with the distance from a market.

He had two basic models:

1. The intensity of production of a particular crop declines with the distance from the market. Intensity of production is a measure of the amount of inputs per unit area of land; for example, the greater the amount of money, labour and fertilisers, etc., that are used, the greater the intensity of agricul-tural production.
2. The type of land use will vary with the distance from the market.

The von Thunen's location theory or model states that if environmental variables are held constant, then the farm product that achieves the highest profit will outbid all other products in the competition for location. The competitive position of a crop or livestock activity (namely, how high the bidding needs go to secure a desirable site) will depend on the level of return anticipated from producing at the particular location.

A product with a high expected return and therefore, high rent-paying ability will be able to outbid a product with a lower profit level and, therefore, a relatively modest rent-bid ceiling.

By carefully compiling economic data on different farming activities on his own large estate Tellow in north-eastern Germany, von Thunen was able to determine the relative rent-paying abilities of each major agricultural product. Of course, the technology and agricultural products he managed in the early 19th century were different from those of today.

But, there are sufficient similarities to allow the analysis to be updated for our purpose. Moreover, his explanation was truly general, allowing his explanation approach to be applied to most contem-porary agricultural situations.

Following von Thunen's reasoning, the ranking of agricultural activities on the basis of rent-paying ability in the decreasing order are as follows:

Hierarchy of agricultural crops

1. Truck farming (fruits and vegetables)
2. Dairying
3. Mixed crop and livestock farming (corn belt agriculture)
4. Wheat farming
5. Ranching (yearlings often sold to feedlots of mixed crop and livestock farming)

Von Thunen's theory is based on certain assumptions.

These are as follows:

1. There is an 'isolated state' (as von Thunen called his model economy), consisting of 1 market city and its agricultural hinterland.

2. This city is the market for surplus products from the hinterland and receives products from no other areas.
3. The hinterland ships its surpluses to no other market except the city.
4. There is a homogeneous physical environment, including a uniform plain around the city.
5. The hinterland is inhabited by farmers who wish to maximise their profits, and who adjust automatically to the market's demands.
6. There is only one mode of transport – the horse and wagon (as this was 1826).
7. Transportation costs are directly proportional to distance, and are borne entirely by the farmers, who ship all produce in a fresh state.

Von Thunen's model examines the location of several crops in relation to the market.

The location of crops, according to him, is determined by:

(i) The market prices,

(ii) Transport costs, and

(iii) The yield per hectare.

The transport cost varies with the bulk and the perishability of the product. The crop with the highest locational rent for the unit of land will always be grown, since, it gives the greatest returns and all farmers attempt to maximise their profit. Two crops may have the same production costs and yields but difference in transport costs (per ton/kilometre) and market prices influence the decision-making of the farmers. If commodity A is more costly to transport per ton/kilometre and it has a higher market price, A will be grown closer to the market than Â.

Thus, the market of the locational rent of A is greater than B, because production costs are the same and no transport costs are incurred. If the market price of Â was greater than that of A, A would not be grown at all.

The single urban centre and undifferentiated landscape of von Thunen's model landscape. Where are the most desirable farming locations situated? For every farmer, regardless of the crop or type of livestock raised, the answer is indisputable: as close as possible to the central market. The market is the destination for agricultural goods produced throughout the region.

Next, assume that all the land in the heretofore undifferentiated landscape is placed on the auction block at the same time. The myriad of vegetable, dairy, mixed crop and livestock, wheat, and cattle-ranch land users eagerly submit their rent-bids to the landowners. All these actors prefer to purchase the right to use farmland near the market.

However, vegetable farmers have a higher relative rent-paying ability near to the market than their competitors; hence, at the auction the vegetable farmers will outbid all the others. The vegetable producers will thereby acquire the right to farm the land adjacent to the market.

Since, the undif-ferentiated landscape presents no advantages of being on a particular side of the market, the land users will distribute themselves circularly around the centre so as to minimise their distance to the town.

The bidding continues after vegetable farmers are accommodated. Since, dairy farmers rank next highest in rent-paying ability, they will successfully outbid the remaining contestants for locations in the next most accessible zone. Dairy farmers, too, arrange themselves in a circular fashion.

There arises a definite formation of concentric rings of different land uses circumscribing the market. The remaining agricultural systems can be arranged concentri-cally around the market centre in the same fashion, according to their competitive economic positions. The completed pattern of production rings.

VON THUNEN'S GENERAL THEORY OF LAND USE

On the basis of the above-mentioned assumptions, von Thunen constructed a general land use model; having a number of concentric zones around a market town (its three stages of growth have already been mentioned).

The perishable, bulky and/or heavy products, according to this model, would be produced in the belts nearer to the town. The more distant belts would specialise in products which were less in weight and volume but fetched higher price in the market as they could afford to bear relatively higher transportation costs.

The final model was conceived as having specialised agricultural enterprises and crop-livestock combination. Each belt, according to von Thunen, specialises in the production of those agricultural commodities to which it was best suited. The production of fresh milk (in the context of Europe) and vegetables was concentrated in the Zone I nearest to the city, because of the perishability of such products.

In this zone, the fertility of land was maintained by means of manuring and, if necessary, additional manure was brought from the city and transported to short distances to the farm.

The Zone II was used for production of wood, a bulky product in great demand in the city as a fuel in the early part of the 19th century. He showed, on the basis of his empirical data, that forestry yielded a higher locational rent, since its bulkiness meant relatively higher transport cost.

The Zone III represents crop farming where rye was an important market product, followed by other farming zones with a difference of the intensity of cultivation. As the distance from the market increased, so the intensity of rye production decreased with a consequent reduction in yields. There was no fallowing and manuring to maintain soil fertility.

In the next Zone IV the farming was less intensive. Farmers used a seven-year crop rotation in which rye occupied only one-seventh of the land. There was one year of rye, one of barley, one of oats, three of pastures and one of fallow.

The products sent to the market were rye, butter, cheese, and occasionally, live animals to be slaughtered in the city. These products did not perish so quickly as fresh milk and vegetables and could, therefore, be produced at a considerably greater distance from the market. In the most distant of the zones supplying rye to the city Zone V, farmers followed the three-field system.

This was a rotation system whereby one-third of the land was used for field crops, another one-third for pastures and the rest was left fallow. The farthest zone of all, i.e., Zone VI was the one of livestock farming. Because of the distance to the market, rye did not produce so high a rent as the production of butter, cheese or live animals (ranching). The rye produced in this zone was solely for the farm's own consumption. Only animal produce were marketed.

The economic rent considering three crops (horticulture, forest products and intensive arable cereals), a simplified model.

It von Thunen's model that Zone 1 in which the economic rent is high is devoted to horticulture (fruits and vegetables), while Zone II was devoted to forest products (like fuel wood) as the transportation cost of fuel wood is high. The Zone III is that of intensive arable land devoted to cereal crops.

In this model, the distinctive aspects are land values, land use intensity and transportation costs. A brief explanation of these aspects is as follows:

LAND VALUES

For agricultural land users the locations with better access (nearer) to the central market, bids up the value of land. Land values become so high that only those producers who yield the greatest locational rents can afford it.

A distance-decay relationship and an inverted cone is revealed, with land values declining as distance from the central peak increases. The locational advantage of proximity to the market is reflected in higher land values; as accessibility declines, so do land values.

Land Use Intensity

In direct response to the land value pattern, land use intensities also decline with increasing distance from the centre.

Producers on farmland with better access to the central market must use that land intensively to produce high enough revenues to afford to be located there. This results in high person-hour inputs per unit area of land for central farms, thereby requiring large hired-labour forces.

Farm size is another indicator as to the intensiveness of agricultural production; farm size generally increases with increasing distance from central markets. High land prices encourage farms to be comprised of fewer acres.

Thus, in the inner zones, financing may be difficult to obtain on a scale necessary to support large farm operations. Relatively less capital intensive land (such as chicken sheds) will therefore, substitute for relatively more expensive land.

The lower value of outer farmland permits the more lavish or extensive use of agricul-tural space. Because, both the cost of land and farm size change with changing accessibility to the market and aggregate locational rent per farm can be fairly constant across the landscape. For example, the aggregate locational rent for a 50 acre vegetable farm in the inner production ring can be roughly equivalent to a 1,000 acre ranch in the most peripheral zone.

Transportation Costs

The small variation of per farm aggregate locational rent across the Thunian zones is a result of site cost decreasing at approximately the same rate as transpor-tation costs increase.

High land values near the market are in a sense payments for savings in product-movement costs. Moreover, inner-ring farming is distinguished by the production of goods that do not easily withstand long-distance transportation. Highly perishable commodities such as fruits, vegetables, and dairy products share this low transferability.

In fact, situations discussed in von Thunen's model were that of early 19th century era. The original Thunian model contained forestry (in its second ring) near to market, because heavy weight wood used for fuel and construction was expensive to transport. By the second half of the 19th century, cheaper rail transportation changed the entire pattern.

Finally, von Thunen incorporated two examples of modifying factors in his classic model. The effect can clearly be seen of a navigable river where transport was speedier and cost only one-tenth as much as on land, together with the effect of smaller city acting as a competing market centre. Even the inclusion of only two modifications produces a much more complex land use pattern.

When all the simplifying assumptions are relaxed, as in reality, a complex land use pattern would be expected. The catalytic factor in von Thunen's model was transport cost and the main assumption was the assumption of an 'isolated state'. In the modified von Thunen model, the influence of fertility, subsidiary town, information, etc., has been incorporated.

The concentric zones of the model get modified under the impact of various physical, socio-economic and cultural factors. The influence of availability of information also substantially modifies the concentric zone of agricultural land use.

Critical Analysis

The theory of agricultural location was presented by von Thunen in the early 19th century. Since then, several scholars including geographers have applied it in various parts of the world and have pointed out certain aspects which are not applicable in a way as pointed out by von Thunen.

Many aspects of this model have changed due to development in agricultural system, transportation system and also due to other technological developments. There are also certain regional geo-economic factors which not only direct but determine the pattern of agricultural land use. The main points raised by scholars regarding this theory are as follows:

1. The conditions described in this model, i.e., in an isolated state, are hardly available in any region of the world. There are internal variations in climatic and soil conditions. The von Thunen's assumptions that there are no spatial variations in soil types and climate are rare.
2. It is not necessary that all types of farming systems as described by von Thunen in his theory exist in all the regions. In many European countries location of types of farming in relation to market are no longer in existence.

3. The Thunen's measures of economic rent and intensity are difficult to test because of their complexity. The measurement of number of man-days worked in a year, cost of labour per hectare or cost of total inputs per hectare is not uniform in intensive and extensive types of farming. Similar is the case with the measures of intensity,
4. Von Thunen himself has admitted that with the change in location of transportation or market centre the pattern of land use will also change.
5. The location of transport link and its direction used to change the pattern of agricultural land use.

In von Thunen's day, heavily loaded horse-drawn carts moved to market at the rate of about 1 mile an hour.

A journey from the wilderness edge to the market centre would require more than two full days, without pauses for rest. Therefore, the truest measure of economic distance in the Thunian model – the absolute mileage beyond which farming was simply too far from the market and could no longer yield locational rent — is in terms of a 50-hour time – distance.

If that 50-hour time – distance radius is constant as the Thunian farming system evolves, what would be its territorial extent today? It may be in thousands of kilometres in case of USA or Russia.

Environmental variables, as pointed out in connection with the physical limits model, are only a general locational constraint and play a passive role in shaping the distribution of modern commercial agriculture. In the human-technological context, the employment of artificial irrigation, chemical fertilisers, and the like, allows farmers to overcome most environ-mental barriers.

With changes in transportation conditions, the macro-Thunian system has also been modified since its emergence. A continuous process is involved that works to maximise locational utility. Demand for better access begets technological development, which results in transport innovation and culmi-nates into change in pattern of agricultural land use.

Three kinds of economic empirical irregularities can be anticipated to influence the national Thunian pattern:

transportation biases, distant concentrations of production that appear inconsistent with his model, and secondary markets.

The von Thunen model is also static and deterministic. Today, we know that economic growth and changes in demand will alter the spatial patterns of agricultural systems and land use, which in turn influence the rate of change. It might be possible to postulate a dynamic von Thunen model that could be applied to the changing conditions.

But, the model, despite these possible manipulations, is really static, since, it represents a land use system at one point in time, von Thunen was not concerned with transitional changes, since, he and most of the direct extenders of his model assumed that any change in technology, demand, or transport cost would automatically be accompanied by an adjustment in the land use system.

The Thunian model was developed in the early 19th century, since then, conditions have entirely been changed. Therefore, it is not desirable to accept this model in its original form as observed by many scholars. But this model is still considered to be significant in many ways.

RELEVANCE OF VON THUNEN MODEL

Almost two hundred years ago, Johann Heinrich von Thunen demonstrated that the geographic pattern of agricultural land use was highly regular and predictable. He first described the pattern of land use within and surrounding his own large estate.

Based upon these descriptions he next formulated a hypothesis to explain the geographic pattern. His hypothesis was that the higher the cost of transpor-tation, the lower the amount a tenant farmer would be willing to pay to use the land.

He expressed his hypothesis using clear and unambiguous mathematics. He reasoned that by placing reasonable numerical values into his mathematical formulation he could closely predict actual land values and land uses.

Among his general conclusions were that land values decline with increasing distance from the market centre; and that land values and land uses change as the various costs of production, transportation, and prices of agricultural commodities change.

Today, the cost and technology of transportation has had a dramatic effect upon the agricultural land use patterns that one would expect by applying von Thunen's logic. Agricultural land use patterns that are evident surrounding market centres are thought to be historic remnants of a bygone era, or the result of administrative institutions whose existence brings about a usage to the historic patterns of land use. At the scale of the continent and the globe we now can observe von Thunen-like market forces and patterns of land use.

The von Thunen logical framework has been important in the evolution of our thinking of how land values and land uses came about in the modern city. Indeed, von Thunen's general theory of land values and land uses has been important in the evolution of thought.

Von Thunen was one of the first to adopt the 'new math's' of his era, calculus, and to apply that mathematics to a problem of the social sciences. He was a pioneer in the use of data for the verification of his normative theory, von Thunen's innovative research method was similar in composition to what we would today call computer simulation. Indeed, much of the approach to social science thought today can be traced back to von Thunen's general method of analysis as its precursor.

His contribution to modern thinking in the social sciences stands unparalleled. His general approach became diffused through its adoption by the leading scholars of the generations that followed him, and by their adoption of his general method in their own work, von Thunen's application of his general method to his own land use theory became generally accessible only in the early 1950s when Edgar S. Dunn published his interpretation in English, von Thunen is no exception among the greats whose reasoning in time is recognised to have contained an error.

The beauty of using mathematics over mere verbalisation to express concepts or hypotheses is that when an error is made it can often be corrected irrefutably. Dunn found an error in von

Thunen's treatise and corrected it. It can be recalled from the discussion above that a caveat was to be presented to von Thunen's general theory: once the hierarchical ranking of farming systems was established, such as that listed in Table 14.1, those of lower ranking would always be outbid by those of higher ranking should both happen to be competing for the same land.

Instead, Dunn correctly reasoned that since locational rent changed by a different amount for each agricultural product with distance from the central market, then at some locations a lower ranking farming system could indeed outbid a higher ranking farming system, even though positive rents were bid by the higher ranking farming system.

All over the world, scholars have tested and applied the von Thunen's theory of agricultural location. The greatest importance of the theory lies in this fact that it has given a new direction of thinking, resulting into the modified way of its application.

Von Thunen himself relaxed certain assumptions of his model. First, he introduced a canal along which transportation costs were lower than by horse and wagon. The effect was to create a series of wedge-shaped land use zones along the canal. Second, he introduced a second and smaller market, around which he postulated that a series of separate zones would be created.

Similarly, we could relax the assumptions by introducing yet another means of transport, such as a railroad or allow variation in the physical environment.

The extent to which these relaxations affect the simple von Thunen model will depend on how they affect the simple conceptual framework put forward earlier.

Some researchers have used von Thunen's model as a general framework for interpreting the spatial framework of the economy. Others have worked on a more direct basis. Thus, von Thunen's model has been applied to the distribution of European agriculture in 1925.

Muller's interpretation of a normative macro-Thunian model for the United States, anchored by a megalopolis. Its utility for explaining the national pattern of agricultural production is demonstrated as follows:

We begin again by relaxing the normative assumptions of the isolated state model, but this time with the realisation that empirical irregularities will be complex in the sophisticated economic space of the present-day continental United States.

However, because we are concerned only with the overall organisa-tional framework of farming regions at a high level of spatial generalisation, the search is not complicated: if macro-Thunian processes have shaped the production pattern, then empirical response to them will be easily discernible.

The main task is to set up the investigation by cataloging physical-environmental and economic-empirical irregularities in order to derive an appropriate map of the expected real-world spatial pattern.

Empirical evidence of Thunian spatial systems is also widespread beyond the United States. The macro-scale pattern of agricultural intensity for the European continent, which is sharply focused on the conurbation ringing the southern margin of the North Sea, from London and Paris to Copen-hagen. By combining the American and European patterns and proceeding to a yet greater level of spatial aggregation, one can even perceive a global-scale Thunian system focused on the "world metropolis" that borders the North Atlantic Ocean.

Regarding application of the Thunian model in developing countries M.H. Hussain (2010) has observed that in many of the underdeveloped and developing countries of the world, in both the villages and towns, cropping belts are found. In the villages of the Great Plains of India similar patterns can be observed.

The highly fertile and adequately manured lands around the village settlements are devoted to the perishable and more fertility requiring crops, e.g., vegetables, potatoes, oats and orchards in the land lying in the middle belt; crops like rice, wheat, barley, pulses, sugarcane, gram, maize, etc., are grown subject to the texture, drainage and other properties of the soils.

In the outer fringes fodder crops and inferior cereals (bajra, millets) are sown. Alter the introduction of tube well irrigation in the great plains of India, this pattern has, however, been largely modified as the farmers with better inputs are able to produce perishable crops even in the distant fields from the settle-ments.

The consolidation of holdings in India has also modified the crop intensity rings as each of the farmers is interested in growing the commodities tor his family consumption as well as some marketable crops for earning cash to clear his arrears of land revenue and irrigation charges and to purchase the articles from the market for his family consumption.

In some of the developing countries like India, Pakistan and Mexico the introduction of HYV (high yielding variety) has disturbed the application of von Thunen model. The fast development of means of transportation has made it possible to transport the perishable goods at long distances in short period of time. Thus, the model advocated by von Thunen is no longer operative in its original form.

Thunian distance relationships can also be discerned at the national level in smaller developed countries such as Uruguay. Allowing for that nation's empirical irregularities, Ernst Griffin discovered that the expected Thunian pattern accorded nicely with the actual intensity of agricultural land use. Continuing down the level of generalisation continuum from mesoscale to microscale, Thunian influences are often observed to shape farming at the local level. Moreover, local agricultural productions in the less developed world, where technological conditions are more comparable to those of von Thunen s days, May even exhibit spatial structures reminiscent of von Thunen's landscape.

Ronald Horvath found just such a pattern for the area surrounding Addis Ababa, Ethiopia. Of particular significance was his discovery of an expanding transporta-tion-oriented eucalyptus forestry zone in its classical inner position.

LEARN ABOUT THE VON THUNEN MODEL

The Von Thunen model of agricultural land use (also called location theory) was created by the German farmer, landowner, and amateur economist Johann Heinrich Von Thunen (1783–1850). He presented it in 1826 in a book called "The Isolated State," but it wasn't translated into English until 1966.

Von Thunen created his model before industrialization and in it, he laid the foundation for what we know as the field of human geography. He strove to identify trends of people's economic relationship with the landscape surrounding them.

What Is the Von Thunen Model? The Von Thunen model is a theory which, after Von Thunen's own observations and very meticulous mathematical calculations, predicts human behavior in terms of landscape and economy.

Like any other scientific experiment or theory, it is based on a series of assumptions, that Von Thunen sums up in his concept of an "Isolated State." Von Thunen was interested in ways people tend to use and would use the land around a city if the conditions were laboratory-like, as in his Isolated State.

His premise is that if people have the freedom to organize the landscape around their cities as they wish, they will naturally set up their economy—growing and selling crops, livestock, timber, and produce— into what Von Thunen identified as "Four Rings."

Isolated State

The following are the conditions Von Thunen noted as the basis for his model. These are laboratory-style conditions and don't necessarily exist in the real world. But they are a workable basis for his agricultural theory, which seemed to reflect how people actually organized their world and how some modern agricultural regions are still laid out.

The city is located centrally within an "Isolated State" that is self-sufficient and has no external influences.

The Isolated State is surrounded by an unoccupied wilderness.

The land of the State is completely flat and has no rivers or mountains to interrupt the terrain.

The soil quality and climate are consistent throughout the State.

Farmers in the Isolated State transport their own goods to market via oxcart, across the land, directly to the central city. Therefore, there are no roads.

Farmers act to maximize profits.

The Four Rings

In an Isolated State with the foregoing statements being true, Von Thunen hypothesized that a pattern of rings around the city would develop based on land cost and transportation cost.

Dairying and intensive farming occur in the ring closest to the city: Because vegetables, fruit, milk, and other dairy products must get to market quickly, they would be produced close to the city. (Remember, in the 19th century, people didn't have refrigerated oxcarts that would enable them to travel larger distances.)

The first ring of land is also more expensive, so the agricultural products from that area would have to be highly valuable ones and the rate of return maximized.

Timber and firewood: These would be produced for fuel and building materials in the second zone. Before industrialization (and coal power), wood was a very important fuel for heating and cooking, and thus comes in second in value after dairy and produce. Wood is also very heavy and difficult to transport, so it is located as close to the city as possible to minimize additional transportation costs.

Crops: The third zone consists of extensive field crops such as grains for bread. Because grains last longer than dairy products and are much lighter than wood, reducing transport costs, they can be located farther from the city.

Livestock: Ranching is located in the final ring surrounding the central city. Animals can be raised far from the city because they are self-transporting—they can walk to the central city for sale or for butchering.

Beyond the fourth ring lies the unoccupied wilderness, which is too great a distance from the central city for any type of agricultural product because the amount earned for the product doesn't justify the expenses of producing it after transportation to the city is factored in.

What the Model Can Tell Us: Even though the Von Thunen model was created in a time before factories, highways, and even railroads, it is still an important model in geography. It is an excellent illustration of the balance between land cost and transportation costs. As one gets closer to a city, the price of land increases.

The farmers of the Isolated State balance the cost of transportation, land, and profit and produce the most cost-effective product for the market. Of course, in the real world, things don't happen as they would in a model, but Von Thunen's model gives us a good base to work from.

7

Crop Efficiency and Productivity

EFFICIENCY OF UTILISATION AND CONSERVATION

How much energy is consumed is influenced by how much is wasted and used inefficiently. Americans and Canadians, accustomed in earlier years to very cheap electricity and other fuels, persist in extravagant consumption by driving large motor vehicles, high power consumption in advertising signs, in public buildings and private homes, over heating during the winter and excessively cool air-conditioning in summer months. The efficiency with which motor vehicles of similar size and engine power burn fuel depends on how effectively they are maintained, how, where and at what speeds they are driven. Energy consumed to heat or air condition a building is determined by design, structure, insulation and patterns of air circulation.

Thermal energy in factory processes is wasted by steam leaking, by poorly insulated steam pipes, by process scheduling that fails to use heat generated economically and conservatively. Prudent managers conduct frequent energy audits of total consumption and use by high energy consuming processes. Large companies can install integrating watt-meters, liquid and gas flow meters to measure actual consumption. Smaller companies rely on historical and account records received from suppliers.

India is believed to lose more than 20 per cent of electric power generated during transmission over long distribution grids.

Though the generation cost per unit from small-scale generators is higher than from large central installations, transmission losses from small generators located close to users are significantly lower. To supply power to small rural industries, small generators are more economic and reliable than power from a large electrical grid. Urban motor vehicles when powered by electric motors use no energy when stuck in a traffic jam and emit no obnoxious fumes. Since the mid-1930s in cities in Britain, foods have been economically and hygienically transported in electric vehicles. Electric engines operate efficiently in the higher temperatures of the tropics.

Regrettably, politicians in many nations, unwilling to offend their electorates, lack the courage and commitment to raise energy prices to levels that would encourage greater conservation. North Americans oppose a carbon tax on vehicle fuels that would serve to reduce atmospheric pollution. It is gratifying that the Canadian province of Quebec has recently imposed a carbon tax.

Efficiency of Common Crops

As ethanol yields improve or different feedstocks are introduced, ethanol production may become more economically feasible in the US. Currently, research on improving ethanol yields from each unit of corn is underway using biotechnology. Also, as long as oil prices remain high, the economical use of other feedstocks, such as cellulose, become viable. By-products such as straw or wood chips can be converted to ethanol. Fast growing species like switchgrass can be grown on land not suitable for other cash crops and yield high levels of ethanol per unit area.

Reduced Petroleum Imports and Costs

One rationale given for extensive ethanol production in the U.S. is its benefit to energy security, by shifting the need for some foreign-produced oil to domestically-produced energy sources. Production of ethanol requires significant energy, but current U.S. production derives most of that energy from coal, natural gas and other sources, rather than oil. Because 66% of oil consumed in the U.S. is imported, compared to a net surplus of coal and just 16%

of natural gas (2006 figures), the displacement of oil-based fuels to ethanol produces a net shift from foreign to domestic U.S. energy sources.

According to a 2008 analysis by Iowa State University, the growth in US ethanol production has caused retail gasoline prices to be US $0.29 to US $0.40 per gallon lower than would otherwise have been the case.

Criticism and Controversy

There are various current issues with ethanol production and use, which are presently being discussed in the popular media and scientific journals. These include: the effect of moderating oil prices, the "food vs fuel" debate, carbon emissions levels, sustainable biofuel production, deforestation and soil erosion, impact on water resources, human rights issues, poverty reduction potential, ethanol prices, energy balance and efficiency, and centralised vs. decentralised production models.

Food vs fuel is about the risk of diverting farmland or crops for ethanol production to the detriment of the food supply. The debate is internationally controversial, with good-and-valid arguments on all sides of this ongoing debate. There is disagreement about how significant this is, what is causing it, what the impact is, and what can or should be done about it.

Livestock production systems

Animals, including horses, mules, oxen, camels, llamas, alpacas, and dogs, are often used to help cultivate fields, harvest crops, wrangle other animals, and transport farm products to buyers. Animal husbandry not only refers to the breeding and raising of animals for meat or to harvest animal products (like milk, eggs, or wool) on a continual basis, but also to the breeding and care of species for work and companionship. Livestock production systems can be defined based on feed source, as grassland - based, mixed, and landless.

Grassland based livestock production relies upon plant material such as shrubland, rangeland, and pastures for feeding ruminant animals. Outside nutrient inputs may be used, however manure is returned directly to the grassland as a major nutrient source. This system is particularly important in areas where crop production is not feasible because of climate or soil, representing 30-40 million pastoralists. Mixed production systems use grassland, fodder crops and grain feed crops as feed for ruminant and monogastic (one stomach; mainly chickens and pigs) livestock. Manure is typically recycled in mixed systems as a fertilizer for crops.

Approximately 68% of all agricultural land is permanent pastures used in the production of livestock. Landless systems rely upon feed from outside the farm, representing the de-linking of crop and livestock production found more prevalently in OECD member countries. In the U.S., 70% of the grain grown is fed to animals on feedlots. Synthetic fertilizers are more heavily relied upon for crop production and manure utilization becomes a challenge as well as a source for pollution.

Production practices

Tillage is the practice of plowing soil to prepare for planting or for nutrient incorporation or for pest control. Tillage varies in intensity from conventional to no-till. It may improve productivity by warming the soil, incorporating fertilizer and controlling weeds, but also renders soil more prone to erosion, triggers the decomposition of organic matter releasing CO_2, and reduces the abundance and diversity of soil organisms. Pest control includes the management of weeds, insects/mites, and diseases. Chemical (pesticides), biological (biocontrol), mechanical (tillage), and cultural practices are used. Cultural practices include crop rotation, culling, cover crops, intercropping, composting, avoidance, and resistance. Integrated pest management attempts to use all of these methods to keep pest populations below the number which would cause economic loss, and recommends pesticides as a last resort.

Nutrient management includes both the source of nutrient inputs for crop and livestock production, and the method of utilization of manure produced by livestock. Nutrient inputs can be chemical inorganic fertilizers, manure, green manure, compost and mined minerals. Crop nutrient use may also be managed using cultural techniques such as crop rotation or a fallow period. Manure is used either by holding livestock where the feed crop is growing, such as in managed intensive rotational grazing, or by spreading either dry or liquid formulations of manure on cropland or pastures.

Water management is where rainfall is insufficient or variable, which occurs to some degree in most regions of the world. Some farmers use irrigation to supplement rainfall. In other areas such as the Great Plains in the U.S. and Canada, farmers use a fallow year to conserve soil moisture to use for growing a crop in the following year. Agriculture represents 70% of freshwater use worldwide.

Processing, distribution, and marketing

In the United States, food costs attributed to processing, distribution, and marketing have risen while the costs attributed to farming have declined. This is related to the greater efficiency of farming, combined with the increased level of value addition (*e.g.* more highly processed products) provided by the supply chain. From 1960 to 1980 the farm share was around 40%, but by 1990 it had declined to 30% and by 1998, 22.2%. Market concentration has increased in the sector as well, with the top 20 food manufacturers accounting for half the food-processing value in 1995, over double that produced in 1954. As of 2000 the top six US supermarket groups had 50% of sales compared to 32% in 1992. Although the total effect of the increased market concentration is likely increased efficiency, the changes redistribute economic surplus from producers (farmers) and consumers, and may have negative implications for rural communities.

Crop alteration and biotechnology

Crop alteration has been practiced by humankind for thousands of years, since the beginning of civilization. Altering crops through breeding practices changes the genetic make-up of a plant to develop crops with more beneficial characteristics for humans, for example, larger fruits or seeds, drought-tolerance, or resistance to pests. Significant advances in plant breeding ensued after the work of geneticist Gregor Mendel. His work on dominant and recessive alleles gave plant breeders a better understanding of genetics and brought great insights to the techniques utilized by plant breeders. Crop breeding includes techniques such as plant selection with desirable traits, self-pollination and cross-pollination, and molecular techniques that genetically modify the organism.

Domestication of plants has, over the centuries increased yield, improved disease resistance and drought tolerance, eased harvest and improved the taste and nutritional value of crop plants. Careful selection and breeding have had enormous effects on the characteristics of crop plants. Plant selection and breeding in the 1920s and 1930s improved pasture (grasses and clover) in New Zealand. Extensive X-ray an ultraviolet induced mutagenesis efforts (*i.e.* primitive genetic engineering) during the 1950s produced the modern commercial varieties of grains such as wheat, corn (maize) and barley.

The Green Revolution popularized the use of conventional hybridization to increase yield many folds by creating "high-yielding varieties". For example, average yields of corn (maize) in the USA have increased from around 2.5 tons per hectare (t/ha) (40 bushels per acre) in 1900 to about 9.4 t/ha (150 bushels per acre) in 2001. Similarly, worldwide average wheat yields have increased from less than 1 t/ha in 1900 to more than 2.5 t/ha in 1990. South American average wheat yields are around 2 t/ha, African under 1 t/ha, Egypt and Arabia up to 3.5 to 4 t/ha with irrigation. In contrast, the average wheat yield in countries such as France is over 8 t/ha. Variations in yields are due mainly to variation in climate, genetics, and the level of intensive farming techniques (use of fertilizers, chemical pest control, growth control to avoid lodging).

Genetic Engineering

Genetically Modified Organisms (GMO) are organisms whose genetic material has been altered by genetic engineering techniques generally known as recombinant DNA technology. Genetic engineering has expanded the genes available to breeders to utilize in creating desired germlines for new crops. After mechanical tomato-harvesters were developed in the early 1960s, agricultural scientists genetically modified tomatoes to be more resistant to mechanical handling. More recently, genetic engineering is being employed in various parts of the world, to create crops with other beneficial traits.

Herbicide-tolerant GMO Crops

Roundup Ready seed has a herbicide resistant gene implanted into its genome that allows the plants to tolerate exposure to glyphosate. Roundup is a trade name for a glyphosate-based product, which is a systemic, nonselective herbicide used to kill weeds. Roundup Ready seeds allow the farmer to grow a crop that can be sprayed with glyphosate to control weeds without harming the resistant crop. Herbicide-tolerant crops are used by farmers worldwide.

Today, 92% of soybean acreage in the US is planted with genetically modified herbicide-tolerant plants. With the increasing use of herbicide-tolerant crops, comes an increase in the use of glyphosate-based herbicide sprays. In some areas glyphosate resistant weeds have developed, causing farmers to switch to other herbicides. Some studies also link widespread glyphosate usage to iron deficiencies in some crops, which is both a crop production and a nutritional quality concern, with potential economic and health implications.

Insect-resistant GMO Crops

Other GMO crops used by growers include insect-resistant crops, which have a gene from the soil bacterium Bacillus thuringiensis (Bt), which produces a toxin specific to insects. These crops protect plants from damage by insects; one such crop is Starlink. Another is cotton, which accounts for 63% of US cotton acreage. Some believe that similar or better pest-resistance traits can be acquired through traditional breeding practices, and resistance to various pests can be gained through hybridization or cross-pollination with wild species. In some cases, wild species are the primary source of resistance traits; some tomato cultivars that have gained resistance to at least nineteen diseases did so through crossing with wild populations of tomatoes.

Costs and Benefits of GMOs

Genetic engineers may someday develop transgenic plants which would allow for irrigation, drainage, conservation, sanitary engineering, and maintaining or increasing yields while requiring fewer fossil fuel derived inputs than conventional crops. Such developments would be particularly important in areas which are normally arid and rely upon constant irrigation, and on large scale farms. However, genetic engineering of plants has proven to be controversial. Many issues surrounding food security and environmental impacts have risen regarding GMO practices. For example, GMOs are questioned by some ecologists and economists concerned with GMO practices such as terminator seeds, which is a genetic modification that creates sterile seeds. Terminator seeds are currently under strong international opposition and face continual efforts of global bans.

Another controversial issue is the patent protection given to companies that develop new types of seed using genetic engineering. Since companies have intellectual ownership of their seeds, they have the power to dictate terms and conditions of their patented product. Currently, ten seed companies control over two-thirds of the global seed sales. Vandana Shiva argues that these companies are guilty of biopiracy by patenting life and exploiting organisms for profit Farmers using patented seed are restricted from saving seed for subsequent plantings, which forces farmers to buy new seed every year. Since seed saving is a traditional practice for many farmers in both developing and developed countries, GMO seeds legally bind farmers to change their seed saving practices to buying new seed every year.

Locally adapted seeds are an essential heritage that has the potential to be lost with current hybridized crops and GMOs. Locally adapted seeds, also called land races or crop eco-types, are important because they have adapted over time to the specific microclimates, soils, other environmental conditions, field designs, and ethnic preference indigenous to the exact area of cultivation.

Introducing GMOs and hybridized commercial seed to an area brings the risk of cross-pollination with local land races Therefore, GMOs pose a threat to the sustainability of land races and the ethnic heritage of cultures. Once seed contains transgenic material, it becomes subject to the conditions of the seed company that owns the patent of the transgenic material.

Modern agriculture

Modern agriculture is a term used to describe the wide majority of production practices employed by America's farmers. The term depicts the push for innovation, stewardship and advancements continually made by growers to sustainably produce higher-quality products with a reduced environmental impact. Intensive scientific research and robust investment in modern agriculture during the past 50 years has helped farmers double food production while essentially freezing the footprint of total cultivated farmland.

Safety

The agriculture industry works with government agencies and other organizations to ensure that farmers have access to the technologies required to support modern agriculture practices. Farmers are supported by education and certificationprogrammes that ensure they apply agricultural practices with care and only when required.

Sustainability

Technological advancements help provide farmers with tools and resources to help reduce their environmental footprint and to make farming more sustainable.

New technologies have given rise to innovations like conservation tillage, a farming process which helps prevent land loss to erosion, water pollution and enhances carbon sequestration.

The World Bank, the Bill and Melinda Gates Foundation and others have noted that integrated crop management is based on agro-ecological principles and can increase yields while reducing environmental damage.

Affordability

The goal of modern agriculture practices is to help farmers provide an affordable supply of food to meet the demands of a growing population. With modern agriculture, more crops can be grown on less land allowing farmers to provide an increased supply of food at an affordable price.

CROP PRODUCTIVITY

Global demand and consumption of agricultural crops for food, feed, and fuel is increasing at a rapid pace. This demand for plant materials has been expanding for many years. However, recent increases in meat consumption in emerging economies together with accelerating use of grain for biofuel production in developed countries have placed new pressures on global grain supplies. To satisfy the growing, worldwide demand for grain, two broad options are available:

(1) The area under production can be increased or

(2) Productivity can be improved on existing farmland.

These two options are not mutually exclusive and both will be employed to produce the additional 200 million tonnes/year of corn (Zea mays) and wheat (Triticum aestivum) estimated to be needed by 2017. Both options will alter the environmental footprint of farming. Of the two options, increasing productivity on existing agricultural land is preferable as it avoids greenhouse gas emissions and the large-scale disruption of existing ecosystems associated with bringing new land into production.

In the United States, breeders, agronomists, and farmers have a documented history of increasing yield. U.S. average corn yields have increased from approximately 1.6 tonnes/ha in the first third of the 20th century to today's approximately 9.5 tonnes/ha. This dramatic yield improvement is due to the development and widespread use of new farming technologies such as hybrid corn, synthetic fertilizers, and farm machinery. The introduction of biotechnology traits and development of new breeding methodology using DNA-based markers are further improving yields. Outside the United States, similar farming practices have been adopted in some agricultural nations, but in many major grain-producing countries, yields still lag well behind world averages. By continuing to develop new farming technologies and deploying of them on a global basis, demand for feed, fuel, and food can be met without the commitment of large land areas to new production.

Soil resources

The soil resources in this table fall into three broad groups, reflecting their underlying interrelationships: those related to soil structure (water use, structure, erosion) are dealt within this Chapter, those related to nutrition or biological factors.

As this *Bulletin* deals with dryland crops, water availability is the major constraint on crop performance. Table suggests that water use efficiency (WUE) is a key measurement of performance. WUE reflects water availability (seasonably of rainfall) but also, importantly for management, it integrates the influences of factors such as the volume of soil exploitable by roots.

Long-term trends with time in WUE and trends between areas provide estimates of the relative sustainability of specific cropping systems. The theoretical WUE line are less efficient or effective than they should be. One reason for such ineffectiveness is poor management during the growing season, for example weediness and nutrient deficiency. This is correctable, as shown by the vertical lines, where WUE was increased during experimental treatments. Other reasons for poor WUE are related more to fundamental issues associated with soils.

soil resources and cropping systems

A traditional view of the influence of soil is that it provides an opportunity, or a constraint on the type of cropping system that can be implemented and its productivity. A more responsible view is that 'the soil' combines various properties which interrelate and are directly influenced by the procedures of cropping. A non-sustainable cropping system, in which soil resources are declining through changes in surface properties, subsoil compaction, loss of organic matter and reduced biological activity. It shows that each of these properties may affect the others and that all can directly and indirectly reduce plant performance, as well as affecting other aspects including erosion, salinisation and acidification. Some of the mechanisms underlying these interconnections.

Soil pores and water characteristics

Soils are made up of three parts: mineral materials, organic matter and space (called pore-or void-volume). The relative importance of these varies with soil type but pore space can occupy about half the volume of a medium-textured soil. At optimum water content for plant growth, approximately half the pore space is filled with water and half with air. The proportions of water and air can change rapidly depending on weather, evapotranspiration and other factors. The dimensions (size, shape and arrangement) and number of pore spaces are most important in determining soil water and soil structure.

Porosity is the volume of soil voids (*pore* space). It is expressed in relation to the bulk volume of the soil. The water holding capacity of a soil depends on its porosity, and the size distribution of its pores. Small pores retain water at greater suctions than larger pores. The moisture (or water) potential is the amount of energy required to remove water from a soil; field capacity is the water-holding capacity after a free-draining soil has been allowed to drain.

Available soil water (ASW) is the amount of water which is available for uptake by plants, namely that held at suctions between wilting point and field capacity. It varies with soil type and can be correlated with the clay content and structural arrangement of the soil. It varies also with soil treatment because the size and distribution of pores in the topsoil reflects surface exposure, normal seasonal wetting and drying, and management. Williams *et al.* (1983), studying the water content of 244 soil samples, found that the ASW of well-structured soils was one-third to twice as large as that in comparable (similarly-textured) poorly structured or degraded soils. Bearing in mind that ASW varies with natural weathering and management,

Hydraulic conductivity (K) of a soil is its conductivity to movement of water down a pressure gradient. High values of K are associated with well-structured soil and contiguous pores; they allow high infiltration rates and rapid drainage. Earthworm channels, which can have populations of 500 m^{-2} in Mediterranean climates, and continuous deep voids left by dead roots (5-10 000 m^{-2}) contribute greatly to hydraulic conductivity. Hydraulic conductivity varies with soil type and management. K values below 10 mm/h are low and likely to cause run-off following rainfall or problems with irrigation, given that steady rain falls at about 10 mm/h. K values of 10 to 20 mm/h can give intermittent run-off (a downpour falls at about 50 mm/h) while values up to 120 mm/h are associated with occasional, increasingly rare run-off. Values above 120 mm/h may facilitate regular drainage to the groundwater, causing potential problems for heavily-fertilised soils, and those treated with effluent, herbicides or pesticides.

Both soil water content and saturated hydraulic conductivity generally relate to the number and continuity of pores, particularly the larger macro-pores. It is, however, difficult to measure these soil attributes and they are highly location-specific, so that variability is great and they sometimes have little interpretive value. Moran *et al.,* (1988), however, in a study of a soil in a wet-and-dry environment, show that a soil treated with minimum tillage had more pores, identified directly by image analysis, and higher hydraulic conductivity, measured in the field, than did a similar soil traditionally cultivated. The impact of management on soil pore soil water characteristics.

Surface sealing and crusting are common in wet-and-dry climates. Sealing increases run-off and seriously reduces the amount of water infiltrating into the soil thus reducing the water held in the soil. Sealing can also increase ponding at the surface and thereby evaporation.

Infiltration rates are often reduced 1000-fold by crusting. The crust can have a skin with a conductivity of only about 0.1 mm/h, able only to accommodate the lightest rate of precipitation (fine mist) and commonly overlies a layer of poorly-aggregated material which also has a conductivity substantially lower than that of the underlying soil. Chase and Boudouresque (1989) and Chase *et al.,* (1989) illustrate the impact of crusting in the Sahel on increased run-off from soils. They show how run-off may be reduced, and the depth of wetting increased, by covering the soil surface with mulch.

These solid fractions contribute to the consistence and strength of the soil, and their packing determines bulk density.

Bulk density is a measure of the packing or compression of the three constituents of soil. Just as the inherent bulk density of a soil will vary by 30 per cent according to its constituents, so the limiting values of bulk density for root penetration will range from about 1.4 g cm^3 in a soil of clay texture to 1.8 g cm^3 in a sandy one.

Soil strength is the resistance of soil to shearing or structural failure. This reflects the friction which is built up between the soil and an implement, and depends on the density, and the roughness and shape of the soil particles. The shear strength of an individual clod decreases with wetting but, more importantly, the strength of the bulk soil increases with increasing moisture to about the lower plastic limit (known to field operators as the 'sticky point'), at which each particle is surrounded by a film of water which acts as a lubricant. Soil strength drops sharply from that point to the upper plastic limit, where the soil becomes viscous. The difference between the moisture content at the upper and lower plastic limits, termed the plasticity index, is an index of the workability of the soil. A large range or high plasticity index implies a need for large amounts of energy to work the soil to a desired tilth.

Soil physical properties affect root and shoot growth

Soil physical properties affect root and shoot growth directly and indirectly, the latter for example through poor drainage causing pores to fill with water and plants to suffer from anaerobiosis. Root growth has been described under various soil physical conditions, but relationships have only rarely been established between features such as crop yield, root growth and soil pore size distribution or conductivity, a more aggregate measure.

The difficulty in establishing simple relationships does not mean that soil has little influence upon root growth; rather it points to the complexity of the interactions and the internal homeostasis which plants maintain. Roots both elongate and proliferate and spread laterally as they grow and age. Concomitantly some roots die and others become suberised and function as conduits, but not as absorbers, of water and nutrients. Roots can elongate downwards as fast as 8 cm/d, as for example, soybean growing in a silt loam in a rhizotron. Deep-rootedness and maximum rooting depth reflect soil properties (for example, roots will not grow through pores that they cannot deform to a larger diameter than the root).

However, relationships are not often reported. Maximum rooting depth varies with species and soil type. For example, wheat roots penetrated to 0.8 m in heavy-textured soils and to 1.2 m in a loamy sand but it is often found that a variety will have a consistent rooting depth across similar soil types in a particular year or in one soil across several years. Angus *et al.* found that rice and six dryland crops (mung bean, cowpea, soybean, groundnut, Maize and sorghum) extracted different amounts of stored soil water (ranging from 100 mm for rice to 250 mm for groundnut) and that extraction was, in part, related to rooting depth.

Spread of roots

The spread of roots with age can be related to the growth (increase in weight) of the whole plant, and to accumulated temperature or growing day-degrees (GDD); indeed, there is some evidence that temperature influences the direction of newly-appeared roots as well as the rate of appearance and extent of growth. Clearly, however, there are factors other than plant size, temperature and soil which influence root proliferation. Otherwise the plants sown at three different times of year in the same soil would align their root growth along a single growth-GDD relationship. These other factors, of which day length is probably particularly important, tend to mask underlying relationships between growth and soil structure.

The tillage can affect root length, though in this case its effects took three years to develop. Measurable differences in soil porosity developed under two tillage treatments: in the first year both root growth and water infiltration (K approximately 5 mm/h) were the same under minimum tillage and conventional tillage. By the third year, when differences were measured between roots, infiltration rates were 84 mm/h in minimum tillage and 0.2 mm/h under conventional tillage. Despite the differences in root growth there were no substantial differences in grain yield, reflecting the overall constraint of climate in the semi-arid environment.

One of the clearer associations between soil porosity and plant growth is described by Tisdall and Cockroft and Tisdall. Soil was ameliorated by deep ploughing, inserting gypsum at depth, and incorporation of straw and green manure in the topsoil. This treatment gave 10-fold increases in the number of earthworms and a 4-fold increase in soil pores. Infiltration rates also increased 10-fold relative to untreated soil. Root growth was not measured, but fruit yields from peach trees increased from 18 to 75 t/ha.

Increases in soil density or strength retard root penetration and thus limit the volume of soil exploited by the crop and the water available. It is difficult to quantify the relationships between these soil parameters and plant growth. In the cases of bulk density and strength, particularly, a gross measure of either for an undisturbed mass of soil can give only a remote indication of what a root encounters. A determination of gross bulk density does not assess whether a root is growing within a pore (in which case it may deform surrounding soil before its radial environment reaches the density or strength of the gross soil) or if it is growing within the soil material, in which case it has already exerted a radial force equivalent to that measured for the gross soil.

This problem of scale-what is measured in a gross estimate cannot assess the micro-environment of the root, to which it (and through hormonal signals, the plant top) responds—does not invalidate some general hypotheses about plant behaviour in response to soil compaction and structural arrangement. Roots stop growing when they are unable to deform their micro-environment. This probably occurs at suctions about 60 kPa when they cannot generate adequate internal turgor. It is thought that root elongation declines curvilinearly with increasing either bulk density or shear strength. In the case of bulk density, little effect is noted until a 'critical value' and root elongation ceases within a further 10 per cent increase in bulk density. As explained earlier, these values vary with soil type. Root elongation declines asymptotically with increasing soil strength though the actual critical values would be expected to vary with soil type, water content and the method of measurement.

Effect of bulk density

Studies of the effect of bulk density or strength on other plant processes, particularly germination and shoot elongation, also suffer from the same technical problem of scale. Shoots are able to explore macropores without being subject to the gross values of the soil they are in. The actual local values which inhibit shoot elongation appear to be quite small, for example, 0.76 kPa. These values from controlled situations contrast sharply with gross field values and with the large number of inconsistent correlations which arise from attempting to correlate crop performance with grossly-measured soil structure. Perhaps, most encouragingly, studies of genetic variation in the sensitivity of crops to soil strength suggest that there is appreciable range in plant sensitivity. The relative ranking of genotypes is, however, the same when under near-critical stress as when growing with virtually no mechanical stress. Genotypes suited to stressful situations may be selected, therefore, by screening at a single soil strength.

The above comments relate to the direct effects of soil physical properties on crop growth. Two further points may be made. First, changing soil properties may not cause, or at least not immediately cause, measurable differences in plant performance. This neither invalidates an association between the soil and the plant, nor the need to remain concerned about changes in soil properties. It is common but not often reported, that changes in a cropping system and soil characteristics first affect aspects other than the crop. It is only when a system has become significantly degraded, and there are associated environmental impacts, that reduced plant performance is noticed. Nigeria, where no-till Maize in rotation with cowpea gave similar yields to conventionally cultivated crops. The no-till fields had only one-tenth the run-off and erosion of those conventionally cultivated.

Likewise, alley-cropping of the annuals between six year-old hedgerows of tree legumes (*Leucaena leucocephala, Gliricidia sepium*) caused increased crop yields, but within the alley-cropping systems the yields of Maize were very similar despite substantial variations in run-off and soil loss.

The second point about soil-crop relations is that the crop also affects the soil through ground-cover, depth of rooting and other properties. The crop attributes that most influence soil physical properties are speed of establishment and development of foliage cover. Rapid establishment and growth minimizes topsoil structural decline and soil erosion by wind and water. Thereafter, deep-rooting directly affects soil structure, particularly if deep-rooted crops, such as safflower, are grown in rotation as a 'biological plough' to create macropores and these are minimally disturbed before the next crop is sown. A general list of desirable crop characteristics. Not all these are universally applicable (nor indeed, accepted by all scientists) because some attributes such as stolons and rhizomes, on the one hand, can provide advantageous ground cover and bind the soil, but they are undesirable if the species presents weeding or other problems.

CLIMATE CHANGE ON CROP PRODUCTION IN INDIA

Climate is one of the main determinants of agricultural production Through out the world there is significant concern about the effects of climate change and its variability on agricultural production. Researchers and administrators are concerned with the potential damages and benefits that may arise in future from climate change impacts on agriculture, since these will affect domestic and international policies, trading pattern, resource use, and food security.

The researchers are of the opinion that while crops would respond favourably to elevated CO2 in the absence of climate change, the associated impacts of high temperatures, changed pattern of precipitation and possibly increased frequency of extreme events such as drought and floods, would possibly combine to reduce yields and increase risks in agricultural production in several parts of the globe. In India agricultural production is often determined by the whims of nature. The climate Marginal and Small Farms change is expected to result in higher temperatures and rainfall. The higher expected temperature might lower the yields. However, at the same time, higher rainfall could enhance growing period of crops. Also the higher concentration of $CO2$ in the atmosphere under changed climatic conditions might act as aerial fertilizer and enhance crop yields.

All these factors have to be taken in to consideration while examining the climate change impact on agriculture. During the 1990s, researchers repeatedly claimed that global warming would have dire consequences for key crops. Professor Richer Adams, an agricultural economist says, "If you just take an agronomic model and make conditions hotter and drier, then, yes, crop yields go down." " But if you are a farmer, you see your crops aren't doing so well and plant a more resistant type. In India, climate change is expected to make an impact in agriculture, resulting in lower yields of crops. The objectives of this paper are to examine the effect of fertilizer and labour inputs on crop productivity and to investigate the impact of climatic variables such as rainfall and temperature on crop production. Climate response functions have been estimated, using regression model by incorporating weather variables, in order to examine the impact of climate change on productivity of two crops. The impact of weather variables has been examined and the study is confined to two states.

Methodology

In a study Kaufmann R. K. and Seth E Snell (1997) had specified yield as a linear function of purchased inputs. For the purpose of analysis seed, fertilizer and labour inputs were considered in the regression model as explanatory variables and yield as the dependent variable. However, crop yield is affected not only by these purchased inputs but also by climatic variables and social factors. This integration allows complementing the earlier methodologies, which concentrate only on the purchased inputs and thereby, allows to better evaluating the adaptation strategy to climate change. The results show that climatic variables account for 19% of the yield change while the social variables account for 74% of the yield change.

Kavi Kumar and Parikh (2001) has also established a functional relationship between farm level net revenue and climatic variables, with a view to estimate the climate sensitivity of crop production in Indian agriculture.

To assess the impact of climate related variables and agricultural production in India, the present study has been undertaken. For this purpose, two crops viz. Rice and Jowar have been selected. These two crops are predominantly grown in monsoon season and any change in climate, particularly rainfall and temperature would effect the productivity of these crops significantly. In the present paper an econometric bio-model of crop production has been attempted. Agricultural production depends on not only climate related variables, but also on use of several factors like fertilizer, labour and other resources. For the purpose of present study, the following model has been used:

Y= f (F, HL, AR, NR, DFNR, MAXTEMP, MINTEMP)

Where,

Y= Crop yield on per hectare basis

F = Fertilizer used/ha.

HL = Human labour in hours/ha.

AR = Actual Rainfall (mm)

NR = Normal Rainfall (mm)

DFNR = Deviation from normal rainfall (mm. or %)

MAXTEMP = Mean maximum temperature during crop season (0C)

MINTEMP = Mean minimum temperature during crop season (0C)

The model was estimated for Rice and Jowar crops. The analysis was undertaken for the country as a whole, using state wise data for both these crops. The study was also undertaken using district wise data as well.

For Rice crop, the state of Orissa has been selected, because this is the main crop of the state. For Jowar, the state of Karnataka has been selected, because of it's significance in the region. Data on different variables for various states has been collected from the publications of Directorate of Economics and Statistics, Ministry of Agriculture, as well as from the Economics and Statistics Directorates of various states.

Similarly district-wise data has been primarily collected from the publications of these two state govts. Least square technique has been used to estimate different regression equations for the country as a whole as well as for both the states. Several forms of equations were analysed and results were computed. The analysis was done under usual assumptions.

It has been hypothesized that productivity of the selected crops is positively influenced by the application of chemical fertilizers and human labour.

These two are the main purchased inputs in the production of these crops. Climate, in the present model, has been approximated by rainfall – actual, normal as well as deviation from the normal.

Other variables representing the climatic factors are mean maximum and mean minimum temperature in crop growing period. This has been further hypothesized that extreme variations in these variables such as excessive rain or scanty rain and very high or low temperature would adversely affect the crop productivity in the selected states and districts for the selected crops.

Results and Discussion

In order to study the impact of climate change on productivity, regression equations were estimated using the model and data stipulated in the methodology.

As already mentioned, earlier various forms of functions were estimated and out of these, linear form provided the best fit and therefore, only linear regression equations have been presented for Rice and Jowar crops for the country as well as both the selected states.

For rice productivity and climate, using state-wise data for the country as a whole. Variable pertaining to fertilizer use, human labour, actual rainfall and temperature pertains to year 2000-01, whereas normal temperature consists of observations from a period of 30 years. Variation in the productivity of Rice. This implies that productivity of Rice on per hectare basis is influenced by these variables. Moreover, the fertilizer use variable had a highly significant coefficient, suggesting a significant impact of fertilizer use on productivity.

Surprisingly, the variables pertaining to actual rainfall and maximum temperature, during the growing period of the crop, had negative coefficient, implying that these two variables had negative impact on productivity.

The mean minimum temperature had a statistically significant and positive coefficient, implying that this variable would effect the productivity of Rice positively.

Estimated regression equations for Rice crop and climate related variables, using data from various districts of Orissa state. Similar to the earlier analysis, results pertaining to the linear regression have been presented.

The results indicate that the variable of fertilizer use, normal rainfall, minimum and maximum temperature could explain 28% of variation in Rice yield. When actual rainfall variable was replaced by the deviation in the rainfall from the normal, the value of R2 dropped down to 7 percent, implying that the actual rainfall had better explanatory power, than that of deviation in rainfall from normal. Results also indicated that mean maximum and minimum temperature could explain a larger part of variation in the Rice yield. Maximum temperature had a negative coefficient. It has implication that the increasing temperature would effect the productivity of Rice negatively, in the state.

The results indicated that the use of fertilizer variable has a negative impact on Jowar productivity, which is not correct on theoretical grounds. However, the human labour variable has a positive and statistically significant impact on Jowar productivity. The deviation from normal rainfall had negative impact on productivity. This implies that rainfall contributes significantly in raising productivity of Jowar, which is normally a rainfed crop.

The mean maximum temperature, during the growing season of the crop had a negative implication for the crop, while the minimum temperature, during the same period, would effect the crop productivity positively. The R2 in all five selected equations are good and it's value ranges between 40% to 52%.

The rainfall during the crop growth period has also negative coefficient. Whereas mean maximum temperature will effect the crop positively. The results indicate that the effect of climate related variables have mixed effects on productivity of Jowar, as rainfall shows negative impact, while maximum temperature has a positive effect. However, for understanding the real effect of these variables on productivity of Jowar crop, a detailed study is required.

8

Land Policy and Farm Management in Agriculture

INTRODUCTION

The land surface of the United States covers 2.3 billion acres. Private owners held 61 percent in 2002, the Federal Government 28 percent, State and local governments 9 percent, and Indian reservations 3 percent. Virtually all cropland is privately owned, as is three-fifths of grassland pasture and range and over half of forestland. Federal, State, and local government holdings consist primarily of forestland, rangeland, and other land. Most land in Federal ownership—largely in the West—is managed by the Department of the Interior (68 percent) and the Department of Agriculture (28 percent) (U.S. GSA, 2005).

Farm operators do not own all the land used in agriculture. According to the 1999 Agricultural Economics and Land Ownership Survey (AELOS), farmers held 58 percent of the land in farms in 1999 (USDA, 2001). These landowning farmers also made up 58 percent of the 3.4 million farmland owners.

Nonoperator landlords accounted for the remaining 42 percent of land in farms. Ninety-five percent of nonfarm landlords were individuals/families or partnerships. Of these unincorporated landlords, 55 percent were at least 65 years old. Many nonfarm landlords have a historic connection to farming. Among the people who have exited farming or inherited farmland since the number of farms peaked during the Great Depression, a number have retained ownership of some or all their land.

LAND POLICY

Land policy in India has been a major topic of government policy discussions since the time prior to Independence from British rule. The peasants of the country strongly backed the independence movement and the "Land to the Tiller" policy of the Congress Party because of the prevailing agrarian conditions. The agrarian structure during British administration emerged with a strong historical background (Baden Powel, 1974; Dutt, 1976; Appu, 1996). The land-revenue system implemented by Todar Mal during Akbar's regime can be traced as the possible beginning of systematic efforts to manage the land. This method incorporated measurement, classification and fixation of rent as its main components. Under the various pre- British regimes, land revenues collected by the state confirmed its right to land produce, and that it was the sole owner of the land. British rulers took a cue from this system and allowed the existence of noncultivating intermediaries. The existence of these parasitic intermediaries served as an economic instrument to extract high revenues (Dutt, 1947) as well as sustaining the political hold on the country. Thus at the time of Independence the agrarian structure was characterized by parasitic, rent-seeking intermediaries, different land revenue and ownership systems across regions, small numbers of land holders holding a large share of the land, a high density of tenant cultivators, many of whom had insecure tenancy, and exploitative production relations (Appu, 1996).

Immediately after Independence a Committee, under the Chairmanship of the late Shri J. C. Kumarappa (a senior Congress leader), was appointed to look into the problem of land. The Kumarappa Committee's report recommended comprehensive agrarian reform measures. India's land policy in the decades immediately following its independence was dominated by legislative efforts to address the problems identified by the Kumarappa Committee . A substantial volume of legislation was adopted, much of it flawed and little of it seriously implemented.

Several important issues confronted the policy-makers.

1. Land was concentrated in the hands of a few and there was a proliferation of intermediaries who had no vested interest in self-cultivation. Leasing out land was a common practice.
2. The tenancy contracts were expropriative in nature and tenant exploitation was ubiquitous.
3. Land records were in extremely bad shape giving rise to a mass of litigation. It is ironic that the Supreme Court of India in 1989 commented that the revenue records are not legal documents of title (Wadhwa, 1989). This is a sad commentary on the land records of the country.

It is against this background that land policy has been shaped in India. While land-reform legislation remained active, land policies in more recent decades have focused less on land reform and more on land development and administration.

Land policy in India has undergone broadly four phases since Independence.

1. The first and longest phase (1950 - 72) consisted of land reforms that included three major efforts: abolition of the intermediaries, tenancy reform, and the redistribution of land using land ceilings. The abolition of intermediaries was relatively successful, but tenancy reform and land ceilings met with less success.
2. The second phase (1972 - 85) shifted attention to bringing uncultivated land under cultivation.
3. The third phase (1985 - 95) increased attention towards water and soil conservation through the Watershed Development, Drought-Prone Area Development (DPAP) and Desert-Area Development Programmes (DADP). A central government Waste land Development Agency was established to focus on wasteland and degraded land. Some of the land policy from this phase continued beyond its final year.
4. The fourth and current phase of policy (1995 onwards) centres on debates about the necessity to continue with

land legislation and efforts to improve land revenue administration and, in particular, clarity in land records.

This paper is an attempt to discuss the critical issues pertaining to land policy in India beginning with the emergence of a post-Independence policy in a historical context, and from a viewpoint of differential provincial policies. Naturally, land reforms predominate the discussion here. Land reforms have been one of the important land policy initiatives in India that have brought a fundamental change in the entire approach towards development. The paper discusses the impact of land reforms and the changing phases of land administration. The focus is on the role and development process of land policy in India in the context of overall changes in India's development policies. It also addresses the political and economic aspects of the policy initiatives, beginning with the various land-reform efforts and finally analysing the recent land development and administration policies. The paper incorporates a discussion on the closely related goals of land policy, i.e. poverty elimination, conflict management, sustainable economic growth and good environmental management. In the final analysis, the paper highlights current issues pertaining to the relationships among land policy, poverty and the development initiatives.

EMERGENCE OF LAND POLICY IN INDIA

Given India's vastness, diversity and various political, economic and social influences from a history of various rulers and foreign conquerors, it is not surprising that land tenurial and administration practices varied significantly throughout the subcontinent at the time of Independence. One common factor was that land policies had been driven by the rulers' efforts to extract land revenue or tax from those working on the land. Throughout much of the country, the rulers appointed Zamindars, or tax collectors, who were contracted to collect land revenue for a given large territory and pay fixed sums to the government (but often extracted as much as they could from the landholders and pocketed the difference). Though tenurial conditions varied significantly from region to region, the numerous tenures could be classified under two broad categories - the Zamindari and Rayatwari systems. The Zamindari system was characterized by one or more layers of proprietary rights between the state and the actual landholder. In the Rayatwari (or peasant proprietorship) system, no intermediaries existed in design but emerged in the process.

The British rulers continued with existing land-revenue policies and procedures with a few but significant modifications. Perhaps most importantly, the British made the tax-collecting Zamindars into proprietors of the estates over which they had tax collection duties. This change was aimed at accomplishing two objectives: simplifying the land-revenue collection process and creating a rural elite with a vested interest in British rule. Unfortunately, it converted the erstwhile landowners into insecure tenants. Over time, many Zamindars assigned their land-revenue collection duties to one or more layers of intermediaries who were also given interests in the land. The historical emergence and perpetuation of intermediaries served the purpose of land revenue administration and political control of the successive rulers, but their numbers swelled. The large patches of land held by them were let to tenants at exorbitantly high rents. That created a disincentive among the tenant cultivators to develop the land, and consequently impacted upon production. Thus, the Colonial Government, out of its interest to administer the country effectively, did not make any substantial changes in the land-revenue system but promoted the class of non-cultivating intermediaries.

At the time of Independence, India faced a major challenge of setting right the agrarian structure as promised during the independence struggle. Thorner and Thorner (1961), in an analysis of the agrarian structure of India, vividly describe the pre-Independence structure as a complex of legal, economic and social relations - a multilayered structure that pulled down the production efficiency in the agricultural sector. A brief review of the literature also reveals a myriad of agrarian relations in India, varying from peasant proprietorship to a pure landlord - serf relationship. The first task placed before the first Indian parliament was to address land policy. Because India has a densely populated agrarian economy, almost all other developmental initiatives also involved land as a central and a complex issue, as it clearly represented social status and not just the means of production.

While recognizing the need to bring about land reforms in the country, the Constitution of India provided under Article 39 that: (1) the ownership and control of the material resources of the country should be so distributed as best to serve the common good; and (2) the operation of the economic system should not result in a concentration of wealth or a means to production to the common detriment.

The Constitution of India also made land a state (provincial) subject. So, only state (provincial) legislatures have the power to enact and implement land-reform laws. However, the central government played a significant advisory and financial role in land policy based on its constitutional role in social and economic planning (a role held concurrently with the states). The Government of India established a National Planning Commission immediately after Independence to fulfil this role of social and economic planning.

The Planning Commission has prepared a series of Five-Year Plans since 1951. Land policy has been one of the important components incorporated in all the plans. The policy statements are sometimes quite explicit in the plan documents, but are more often implicitly stated. An overview of changes in the land policy as reflected through the various plan documents. Land reform policy was spelt out in the First Five-Year Plan. The plan aimed to reduce disparities in income and wealth, to eliminate exploitation and to provide security to tenants, as well as to achieve social transformation through equality of status and an opportunity for different sections of the population to participate in development initiatives.

FARM MANAGEMENT

Farm management deals with the organisation & operation of a farm with the objective of maximizing profits from the farm business on a continuing basis. The farmer needs to adjust his farm organisation from year to year to keep abreast of changes in methods, price variability & resources available to him.

Thus farm management is the science which deals with the analysis of the farming resources, alternatives, choices & opportunities within the framework of resource restrictions & social & personal constraints of farming business. This complex information is integrated and synthesized to increase profitability of the farming business, the ultimate aim being to raise the standard of living of the farming people. This does not mean that farm management deals exclusively with the maximization of income; in fact, it takes into account the goals and objectives of the individual farmer, other than income maximization. Thus this discipline deals with people or organisers and decision-makers in respect of farms and agricultural production. It is people-oriented rather than crops or livestock per se.

Farm management is a decision-making science. It helps to decide about the basic course of action of the farming business. The basic decisions of the farming business are:

(a) What to produce or what combination of different enterprises to follow?

(b) How much to produce and what is the most profitable level of production?

(c) What should be the size of an individual enterprise, which, in turn, will determine the best overall size of the farm business?

(d) What methods of production (production practices or what type of quality of inputs and their combination) should be used?

(e) What and where to market?

LONG-TERM TRENDS AND AGRICULTURAL POLICIES

The Partition, both in India and in Pakistan. Total output growth rates turned from zero or little to significantly positive levels, which were sustained throughout the post-independence period; crop mix changed with increasing concentration since the mid 1950s.

Therefore, as far as the data suggest, agriculture in both countries has been experiencing one-way concentration of crops since the mid 1950s, when agricultural transformation in terms of output per agricultural worker was proceeding.

According to Timmer's (1997) stylization, this is a stage before a mature market economy with diversified production and consumption at the national level. Against our initial expectation, these trends were not reversed in the 1990s in the direction of more diversified production if we focus on major crops.

The trends were strengthened in India during the 1990s while they became less significant in Pakistan. The performance in the 1990s suggests that agriculture in India has remained in the phase of diversification where concentration into high value-added crops is strengthened.

To investigate the impact of institutional and policy changes in the 1990s, we compare major changes in political institutions compiled with long-term trends in production. The colonial period in the early twentieth century was associated with free trade of agricultural commodities. Under this institutional setting, public investment into irrigation contributed to the rapid expansion of production, especially in regions currently belonging to Pakistan. The colonial period ended with increasing state control on trade and marketing under the war pressure. This period was associated with stagnation in agricultural production.

THE BUSINESS SIDE OF FARMING

Farming as a Business

Farming has not usually been considered a business. The diversity of the duties of the farmer, the area over which the operations of the farm extend and the complexity of the records required, combine in making difficult the organization of the details of farming into business form. The successful financial operation of a farm presents quite as complex problems and calls for at least as much business ability and judgment as is required in operating a store with the same investment.

Farming, therefore, should be considered as a business, and the man who can produce his crops and products at the lowest cost and sell them at the highest price, investing the proceeds to the best advantage, should be considered the best farm manager. The man who knows the details of the cost of production and operation, and whose records show the profitable and unprofitable lines of production, thus enabling him to eliminate those that do not yield a profit, may be counted as the best business man.

A farmer should know the elements of soil fertility. He must understand the principles of the movement of soil water, and the action of soil bacteria. He should understand the nature of plant growth and be familiear with varieties and species of plants and with the effect of one crop on the crop following. He must also be familiar with animals and their habits and know how to feed and care for them. In addition, he must know how to buy and sell to advantage, make contracts, and plan his buildings and his farm so as to necessitate a light expenditure for labour, also that he may distribute his labour to advantage over the various farm enterprises. And he should know how to keep accounts. The farmer in organizing his business could well follow the example of the merchant. The merchant first takes an inventory of his stock. He studies the demand for his goods, both present and prospective. He notes the supply, the cost, and the demand for each article.

He calculates the labour required to operate his business and such other items of expense are considered as may be legitimately charged against the business. He regulates his purchases and his prices according to the cost of securing his goods and putting them on the market. In conducting a large store business, it is customary to organize it into departments, putting some competent person in charge of each department and having the labour and accounting charges so systematized and recorded as to show the profit or loss from each department and from the business as a whole.

The farmer should likewise take an inventory of his capital, stock, and equipment. He should consider the type of farming to which the soil and climate are adapted. He should consider the fertility of the soil and the demand that will be made upon it by the crops grown.

He should consider, in connection with the soil fertility, the sources from which it may be renewed and at what cost. He must study the markets, the transportation, and the demand for such crops as he grows; also the cost of producing each of the crops and the probable net profit that will be returned. His labour likewise should be charged against the various crops or enterprises and distributed to the best advantage.

In studying the problems of farm organizations, interest on investment, taxes, insurance, and other expense must be included as they affect the financial result. As in a large store business, it is frequently necessary to organize the large farm into departments, keeping accounts with the dairy, with the swine, the grain crops, the garden, and other similar enterprises. Where the business is large enough, it is well to put an expert in charge of each large branch or group of enterprises, thus enabling one to use cheaper labour for performing the work or making the labour more effective by closer supervision.

Where the farming is conducted as an organized business, and accounts are kept with the various lines of work, it is possible at the end of the year, to make a business statement which will show which lines have been profitable. The manager then can change his methods or drop out those lines that prove to be unprofitable and the business as a whole may be put on a better basis.

Investment

The investment of money in land, buildings, and equipment demands careful consideration. It is possible to pay so much for a farm that it will be impossible to produce sufficient revenue to meet the expense of operation and to pay a normal rate of interest on the money invested. This is particularly true where low-priced products are produced. A farm may be highly productive but so located that it will be impossible to market the produce on a profit bearing basis. One should study closely the market facilities of the neighbourhood and raise supplies which can be successfully marketed locally, or which can be transported to a market that pays well for such produce. Unless the produce of the farm is well related to the market, the farm is likely to be operated at a loss.

Proportion in Real Estate

It is a mistake for one to invest all of his capital in the real estate itself. Sufficient capital should be reserved for operating the farm. The hunger for land has induced many farmers to buy more land that they can equip and operate well. Such farmers are said to be land poor. They would secure greater profit from a medium sized farm, well tilled and managed, than from a large one which is insufficiently equipped and poorly operated. Rarely should more than 50 or 60 per cent of the capital be tied up in the land. The size of the farm and the amount of equipment are closely related to the possible profits. A farm of forty or eighty acres devoted to diversified crops and live stock, cannot be so economically equipped per acre as a larger farm. The investment per acre in machinery will be higher as the cost will be spread over fewer acres than the machinery has capacity to handle. Investment in other equipment will also be correspondingly high. Often the labour on such a farm is not fully employed and loss results from inactivity of labour and equipment. A medium to large sized farm, when well organized, fully equipped, and with sufficient capital reserved to operate it well, will pay a much better labour income than a small farm.

Proportion of Investment in Machinery

Investments in machinery are worthy of quite as much consideration as investments in land. Machinery is looked upon as one of the means of reducing the cost of production. The wise use of machinery saves time and labour and enables the farmer to handle large acreages. In this light, the use of ample machinery is wise. The fact remains, however, that investments in machinery are often poorly made and that many farmers are embarrassed by debts for machinery. Frequently, farmers purchase machinery because it is fashionable or because a neighbor has it, rather than because carefully made calculations show that a certain machine can be used profitably.

A safe rule is to buy no machine until carefully made calculations show that the cost of production of a certain crop or product will be reduced sufficiently by the purchase to cover the cost of the machine. That machinery investments can be studied from a business standpoint is quite plain. The following example, showing the relative cost of cutting corn with a machine versus cutting by hand, will illustrate:

The original cost of a corn binder is $125. The annual depreciation, as shown by statistical records covering ten years' work with farmers in Minnesota, is $12.50. The interest on the investment at the average value of the binder throughout its life will be $4.12. Repairs, shelter, and insurance will cost $2 annually. The total annual cost for the use of the binder, therefore, will be $18.62. If only twenty acres of corn are grown each year, the annual cost an acre for the corn binder will be $.93. The cost of cutting corn would be as follows:

It will be noted that a twenty-acre corn field can be more economically harvested by hand where labour is available. On a ten-acre field, the difference in expense would be still greater in favour of the hand harvesting, as the cost of machinery per acre would be doubled. The scarcity of labour, however, and the necessity of harvesting corn quickly to save it from frost, would often warrant the expenditure for the machine, even though it does slightly raise the cost of harvesting per acre. The greater the acreage, the more useful the machine becomes in harvesting, and the less the expense per acre for machinery use.

Calculations similar to this should be made before purchasing a machine for any purpose. If it can be shown that the cost of performing the labour may be reduced by the machine, and that the labour can be performed in a more satisfactory and efficient manner with the use of it, then the purchase may be warranted. In many cases, however, calculation will show that the purchase is not warranted and that it would be better to hire labour and rent the machine, or to buy in partnership with some one else.

Cost of Motive Power

Another factor that should receive consideration is the cost of motive power in use on the farm. Horses usually furnish the farm motive power, though tractors are used to advantage in some cases. Auto trucks and automobiles can often be used to advantage in marketing dairy, fruit and garden products and the cost of using them, when it can be ascertained, should be compared with the cost of horse power. It costs from $40 to $100 per year to keep a work horse, depending on the locality and on the price of feed stuffs; also on the work that the horse does.

The average cost a year of keeping a horse in Minnesota for the years 1904 to 1907, varied from $75.07 at Halstad, to $90.40 at Northfield.* Often a large number of horses are kept because the farm has been devoted to grain raising and the horses are needed at seeding and harvest times. They run in the pasture during the summer and are idle during the winter months. They must be fed and cared for during this time. The money invested in them would be drawing interest if invested somewhere else. Farmers should reduce the horses kept to the number actually required to do the work, unless the surplus are colts growing in value as one of the market products of the farm. The work of a farm can often be lessened by adopting a good crop rotation and using such crops as do not demand large amounts of horse labour at the same time. In this way a farm of 160 to 240 acres can often be worked with four to six horses, whereas eight to ten are frequently kept. The support of two or three extra horses per year would amount to $200 to $250 and is an item well worth saving.

Investment in Buildings

Investment in buildings, fences, and other items of equipment should be considered in the same business-like way. A barn costing $4,000 and providing shelter for forty head of cattle would carry with it an annual cost of $440. This annual cost is made up from the interest on the investment, insurance, depreciation, paint, and repairs. It will be about 11 per cent on the total investment. If the same forty cattle could be housed in a barn costing $2000 the total annual cost would be only $220, charging the same interest and expense rates as in the first instance, and assuming that the rate of depreciation would be the same. While the $4000 barn would undoubtedly be a better barn, it would not add to the production of the cows housed, unless it was much more comfortable. It would not add to the net profit from the investment unless the labour of doing the chores and caring for the cows would be considerably reduced by greater convenience. The cost of horse barns, swine barns, and other buildings can be similarly calculated. One should not erect a building unless it is going to add to the efficiency of the live stock, shelter hay or machinery, or lessen the labour of doing the chores. It is wiser to invest money in drainage or in better tillage of the soil, than to invest it in buildings that shelter unproductive stock, or that add nothing to the earning power of the farm.

Cost of Labour

The employment, organization and direction of labour demands considerable study. The value of a good farm manager lies quite as much in his abilitiy so to select and direct labour as to yield a profit, as it does in his ability to drive a good bargain or sell his crops well. The only reason for employing labour is to increase the product and consequent profit. If a farmer can, by employing a man eight months in the year at $40 per month, increase the product of his farm by $500, he will be warranted in employing the labour. If, however, the $320 invested in labour should yield an increase of only $200 in the products of the farm, employment would be at a loss.

The Factors of Production

Three primary factors are necessary in agricultural production. These are capital, land, and labour. The adjustment of these three factors is an important part of the business of the farm owner or manager, and determines largely the profits that may be made from the individual farm.

Capital, as commonly understood, includes the money value represented in the investment of the farm property, no matter what the form may be. Implements, live stock, teams, buildings, and other articles of equipment, are each a part of the capital of the farm. Cash for operating is also included.

Land represents the larger part of capital on most farms, and demands special consideration because the amount of land available for agricultural purposes is limited. Farmers have for this reason, regarded it wise to secure large quantities in localities where it was cheap, anticipating a rise in value. Location and demand for land in particular sections has led to much speculation, and land values fluctuate frequently.

The proportionate investment in each of the three forms,—circulating capital, land, and labour—bears a vital relation to the profits possible from the farm, and must be given the most careful consideration by the person who is buying and equipping a farm.

Capital Classified

There are two forms of capital in common use. They are known as fixed or invested capital, and circulating or working capital. The fixed capital properly includes all forms of permanent equipment, such as investment in land, buildings, implements, teams, and other articles that are used continuously. In land it includes the natural value and the value of the improvements that have been made upon it.

Picking stones from a rough section of land adds to its value and increases the capital invested. Clearing trees from the land has the same effect. Wells, drainage, roads, fences, and other forms of improvement which are permanent and which become part of the land, also add to the natural value and become a part of the fixed capital.

Buildings also are looked upon as part of the fixed capital. Strictly speaking, only those buildings which add to the producing power of the farm should be included in the capital invested in the farm. The dwelling house, while commonly added to the investment in the farm, is really intended for the personal use of the farmer and his family. Except in so far as it shelters the help employed on the farm, it can add but little to the returns from it. So far as making a statement of the business of the farm is concerned, it would be better were the farm-house inventoried separately from the other buildings and regarded as a personal expense to the farmer, just as the house of the banker in the city is separated from the business of the bank. All other buildings including silos, corn cribs, granaries, and buildings for sheltering the stock and necessary in conducting the farm business, should be included in the inventoried capital of the farm. Equipment in the way of teams for work purposes; implements; live stock, such as cows, brood sows, sheep and poultry, that are kept for live stock products, are all a part of the permanent equipment, since they are permanently employed and if sold are replaced by other animals for the same purpose. The circulating or working capital, includes such items of equipment as are frequently changing.

Seed grain, household and farm supplies that are immediately used or marketed, live stock, such as fattening steers, and money for hired labour, are examples of circulating capital. The classificiation intends that the term "circulating capital" shall include only those items that are used once and disappear. If sold for cash, the cash may be invested in other forms of working capital which in turn disappear. Needless to say, the amount of working or circulating capital varies greatly in accordance with the type of business done, with the market, and with the tastes of the farmer. No rule can be given for the exact adjustment of capital for these reasons.

ACCENT ON EMPOWERING THE SMALL FARMERS

Contributions of small holders in securing food for growing population have increased considerably even though they are most insecure and vulnerable group in the society. The off-farm and non-farm employment opportunities can play an important role. Against expectation under the liberalized scenario, the non-agricultural employment in rural areas has not improved. Greater emphasis needs to be placed on non-farm employment and appropriate budgetary allocations and rural credit through banking systems should be in place to promote appropriate rural enterprises. Specific human resource and skill development programmes to train them will make them better decision-makers and highly productive. Human resource development for increasing productivity of these small holders should get high priority. Thus, knowledge and skill development of rural people both in agriculture and non-agriculture sectors is essential for achieving economic and social goals. A careful balance will therefore need to be maintained between the agricultural and non-agricultural employment and farm and non-farm economy, as the two sectors are closely inter-connected.

Raising agricultural productivity requires continuing investments in human resource development, agricultural research and development, improved information and extension, market, roads and related infrastructure development and efficient small-scale, farmer-controlled irrigation technologies, and custom hiring services. Such investments would give small farmers the options and flexibility to adjust and respond to market conditions.

For poor farm-households whose major endowment is its labour force, economic growth with equity will give increased entitlement by offering favourable markets for its products and more employment opportunities. Economic growth if not managed suitably, can lead to growing inequalities. Agrarian reforms to alleviate unequal access to land, compounded by unequal access to water, credit, knowledge and markets, have not only rectified income distribution but also resulted in sharp increases in productivity and hence need to be adopted widely. Further, targeted measures that not only address the immediate food and health care requirements of disadvantaged groups, but also provide them with developmental means, like access to inputs, infrastructure, services and most important, education should be taken.

Identification of need-based productive programs is very critical, which can be explored through characterisation of production environment. We have to develop demand-driven and location-specific programs to meet the requirements of different regions to meet the nutritional security of most vulnerable population in the rural areas. Improved agricultural technology, irrigation, livestock sector and literacy will be most important instruments for improving the nutritional security of the farm-households. Watershed development and water saving techniques will have far reaching implications in increasing agricultural production and raising calorie intake in the rainfed areas. Livestock sector should receive high priority with multiple objectives of diversifying agriculture, raising income and meeting the nutritional security of the poor farm households.

Need based and location-specific community programs, which promise to raise nutritional security, should be identified and effectively implemented. Expansion of micro credit programmes for income-generation activities, innovative approaches to promote family planning and providing primary health services to people and livestock and education should enhance labour productivity and adoption of new technologies.

Development of the post-harvest sector, co-operatives, roads, education, and research and development should be an investment priority. A congenial policy environment is needed to enable smaller holders to take the advantage of available techniques of production, which can generate more incomes and employment in villages.

For this poor farmer needs the support of necessary services in the form of backward and forward linkages. Small-mechanised tools, which minimise drudgery and do not reduce employment, but only add value to the working hours are needed to enhance labour productivity.

Special safety nets should be designed and implemented for them. Can agricultural co-operatives internalise and galvanize these marginal and excluded people? Off-farm employment provided through co-operatives will go a long way in pulling them out of the state where poverty breeds poverty. Therefore, investment in the empowerment of the small landholders will pay off handsomely.

Let us create rural centres of production and processing by masses through co-operatives or empowerment of Gram Panchayats to promote co-operatives. This will improve efficiency of input and output marketing and give higher income. There is need to disseminate widely post-harvest handling and agro-processing and value addition technologies not only to reduce the heavy post-harvest losses but also improve quality through proper storage, packaging, handling and transport. Panchayati Raj institutions and co-operatives can play significant role in all these directions. Giving them power over the administration, as contemplated under the 73rd and 74th Amendment of the Constitution has not been implemented seriously so far in any of the states.

Disaster Management

The frequency and intensity of disasters such as floods, droughts, cyclones and earthquakes have increased in the recent years. The devastating earthquake in Gujarat has brought untold miseries to the whole state and caused a national disaster. Special effort should be made to develop appropriate technologies for increasing preparedness to predict and to manage the disasters. Effective and reliable information and communication systems, contingency planning and national and international mobilization of technologies and resources are a must. Experiences of other countries in prevention and management of the disasters should be shared.

Keeping Pace with Globalisation

The globalization of agricultural trade will bring to the fore access to markets; new opportunities for employment and income generation; productivity gains and increased flow of investments into sustainable agriculture and rural development. I believe that if managed well, the liberalization of agricultural markets will be beneficial to developing countries in the long run, It will force the adoption of new technologies, shift production functions upwards and attract new capital into the deprived sector. However, this will only come to pass if we are mindful of the interests of billions of small and subsistence oriented farmers, fisher folk and forest dwellers in the short and medium tern.

So far the magic of globalization has not been felt in India. During the past one-decade of liberalization certain trends such as deceleration of the growth rate of agricultural GDP, declaration in yield growth rates, and low non-agricultural employment have emerged against expectations. As we globalize, however, it is imperative that we do not forget social aspirations for a more just, equitable and sustainable way of life. Trade agreements must be accompanied by operationally effective measures to ease the adjustment process for a small farmer in developing countries.

Exploiting Cyberspace

Information is power and will underpin future progress and prosperity. Efforts must be made to strengthen the informatics in agriculture by developing new databases, linking databases with international databases and adding value to information to facilitate decision making at various levels.

Development of production models for various agro ecological regimes to forecast the, production potential should assume greater importance. Using the remote sensing and GIS technologies, natural and other agricultural resource should be mapped at micro and macro levels and effectively used for land and water use planning as well as agricultural forecasting, market intelligence and e business, contingency planning- and prediction of disease and pest incidences.

RELATION OF LIVE STOCK TO FARM MANAGEMENT

Live Stock and Soil Fertility

The opinion commonly prevails that live stock raising helps to maintain the fertility of the soil. This is true only under certain conditions. An oats crop yielding 50 bushels per acre will require from the soil 50 pounds of nitrogen, 18 pounds of phosphoric acid, 45 pounds of potash, besides small amounts of numerous other elements.* If the grain is sold and the straw is burned, the entire amount may truly be said to be removed form the soil.

If the grain is fed to cows, the milk or butter-fat sold, and the straw used for bedding, but the manure is allowed to remain in the yard or barn, just as much fertility is removed form the land as though the crop was sold and the straw burned. However, if in feeding the grain and using the straw for bedding, care is taken to save all of the manure an dlitter, returning it to the fields from which the crop came, there will be little loss of fertility.

It is very difficult to prevent some loss through decomposition, evaporation, or leeching. There may also be much or little loss from mechanical sources. This will depend upon the methods employed in getting the manure to the field. The loss from all of these sources varies from forty to sixty per cent. About three fourths of the fertility contained in the feed is recovered in the manure as it comes from the animals. This may all be returned to the field where leeching and mechanical losses are prevented. On most farms, nearly half of the fertilizing value of the feed is lost before the manure is returned to the field.

The animals through which the foods pass add nothing to the fertilizing qualities of the manure. The food stuffs if returned directly to the field upon which they grow, would quite as well maintain the fertility of the soil. In case of the growth of certain of the crops, as clover and alfalfa, the fertility may even be increased through the addition of nitrogen which these plants have the power to gather from the air in the soil.

The mastication and digestion of the food stuffs by animals, however, renders available more quickly the fertilizing elements of the plants. It is this factor which is largely accountable for the belief that the process of mastication and digestion has added to the fertilizing value of the food stuffs. Animal manures without question are one of the best possible sources for maintaining soil fertility, but the farmer should recognize the fact that to get their full value, he must prevent all mechanical and chemical losses and that they must be distributed evenly over the farm and incorporated with the soil.

How to Save the Manure

So far as possible, the best way of saving the manure and preventing loss of fertilizing elements, is to haul it from the barns as made, directly to the fields, spreading it at once and incorporating it with the soil. Besides saving the fertilizing value of the manure, this method of application has the added advantage of economizing labour as well. It requires no more time to throw the manure directly into a manure spreader or wagon, than to wheel it out of the door and throw it in a pile, which must later be loaded and hauled to the field. Less labour is required than where the manure is loaded into a wagon and hauled to a compost heap from which it must again be loaded into a wagon or manure spreader and taken to the field.

It is not possible on many farms to haul manure from the barn directly to the fold throughout the year. Growing crops frequently interfere during the summer season at least, and the other work of the farm often prevents. In the North, snow and hard freezing weather make it difficult to operate the manure spreader in the winter time.

The manure can be hauled on a wagon or sleigh and spread by hand, but it is at the expense of uniformity of application. Manure so applied should be spread after the frost leaves in the spring.

This may be don by spreading out the thick places with a fork or by going over the field with a spring tooth or smoothing harrow. Whenever land is available, however, upon which to spread the manure, it should be taken directly from the barns or yards to the fields and spread evenly and ratherthinly as hauled.

In many places the practice prevails of hauling manure to the fields and unloading in half load to load piles.

It is allowed to stand in these piles during the winter and is then spread by hand in the spring. Nearly as much loss occurs from decomposition and leaching where manure is handled in this manner, as where it is allowed to lie in piles under the eaves of the barn.

The labour of applying is also increased and the fertilizing value is not uniformly distributed. Where manure cannot be hauled directly to the fields, it should be spread out evenly over a level yard and the stock allowed to run over it, tramping it firmly.

If the yard can have a concrete bottom there will be less loss from leaching than where it lies on open ground. In the East where the barn-yard manures are highly valued, manure pits are made and frequently covered with a roof.

If the manure from all classes of animals can be mixed together in such a yard, or pit the loss from heating and evaporation will be very much lessened. In countries where the population is very dense and all of the manure must be saved, cisterns are made in which the liquid excrement may be collected. The liquid is pumped into tanks and hauled to the fields. Cement pits are also constructed in which both solid and liquid excrement are collected for decomposition. Such systems avoid the loss of fertilizing elements but are epensive.

Live Stock Consumes Unsalable Products

On most farms, large quantities of cheap rough foods are grown for which there is no market or which cannot be transported to market profitably. Straw from the various grains, corn stover, corn fodder, ensilage, and grass aftermath are examples of this class of food stuffs.

Many farms contain a portion of rough land which is difficult to till. This land often makes desirable pasture and can be made to return something of profit to the farm by the use of live stock. The cheapest foods are those on which little labour is expended in growing.

The cheapest way to feed foods is to let the animals gather them themselves. Pasture, even on comparatively expensive land, is one of the cheaptest animal foods that can be provided. It is the natural food of most classes of live stock and naturally adapted to their needs.

As a consequence, they gain rapidly on it or yield a large amount of product, if protected from annoying storms and insects. It rquires but little labour to provide pastures for live stock. When a good sod has been formed all that is necessary is to maintain the fences, keep out the weeds, and dress up the thin spots. The amount of labour is much less than would be required to grow a crop and harvest it for hay or forage. The silo fills an important place in providing cheap forage for live stock. Corn and other bulky, heavy yielding crops are preserved in very palatable and digestible form without waste by running them through an ensilage cutter and storing them in a silo. Silage is especially desirable for feeding dairy cows. It is also a valuable food for beef cattle and sheep. It is by making use of cheap forage and pasture that the farmer can hope to support large quantities of live stock, which by being stabled and yarded in the winter, will enable him to provide manure for the land that is not pastured.

Profits come from Cheap Crops

Investigations of cost of production indicate that the greatest profit from live stock is made where the animals are fed on these cheap foods. Where chickens, pigs, or cattle are fed on highly concentrated marketable products, it has been possible to make but very littleprofit. Where chickens are confined in close yards they have frequently been handled at a loss.

On farms where they are allowed to run in the barnyards and through the fields, picking the larger part of their living, a flock of fifty to one hundred chickens appear to cost nothing for feed. This is because they exist on natural foods that would otherwise be wasted.

Likewise, the farmers who have provided good grass or annual pasture for their brood sows and pigs, or who have allowed them to run in the fields gathering their own forage during the summer months, and who have finished them by turning them into a corn field allowing them to pull down and harvest their own feed, have made good profits at hog raising. Those who have confined their hogs in close yards, have expended labour in mixing feed and carrying it to them, and in husking corn and feeding it to them in small dry lots, have seldom made large profits.

It is commonly believed that dairying is a profitable business. This opinion is due to the fact that the farmers who have a few cows seem to have better crops and appear to have more money than those who do not raise cows.

An analysis of the business shows, however, that the main income from the farm in many cases is not made from the cows, but comes from some grain crop or other product.

The cows do add to the profits of the farm by utilizing the cheap feeds and converting them into a concentrated salable market product. Most of the dairy product of the United States is made by low grade cows in which little money is invested, feeding on coarse feeds from which no returns would be made otherwise. It is the conversion of this material into a market product which makes the cows popular and profitable to the average farmer.

On a farm of 160 acres, four horses ordinarily would be required to do the work. The time of these horses would be so fully occupied that it would not be wise to undertake to raise colts from any of them. By adding another horse it would be possible to raise colts from two of them and still do the work of the farm. The work mare will do as much work as a gelding if she does not raise a colt. She will do nearly as much when required to raise a colt, but will not last so long if required to work full time. For this reason it is good policy to allow some leisure time just previous to and shortly after foaling. Colts raised by farm work mares offer a reasonable source of profit to most farmers.

In planning for the crops to be used as food for live stock, it is well to consider not only yields but feeding values as well. An acre of corn will yield 12 tons of ensilage which will contain approximately 3600 pounds of digestible nutrients.

An acre of timothy yielding 2 tons would contain only 1700 pounds of digestible nutrients, of which about 110 pounds is protein. An acre of clover yielding 2 1/2 tons of hay would contain 2300 or more pounds of digestible nutrients; 350 pounds of this would be protein. Alfalfa yielding 4 tons per acre, would give 4100 or 4200 pounds of digestible nutrients, of which 840 pounds or more will be protein.

These nutrients will not all be produced at the same cost, however. An acre of hay of any kind can be produced at a much lower cost than an acre of ensilage.

The labour cost of providing the foods must be considered as well as the value of the nutrients yielded by the various crops. It costs about $5.60 to produce an acre of timothy hay and $20.60 to produce and store an acre of ensilage.

The food nutrients in hay would, therefore, cost only 3.29 cents a pound, while the nutrient in the ensilage would cost 5.72 cents. The succulence of the ensilage gives it a greater feeding value than is shown by the analysis, however, and it will be found a most profitable food for the classes of animals called ruminants.

It should be borne in mind that the one who feeds salable grain, such as wheat, corn, and oats, to live stock, is in competition with the farmers who raise their stock on grass, corn fodder, ensilage, and other cheap waste products of the farm. To compete successfully with them, the quality oproduct must be higher or more must be produced for the same value in feed. For this reason, those who feed large numbers of animals on high priced grain, usually raise pure bred stock which has a breeding value as well as a market value for product produced. In this way a margin of profit may be secured above the cost of the feed.

Live Stock Provides Employment for Cheap Labour

On most farms there are children old enough to perform some light labour. They can often be profitably employed in caring for the poultry, sheep or other live stock. In many cases most of the milking is done by the farmer's wife and children. They are not paid wages for doing the work and the product secured from the expenditure of their labour is nearly clear gain, as they must be fed and clothed whether they work or not.

Likewise, where two or three cows apiece are milked by the hired man after a full day's work in the field, the product is secured at a low cost so far as labour is concerned. It is because live stock raisers are thus able to give employment to otherwise nonproductive labour or to labour that is not fully employed, that they often make larger farm incomes than those who raise hay or grain only. A small amount of live stock can be cared for without appreciably reducing the amount of labour available.

Live stock raisers who have children old enough to work, are thus placed at an advantage over live stock raisers who must hire all labour used. While farmers do not always realize the facts in the case, it is true that most of the profits from live stock raising are derived from these two sources: (1) A conversion into concentrated marketable products of cheap bulky foods that would otherwise be wasted; (2) By the use of labour that does not have full value but which must be supported, whether employed or not. The margin of profit is seldom large but the income on a stock and grain farm is less likely to fluctuate than where grain raising only is followed.

Kind of Live Stock to Keep

The kind of live stock to keep depends upon several factors. It has not yet been proven that one kind of live stock is more profitable than another. Some men make excellent profits in raising horses while others fail. There are many farmers who make generous labour incomes from keeping dairy cows, but the average cow barely pays for the feed consumed and the interest on the investment and the labour cost of caring for her. A few farmers have become rich from raising beef cattle, or raising hogs or sheep, but in all of these cases it is the man and methods of management, not the particular kind of stock that are responsible for the profit.

The tastes of the individual farmer are an important factor in the decision. A man who does not like cows and who "hates" to milk will do better in some other line of stock raising than dairying, though he may learn to love the cow and overcome his dislike for milking if he finds a good profit in doing it. The man who "loves" a horse and dislikes a pig is more likely to make a profit on horse raising than on pig feeding.

The size of the farm must also be considered. As a rule, small animals go with small farms. A twenty-acre farm may be well adapted to poultry raising and would do fairly well for a small number of pigs or sheep, if well farmed.

It would not be at all adapted to dairying, stock feeding, or horse raising, as too large a proportion of the feed would need to be bought. Pasutre and rough feed could not be supplied and labour in caring for the stock would be expensive on account of close confinement. While a few horses or cows might be kept, it would be impossible to build up a big business on so small a farm.

Surveys of typical farming areas indicate that it commonly requires three to five acres of good arable land to support a horse. Two and on-half to three acres will be required to support a cow. Three-fourths of an acre to one and one-fourth acres for a hog, and one-fourth to one-half acre to support a sheep. Consequently, on a farm of 160 acres, 32 to 53 horses would be the maximum number that could be kept if all other live stock was excluded and all of the land devoted to growing horses. Few farms are so intensively stocked. A combination of two or more kinds of stock will usually be made.

Market demands and shipping facilities must also be considered in deciding what kind of stock to keep on a certain farm. Live stock products are concentrated and easily shipped if transportation is rapid and frequent. Milk and cream are perishable, however, and must be marketed daily or at least every other day. Eggs also may deteriorate in reaching market if shipping facilities aroor. Live animals may be shipped long distances but are subject to heavy shrinkage or loss by accident or death. Freight charges and care while on the road must also be covered. Short distances are most favorable for live stock shipment. Grain and other imperishable products may more safely be shipped long distances.

The amount of capital to invest often determines the kind of stock that should be kept. Usually a farman be more cheaply stocke with the small animals than with the large ones. There is also need of considering, in connection with the investment, the length of time which must elapse before returns will come in. In this respect the advantage lies with the cows, as the milk and butter-fat are immediately available for sale. With sheep, the lamb or wool crop is likely to mature within six months. The returns from hogs can rarely be realized short of six or eight months, while in horse raising, the colt crop is not mature for market inside of three years, though younger colts are often sold. Better prices can be secured, however, when they are over, rather than under, three years of age.

Limitations in Stock Raising

There are certain limitations to each kind of stock raising which should be considered also. The number of colts raised should be determined by the number of mares that can be profitably employed on the farm. Horses must be raised as an adjunct to other lines; unless they are, the first cost of the colts is too great. It costs from $60 to $100 per year to keep a mare and unless she performs some labour, the colt will not be valuable enough when a year old to meet the charge for keeping the mare. On the range or on very cheap land, the cost may be reduced and colts profitably raised, even though the mares are not worked. On the arable farms, the first cost of a colt including stallion fees, can be reduced to $50 if the mare is required to perform a reasonable amount of work.

The number of dairy cows that can be kept is limited by the amount of pasture that can be furnished or of roughage grown. It is not profitable to buy or ship roughage. Milkmen located near favourable markets may be able to produce milk at a profit, even though the rough feed must be shipped, but when applied to the business as a whole, it cannot profitably be done. Another factor which limits the number of dairy cows that can be kept is labour. One man cannot feed and cere for more than ten to twelve cows, as not more than that number can be milked in the time usually available for milking. Some other farm work can always be profitably combined with darirying. It is because the labour is better distributed, that the farmer who grows some crops and keeps some cows, makes a better profit than the one who conducts either line alone.

Beef cattle raising is limited by the amount of grazing land. The business cannot be conducted on small areas. Cheap pasture and forage are essential to secure profits. Beef cattle raising must not be confused with stock feeding which can profitably be carried on, on small areas of land, provided the proper feed can be purchased. One man can care for 50 to 60 head of beef cattle. Large numbers must be kept together to reduce the cost of care. They are best adapted to large farms or to the ranges.

Sheep raising cannot be conducted on low wet land. Foot-rot and other diseases are sure to attack them on such land. They require high land and dry quarters. Pasture and cheap roughage are essential. They do not do well in close confinement except for short periods. If kept in close quarters they are likely to be infested with vermin and to become infected with parasic diseases. The best profits will be made on a few sheep kept as scavengers on a diversified farm.

It has been customary in the past to keep swine in close quarters. They require large quantitites of concentrates, but can use profitably good clover, alfalfa, or rape pasture. These crops are especially valuable for raising small pigs. The number that can be kept is determined by the amount of concentrated food that can be grown and the amount of pasture furnished. Swine are subject to cholera, swine plague, and other diseases, and should not be herded in large numbers.

Pure Bred vs. Grade Stock

Pure bred stock is often advised. For productive purposes it is doubtful whether pedigreed animals are any better than those without pedigree. Grades of the right conformation and descending from families of heavy producers will yield as great a profit for the market product as pure bred stock. The great advantage of pure bred stock is the guaranty that they do come from good families. This gives them a breeding value which can often be sold to advantage.

To be worth more than grade stock, they must come from highly productive families and attention should be given to keep them up to a high standard. When one can combine good breeding value with large production of market commodities at a low cost, the profits can be greatly increased. It is for this reason that pure bred stock raising can be made to pay large profits. If market products alone are desired, grades may be kept quite profitably.

When is a Farm Well Stocked

It is difficult to tell when a farm is fully stocked, or to know whether one farm is carrying as much live stock as another one. It is especially difficult to compare a farm on which horse raising is the main line of live stock, with one on which hogs and cattle may be kept. G. F. Warren, of Cornell University, New York, offers a basis for comparing the amount of livestock kept. This comparison is made on the basis of feed required and value of manures produced.

The figures will vary somewhat as one farmer may feed more heavily than another, but it is believed that the figures offered are fairly exact and that satisfactory comparisons can be made. For the purpose of comparison, one cow, bull, steer or horse, two years old or older, is called an animal unit. Two head of colts or young cattle are counted as a unit.

Seven sheep, fourteen lambs, five hogs, ten pigs, and 100 hens may each be called an animal unit. On a farm having six horses, two colts, twelve cows, eight young stock, six brood sows, thirty pigs, twenty sheep, and 100 chickens, there would be approximately thirty-two animal units. On a 160-acre farm, this would be one animal unit for each five acres of land. This is considered a fair proportion. By counting the number of animals on other farms and reducing them to animal units, a comparison may be made to determine which farm is stocked more heavily. The knowledge is valuable also in determining how much manure can be supplied and how often an application can be made to the fields.

FARM NUMBERS, FARM TYPES, AND CONSERVATION PROGRAMS

The number of farms has declined dramatically since its peak of 6.8 million in 1935, with most of the decline occurring during the 1940s, 1950s, and 1960s. The decline in farm numbers has levelled off since the 1970s. By 2002, 2.1 million farms remained. The remaining farms have a much larger average acreage, but averages mask differences among farms. Today's farms range from very small retirement and residential farms to industrialized operations with sales in the millions. Part of this diversity stems from the very low sales threshold ($1,000) necessary for an operation to qualify as a farm for statistical purposes.

One way to address the diversity of farms is to categorize them into more homogeneous groups. The farm typology developed by ERS identifies five groups of small family farms (sales less than $250,000): limited-resource, retirement, residential/ lifestyle, farming-occupation/low-sales, and farming-occupation/ high-sales. The typology also includes large family farms, very large family farms, and nonfamily farms. In addition, very small farms (sales less than $10,000) make up more than half of all farms. Very small farms account for a particularly large share of farms in the limited-resource (72 percent), retirement (76 percent), and residential/lifestyle (76 percent) groups. Production, however, is concentrated among larger farms; small farms account for only 27 percent of the total value of production.

The smallness of most farms has implications for conservation and the environment. An ERS study found that smaller corn farms are less likely to use conservation tillage than are larger farms. The practice is more practical for larger farms because they have more acres over which to spread the cost of new or retrofitted equipment necessary to adopt conservation tillage. Small farms whose operators are retired or farm part-time are also less likely to adopt conservation tillage, possibly because of hesitancy to change familiar production practices. Small farms, however, participate widely in the Conservation Reserve Program (CRP) and the Wetlands Reserve Program (WRP).

9

Technology Development and Delivery System in Agriculture

INTRODUCTION

Owing to globalization and liberalization, agriculture in India need to change and change for better than the best. Diversification of production is fast happening along with widespread dietary evolution. Commodity based production is giving way to system based production and there is a paradigm shift using farming system to production to consortium system of operation. Private sector participation is increasing. Agriculture is becoming more and more knowledge-intensive and market-driven. Hence for more innovative research, efficient policies and effective delivery of services, supplies and markets are imperative. Agriculture is no more closed and protected, but globalized and open.

THE CHALLENGES

Against the anticipated annual growth rate of 4% plus, the agricultural sector grew only at 2% p.a. during the X Plan. National Commission on Farmers in its 3 rd Report suggests attention to soil health care, water harvesting and management, credit and insurance, quality and safety, technology and inputs and farmer-friendly marketing in order to help our hard working farm families to help the country achieve 4% plus growth rate in agriculture.

Suggesting to measure progress in agriculture by the growth rate in the net income against the current measure of physical production of foodgrains and other farm commodities, the NCF recommended review and reform of the service, support, research, extension and input supply and market system. The suggestions of the mid-term review of X Plan by the Planning Commission are not much different. Thus, to achieve a growth rate of 4% plus p.a. in agriculture as well as to serve framers and save farming from increasing distress, a new model for technology development and delivery system in agriculture is necessary.

The Role of R&D in agriculture

Since Science and Technology are the drivers of change, the agricultural revival / renewal has to be basically knowledge-intensive, technology led and resource based. Stagnating productivity growth in the sector and declining total factor productivity in agriculture are major challenges to meet the needs of a market-driven, competitive regime. In this context, R&D assumes more importance because it is a cost-effective method for promoting sustainability and attaining competitiveness. Harnessing advances in frontiers of science in selected priority areas with larger spin-off benefits by focusing on basic and strategic research also assumes significance. There is also a need to revisit the existing public extension system which is considered to have been weakened over the years at the state, districts and block levels. Hence, there is a serious search for alternatives to the present public agricultural extension system in the country.

REENVISIONING EXTENSION SYSTEM

The main extension system primarily responsible for delivery of technical messages is operated by the State Department of Agriculture (DOA), through the state, district and block level machinery. Other state governments departments, such as Animal Husbandry, Horticulture, Soil and Water Conservation, and Fishery have been providing very limited extension services. The main focus of the Departments of Animal Husbandry has been treatment of animals and for the Departments of Horticulture, distribution of seeds/seedlings (of fruit and vegetables) is the prime activity. While the Department of Soil and Water Conservation are mainly engaged in constructing soil and water conservation structures, the Departments of Fisheries is mainly engaged in providing fingerlings and some financial support to Fish Farmer Development Associations. The research centres and agricultural universities play a very limited role in extension service.

The system, however is more pre-occupied with implementation of a number of central and state sector schemes having input/subsidy delivery. The performance of the main extension system has been adversely affected by the difficulty in recruiting and retaining extension staff due to budgetary constraints, depleting operational support and inadequate technical background of the majority of the staff commensurate to the changing scenario of agriculture, resulting in the dependence of farmers on input dealers and others, as sources of information. Their role in technology up-scaling has been minimal and even non-existing. Through Centrally Sponsored Scheme on Support to State Extension Programmes for Extension Reforms, Agricultural Technology Management Agency (ATMA) has been established in 252 districts so far. The ATMAs are expected to support the state extension system by making it more broad-based and participatory for planning, implementing and monitoring the extension activities of a district.

Diversified nature of farming demands, against a background of the economic liberalization and globalization, is radically changing the spectrum of service providers to the farmers. Indeed, the private sector, farmers' organizations, cooperatives, self-help-groups, Para-professionals, non-governmental organizations, input suppliers and small agri-businesses are increasingly engaged in providing information and services. Increased reliance on private sector extension does not imply a complete withdrawal of the public sector, which must continue to finance public goods extension and information services and coordinate extension activities.

In view of the above, the basic concept of extension needs to be re-looked from persuasive technology transfer originally conceived, to the model of interdependence within specific innovation system framework of the stakeholders and institutional context based on the strengths of both public and private sector.

The Approach Perspective

The models for technology development and delivery system in various sectors of agriculture is essentially indicative of a pluralistic environment right from research institutions engaged in technology development, up scaling and integration of technology, and its adoption by the end users. The models can be modified as per the need for various states and districts for appropriate multi-agency extension arrangement with the state, district, block and village level functionaries of various development departments, including the farmers' organizations and the private sector. While in floriculture, there is an emphasis on quality production of cut and dry flowers with appropriate institutional arrangement for cold chain and collection centres; in dairying the emphasis is on the institutional arrangement for availability of progeny tested semen/ bulls, complete balanced feeds, shelter management, diagnostics, vaccines and drugs, post-harvest processing and value addition. Similarly, the emphasis in aquaculture is on establishment of Aquashops with cold chain and collection centres; there is need for formulation of location and commodity specific packages of tools and equipment and its availability through entrepreneurship development for manufacture and supply of those to the farmers at an affordable price or on custom hire service. There is a need for promotion of agro-processing centres in rural sector/ production catchments for value addition of agricultural produce including technological back-up support. The participatory resource management will be the key to watershed management. The pluralistic extension pattern requires that the programmes are jointly planned, implemented and evaluated by all service providers.

Unified Production System Approach

The activities of different agencies from technology development to its dissemination at the user level need to be unified. For example, once the production and protection technology of high yielding varieties / improved parental lines and hybrids are developed, its dissemination needs to be initiated through frontline demonstrations by the technology development institutions, and the mini kit testing of technology by the development departments, ensuring quality seed of improved variety/hybrid to each Village Panchayat in the region for which the variety is recommended/released. Breeder seed production and test stock seed production for Panchayats must be simultaneous to cut short the time lag and ensure demand for seed by the time breeder seed is converted to certified seed and it is ready for distribution.

The demonstration plot seed in each Village Panchayat of inbred variety would also move from farmer to farmer in each of the villages. Simultaneously, there is need for integrated programmes for production of breeder, foundation and certified seed by seed producing agencies including the production of parental lines for hybrid seed production, supported by marketing, transport, storage, credit and policy environment. Similarly, with the development of appropriate varieties, production technologies, post harvest technology for quality production of cut and dry flowers, the support for packaging and wholesale market/agencies for export is imperative. In aquaculture, along with aquashops for increased production, there is need for unification of processing plants and marketing both for domestic and export.

Knowledge Centric Approach

In knowledge-driven development, there is need for providing extension education keeping in view their diverse needs not only on production procedures, but also quality certification and reporting procedures, grading, packaging, storage, transportation and other requirements of both domestic and export markets. The farmers need to have knowledge about the whole range of agri-business, production systems, research institutions, programmes and schemes of the development departments, open markets both at domestic and global scale, and other unlimited partners is to be provided through training, demonstration, literature, and other human resources development support including interfaces at different levels. The development of Information Communication Technology (ICT) and Telecommunication Network have paved the way for creation of information network, knowledge pool and services on new agricultural technology, products and marketing of produce, which must be intensively used. It will be appropriate to develop farmer-friendly information network to provide whole range of information leading to delivery of knowledge of new agricultural technology, products, procedures, and related services to enable them to take control of their farming environment in near future.

Research-Extension-Farmer Interface

The strategy for technology development and the strategy for technology dissemination are not mutually exclusive. Agricultural extension is a process of bringing about innovation and change. There is an inherent degree of overlap among them; however, the fundamental point is that they are potentially useful in joint assessment, diagnosis, planning, implementation, monitoring and evaluation. The models presented in various sub sectors of agriculture have made it clear that research and extension are part of a continuum. While research-extension linkages were theoretically possible in inter-personal mode, in the new regime, effective linkages of production systems with marketing, agro-processing and other value added activities have acquired greater importance. In the present competitive environment, the research and extension service must be reoriented to overcome the exclusive focus on production that ignored market demand, profitability and institutional arrangement in the past.

Although a variety of farmers' organizations including cooperatives, farmers' club/self-help groups, and farmers' companies has been promoted in the past, there is lack of sustainability of their existence and the purpose for which they were promoted. These farmers' organizations need to be looked as a kind of business federation for undertaking primary processing and marketing of local products and to facilitate much needed organizational support for effective implementation of quality control and standardization of farm products.

The new mechanisms and protocol suggested for technology development and delivery system for various sectors of agriculture would need spatial and functional integration and complementarities and institutional arrangements in the context of creating an environment to encourage and assimilate results of innovativeness.

There is need for introducing MBO based agenda and clear delineation of task components in the form of assembly line and also creating coherent synergy within and amongst state development departments, SAUs, ICAR institutes and all related functionaries. This would require policy support in terms of integration of efforts of institutions dealing with technology development, assessment and refinement, and dissemination including encouraging and accepting the contribution of corporate sectors, private sectors, cooperatives and farmers' associations in delivery systems.

Growth of Agriculture both in terms of GDP and livelihood security with social equity has been ever challenging and more so in the present context of inadequate public sector investment and services, and pressure of globalization of agriculture leading to a greater demand for highly knowledge-intensive services. Investments in present Indian agriculture need to be rationalized and appropriate knowledge driven institutional reforms have to be brought in. Appropriate framework for technology development and dissemination would be very much needed for transforming Indian agriculture from the present approach of its sustenance as a way of life to a vibrant economic activity with a sense of pride for future generations.

AGRICULTURAL DEVELOPMENT STRATEGIES

The lack of development in African countries has caused their economies to fall further and further behind those of the leading industrial nations. Many different development strategies have been tried. Some African countries have successfully encouraged investment in mining, tourism and industry. In agriculture, producers have been encouraged to move away from subsistence farming towards a more commercial approach as governments realised that income generated from the sale of surplus production could be used to improve productivity.

Agricultural development in ECA has faced an uphill struggle for the last twenty years. In an effort to stimulate development many countries borrowed heavily from bodies such as the IMF and from the commercial banking sector. These loans were not granted without strings attached, however. Most African countries were obliged to liberalise their economies by adopting significant policy changes often applied in packages known as Structural Adjustment Programmes (SAPs). These programmes included a number of elements but generally included requirement to:

- devalue the currency (to discourage imports and make exports more competitive),
- to make the currency freely convertible with other currencies,
- to cut public expenditure (in order to lower taxes),
- to dismantle state controlled marketing boards,
- to privatise state-owned industries (to raise capital and stimulate competition),
- to cut import restrictions (to encourage local industries to become more efficient),
- to allow foreign companies to freely repatriate profits (to encourage inward investment),
- and to boost exports.

The economists who designed SAPs were convinced that the only way African countries could transform their economies was to encourage inward investment and earn foreign exchange to invest in infrastructure and lay the foundations for industrialisation. These measures assumed that any country could compete in the world market if production and investment was concentrated in areas where they were deemed to have a competitive advantage. The only activity in which ECA nations could be said to have a competitive advantage in the world market was in the production of agricultural products and the exploitation of natural resources such as forestry, fishing and mining. The major flaw in this strategy was that similar advice was given to almost all tropical countries at the same time. Coffee-producing countries were encouraged to boost coffee production; sugar producers should produce more sugar, and so on. This resulted in over-production of these commodities which caused prices to plunge in the international markets. On average, current prices of tropical products (taking dollar inflation into account) are only about one seventh of those prevailing in 1980 (UN General Assembly). Economists call this phenomenon the fallacy of composition - less income is earned as more commodities are produced.

Another component of SAPs which many observers believe to have been counter-productive was the requirement to cut public expenditure. All too often this meant a cut in health programmes, education and agricultural extension. These measures have tended to reduce, rather than enhance the flexibility of the workforce and to curtail agricultural development. Overall, the record of inward investment has been poor and the ending of currency controls has increased opportunities for transfer pricing abuse (where companies over-price imports and under-price exports to reduce tax liability).

The most important SAP reform affecting the distribution of agricultural products has been the dismantling of state-controlled marketing boards and the practice of setting fixed purchasing and sales prices for commodities. It was assumed that government control of markets had obscured the forces of competition in supply and demand in the economy. A free market system would unleash these forces and increase productivity. It would force producers to meet the demands of consumers both in price and quality. Farmers would be able to buy inputs cheaper from competing suppliers, and the country, as a whole, would become more competitive in world markets.

Unfortunately, competitive and transparent markets did not emerge spontaneously (Shepherd). Most African farmers have too little land to produce truck-loads of goods and they are widely dispersed over the countryside. There is not enough business to encourage more than one trader to operate in many areas. Farmers have no means of communicating with the outside world or even the nearest town and they are often unwilling to risk the investment of bringing their goods to market resulting in considerable waste. Laws may have been passed which ban collusion among traders to pay low prices to farmers and charge high prices to consumers, but there are often insufficient resources to enforce such laws. Most traders have no experience of free market conditions and are reluctant to put their fellow traders out of business with serious competition.

Advocates of SAPs point to examples of countries that have improved their economies after adopting SAPs (World Bank) but there are few in Africa. Most ECA countries were not able to implement SAPs until relatively recently but rates of poverty have increased in many of these countries. Intense conflict, both within and between countries of the region, drought, desertification and, now HIV/AIDS have further weakened economic development in ECA. Most critics of the reform process, however, acknowledge that markets in African countries must be made more competitive and SAPs are designed to do that but this process may take a considerable time.

Trade Agreements

Economic links between ECA countries and their former colonial rulers have been maintained since independence. The economies of these countries have been moulded to meet the needs of their European counterpart for a hundred years or more and it would have been difficult for them to make the necessary changes in production patterns to trade successfully with other countries. The Europeans too needed to maintain supplies of raw materials and export markets in Africa and to protect the business of their trading companies.

In 1975 all ten countries covered by this study became party to the Lomé Convention. The Convention established trade, aid and cultural relationships between 15 European countries and 71 so called ACP (African, Caribbean and Pacific) countries which had either been colonies of, or had had strong historical links with, Europe. This agreement did not rule out bilateral or multilateral agreements with other countries but did give ACP countries preferential access to European markets. ECA countries have also decided to try to stimulate regional trade by bringing their economies closer together in regional economic agreements such as COMESA and SADC.

East Africans have exchanged goods and ideas with many other peoples of the world for millennia. In these exchanges of goods, cultural links have been established which have influenced ECA life at all levels – in religion, the arts, public sector structures, the economy and agriculture. In the last decade or two, however, this process has accelerated tremendously. There is no agreed definition of globalisation. It is simply a term which has been used recently to describe the impact of innovations in communication and transport systems on trade and the growing interdependence of nations due to economic sophistication and burgeoning output. In addition, high levels of protection between trading blocks of countries are breaking down as barriers to trade are reduced. These changes have made it possible to increase the volume of trade between countries in agricultural products.

It became clear that overall levels of trade could be increased if trade barriers were reduced, where there was agreement to do so, and that international trade should be governed by mutually agreed rules. The most active trading nations have been keen to find new markets for their goods and to reduce the barriers to free trade. These countries, however, have been reluctant to expose their own markets to foreign competition, especially unfair competition from subsidised or sub-standard goods.

At the international level, global liberalisation was stimulated by the General Agreement on Tariffs and Trade (GATT) which was first implemented in 1948 as a mechanism to promote free and fair trade among member countries. Several rounds of negotiations of trade rules have occurred throughout the history of GATT. The Uruguay Round, which began in 1986, was the eighth of the GATT rounds. In April 1994, officials from more than 100 countries gathered in Marrakech, Morocco to sign the Uruguay Agreement and to confer the role of further trade reforms on the newly established World Trade Organisation. The reform process is by no means complete. Almost all countries have now committed themselves to the objectives associated with their membership of the WTO. (6 out of the 10 countries covered in this study are WTO members). In order to meet these objectives, countries are obliged to further reform their existing internal economic and external trade policies. The future of trade and agriculture in ECA is inextricably linked to the rate and direction of these reforms.

A CRITIQUE OF THE EXISTING AGRICULTURAL RESEARCH AND EXTENSION SYSTEM

We have a good network of agricultural research institutions in the country, which is facing serious resource crunch to meet the existing and emerging challenges. The National Agricultural Research System (NARS) has although significantly contributed to the agricultural progress since independence, but the situation has changed and challenges foreseen in future are complex and the system has to prioritize and focus itself to the jobs for which it has a mandate as also competitive advantage. A clear-cut delineation of roles at the Central and State level is to be defined. Similarly, the technology delivery system requires an immediate re-look. Technology development and delivery need to be in a continuum and should be interactive. The research system has to forge linkages with the public extension system at all levels, particularly at the district and below levels where the actual uptake and impact happens. It is resolved to establish one KVK in each of the rural Districts of the country by the end of the Tenth Plan. ATMA model is developed and tested in 28 Districts of the country under NATP and now as a successful model is replicated in 252 districts of the country as a plan programme of Department of Agriculture and Cooperation.

Keeping in view the needed change in technology development and delivery system discussed earlier, at the same time utilizing the existing system, a framework for technology development and delivery is suggested. It is realized that far greater emphasis on basic and strategic research is essential in pursuit of effective technology development. With the new tools and techniques available now, it is possible what was considered impossible in the past *viz*., with the new tools, designer genotypes could be developed as indicated sequentially by Prof. V.L.Chopra, Member, Planning Commission, in the flow diagram.

Suggested Framework

In the proposed Framework for Technology Development and Delivery System, it is envisaged that basic and strategic research will be substantially carried out by the ICAR institutes, while region-specific strategic research will be done by SAUs and AICRPs. The strategic research of AICRPs will also feed other areas of the country and a generic model for the purpose is presented and the working of this generic model in some selected representative individual sectors / cases is illustrated through. Applied and adaptive research will substantially be carried out by the SAUs and AICRPs where location, situation and system-specific technology generation, testing and refinement will take place. In this task, private sector involvement will be mutually beneficial. As regards private sector research, proprietary technologies can directly go to farmers and others as per agreements/understanding, can also flow to SAUs/ATMAs for integration.

Technology transfer will be through ATMAs (registered societies) located at the district and bodies at district-subsidiary levels. It is a focal point for integrating research and extension complemented with development supplies and services. ATMA is a tested platform where all service providers will converge and share their strengths. It is an interactive backstopping system supported by research system, service providers like line departments, involvement of PRIs, NGOs, etc. ATMAs will decide on the kind of technologies to be transferred through which agencies. For example, if the technologies are commercial in nature, they will be transferred through private sector. If they are not commercial in nature, the help of NGOs or other civil society organizations will be sought with needed incentives. Knowledge empowerment of the whole system (research and technology transfer) will be through the proposed ICAR portal which is interactive.

Knowledge management includes HRD, policy, and national and international perspective related information and products.

Training to extension functionaries will be provided by State Agricultural Management & Extension Training Institute. At the block level, there will be a Farm Information and Advisory Centre (FIAC) which is an extension planning and operational arm of ATMA. It would have two bodies, *viz*., Farmer Advisory Committee (FAC) and Block Technology Team (BTT). FAC would review Block action plan, prioritize the activities and provide feedback. With high connectivity in terms of computers, Internet, telephone, etc., it would be linked to KVKs, ZRSs, SAUs, etc. BTT would consist of Block officers representing different Departments.

At the village level, there will be Farmer Interest Groups (FIGs) and Farmers Organization (FOs). The FIGs are informal, voluntary and self-governing associations of farmers and farm women, while FOs are federations of FIGs, mandated to support the cause and activities of member FIGs.

POST HARVEST TECHNOLOGY

Post harvest technologies are commodity and location-specific and appropriate basic and strategic research inputs including varietal characteristics of a particular crop, post harvest physiology, nutritional physiology, food biochemistry, and post harvest ecology are assessed before the intended products and processes could be developed by the ICAR institutes, SAUs and IITs.

These research inputs are essential for developing products, processes and ultimately design of pilot plants. Based on the assessment of market response and consumer acceptance, standardization of product, process and equipment is undertaken to ensure the quality and safety of the output. These developments are then evaluated and demonstrated in different locations for the entrepreneurs, NGOs, self-help groups, and cooperatives for large scale promotion and adoption of the post-harvest technologies. Banks, State Development Departments and other agencies are given the exposure for enabling them to extend necessary financial support. Figure 8 provides the linkages of different activities of technology development and delivery and actors in the form of a flow chart.

Rainfed Farming through Watershed Management

The productivity of rainfed areas occupying 60 per cent of cultivated area in the country and supporting 59 per cent of population is still low and is a major concern of policy makers, planners and R&D investments portfolio. Even after achieving the full irrigation potential, nearly 50 percent of cultivated area will remain rainfed, constituting an important source of food and livelihood.

Therefore, integrated and holistic development of rainfed areas within the perspective of watershed management constitutes one of the key elements of increased production in the country. There is a need to develop appropriate technology to remove the production constraints of these areas and establish an effective system for the dissemination of the technology to the farmers.

The research back up concerning basic and strategic issues would be provided by the ICAR Institutes, SAUs and related National Institutes. Research is required to be focused on run-off and recharge modelling, soil-water-plant interactions, water harvesting, *in situ* moisture conservation, integrated nutrient and pest management, contingent crop planning during droughts and drip / sprinkler / fertigation systems. The socio-economic-environmental-market imperatives should be given due consideration while framing up technologies.

The technology generated is required to be further assessed and refined for different agro-climatic situations through AICRPs and SAUs and disseminated through State Development Departments (Agriculture, Horticulture, Animal Husbandry, and Forestry), ATMAs, KVKs, SAUs, SHGs, NGOs, Cooperatives and web-based Agro-advisory Services. The financial institutions like NABARD would need to provide financial support for development of infrastructure like water harvesting ponds and pressurized irrigation systems.

The cooperatives and contracting / leasing agencies could be associated in agro-forestry / bio-fuel plantations. The activities and functioning of the watersheds need to be in a participatory mode, ensuring transparency and equitable sharing of services and benefits among different stakeholders. The participatory watershed management will be facilitated through formation of watershed associations (Pani Panchayats, Van Panchayats, and Joint Forest Management Committees). The technological interventions would have deliverables in terms of water conservation, increased land productivity, enhanced employment, livelihood security, equitable sharing of benefits, and empowerment of women, environmental upkeep and better quality of life.

INTEGRATED FARMING SYSTEMS

Development and adoption of integrated farming system provides high opportunities of productivity enhancement, employment, income generation and nutritional security by diversifying and integrating different components of farming, *viz.* crops, horticulture, livestock and fisheries (depending upon location specificity). The systems based on multiple recycling of carbon, energy and nutrients would also help minimize environmental loading with pollutants. The different components of the system have complementarities with waste products of one component becoming source of food and energy for another.

The researchable issues encompassing analysis of nutrient and energy fluxes among system components, path analysis of bio-physical constraints, multiple uses of water, water harvesting and recycling, socio-economic conditions of people, internalization of ITK and market analysis, etc. are to be addressed through basic and strategic research by ICAR institutes and SAUs. The integrated technology would be developed integrating crops, horticulture, fisheries & livestock by ICAR Research Complexes having R&D facilities on different system components at SAUs.

Further assessment and refinement of developed farming systems to cater to region and location specific requirements would be accomplished through centres of AICRPs on Cropping/Farming System Research and SAUs. The technology would be disseminated through KVKs, SAUs, NGOs, SHGs, etc. with true participation of ATMAs and different functionaries of State Line Departments (Agriculture, Horticulture, Animal Husbandry, Fishery) at district and block levels. The backward and forward linkages between

KVKs and state functionaries would provide the required feedback to SAUs and ICAR institutes on upgradation of technology. The KVKs would organize regular trainings on different aspects of technology to extension personnel and various stakeholders.

Establishment of Agri-India Knowledge Portal-A Single Electronic Gateway

The information on improving agricultural productivity and protection of crops, livestock and natural resources from damages caused by disasters and unsustainable activities is focal to the rural farming communities. This would require access to a wide range of information on new technologies, alternate varieties of crops, improved breeds of livestock, information related to soil, water quality, information on pesticides, farm implements, animal health, weather and other related aspects. Besides farm-activities, non-farm activities also constitute sources of income and livelihood for the rural farmers. Therefore information is also required on the means to produce food products required by markets and ability to sell them as also the markets, cold-chains, warehouses, processing and other avenue.

ICAR-ERNET network consists of 274 Institutions including National Agriculture Institutes, State Agricultural Universities including some of their colleges and Research stations, National Research Centres, Project Directorates connected through Leased line and VSATs. Besides, a VSAT-based network of Krishi Vigyan Kendras could be had. Both these networks will be linked through a high capacity leased line to make a unified high speed secured Intranet. Since the intranet of NARS institutions is built over the existing ERNET network, it is planned to host the core components of knowledge portal application at the ERNET Hub.

The Department of Telecommunications has set up several sub-groups on network expansion, broadband, telecom equipment manufacturing and R&D to examine various options to enhance growth. The sub group on network expansion has targeted that subscribers numbers must cross 250 million by 2007 and 500 million by 2010. Another target is mobile coverage of 85% of the country by the end of 2007. To boost the broadband penetration in the country, another sub-group will examine the ways to provide broadband coverage for all panchayats by 2010 and all secondary/ higher secondary schools and public health care centres by 2007. The Portal application will be constructed and deployed using suitable Portal management software. The core functional components of the portal application software are:

User Registration: The user registration process is a mechanism for acquiring the information related with the user of portal which is an integral part of the portal.

User Authentication: The user ID and the password pair generated as end result of registration process are authenticated through a carefully designed mechanism and form a basis for accessing the various resources of a portal.

User Access Control: Once the users are authenticated, an access control mechanism built into the portal determines which data and information can they see/manipulate, and how will it be displayed? The User Access Control mechanism is designed based upon the specific role that the particular user will perform in the portal.

Personalization: Personalization is a feature that enables a user to access targeted web content that meets a user's needs and preferences from the enormous web content on the portal.

Content and Document Management: Content and document management system in the portal application streamline redundant content development, publishing and management processes to increase operational efficiencies, and improve content quality.

Document/workflow: The various rules to manage the workflow and lifecycle of documents are established in a portal, which automates the manual, labor-intensive process and results in consistency and auditability in authoring and producing content.

Collaboration: The portal applications facilitate collaboration among the various stakeholders/ partners via online chat rooms, discussion groups, online document sharing, messenger applications, etc. The digital content of the portal will be developed through a peer review process. For this purpose, 15 Content

Accreditation Centres, i.e. one each in the 15 Agro-climatic regions of the country could be had. Each accreditation centre will coordinate with other SAUs and agricultural institutions in their region for development of content in regional language as well as in English and also do its validation, which will be collected in the central data warehouse integrated in the knowledge portal.

The intranet network consisting of various stakeholders primarily ICAR institutes, SAUs and KVKs will facilitate the development of Central Agriculture Data warehouse, Content Development and Validation System, Agricultural Best Practices, Expert System for users, Multi-lingual content development and convertibility. The portal will also serve as a platform for facilitation of interaction among researchers and extension workers in KVKs through high speed secure intranet.

Various applications and services of the knowledge portal will be accessible to the users including farmers, entrepreneurs, private sector organizations, other participating government and non-government organizations, extension workers, etc. through Internet. The services include Agro-met advisory services, Market intelligence, Packages of practices, Agri-business consultancy, e-learning, knowledge on indigenous farming practices, and agriculture related FAQs. Besides, it will also act as information gateway for all agriculture related schemes and programmes etc. The Portal will also serve as a gateway for up-to-date websites of various agricultural research and education organizations accessed through Internet. The portal will provide a platform for facilitation of interaction among the end user communities through Internet also.

The Agri-India Knowledge portal will also provide for collaboration among other agencies related with agriculture like Meteorological Dept, Agricultural Markets, Banks and other financial organization, Input suppliers, Agricultural equipment manufacturers, Non-agricultural universities for providing services through Agri-India knowledge portal both through secure and high speed Intranet and Internet. The services proposed to be implemented in the collaborated mode include On-line education, Information on Market Prices, Weather Information including early warning system, Agricultural Input status information, Credit and crop insurance services, land record information, etc. The AIK Portal is neither intended to replace any agency websites nor any other government portal. This Portal will, however, provide additional means by which those sites might be accessed by a possibly wider and more varied client base. The AIK Portal will open opportunities for multiple agencies to participate in web delivery and development opportunities. The Portal would be able to integrate diverse interaction channels at a central point, providing a comprehensive context and an aggregated views across all information related to agriculture including *know-what* or declarative knowledge, *know-how* or procedural knowledge, and *know-why* or usual knowledge and *creation of new knowledge*.

IMPROVED AGRICULTURAL TECHNOLOGY

There has been much concern over the possibility that improved crop varieties are associated with increased output instability in addition to higher yields. If this is the case, it could deter adoption of more productive technology and hence retard agricultural development.

Instability at the Farm Level

In discussions of farmers' adoption of HYVs, it is often assumed that new seeds have more volatile yields. Indigenous landraces often have the characteristic of being fairly unresponsive to improved management and increased inputs, but also robust in the face of unfavorable agroclimatic conditions, such as drought. HYVs, on the other hand, often are characterized as being highly responsive to management and inputs, but very low yielding in the event of bad weather. If this is the case, then plant breeders must breed on the basis of one strategy (high average yield) for high potential areas and another (risk minimization) for low potential areas.

Research on pearl millet, which is commonly grown in unfavorable agroclimatic areas, suggests that the above characterization of traditional varieties and HYVs is not necessarily correct. Witcombe (1989), in a study of Pakistan and India, found that good performance of a particular millet seed over all environments appears to indicate good performance in environments of low potential. In three years out of his four year study, the highest yielding entry across all environments was also one of the two highest yielding entries in the lowest yielding environment. These results suggest that the typical plant breeder's strategy of selecting among the highest yielding seeds across all environments is satisfactory. Farmers who adopt HYVs do not necessarily subject themselves to greater risk of catastrophic loss in the event of bad weather.

Farmers' Strategies to Reduce and Cope with Risk. Walker and Jodha (1986) point out that dryland farmers have various methods to reduce their exposure to crop production risk. Cultural practices play an important risk-reducing role; they include planting different crops with relatively low covariate yield (either in an intercrop or on separate fields); diversifying spatially by operating multiple plots with different environmental characteristics; and staggering planting dates in the face of variable rainfall patterns. Sharecropping is a common tenancy arrangement that distributes risk between the tenant and landlord. Many farmers have multiple sources of income, reducing risk if they have low covariation.

Farmers also have various mechanisms to cope with risk that they cannot eliminate. For example, they can borrow from local stores or money lenders, draw down food stocks or savings, sell assets, obtain transfers from relatives, participate in government relief programs, or migrate. Most of these options are not particularly desirable; for especially poor people they can be quite devastating: selling assets or going into debt may make a family permanently worse off even after drought is over. Jodha (198_) indicates that some families will reduce their food consumption as much as possible before parting with their assets; this has obvious negative short term health implications that are particularly severe for those who consume only minimum requirements to begin with.

Effect of Risk on Technology Adoption. While weather-related risk undoubtedly presents great hardship for a very large number of people, Walker (1989b) indicated that it may not be as important as generally believed in adoption of new technologies in rainfed areas.

The tradeoff between expected income and the variance of that income suggests that given farmers' measured risk preferences, the overall effect on adoption decisions is modest. Also, Walker stressed that yield instability does not translate into major variability in income due to farmers' mechanisms to absorb risk. As mentioned above, multiple sources of income and diverse cropping patterns mean that yield variability of one crop only affects a portion of the income from crops. Equally important, in many cases farmers can adjust the area under each crop depending on the weather at the start of the season. For example, dryland rabi (postrainy season) sorghum farmers in black soil areas know at the start of the season how much moisture is available and adjust their cropped area accordingly. Similarly, castor farmers in Andhra Pradesh know that pest attacks are more prevalent when the rainy season begins late, so they plant less castor. And farmers with irrigation from tanks or wells know roughly how much water will be available in the postrainy season, so they adjust planted area accordingly. Hazell and Ramasamy (1991), for example, found that sharply reduced paddy production in North Arcot, Tamil Nadu, in the drought year 1982-83 resulted from a fall in area, not yield. Not surprisingly, Walker (1989b) also found that variations in cultivated area This is why SWC programs are sometimes referred to as "drought-proofing" measures.

exceeded those in yield. He also found that given farmers' diversified farming and livelihood strategies, the large variations in yield translated into only small variations in income. The variations were so small that even if plant breeders could develop varieties with perfect stability (zero variation), the contribution to household income stability would amount to less than 1% for most of the crops studied, and a maximum of 2.9% for paddy (which, paradoxically, had the least yield variability to begin with).

Walker's (1989b) results demonstrate the importance of looking beyond yield variability of a single crop to variations in all the crops in a given household, village or region, and beyond crop variation to income variation. From this perspective, yield instability does not appear to be a major determinant of adoption, and hence not a top priority for plant breeders. He pointed out (in his 1989a study) that policies related to international trade and storage between surplus and deficit years can be more cost-effective in coping with increasing yield instability.

Soil and water conservation (SWC) investments also are associated with a variety of risks. First, erosion itself is a matter of risk. For example, some plots may be at risk of productivity loss from continuous, gradual erosion, but others may be more susceptible to significant erosion only in the event of a once-in-five-years or once-in-fifty-years storm. For such lands, in normal years there is no gain from investments to reduce erosion, but in exceptional years the gain — actually the avoided loss — may be quite high. Second, often SWC practices serve to conserve soil moisture as well as reduce erosion. Soil moisture retention is more likely to offer immediate, productivity-increasing benefits than erosion prevention. However, these benefits may exceed the costs only when rainfall is unusually low or unevenly distributed, so that moisture stress constrains productivity.12 In a good rainfall year, on the other hand, short term gross returns to increased moisture retention may be low or zero, and in a very high rainfall year they may even be negative if they lead to waterlogging. Little information is available regarding the impact of risk on Indian farmers' SWC investments.

Instability at the Aggregate Level

Ramakrishna (1993) used a log function to calculate CVs to compare instability of production, yield and area cultivated for cereals between the pre-green revolution and green revolution periods. Ramakrishna found that for food grains, output was more stable during the green revolution than before. Yields were about equally stable between the two periods, and area became more stable. For other crops, on the other hand, Ramakrishna found that output and yield instability both increased during the green revolution, while area again became more stable. Combining food grains and other crops, output and yield instability increased slightly during the green revolution, while area instability was constant. On the whole, Ramakrishna's data suggest that the green revolution had little impact on agricultural instability.

Hanumantha Rao (1994) took a slightly different approach and found different results. Instead of taking CVs of output levels, he took the standard deviation of annual output growth rates as a measure of instability. He found that the standard deviation of output growth of food grains was 8.1 in 1950-51 but 11.4 between 1968-85, and took this to indicate that output instability increased with the green revolution. He also found that the standard deviation rose from 9.4 in the first decade of the green revolution to 11.8 in the second decade. Hanumantha Rao did not provide detailed figures regarding yield and area instability. His figures do not really offer a good comparison to those of Ramakrishna, because his pre-green revolution figures are based only on a single year. Also, it is difficult to compare the magnitude of Hanumantha Rao's figures (expressed as the standard deviation of output growth rates) to Ramakrishna's (expressed as the CV of the level of output). Since we do not know the growth rates from which Hanumantha Rao calculated the standard deviation, we cannot relate his standard deviations to Ramakrishna's CVs. Hazell (1982) examined cereal crop production between 1954-55 and 1964-65 (before the green revolution) and 1967-68 and 1977-78 (during the green revolution, after the introduction of high yielding varieties).13 He found that the CV of production increased by about 50%, from 0.04 to 0.059 between the two periods. Hazell hypothesized that if the increased instability were due to HYVs, variances in production within states would have to rise. However, he found that changes in yield covariances were much more important than changes in yield variances. Only about 18 percent of the increase in variance of total cereal production resulted from changes in crop production variances; the remaining 82 percent was explained by changes in covariances; interstate covariances within crops contributed 41 percent to the change in variance in total cereal production. As a result, Hazell concluded that HYVs were probably not the primary cause of increased variability. In a later paper, Hazell (1984) suggested that HYVs could possibly affect yield covariances of maize in India and the United States, because the narrower genetic base of improved varieties would make them susceptible to common yield inhibitors such as pests and diseases. This would then be a contributing factor to greater variability in national ceral production.

Walker (1989a) studied changes in yield and output variability of sorghum and pearl millet in India resulting from the spread of HYVs. This study followed Hazell's 1984 study relating the rising covariance of yields between states to the spread of HYVs; it used districtlevel data for the 48 largest sorghum districts and the 40 largest pearl millet districts. Walker found that variability had indeed increased significantly between the period 1956-57 to 1967-68 and 1968-69 to 1979-80, from 8% to 16% for sorghum and 11% to 34% for pearl millet. He also found that covariance of yields across districts was by far the most important factor in overall output variance of sorghum and pearl millet. Walker examined several possible causes of increased covariance, including 1) changes in rainfall covariance, 2) changes in irrigated area, and 3) adoption of HYVs. He found evidence that provided weak support for each of these possible sources of covariance. However, he also stressed that the contribution of HYVs to increased instability is dwarfed by their contribution to productivity, so he did not recommend changes in existing breeding strategies that develop HYVs for adoption over a large area.

Walker's (1989a) study helps clarify that numerous factors can contribute to changes in stability. Researchers who find that stability increased or decreased with the green revolution should hesitate before proclaiming that HYVs were the cause. Changes in cropping patterns, fluctuations in weather, and the quality of land on which a particular crop tends to be planted all can have an impact on the variations in yield. More importantly, variations in area may either counteract or reinforce those in yield; it is important to know the composition of output fluctuations between yield and area variations. The studies by Hazell and Walker also highlight the need to distinguish between variability at the regional or national levels from farm or field level risks. Because of the dominance of covariance relations in aggregate production data, variability can increase at the aggregate level even while farm level variability changes little or not at all. Although diets were stable, health problems increased due to a shortage of clean drinking water in the village resulting from the drought.

TECHNOLOGY DEVELOPMENT AND DELIVERY SYSTEM IN VARIOUS SECTORS OF AGRICULTURE

In different models, linkages will vary depending upon the nature of crop/ commodity/enterprise and technology service in involving relevant stakeholders to a specific technology-enabled zone/area/situation.

Such linkages will not only boost the production and productivity but also will create an enabling environment for job opportunities, rural marketing economy and export opportunities. Some sector-specific models for technology development and delivery system in crop, horticulture, livestock, fishery, farm mechanization, processing and value addition, and natural resources management have been described. Knowledge drives development, and today, investment in knowledge development is becoming more and more important along with investment in capital development.

The farmers need to connect with agri-business, production systems, research institutions, public administration, other farmers, open market both at domestic and global scale, and other numerous partners. Conventional systems of dissemination of farm information through face-to-face communication by the development functionaries, providing information in the form of printed publications, organizing agricultural exhibitions, etc. are becoming limiting propositions. A model of 'Agri-India Knowledge Portal' to serve as a single electronic gateway for providing information to all those engaged in the task of development of agriculture has also been described subsequently.

Development of High Yielding Seeds

Development of improved varieties and hybrids and availability of their quality seed is the most vital and critical input for increasing the productivity of crops. Appropriate seed ensures its suitability for adoption in specified agro-ecologies. It also ensures its acceptability for consumer quality preferences, trade and industry suitability for various products for domestic and international markets. There is a tremendous diversity of crops and agro-ecologies in the country. The Breeders, Geneticists, Plant Pathologists, Physiologists, Biotechnologists and others are engaged to work on basic, strategic and applied aspects in order to develop quality seed and associated production and protection technologies in various institutes / Directorates/National Research Centres (NRCs), All India Coordinated Research Projects (AICRPs) and State Agricultural Universities (SAUs).

These technologies are tested and demonstrated in the first instance. Breeder seeds are produced for production of foundation and certified seeds in the chain before it is made available to the farmers. For efficient development and delivery of improved seeds of varieties / hybrids and associated production and protection technologies, the following system is being suggested:

(i) The Institutes/Directorates/NRCs need to interact with various Advanced Research Institutes (ARIS), CGIAR Centres/ other international institutes and Centres of Excellence for exchange of knowledge, germplasm and human resource development and relate these developments to the national/regional requirements. Relevant basic and strategic research issues need to be identified and investigated by the institutes utilizing adequate resources.

(ii) Interfaces with relevant commodity (crop, horticultural, animal and fisheries) Institutes, Central Government Departments (DOAC, DAHDF, DBT, DST)/State Departments/SAUs/other Universities/Institutes and Industries to take up applied R & D related to production of varieties/hybrids, so that output reaches the intended stakeholders without loss of time and gets converted into outcome. An applied R&D effort must have a pre-identified stakeholder/public-private partnership to accept the output.

(iii) Frontline demonstrations, supply of mini kits and training by the ICAR Institutes/Directorate of Seed research/Private sectors for technology dissemination and feed back including the preparation of training manuals and organizing institute-stakeholder interface meetings.

(iv) Multidisciplinary commodity and multilocation/region specific technology development and testing by the AICRPs in a network mode in involving the local scientists, farmers, extension agencies and industries so that the output reaches the stakeholders without any gestation period. AICRPs will also undertake frontline demonstrations in collaboration with KVKs of the region to ensure technology absorption and awareness creation to the maximum extent.

(v) Production of breeder seed and test stock seed of varieties and parental lines of hybrids to be undertaken by the ICAR institutes/directorates/NRCs, AICRPs and SAUs, while the central/State seed developmental agencies/private sectors/self help group/ farmers associations/individual farmers will take up the production of foundation/ certified/ truthfully labeled seed including delivery mechanism for availability of seed to the farmers/growers.

(vi) Production of truthfully labeled seed by the ICAR institutes/ Directorates/NRCs/ AICRPs/SAUs at their own farm to a limited extent in addition to production of more parental lines of hybrids/other varieties to expand the base of availability of quality seed to the farmers. Besides, SAUs can also augment the production of foundation seeds.

(vii) Appropriate policy interventions by the central/state developmental departments/ agencies for ensuring the availability of critical quality inputs, adequate price support policies, market infrastructure development, agro-processing industries and other facilities for optimum utilization of potential of high yielding/hybrid seed.

(viii) Seeing is believing. Also in the fast changing technology domain, it is imperative that awareness is brought about without any loss of time. Hence, it is necessary to ensure stock seed production and ensure supply of a limited quantity of seed by breeder institutions as Centre/State supported development activity to each Panchayat which can serve as demonstration, demand generation as well as in inbred varieties farmer-to-farmer seed flow in the Panchayat in the shortest possible time. This new system is believed to bring much needed transformation by cutting the time lag. To avoid any misuse of precious seed, treated seed could be supplied which will also take care of seed borne diseases.

Cut and dry Flowers for Export

The country has diverse agro-climatic conditions for growing several cut flowers like rose, chrysanthemum, carnation, gerbera, lilium, tuberose, etc., which can effectively be grown in glasshouses and gladiolus in open fields.

The protected cultivation is presently undertaken by about 70 export oriented floriculture units, with an area, of about 1000 ha. Flower export has now grown worth more than Rs. 200 crores; however, the domestic market still plays a dominant role. Among the loose flowers, marigold ranks the first followed by chrysanthemum, jasmine, tuberose, gaillardia and crossandra. In a planned way, the cultivation and export of cut flowers will bring foreign exchange to the country manifold.

Besides cut flowers, there is a tremendous scope of dry flowers, which constitute 70% of the total floriculture export of the country. Many of the plant species having ornamental value include floricultural crops, horticulture crops, grasses, legumes and edible crops. Even wood carving and clippings are considered in this class of product. The added advantages of dry flowers are that the maintenance is easy and cheap and the product is durable.

The dry flowers as well as live flowers and cut leaves of certain plants may also be used for preparing floral crafts. There is therefore, a great need of production of fresh and dry flowers with novelty and strengthening the delivery system to promote the export of these products. The action points in this regard are suggested below:

- Identification of crop and product and quality requirement for export.

- Development of varieties/hybrids for cut flowers and their testing for region-specific adaptation.
- Development of protected cultivation for cut flowers
- Agro-techniques including substrate, integrated nutrient and water management and integrated insect pests and disease management for cut flowers.
- Post-harvest technologies including time of cutting, post-harvest handling and standardization of holding, storage, wrapping, transport, etc. for cut flowers.
- Facilitating production of quality cut flowers in greenhouses by the entrepreneurs with support of NHB, APEDA and NABARD.
- Institutional arrangement of collection and delivery mechanism of cut and dry flowers from entrepreneurs to the export point.
- Establishment of packaging houses by the exporters/ entrepreneurs with the technical guidance of APEDA.
- Establishment of cool chamber at the airport/sea port points by the Air/Sea Port Authorities of India and private exporters.
- Standardization of drying, value addition, packaging, moisture level in finished products and management of insect problems with dry flowers.
- Demonstration of technology/product of dry flowers by the research institutes to the entrepreneurs.
- Market research for destination of product and requirements.
- Policy support or incentive for export.

The model system for cultivation and commercialization/ marketing of cut flowers for trade is presented.

Dairying

The Livestock is a rapidly growing sector in Indian economy contributing 5.22% to GDP and 28% of the value of output of agricultural and allied sector. India is the highest producer of milk with an annual production 91 million tonnes. The milk production has grown @ 3.4% in the last few years, and the productivity @ 2.6% in last ten years. The productivity of milch animal is 987 kg per year as compared to world average of 2200 kg. The per capita availability of milk is 231 gm/day as compared to world average of 270 gm/day.

The true potential of Indian farmers was realized through Operation Flood which is a classic example of fusion between technology intervention and linkage with the end-user. The innovative technologies has the potential to revamp growth of dairy sector. A number of technologies has been developed in the field of dairying including improved growth and reproduction; area specific recommendation on feed and fodder including mineral mixtures; diagnostics, vaccines and drugs; process of value addition, quality assurance and shelf life enhancement. There is a need to re-structure the mechanism of technology dissemination from individual to collective mode because common resources and its open access play a major role in adoption of dairy practices. The suggested steps of facilitating the adoption of dairying will be as follows:

(i) Addressing the research gaps in genetic improvement in cattle, area specific feeds and fodder including mineral mixtures, development of diagnostics, vaccines and drugs, and process improvement for value addition, quality assurance and shelf life enhancement.

(ii) Identification of high producing dairy animals

(iii) Supply of progeny tested semen/bulls from ICAR institutes and state livestock farms for upgradation of the breedable cattle

(iv) Organizing large scale training and demonstration through State DAHDF, KVKs and NGOs.

(v) Organizing milk cooperatives, federations and feed manufactures for supply of key inputs and credit from NABARD and other financial institutions.

(vi) Capacity building and networking for organizing collection centres, increasing shelf life and value addition with dairy cooperatives and unions, public/private sector milk chilling plants, local milk based business organizations

(vii) Certification of hygienic milk production procedures by APEDA and its franchise

(viii) Integrating the use of information technology

(ix) Providing enabling policy and environment

Aquaculture

Aquaculture provides for diversification of agriculture, as well as value addition in terms of higher returns from a unit area. Along with high potentials for ensuring domestic nutritional food security, it also generates high employment and contributes to export earnings.

All the three segments, *viz*., freshwater aquaculture, coastal aquaculture and mariculture have been showing high growth rates in the recent past.

While freshwater aquaculture comprises mainly of carps, along with catfishes, giant freshwater prawn and ornamental fishes, shrimp has been singly contributing to coastal aquaculture production which is also the main export commodity in the fisheries sector. Mariculture has come up in the last ten years, with scope for enhancing the coastal economy.

A planned strategy of improved natural resource management, breed improvement, seed production and dissemination, better input delivery systems, cold chain and marketing and human resource development in the relevant aspects would enable realization of full potentials of the sector.

This requires a mix of basic and strategic research to address the key issues of the biology of the species including growth and disease resistance, feed and health management measures. At the same time, aspects of scaling up of hatcheries, design of seed production systems for different species in varied ecosystem conditions are addressed in the applied research mode to develop and or refine technologies. A key concern in aquaculture has been the ready access and availability of all quality inputs in one place that has hindered the development. The concept of 'Aqua-shops' is intended to provide the seed, fertilizers, feed, prophylactics, therapeutants and diagnostics, nets and implements along with advisory services in one place, with a number of Institutions involved in these areas joining hands.

Further, in view of the remoteness of places of fish/shellfish production lacking infrastructure for transport and marketing resulting in low price realization, cold chains of different levels and dimensions linked to the collection centres and marketing is incorporated in the model for Aquaculture.

While research aspects pertain to the aspects of breed improvement, nutrition and health management, as ingredients of breeding and culture of fish/shellfishes, policy issues relate to leasing of water bodies and infrastructure development.

Major inputs for enabling the farmers to enlarge the operations and realize the gains would be training and demonstration, quality inputs, information about markets, both domestic and export, for scheduling culture and marketing processes and valued information from production to consumption.

Farm Mechanization

Farm mechanization facilitates timeliness in operations, better placement of inputs, lower cost of production and reduction in drudgery of farm workers.

It plays an important role in enhancing the productivity and profitability of agriculture by 20-30% reduction in cost of production and 5-20% higher cropping intensity. Mechanization involves development of tools, equipment and ensuring adequate power for carrying out the on-farm and off-farm agricultural activities.

The technology development in farm mechanization begins with the identification of local needs and further design and development of tools, equipment and renewable power systems including market search through basic and strategic research by the ICAR institutes (eg. CIAE, Bhopal) in collaboration with SAUs and IITs. Based on the commodity and location-specific packages developed through multilocation trials by the R&D institutions and AICRPs, appropriate training modules and manufacturing drawings are prepared before developing interface with the entrepreneurs and industries for making the tools and implements available to the farmers on reasonable cost.

The State Development Agencies, NABARD and other financial institutions need to provide necessary financial support for large scale promotion of farm mechanization.

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