Global Farming Systems Study:

Challenges and Priorities to 2030

REGIONAL ANALYSIS

SOUTH ASIA

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The Global Farming Systems Study was conducted by FAO under the overall coordination of S. Funes (Director, Rural Development Division) and the technical leadership of J. Dixon (Senior Officer, Farming Systems, Farm Management and Production Economics Service) and A. Gulliver (Economist, Investment Centre). The Study benefited from the guidance of D. Forbes-Watt (Director, Investment Centre), D. Baker (Chief, Farm Management and Production Economics Service) and A. MacMillan (Principal Adviser, Investment Centre) in FAO and of C. Csaki (Senior Advisor/Team Leader-Rural Strategy) and S. Barghouti (Research Advisor) of the Rural Development Department, World Bank.

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Preface

For more than a decade, the proportion of internationally supported public investment directed at agriculture and the rural sector in developing countries has been declining. In the year 2000, World Bank commitments to the rural sector reached their lowest ever levels, measured as a proportion of their total lending portfolio. Moreover, this has occurred at a time when the process of globalisation is bringing about profound changes in patterns of trade and investment, placing agricultural producers and rural communities, more generally, under tremendous pressure to adapt to changing circumstances. Nor is there any evidence of significant progress in reducing the incidence of hunger. In order to reinvigorate its efforts aimed at poverty reduction and sustainable growth among rural populations, the World Bank initiated in 2000 a review of its rural development strategy[1].

As part of this review, the World Bank sought the assistance of the Food and Agriculture Organization of the United Nations (FAO) in evaluating how farming systems might change and adapt over the next thirty years. Amongst other objectives, the World Bank asked FAO to provide guidance on priorities for investment in food security, poverty reduction, and economic growth, and in particular to identify promising approaches and technologies that will contribute to these goals. The identification of future changes affecting farming systems relied heavily on work undertaken in FAO over many years in monitoring trends affecting agricultural production and assessing their likely implications for future output, productivity and nutrition levels.[2]

The global study commenced with the delineation and characterisation of almost 70 major farming systems encompassing all developing regions of the world. As existing data systems are based, almost without exception, on national and sub-national administrative areas, while farming systems cross national and even regional boundaries, it was necessary to re-estimate and re-analyse a wide variety of data relating to system characteristics, including physical, social, economic, demographic and environmental parameters. This analysis provided the necessary quantitative underpinning for the central, qualitative, task of developing expert judgements on the future evolution of farming systems and their developmental priorities. In all, the study encompassed the contributions of over 40 specialists in a range of disciplines, both within and outside of FAO, and took into account comments from many others.

Although any specific farming system embraces considerable heterogeneity, the diagnosis of the dynamics, constraints and opportunities of typical farm households contributes to the identification of interventions to improve system performance and sustainability. Therefore, the farming systems presented in this study are considered to provide an effective broad framework for the prioritisation of development actions and investments for accelerating agricultural development, particularly in ways which can reduce rural poverty and hunger.

The results of the study are summarized in a set of seven documents, comprising six regional reports and a global overview. This document, prepared for the Consultation on the draft South Asian Rural Development Strategy, summarises the analysis and strategic priorities for the reduction of rural poverty and improvement of food security through farming systems development in the region. This document is supplemented by case study reports of successful development initiatives in the South Asia region.

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[1] "Rural Development: From Vision to Action". World Bank, Washington D.C., 1997.
[2] Most recently in "Agriculture: Towards 2015/30. Technical Interim Report" Global Perspective Studies Unit, FAO, Rome, April, 2000.

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1 Introduction

CHARACTERISTICS OF THE REGION

Population. The South Asia region[3] supports a population of 1 344 million[4] people, equivalent to 26 percent of the population of developing regions. Of these, 970 million live in rural areas – representing 32 percent[5] of the total rural population of developing regions. Approximately 150 million households with 751 million people can be classed as farming, fishing and pastoral families[6]. Because the region covers only 514 million ha, the rural population density is higher than in any other region, *viz.* 1.88 persons per ha. Moreover, the large proportion of inhospitable terrain has led to the concentration of most of the population on less than half of the total land area, resulting in extreme pressure on natural resources.

Natural Resources. The long history of human settlement in the region has resulted in the utilisation of all significant natural resources for agriculture, despite their diversity. From an agro-ecological zones perspective[7], 20 percent of the region's land consists of steeply sloping hills and mountains containing 5 percent of the total regional population; 19 percent is humid or moist sub-humid lowland containing 43 percent of the regional population; 29 percent is dry sub-humid containing 33 percent of the population, and 32 percent is semi-arid and arid lowland containing only 19 percent of the population. Hill and mountain areas are found in all the countries of the region, but predominate along the southern slopes of the Himalayan range across India, Bhutan, Nepal, Pakistan and Afghanistan. Because of the long history of high population density, the hills have suffered extensive deforestation and soil erosion.

The humid and moist sub-humid agro-ecological zones, with more than 180 growing days per year, are located in Bangladesh and around the north-eastern, eastern and southern fringes of India and cover the centre, west and south of Sri Lanka. With large areas of alluvial soils and a high proportion of the land under intensive rice cultivation, these areas support a high population density. The dry sub-humid areas, characterised by 120 - 179 growing days each year, cover most of the Deccan Plateau in Central India. The Northwest of India, most of Pakistan and Afghanistan are semi-arid or arid with less than 120 growing days, low population density and large areas of desert. Throughout the region, there are about 74 million ha of forest (14 percent of total area), 49 million ha of grazing land and about 213 million ha of cultivated land and permanent crops – equivalent to less than 0.16 ha of agricultural land per capita. Freshwater resources are relatively scarce.

Poverty. Of the 1.2 billion people world-wide living on less than US$1 per day, 43.5 percent are found in South Asia. Of these poor, the vast majority live in rural areas – see Table 1. Similarly, improvements in national food security have not yet reached the entire

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[3] The region as defined by the World Bank includes Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

[4] FAOSTAT, 2000 (the FAO agricultural statistics database). A majority of the statistics in this report are drawn from FAO or World Bank databases.

[5] FAOSTAT 2000.

[6] FAOSTAT 2000.

[7] Agro-ecological zones are defined and delineated by FAO based on the average annual length of growing period for crops, which depends on, *inter alia*, precipitation and temperature.
The length of growing period for these zones are: humid, greater than 270 days; moist sub-humid, 180-269 days; dry sub-humid, 120-179 days; semi-arid, 60-119 days; arid, 0-59 days.

population and FAO estimates that 254 million people are still under-nourished. Indicators of other dimensions of poverty, such as female illiteracy of 59 percent, child mortality of 89 per 1 000 in children under 5 years, and a child malnutrition rate of 51 percent[8], also point to extensive poverty in the region. The rural poor are particularly vulnerable to droughts, floods and other natural disasters. According to IFAD estimates[9], about 66 percent of the vulnerable population in India are small farmers and 2 percent are artisanal fishing families. Women are particularly disadvantaged; women-headed farm households have far lower average incomes than equivalent male-headed farm households.

Table 1: Selected National Poverty Indicators

Country	Nationally Calculated Poverty percentage		Percent of Population below US$1/day
	Rural	Urban	
Bangladesh	46.0	23.3	29.1
India	43.5	33.7	44.2
Nepal	44.0	23.0	37.7
Pakistan	36.9	28.0	31.0
Sri Lanka	45.5	26.8	6.6

Agriculture in the Economy. Of the eight countries in the South Asia region, only Maldives and Sri Lanka have achieved middle income status. Average per capita income in the region is low: GDP of US$440 per capita – or US$2 030 per capita in purchasing power of parity terms. Official development assistance in 1998 amounted to only US$4 per capita (cf. US$21 per capita in Sub-Saharan Africa) representing 0.9 percent of regional GNP. Historically, the agriculture sector has generated the surpluses that supported the growth and development of other sectors of the economy. This process is more advanced in India and Pakistan, where GADP comprises 25 percent[10] and 24.6 percent[11] respectively of national GDP. The value added from agriculture in 1999 was 28 percent of regional GDP[12]. The sector employs 59 percent[13] of the labour force and generates 16 percent of the value of total exports[14].

MAJOR FARMING SYSTEMS[15]

For the purposes of this study, eleven broad farming systems have been identified, based on criteria that include: resource base, dominant livelihoods (main staple and cash income source and the balance between crops, livestock, fishing, forestry and off-farm activities), and the degree of crop-livestock integration. Their geographical distribution is shown in Map 1. In defining these systems, the emphasis was placed on the characteristics of the typical core farm-household system. Whilst mapping such aggregate farming systems, it is inevitable that significant heterogeneity is included within each farming systems unit and thus important subsidiary system types are noted in text. The boundaries between systems are generally fuzzy, because of the interpenetration of system attributes in the boundary areas, i.e. on the ground there is a gradual transition from one farming system to the next. Table 2 illustrates the relative importance of the different farming systems. The relationships of these systems to important features of the resource base are shown in Map 2 (length of growing period), Map 3 (elevation), Map 4 (environmental constraints) and Map 5 (irrigation).

The distinct features and typical production pattern of each farming system allow the identification of system-specific constraints, and strategic options and interventions for rural poverty alleviation. Brief descriptions of nine of the farming systems are given below. The descriptions refer to the dominant farm system prevailing in each respective area, but significant heterogeneity usually exists. A considerable number of diverse, less important farm systems may occur within each broad farming system, especially around its periphery. In order to estimate the resource base and population of each farming system,

[8] WDR 2000.
[9] Jazairy, I, M. Alamgir and T. Panuccio, 1992, The State of World Rural Poverty, New York University Press for IFAD.
[10] http://www.nic.in accessed on 24-10-2000.
[11] Agricultural Statistics of Pakistan 1997-98.
[12] WDR 2000.
[13] FAOSTAT 2000.
[14] FAO Trade Yearbook 1998.
[15] The process of delineation of farming systems and estimation of data involved a range of sources and substantial input of expert knowledge of agricultural conditions in different parts of the region. The figures provided herein should therefore be considered as provisional estimates, which will be refined in future.

farming systems' maps have been overlaid on a variety of geo-referenced databases including human populations and cultivated areas. The Urban-Based and Tree Crop Farming Systems are not mapped. A brief description of each farming system appears in the following paragraphs, and four of them are analysed in greater depth in the succeeding sections.

Rice Farming System. This farming system is dominated by intensive wetland rice cultivation[16] by farmers and sharecroppers in fragmented fields with or without irrigation. Total system area is 36 million ha with an estimated 22 million ha – more than 60 percent – under cultivation. An estimated 10 million ha, or 43 percent of the cultivated area, is irrigated. Of the total system population of 263 million, 130 million are classified as agricultural. Typical examples of the system are found in Bangladesh and West Bengal, Tamil Nadu and Kerala States of India, and southern Sri Lanka.

Rice-Wheat Farming System. With a summer paddy crop followed by an irrigated winter wheat crop (and sometimes also a short spring vegetable crop), the Rice-Wheat Farming System extends from the Indus irrigation area in Sindh and Punjab, Pakistan, across the Indo-Gangetic plain in northern India and southern Nepal to the north-east of Bangladesh. Total system area is 97 million ha with an estimated 62 million ha – more than 60 percent – under cultivation. An estimated 48 million ha, or 78 percent of the cultivated area, is irrigated. There are an estimated 119 million bovines and 73 million small ruminants associated with this farming system. Of the total system population of 484 million, 254 million are classified as agricultural. The Rice and Rice-Wheat Farming Systems together produce the major share of the marketed foodgrains that feed the major cities of South Asia.

Rainfed Mixed Farming System. This predominantly rainfed cropping and livestock farming system occupies the largest area within the sub-continent and includes parts of Sind, Punjab and North West Frontier Province in Pakistan; large areas of Central, Southern and Western India; the northern part of the Terai bordering the Shivaliks and the dry zone of Sri Lanka. Total system area is 147 million ha with an estimated 87 million ha – 59 percent – under cultivation. Only an estimated 14 million ha, or 16 percent of the cultivated area, is irrigated. There are an estimated 126 million bovines and 64 million small ruminants associated with this farming system. Of the total system population of 371 million, 226 million are classified as agricultural. In many instances relatively small areas irrigated from reservoirs and in recent decades, tubewells, ensure the sustainability of the Rainfed Mixed Farming System.

Dry Rainfed Farming System. Located in a rain shadow in the Rainfed Mixed Farming System in the western Deccan, this farming system has a relatively high proportion of irrigation which supports a wider range of crops than the surrounding Rainfed Mixed Farming System. Total system area is 18 million ha with an estimated 10 million ha – about 53 percent – under cultivation. An estimated 3.5 million ha, or 36 percent of the cultivated area, is irrigated. Of the total system population of 45 million, nearly 30 million are classified as agricultural.

Highland Mixed Farming System. This farming system, in the upland areas of Afghanistan, Pakistan, India, Nepal, Bhutan, and in central Sri Lanka, includes cereals, legumes, tubers, vegetables, fodder, fodder trees, orchards and livestock. Total system area is 65 million ha with an estimated 19 million ha – about 29 percent – under cultivation. While most cultivated land is rainfed, an estimated 2.6 million ha, or 14 percent, is irrigated. There are an estimated 45 million bovines and 66 million small ruminants supported by this farming system. Of the total population of 82 million living within the system, nearly 53 million are classified as agricultural.

Pastoral Farming System. Across the semi-arid and arid zones from Rajasthan in India through Pakistan and Afghanistan, transhumant pastoralists keep mixed herds of livestock, especially camels and sheep. The system includes scattered pockets of irrigation, some quite substantial in area, which mitigate the extreme seasonal vulnerability of pastoralists. Total system area covers 55 million ha, that supports an estimated 12 million cattle and 30 million small ruminants, as well as a significant number of camels. There are scattered areas of cultivation occupying an estimated 6.8 million ha. Nearly two thirds of this area (4.6 million ha) is irrigated. Of the total system

[16] Intensive is used here to indicate the growing of two or more crops of paddy during the year.

population of 27 million, around 21 million are classified as pastoral or agricultural.

Tree Crop Farming System. This farming system, in the lowlands of Sri Lanka and the upland areas of India, Nepal, Bangladesh and Sri Lanka, comprises plantation companies and smallholders producing tea, rubber and coconuts. Given the dispersed nature of this system, it is not distinguished on the map.

Urban-Based Farming System. In most large towns and cities in the region the intensive production of perishable high-value commodities, such as milk and fresh vegetables, has expanded. These are generally com-

Table 2: Farming Systems of South Asia Region

Farming Systems	Land area (percent of region)	Agric Popn[17] (percent of region)	Principal Livelihood	Incidence of Poverty	Potential for poverty reduction	Potential for agric. growth
Rice	7	17	Rice (both seasons), vegetables, legumes, off-farm activities	Extensive severe poverty	Moderate	Moderate
Coastal Artisanal Fishing	1	2	Fishing, coconuts, rice, legumes, livestock	Moderate to severe poverty	Moderate	Low
Rice-Wheat	19	33	Rice, wheat, vegetables, livestock including dairy, off-farm activities	Extensive moderate and severe poverty	High	Moderate – High
Highland Mixed	13	7	Cereals, livestock, horticulture, seasonal migration	Moderate to severe poverty	Moderate	Moderate
Rainfed Mixed	29	30	Cereals, legumes, fodder crops, livestock, off-farm activities	Extensive poverty, severity varies seasonally	Moderate	Moderate
Dry Rainfed	4	4	Coarse cereals, irrigated cereals, legumes, off-farm activities	Moderate poverty	Moderate	Moderate – High
Pastoral	11	3	Livestock, irrigated cropping, migration	Severe poverty, especially drought induced	Low	Low
Sparse (arid)	11	1	Livestock where seasonal moisture permits	Severe poverty, especially drought induced	Low	Low
Sparse (mountain)	7	0.4	Summer grazing of livestock	Severe poverty, especially in remote areas	Low	Low
Tree Crop	little, dispersed	little	Export or agro-industrial crops, cereals, wage labour	Moderate poverty, mainly of agricultural workers	Moderate	High
Urban based	neg	little	Horticulture, dairying, poultry, other activities	Moderate	Low	Low

Principal farming systems are shaded

[17] Defined as those working in crop or livestock production, fisheries or forestry, and their dependents.

mercial systems with high levels of external inputs and with well-functioning links to the surrounding rural areas for stock, feed and fodder.

Coastal Artisanal Fishing Farming System. In a narrow band along the major part of the coast of Bangladesh and India, and around the Maldives, households supplement artisanal (inshore) fishing with food production – often rice and such cash enterprises as coconuts and livestock. Total system area is estimated at 5 million ha with nearly half under cultivation. One third of the cultivated area, or 0.8 million ha, is under irrigation. Of the total system population of 45 million, about 18 million are classified as agricultural.

Sparse Farming System. The areas of sparse agriculture (both arid and mountain) are of limited economic importance. There are some scattered irrigation settlements in the arid areas; in most cases used by pastoralists to supplement their livelihoods. The rest of the arid areas are utilised for opportunistic grazing where water is available for livestock. The total area of the Sparse (arid) Farming System is estimated at 57 million ha, supporting an estimated 16 million cattle and 29 million small ruminants. About 1.7 million ha is cultivated, practically all under irrigation. Human population is 23 million, of which 9.6 million are classified as pastoral or agricultural. The Sparse (mountain) Farming System lies at altitudes above 3 000 metres along the southern slopes of the Himalayan Range and occupies an estimated area of 34 million ha with a population of 3.0 million people, of whom 2.8 million are classified as agricultural. A number of small settlements depend on potatoes and buckwheat, plus cattle and yak herds. Cultivated area is 1.9 million ha, or only 5 percent of total area, and only around 10 percent is irrigated. There are an estimated 10 million cattle and yaks and 9 million sheep and goats within this system. During the summer, herders graze cattle, and especially yak, on the higher slopes. Generally, household incomes are supplemented by seasonal migration and in some cases by trade, mountaineering and tourism.

For the purposes of this study, four farming systems were chosen for detailed analysis. These have the greatest overall potential for agricultural growth and poverty reduction during the coming 30 years and can be summarised as the:

- Rice Farming System;
- Rice-Wheat Farming System;
- Rainfed Mixed Farming System;
- Highland Mixed Farming System.

Most of the poor inhabitants in the Region work in these four principal farming systems, which also contribute more than three-quarters of the regional GADP. They are described in more detail in the following sections.

2 Region-Wide Trends

NATURAL RESOURCES AND CLIMATE

Population and Food Intake. The region's 1999 population of about 1 344 million[18] is expected to increase by approximately 1.4 percent annually to 1 650 million in 2015. Thereafter, population growth is expected to slow to about 1.0 percent per annum to reach 1 920 million by 2030. The proportion of the total population living in cities (presently 28 percent[19]) has increased markedly over the last four decades and is expected to continue increasing to some 53 percent in 2030. Despite urbanisation, the population density in rural areas will continue to grow beyond the current density of 1.89 persons per ha of total land. Average food intake was estimated at 2 424 Kcal per person per day in 1995-97 and is expected to increase to 2 790 Kcal by 2015 and to reach 3 040 Kcal by 2030. The quality of the diet is also expected to improve, with consumption per head of both meat and dairy products forecast to double over the period from 1995-97 to 2030.

Mobility. A key factor affecting the pace and direction of change will be the increase in human mobility – reflected in increased urbanisation and increased off-farm employment, especially for adult males. This is likely to impact in various ways within the farming systems. In some cases it will lead to adoption of more extensive, low labour systems of production, such as paddy cultivation rather than cotton cultivation, so as to provide the best returns per labour day for periods that can be fitted-in with off-farm employment. It is also likely to be reflected in an improved asset position on farms, more mechanisation, and also an increase in the area of land per operator. As greater numbers of adult males migrate seasonally and semi-permanently in search of alternative livelihoods, it is anticipated that women farmers will assume greater responsibilities for the management and operation of farms.

Arable land. The area of land under annual cultivation and permanent crops in the region is estimated at 213 million ha (40 percent of total land area) and is expected to show a marginal increase to 216 million ha by 2030. The additional area would come from grazing land, forest land, reclaimed wasteland and fallow land. The development of new lands would therefore involve significant investments, as well as some foregone production. Estimated increases in development of arable land would be greater but for losses to buildings and civil works, since many of the existing urban centres – as well as the urban sprawl along roads and highways – are located in well-developed agricultural areas. Average farm size has been declining and may continue to do so for some time. However, it is expected that it will increase significantly in most farming systems by 2030, as a result of continued migration of rural population to urban areas and through farmers wanting to take advantage of economies of scale, particularly through mechanisation.

Soil erosion in the highland and rainfed watersheds is prevalent (as shown in Map 4) and is aggravated by heavy grazing and the export of nutrients from cropland. Overgrazing has also led to soil degradation in large areas of the Mixed and Pastoral Farming Systems. Severe soil management problems also confront the intensive Rice and Rice-Wheat

[18] FAOSTAT 2000.
[19] WDR 2000.

Farming Systems where yields are increasing more slowly, or even stagnating in some high intensity areas. This is attributed by some analysts to deteriorating soil physical conditions and declining organic matter, unbalanced fertilisation with over-reliance on nitrogen fertilisers, relative neglect of other major and micro-nutrients, and declining use of animal manure.[20]

The overall scarcity of water resources in the region, and their geographic distribution, has shaped the development of farming systems. The region's irrigated land area (see Map 5) is forecast to grow slowly, from 85 million (40 percent of arable land) to 95 million (44 percent of arable land) in 2030. The high cost of developing new, environmentally sustainable, irrigation systems and the reluctance of donors to finance large irrigation projects, may lead governments to place greater emphasis on modernising existing irrigation schemes and improved water use efficiency instead. This will involve participatory management or transfer of ownership to users, improved design of operating systems, better drainage and cost recovery. Considerable potential remains for improving water management through better rainfall conservation and use, further development of water storage, conjunctive use of groundwater using tubewells or agro-wells and increased on-farm water conservation through conservation agriculture – including mulching, bunding, windbreaks and other means.

Shortages of ground water in some localities have already started limiting the development of the intensive Rice and Rice-Wheat Farming Systems using tubewells[21]. The situation is bound to get worse over the next three decades and rainfed mixed and pastoral farming systems will also be constrained by the limited availability of ground water and surface water for crop and livestock production. There will be strongly increasing demand for water from urban and industrial users during the coming decades. As a result, local water markets are likely to develop, with agriculture at a disadvantage except in the case of high value crops. Since off-farm employment would increase and labour costs rise with improvement of rural communications and transport, it is likely that irrigation water would be substituted to a greater extent for labour in land preparation and weed control in rice. Water management would, therefore, depend heavily on the success of measures to introduce realistic water charges. Because of increasing awareness of the links between watershed management and the sustainability of irrigation, increasing investments will be made in participatory watershed development projects.

Forests. Forest resources are under threat in all countries of the region, due to high population densities. In the 1990s, deforestation occurred at the rate of 0.13 million ha, or 0.2 percent, p.a. The pressures causing deforestation are expected to increase still further, particularly in the Highland Mixed Farming System (little forest remains in most other farming systems of the region). In many instances, the main problems appear to arise as the result of deforestation for agriculture in the face of increasing population, and from the conflict of interest between individuals and forest departments. The growing realisation that forest communities have to be fully involved in forest management, and that forests need to be managed for the benefit of such communities, has done much to overcome the latter factor.

SCIENCE AND TECHNOLOGY

Research. Agricultural research in South Asia has been strengthened dramatically over the past 40 years through reorganisation of the national agricultural research systems (NARS) with central co-ordinating bodies, decentralisation into regional research centres, greatly enhanced manpower and increased investment. The NARS in the region have benefited greatly from the strong linkages and networks they have established with international agricultural research centres (IARCs), such as IRRI and ICRISAT. This has particularly included participation in the development of green revolution technology. More recently, the NARS have been focusing on meeting the post-green-revolution challenges of stagnant yields, by developing technologies for resource-poor farmers and farmers in sub-optimal crop environments.

Population growth and degrading resources within the region will continue to pose new challenges to these agricultural research systems. Basically, increasingly complex and diversified technologies will

[20] See case study on rice productivity in this Study. The four main aspects of soil degradation are: limbalanced application of mineral fertilizer (e.g. emphasis on Nitrogen, P and K) leads to nutrient deficiency, especially zinc and, sulphur; a reduction in the application of organic fertilizers (including animal manures, green manures, etc.) leads to low soil fertility; poor drainage and water management practices lead to salinisation; and continuous flooding under intensive wetland rice cultivation leads to changes in soil chemical and biological properties that inhibit the availability of certain nutrient elements to rice crops (e.g. zinc, sulphur).

[21] Even though, groundwater resources in these farming systems are replenished annually, unlike other regions.

be required to meet these challenges. The expansion of agriculture into marginal lands, the growing role of women in farm household decision making and the need for new areas of research (agroforestry, communications, biotechnology, etc.), will require the development of new skills and inter-disciplinary research efforts. Although private-sector research will make increasing contributions to the development of new technologies for improving the profitability of commercial ventures, the focus of public-funded agricultural research is likely to remain the resource-poor small farmer.

Returns from past agricultural research in the region (e.g. the HYV-fertiliser-irrigation technology) seem to have peaked in certain systems, such as the Rice and Rice-Wheat Farming Systems. Emerging problems require a better mixture of upstream (basic or strategic) and downstream (adaptive and participatory, farm-level) research. A major issue is that much of the present agricultural research effort fails to address many topics in which farmers have most interest, e.g. improved low input crop husbandry practices and minimised production risks. Research areas that might pay off in the next two decades include Integrated Nutrient Management, Integrated Pest Management (IPM), post-harvest handling, moisture conservation, appropriate water management and other integrated management technologies. Also, there is much more to be learned about plant associations and even about expanding the range of plants used by man – particularly for erosion control or in preparation for planting on challenging wasteland sites.

Fertiliser. Use of inorganic fertilisers in the South Asia Region has expanded steadily; from 3 kg of plant nutrients per ha in 1970 to 79 kg/ha in the mid-1990s. The rate of consumption is expected to continue to increase albeit at a slower rate, to approximately 104 kg/ha in 2030. Generally, farmers in all parts of the region are regular users of fertilisers except in some of the more remote areas, such as the Highland Mixed Farming System in the mountains of Bhutan, Nepal or Afghanistan, where high transport costs can easily exceed the material cost. Of course, application rates are much higher in irrigated, intensive farming systems than in dry and risky production environments. In some cases there is considerable wastage of nutrients – particularly nitrogen – due to low efficiency in the use of fertiliser. Severe losses by volatilisation occur in Pakistan, for example, which is a large consumer of nitrogen fertiliser.

The future rate of increase in total fertiliser use is expected to decline, although the rate of decline will depend to some extent on progress in raising the efficiency of fertiliser use. Nitrogen losses from N2 and N2O emissions, as well as losses from nitrogen leaching and runoff, could consequently remain constant or even diminish. At present, use of fertilisers for paddy is constrained by low rice prices. The use of fertilisers in the coming decades will be influenced by fertiliser prices (likely to increase in real terms), commodity prices (likely to decrease), use of organic fertilisers (likely to increase) and fertiliser use efficiency (also likely to increase). The possibility of significant contributions from the use of Biological Nitrogen Fixation (BNF) cannot be discounted. In parallel with the increase in fertiliser use, the demand for agricultural chemicals has grown, although moderated somewhat by the spread of IPM.

Crop production. Production of paddy rice, the main crop in the region, increased over the period 1970 to 1999 at a rate of about 2.7 percent annually to around 174 million tons. Production is forecast to further increase to 241 million tons by 2015 and to reach around 269 million tons by 2030. Wheat production, which grew at around 4.2 percent annually over the 1970-99 period to some 92 million tons, is expected to grow to around 126 million tons by 2015 and to reach 169 million tons in 2030. The modest increase in irrigated area and improvement of established irrigation schemes is likely to allow for greater diversity of cropping, including expansion of vegetables and other cash crops. In general, the recent expansion of horticulture is expected to accelerate due to growing demand and improved marketing and processing channels.

Livestock. Cultural factors strongly affect livestock production and consumption throughout the region. Cattle numbers have shown only sluggish growth from some 226 million head in 1970 to 265 million head in 1999; an annual growth rate of about 0.59 percent over the entire period and only 0.55 percent p.a. during 1990-99. Buffalo numbers have increased slightly faster, by 2.11 percent annually over the 1970-99 period, although slowing to 1.67 percent annually during 1990-99 to reach a total of 118 million head. The largest increases in livestock numbers and production have occurred in poultry, sheep and goats. Intensive, large-scale poultry production to meet urban demand has already developed in most countries of the region. In the period 1970- 1990, the rate

of increase in poultry and small ruminant numbers was 4.7 percent and 2.6 percent p.a. respectively. With increased incomes, meat consumption (particularly poultry meat and eggs, sheep and goat meat) and dairy products are expected to continue significant expansion. The large ruminant population is expected to stabilise or even decline. Their management will increasingly focus on commercial production, as tractors replace draught buffalo and oxen, and as the emphasis shifts further towards marketable animal products such as milk.

GLOBALISATION AND MARKET DEVELOPMENT

The recent trend towards increased market liberalisation will probably continue over the next decades. Commercial farmers will be exposed to declining terms of trade, especially for cereals in international markets. Significant diversification is expected in most farming systems, partially in response to external competition for previously protected domestic markets in the case of basic staples such as rice, and partially as a response to increasing export opportunities. South Asia could build upon its dominant world position in a few niche markets – such as that for mango products – and develop a wide range of competitive fruits, spices, colorants and other tropical products. Given the large number of expatriate South Asians living in the industrialised countries, and the popularity of regional cuisine, it is also to be expected that considerable growth will occur in processed foods. This tendency is likely to accelerate as advances in packaging and transport technology allow fresh breads, curries and other perishable products to be delivered to western markets at economical prices.

Although rural populations in South Asia may provide only limited markets for imported foodstuffs in the medium term, the large and expanding urban markets will become increasingly important consumers of both regional and extra-regional produce in the coming decades. Urban-based agriculture will expand and intensify to meet this demand. Dairying is expected to grow still further, as will processed dairy products such as ghee; while poultry, lamb and goat consumption will expand rapidly, as will demand for vegetable oils. As international labour markets grow, remittances from overseas work will increase and a significant proportion will flow into agriculture. These cash incomes are an important source of livelihoods in many marginal rural areas – for example in the Highland Mixed Farming System – and often finance improvements in the resource base of small farms.

POLICIES, INSTITUTIONS AND PUBLIC GOODS

A large proportion of the increase in foodgrain production during the Indian Green Revolution occurred in the 10 percent of districts with adequate local infrastructure – especially for water management, transport, and electricity for tubewells. On the other hand, agricultural development in many areas of the region has been constrained by a lack of infrastructure. In particular, the shortage of roads in remote and sparsely populated areas pushes up transport costs for both inputs and marketed produce, while the lack of health and educational services reduces labour productivity.[22]

Most countries in the region have policies that favour urban areas and the manufacturing sector rather than the rural and agricultural sectors, i.e. there are national trade and price distortions with a negative impact on the commercialisation of farming systems. Interfering in the market to maintain food prices artificially within reach of the increasing, politically articulate, urban population (e.g. by releasing stockpiles) may also aggravate already low internal cereal prices, thus exacerbating the bias against rural communities. Because the majority of the poor are located in rural areas, poverty reduction efforts should be targeted towards increased agricultural income.

Decentralisation and local institutional performance will be key issues in the development of most farming systems. Line departments have already given up some of their functions to the private sector. They also plan to hand over other functions to empowered rural communities and this trend will become more pronounced in future. However, this transfer of functions may not take place very rapidly and the quality of its implementation will require monitoring, given the close relationship between rural community constituencies and politicians and *vice*

[22] Whilst attention to the HIV/AIDS-agriculture linkages has focused on SSA, it is conceivable that AIDS will also cause major suffering and affect agricultural productivity during the coming 30 years elsewhere, including rural SAS.

versa. Another far-reaching change which is occurring in association with decentralisation, is the growing role of women in *panchayat* (local council) and district-level decision making. There is also a growth in public-private partnerships for agricultural development which will have far reaching effects on deciding agricultural research priorities.

Local institutions in some parts of the region, e.g. India, are being mandated to play a larger role in land administration, but often lack the capacity to discharge such functions properly. In general, land reforms in the region have met with limited success in improving access to agricultural resources. Land ceilings have had some limited impact, but larger farmers have often found ways to maintain their holdings. The implementation of these programmes is rendered difficult by the inadequate state of land records in some areas.

INFORMATION AND HUMAN CAPITAL

By 2030, the majority of farm households will be literate and numerate, and nearly all younger people – including women – are expected to have a basic school education. However, continuing investment in rural education is required for two main reasons: (i) to equip workers with the skills to transfer from agriculture to the non-farm economy and, (ii) to equip the remaining farmers to manage the emerging knowledge-intensive farming systems. The strategic research needs outlined above call for the training of professionals in research and agricultural support services. Although total labour requirements in agriculture are not likely to increase, improved skills are required to raise efficiency and productivity. Such local increases of human capital would underpin the development of small-scale local rural industry, perhaps along the lines of some of the more successful examples of rural industry found in China.

The shift to commercial, knowledge-intensive, farming systems requires a greatly improved flow of information to farmers and support services on technologies and on market information. This is emerging as a key issue and is a promising area for public-private partnerships.

3 Rice Farming System

SYSTEM DESCRIPTION

This system covers about 7 percent of the land in the region and is typical of some of the old and well-developed wet land rice farming areas of the region, such as southern Bangladesh, south Punjab, coastal Tamil Nadu and Kerala and the wet zone and irrigated areas within the dry zone of Sri Lanka. Land is farmed by owner operators or sharecroppers. Farm size tends to be bi-modal, with a large number of tenants and sharecroppers with small areas of the order of 0.3–1.0 ha, and a few medium to large owner-operated farms that could be 4–10 ha or more. Rice is invariably grown in the wet season. Rice, or another less water-demanding crop (e.g. coarse grains, oil seeds, legumes, vegetables), is also grown in the dry season.

In most cases the system is supported by supplemental irrigation in the monsoon season and full irrigation in the dry season. Because of the limited resource base of the farming system and the fact that these areas are generally close to urban areas, off-farm employment is common. Similarly, the strategic importance of rice as a food staple and the generally easy access, have resulted in extension services being well developed. With virtually continuous paddy cropping there are limited fodder resources except for paddy straw to support ruminants, which generally include milk and draught animals (buffalo, or oxen in the drier areas, where these have not already been replaced by tractors). Nevertheless, this farming system contains a significant proportion of the cattle and dairy animals in the region, the latter principally because of proximity to large urban centres. Box 1 contains a brief description of a typical farm system household.

Total population	263 million
Agricultural population	130 million
Total land	36 million ha
Agro-ecological zone	Humid
Arable land in use	22 million ha
Irrigated area	9.7 million ha
Bovine population	51 million
Small ruminants	30 million

BOX 1: A TYPICAL RICE FARM SYSTEM HOUSEHOLD

A typical poor sharecropping household with 5 family members cultivates 0.4 ha of irrigated land in West Bengal, India. The kharif (monsoon) rice crop is followed by a second irrigated rice crop and a short vegetable crop. Modern rice varieties are transplanted in both seasons, producing typical yields of 1.9 and 2.4 t/ha, of which the sharecropper retains one third since the landowner provided the land, as well as a draught buffalo and crop inputs (including fertiliser, about 150 kg nutrients/ha and chemicals for about four sprays per season). The household owns two goats and some ducks and chickens and plans to purchase a milking buffalo together with a relative. Both adults work for about 120 days a year, on nearby large farms and in a local factory. The household has very low average income, and is very vulnerable to low crop yields and to lack of labour income due to sickness or lack of work opportunities.

Most farmers in this system know the value of using fertiliser and improved seed. Nevertheless, uptake of improved varieties has not everywhere been as enthusiastic as expected. This is largely due to lack of good and healthy certified seeds, the poorer taste of some new varieties, lower tolerance to early or late

transplanting (an important consideration when both onset of the monsoon and irrigation system reliability are uncertain) and sometimes minimal increase in yield compared to local varieties – perhaps as a result of breeding programmes using parent lines showing inadequate genetic variation. Typical farm households must still supplement their food production with off-farm income.

Considerable diversity exists within this farming system: the north-eastern parts of the system in central-northern Bangladesh (see Box 2) are drier with more dry-season diversification, notably to wheat. Aquaculture is widely practised in southern Bangladesh and some households keep more cattle, including dairy cattle, and more poultry. The south-eastern areas of the system in Tamil Nadu and the south-western parts in Kerala have less risk of cyclone and flood and more tree crops. Even within one location, a gradation in access to resources and job opportunities exists.

BOX 2: CRITICAL POLICY CHANGES FOR THE SPREAD OF SHALLOW TUBEWELLS, BANGLADESH

Major changes in the farming system arose in Bangladesh during the 1990s, resulting from a dramatic expansion of shallow tubewells (STW) that could be traced to specific policy changes. These included liberalisation of the import of engines, pumps and tubewell supplies (allowing full private sector participation) and abolition of STW siting restrictions (arising from recognition that the tapped groundwater was replenished annually). In 1989, some 70 000 small pump engines (at around US$200 each) were imported and were widely used for low-lift irrigation by private sector operators. Irrigation water was supplied to farmers against a 25 percent share in the crop. Since the demand for pumps far exceeded the supply, pump operators made fertiliser application a condition for access to irrigated water supply. The private costs of the ensuing boom in fertiliser use were comparable to earlier investments in agricultural extension services. As a result, grain production in Bangladesh rose sharply and the production target of 20 million tons was achieved by 1990 at no cost to the Treasury.

Typical households, however, depend on a limited crop income that is vulnerable to low yield, as well as to complete failure in flood and cyclone prone areas. The major source of vulnerability, however, is inability to find work in the vicinity, or inability to work because of sickness – a frequent occurrence. There are few traditional mechanisms to which the poor can turn in time of need; access to government safety nets, such as employment guarantee schemes is often inadequate. In this respect, poor small farmers are just as vulnerable as landless rural workers.

SYSTEM-SPECIFIC TRENDS AND ISSUES

During the coming 30 years, land availability per capita is expected to decline because of population increase and the loss of land to urban expansion. However, some market-driven land consolidation can also be expected, together with gradual reduction in sharecropping. Education levels for both men and women are expected to increase substantially. Widespread adoption of hybrid rice – both existing and future new varieties – is expected, except in deep-water and other unfavourable rice ecologies. The declining terms of trade for rice, and increasing costs of production, will induce diversification of production to include inter alia, dairy and aquaculture. Intensive pressure on land will limit the availability of fodder and lead to a decline in the population of buffaloes. Draught buffalo power will be replaced by two-wheel tractors, which will also be widely used for local transportation. Increased labour costs will also favour mechanisation of other operations, such as sowing, weeding and threshing. Given the declining profitability of rice, only a modest increase in external input use is expected overall – with no significant increase in the riskier flood-prone areas. The gradual decline in rice profitability, and increasing population pressure, will force many male household members to seek an ever increasing part of their income from off-farm sources. In these cases, women will shoulder an increasing burden of farm work. Overall, there may be a gradual improvement in household food security and a modest reduction in poverty.

Some improvement is expected in public infrastructure and other aspects of the socio-institutional environment affecting agricultural production. In particular, transport, educational and health facilities will improve. These will be associated with significant decentralisation of decision-making to the district and the local *panchayat* levels. At the local level, farmers' organisations (FOs) are also likely to grow stronger. The prevailing feminisation of poverty in large areas of South Asia will most probably begin to be turned

around. With the enforcement of the one-third quota for women in local office, local governance will increasingly reflect the needs of women, who are currently disproportionately represented among the very poor.

As public sector research and extension budgets decline during this period, greater emphasis will be placed on private sector, FO, and individual farmer experimentation and technology sharing. The enhanced role of farmers and the private sector in advisory services will tend to improve the relevance of extension messages. The success of the Grameen Bank in Bangladesh has generated a plethora of micro-finance activities throughout the region. There is likely to be an increase in seasonal and permanent out-migration, and a slow growth of the non-farm rural economy.

The main issues driving the evolution of the system are the currently low and declining paddy prices plus increasing labour costs. These make it increasingly unattractive to use high rates of fertiliser application and consequently inhibit the growth of rice productivity. The low domestic paddy prices are largely a reflection of declining world prices. In some instances, however, this trend is exacerbated by government attempts to keep rice prices low in order to satisfy urban populations – using price controls and monopoly purchases with countervailing subsidies on fertilisers, irrigation and other inputs[23].

SYSTEM PRIORITIES

While there are some issues related to natural-resources – soil management and flooding – in this farming system, as discussed above the major problem is the low and progressively declining producer price for rice resulting from unfavourable terms of trade. This can only be countered in the long run by using more efficient production practices, thereby increasing the comparative and competitive advantage of local rice production. An effective programme of

BOX 3: INTENSIFICATION AND DIVERSIFICATION IN IRRIGATED RICE FARMING SYSTEMS[24]

Intensification and diversification both offer opportunities to boost food security and incomes among poor smallholders within the intensive irrigated rice-based farming system. These possibilities have been demonstrated in both the Young Bramaputhra floodplain and the Chittagong coastal plain areas of Bangladesh, where the dominant cropping patterns are transplanted deepwater rice - *boro* rice, and transplanted *aman* rice - *boro* rice, depending on inundation in the monsoon season.

The major interventions for intensification of rice production reviewed in the case study were: land selection based on crop suitability, the use of improved seeds sown at the recommended rate, balanced and timely fertiliser use, optimum dates of sowing and harvesting, and plant protection measures. The introduction of irrigated *boro* cropping has increased the food security status of the community in the lowland areas and created extra employment opportunities for the landless. An assured high-yielding *boro* crop in the lowland encouraged farmers to diversify their cropping patterns in other, slightly higher-lying types of land, and thus increasing the overall productivity of their farming system.

In other parts of the system, the case study indicates that higher financial benefits could be derived from the development and intensification of associated livestock, fisheries and homestead production systems than from intensification of rice production. Some farmers practise rice-fish culture during the transplanted *aman* rice season, but the majority avoid this option due to the risk of flooding.

Whether farmers chose crop intensification strategies or crop diversification strategies in a specific area depended on the availability and dissemination of appropriate technologies, which was in turn linked closely with the effectiveness of agricultural research related to the zone. These results suggest that research and extension support focused on the Intensive Irrigated Rice Farming Systems would be a productive intervention for Government.

[23] It is estimated that subsidies and transfers account for nearly 40 percent of Government of India expenditure (WDR 2000).

[24] Hoque, F., 2001, Integrated Intensified Rice Farming Systems, Bangladesh, Case Study, Global Farming Systems Study, FAO, Rome.

research and extension to improve labour and factor productivity is needed to improve farmers' production practices. In order to maintain adequate incentives to farmers it will also be necessary to avoid urban bias in trade and economic policies.

The productivity of this farming system can be increased through intensification. Despite major investments in irrigation infrastructure in the past, many schemes still perform poorly. Upgrading these systems to improve irrigation security, plus the introduction of tubewells for conjunctive use of groundwater, generally results in significant increases in production and farm incomes. The exception is in situations where there is a strong and lucrative opportunity for off-farm employment. The examples in Box 2 show that small adjustments in policies and technology can unleash major investments in the rural sector which, in turn, increase productivity and reduce poverty. Other areas in which interventions can increase productivity of this farming system are research and extension; farmer training (particularly in farm management, Integrated Nutrient Management, IPM and other crop production practices); mechanisation of operations such as weeding and threshing, and improved post-harvest handling and milling.

The main opportunities for improving the productivity of the system through diversification appear to involve the incorporation of income-generating enterprises such as dairying, aquaculture, horticulture and local value-added processing. Where the risk of flooding is low, aquaculture can provide additional income in inter-harvest periods. Duck or chicken raising provide other possibilities; although in order to be adopted all of these potential enterprises need to show better returns to labour than the operator could get from off-farm income-generating activities. Their widespread adoption would also need some strengthening of the relevant support services. The system can also be improved by diversification into vegetable or other cash crops where there is nearby urban demand – as demonstrated by the expansion of horticultural production around Bogra in Bangladesh[26]. The combination of these practices can, in favourable circumstances, lead to highly productive and profitable integrated, intensive farming systems. Similarly, dairying has been a traditional engine of growth for smallholder farming systems in South Asia. One well-known dairy scheme is the Milk Vita programme in Bangladesh (see Box 4).

BOX 4: MILK VITA[25]

From a modest start that involved providing 4 300 very poor, often landless, households in remote rural areas with a complete package of improved milk production technologies, village level organisational skills and a milk collection-processing-marketing system, a two-tier co-operative has grown into a successful commercial dairy enterprise. Today, milk is collected from 40 000 farmer-members, organised into 390 primary village co-operatives, then processed and distributed to all the major cities in the country. Since start-up, regular earnings from milk have increased ten-fold in real terms. The resultant increase in cattle numbers and savings also serves as a cushion against the devastating effects of severe flooding that regularly afflict the country.

Democratically elected milk producer and distributor co-operative members are now in the majority on the Milk Vita Board of Directors. This prepared the ground for the government to withdraw from day-to-day management of the co-operative, thus enabling the board to hire professional managers. In turn, this improved performance and created a platform for expansion to bring more poor people into the milk collection network. The Grameen Bank is currently adapting the model to reach out to some of its poorest female clients involved in inland fish farming.

[25] Dugdill, B.T. and A.Bennett, 2001, Income Diversification in an Intensive Rice-Based System - Milk Vita in Bangladesh, Animal Production and Health Division, Case Study, Global Farming Systems Study, FAO, Rome.

[26] Government of Bangladesh/FAO/ADB Horticultural Development Project..

4 Rice-Wheat Farming System

SYSTEM DESCRIPTION

This system covers 19 percent of the land in the region, and is dominant in the Indo-Gangetic plain including the Terai of Nepal, the Gangetic plain in Uttar Pradesh, Bihar and West Bengal, and the north-west of Bangladesh. The farming system is characterised by a 'summer' (monsoon-season) wetland rice crop and a 'winter' (cool, dry season) wheat crop – sometimes followed by a short and normally quite profitable 'spring' vegetable crop). Poverty and household food insecurity are widespread, principally among landless agricultural workers and sharecroppers. In some areas cotton is part of the system, but its cultivation is constrained by its high labour requirements and the long duration of the crop. Commonly, some form of irrigation supports the system. This farming system contains large populations of cattle, sheep and goats. Thus, livestock is more common than in the rice-based farming system, although often they may not be strictly a part of the farm system but simply belong to large cattle herds owned by landlords or businessmen. These cattle graze the stubble after harvest and return to wastelands or uplands during the crop season. Heterogeneity exists within the farming system chiefly in terms of access to land and water resources.

Total population	484 million
Agricultural population	254 million
Total land	97 million ha
Agro-ecological zone	Dry sub-humid
Arable land in use	62 million ha
Irrigated area	48 million ha
Bovine population	119 million
Small ruminants	73 million

BOX 5: A TYPICAL RICE-WHEAT FARM SYSTEM HOUSEHOLD

A typical rice-wheat poor sharecropping household with 2 adults and 3 children cultivates 0.8 ha of irrigated land in Uttar Pradesh, India. The *kharif* (monsoon) rice crop is followed by a wheat crop, and sometimes a short vegetable crop. The modern rice variety produces a typical yield of 1.9 t/ha, of which the sharecropper retains two-thirds. Wheat yields average about 2.5 t/ha. The household owns a share in a milking cow and the milk is delivered daily to the village milk collection centre. The cow is fed straw, weeds and other herbage that can be cut from the field and path perimeters. Both adults work as labourers, for about 160 days a year, on nearby large farms and in a local factory. The household has a combined average income just beneath the international poverty line, and is vulnerable to low crop yields, loss of the milk cow and to lack of labour income.

With the development of improved varieties of both rice and wheat, and the use of irrigation and fertiliser, the rice-wheat cropping system has shown remarkable increases in production. However, in recent years the declining or stagnant yields and factor productivity of the system have given cause for concern and are the subject of an on-going research programme by the Rice-Wheat Consortium for the Indo-Gangetic Plains. Over time, the system has expanded into areas where groundwater is not so easily accessible. The western parts of the system in Pakistan tend to have fewer animals and be more mechanised. In these irrigated areas, away from major flood-prone districts, vulnerability is associated with price variation, crop pests and inability to earn sufficient off-farm income.

It is not an easy system to practise. In particular, wheat sowing has to follow immediately after the rice harvest if subsequent wheat yields are to be satisfactory. A major problem in many areas is that, because irrigation supply is unreliable, farmers have to transplant with the onset of the monsoon. In order to maintain flexibility they continue using traditional varieties, but these are slow maturing. Consequently, all too often, wheat is sown late thereby depressing yield. Land tenure is often an issue and sharecropping is more widespread than in the other farming systems.

SYSTEM-SPECIFIC TRENDS AND ISSUES

Average farm size will continue to grow due to permanent and seasonal out-migration of youth, although the bimodal farm size pattern is expected to be accentuated in the coming decade or so. Later, it is expected that the number of sharecroppers and small farms will diminish. Land close to urban centres will continue to increase rapidly in value, while some observers expect an increase in absentee ownership. The practice of sharecropping can be shown to have some advantages, but has the big disadvantage of perpetuating a traditional and largely immutable operating system within which it is difficult or impossible to promote any innovation. For example, in parts of the Punjab, improvements in irrigation systems have resulted in an increase in the paddy area rather than the planned expansion of cotton plantings.

The decline in soil productivity, due *inter alia* to excessive reliance on unbalanced application of mineral fertiliser, is likely to continue depressing wheat and rice yields for some time to come. No definite answers have yet emerged from the research being conducted on this problem by the above-mentioned consortium. Similarly, the build-up of soil salinity and sodicity in the dry, western areas of this farming system – caused by poor water management – will also continue until appropriate steps are taken to improve water control at farm level. Reversing these trends will depend on the success of future research and extension, as well as on policy decisions favouring balanced fertiliser use and efficient utilisation of water.

There has been a rapid expansion of tubewells in some areas such as Western and Central Uttar Pradesh, resulting in declining water tables. Unless there is strict monitoring of the quantity and quality of groundwater and control of its exploitation, serious problems of water availability will be faced by farmers within a few years. There will be increasing levels of mechanisation, especially for primary tillage, which is already noticeable in the Pakistan Punjab where most draught oxen have disappeared. The typical enterprise pattern is expected to shift towards more dairy, horticulture and feed grains. Because of the availability of feed grains and crop by-products, plus the proximity of major urban markets, this farming system is a likely growth location for specialised large-scale, industrial poultry production.

Overall, most farmers are expected to achieve both household food security and increased farm household incomes by the year 2030. There may also be a gradual decline in poverty among the landless as wage rates rise – even if opportunities for agricultural employment diminish. Some improvement in infrastructure is probable, particularly better roads. Decentralisation will bring decision making closer to the farm, and in the process women will have a greater role in local governance. It is expected that farmers' organisations will be strengthened. Funding of public-sector research and extension will decline, and the private sector and farmers' organisations may play a larger role in experimentation and advisory services; which may improve the efficiency of the dissemination of technical information. Modest growth of the non-farm rural economy is expected.

SYSTEM PRIORITIES

There are a number of worthwhile options for development of this farming system, although the opportunity cost of labour will be a critical determinant of the viability of interventions. One high priority is to tackle the resource conservation issues of the system, such as declining soil fertility, development of salinity and sodicity problems on irrigated land in western areas, and groundwater depletion in parts irrigated by tube-wells. Research is being conducted to develop technologies that can improve the level of soil fertility; which has fallen as a result of the continuous, intensive cereal production practised since the Green Revolution started. However, governments sometimes pursue policies that work at cross-purposes with such research efforts. Thus, continuance of heavy subsidies on urea fertiliser in India, while at the same time deregulating the prices of P and K fertiliser, is causing an imbalance in fertiliser use among farmers – particularly resource-poor farmers practising the rice-wheat rotation. As a result, there is continuous mining of

P and K nutrients in the soil causing long-term damage to soil productivity.

As mentioned above, an important factor contributing to the development of salinity and sodicity in irrigated areas of this farming system is the inefficient use of water, particularly at farm level. The highly undervalued price of water from canal systems and the heavy subsidies – up to 100 percent on shallow tube wells, and 25 to 50 percent on pumps and variable rates on electricity for pumping – are all incentives for excessive use of water by farmers, with consequent waterlogging. Depletion of water tables by indiscriminate sinking of tubewells also arises from these same subsidies, as well as from the absence of appropriate monitoring and regulatory mechanisms. While waiting for governments to deal directly with these policy issues, another option would be to improve moisture conservation by employing a range of techniques such as zero tillage, use of plastic and other mulches, and planting of windbreaks. Improvement of irrigation security would also materially improve the system, by allowing the adoption of short-duration rice varieties, more timely wheat sowing and production of spring vegetables.

Many of these resource management technologies are scale neutral and thus poor smallholders – although perhaps not sharecroppers – will gain from their adoption. The need for close co-ordination between water management, fertiliser use, pest control and other husbandry practices, has resulted in the development of Integrated Crop Management (ICM)[27]. The dissemination of ICM practices to farmers could be a good option for increasing rice yields and reducing the cost of rice production in South Asia. In some countries the active participation of women will also be a challenge. Another approach that would be appropriate, especially in rainfed areas susceptible to erosion or where labour costs are high, is Conservation Agriculture (CA), in which minimum tillage is practised for better moisture and soil conservation. The objective should be to let farmers choose those approaches and practices that best suit their conditions and circumstances.

Good opportunities also exist for better integration of ruminant livestock into smallholder farming systems, with profitable conversion of crop by-products, increased use of manure, and possibilities of regular cash income from dairying and savings in the form of adult stock. The treatment of straw, using urea or other chemicals to increase its value to livestock, is likely to be adopted more widely. Such labour-intensive expansion of livestock production on smallholder farming systems will increase output and reduce poverty. Large-scale industrial production of animals, especially dairy and poultry, will also expand. The expansion of livestock enterprises will stimulate feed production and the development of a feed industry. It will be desirable to site industrial livestock production units so as to minimise feed transport costs and to contain environmental problems involved in processing. Since industrial livestock production will boost output but not reduce poverty to any significant degree, the challenge will be to promote linkages – between industrial livestock production and smallholder livestock production – which benefit poor farmers. Investments in industrial livestock production in this zone are likely to be short term, since in the medium and longer term the locus of feed production and industrial livestock production may shift to the Rainfed Mixed Farming System, where land values and population densities are lower.

The system can easily incorporate many other forms of diversification, including the introduction of fruit trees or other cash crops in situations where land is owner occupied – but this would normally not be possible under sharecropping arrangements. Diversification will generally require investments in marketing, transport infrastructure, research, extension and other support services. Although governments may continue to provide certain categories of seed and planting material, it is expected that farmer co-operatives and the private sector would progressively take over this activity. Similarly, the demand for technical and market information could be addressed through public-private partnerships.

[27] ICM has been effectively applied to increase rice yield and productivity in Australia, Egypt, the Republic of Korea and the FAO project BGD/89/045, Thana Cereal Technology Transfer and Identification in Bangladesh.

5 Rainfed Mixed Farming System

SYSTEM DESCRIPTION

This system covers nearly 30 percent of the land in the region, and includes parts of Sind, Punjab and North West Frontier Province in Pakistan; large areas of Central, Southern and Western India; the northern part of the Terai bordering the Shivaliks and the dry zone of Sri Lanka. The system is not directly supported by any large irrigation system, but in many instances relatively small areas irrigated from tanks ensure the sustainability of the Rainfed Mixed Farming System. This traditional system has been further supplemented by the use of tubewells and agro-wells, where these have been found feasible. The presence of even a small irrigated area provides some security to the system. However, being mostly dependent on rainfall the system is quite risky, making the introduction of new technology difficult. The crops grown include wheat, barley, vegetables and fodder crops in the cooler northern areas and maize, sorghum, finger millet, vegetables, chickpea, pigeon pea, green gram, black gram and groundnuts in the warmer climates of Southern Asia. Smaller areas of soybean, rapeseed, chilli, onions and sesame are grown mainly as cash crops. Double cropping is possible only in limited areas where irrigation is available. In Southern India and the Dry Zone of Sri Lanka, where land holdings are smaller, farmers prefer to grow wetland rice on any irrigated land available, as well as in the poorly-drained valley bottoms during the wet season. The above-mentioned coarse grains, pulses and oilseeds are grown on the upper parts of the landscape. Some fruit trees such as mango are grown in the home gardens in small orchards.

Total population	371 million
Agricultural population	226 million
Total land	147 million ha
Agro-ecological zone	Dry sub-humid
Arable land in use	87 million ha
Irrigated area	14 million ha
Bovine population	371 million
Small ruminants	64 million

BOX 6: A TYPICAL RAINFED MIXED FARM SYSTEM HOUSEHOLD

A typical rainfed mixed poor farm household with 6 family members cultivates 3 ha of land in Madhya Pradesh, India. The crops include 1 ha sorghum (post-rainy season) with a yield of 1.3 t/ha, about 0.5 ha of chickpea yielding 0.85 t/ha, 0.2 ha of pigeon pea yielding 0.5 t/ha, 0.3 ha of groundnuts yielding 0.6 t/ha, 0.2 ha of rapeseed yielding 0.7 t/ha. The household owns two head of cattle, several goats and some poultry. It has a combined average income just beneath the international poverty line, and it is also vulnerable to crop failures.

Livestock are an important part of the farming system, which supports the largest share of cattle, sheep and goats in the region and which usually provide the major part of the farm family's cash income. This is generally through sales of adult animals or young stock, since in most instances the areas are too remote for commercial milk production.

While the total area covered by the system is larger than the preceding Rice-Wheat Farming System, the heavy reliance on rainfed agriculture imposes a much lower population density – about half that of the latter system. A large proportion of the rural population in the Rainfed-Mixed Farming System lives in poverty. Agriculture is oriented towards subsistence; while most areas are poorly served by infrastructure and services, and are remote from markets. Agricultural extension services in these

BOX 7: SEASONAL VULNERABILITY

Seasonal vulnerability is a critical dimension of livelihoods in the Deccan Plateau. Crop failure is more likely than in any other major cropping area in South Asia, and traditional coping mechanisms have weakened. New forms of risk reduction for smallholders such as rainfall insurance, may offer promise.

areas are typically weak, farmers mostly use traditional technology with a strong bias towards risk avoidance. Land tenure is often an issue and farmers may not have sufficiently clear titles to their land to be able to use it as collateral for obtaining institutional credit.

SYSTEM-SPECIFIC TRENDS AND ISSUES

There will be increasing scarcity of fresh water resources as agricultural and urban demands expand. Land degradation, including soil fertility decline, is expected to continue. Food crop production will increase and the use of hybrid sorghums and millets will become more widespread. Soybean, mung and other higher-yielding legumes will replace traditional pulses. The oilseed component of the cropping pattern is likely to expand. The system will become more commercial, with a modest increase in the use of external inputs and a moderate level of mechanisation. Livestock productivity is expected to increase through more stall-feeding. Although household food security will improve, there will still be food deficits in drought years.

With regard to the external environment, some improvement of transport infrastructure and social services is expected. Government agencies will decentralise to a significant degree and the role of women in local decision making may be strengthened. Whilst the scope of public sector research and extension will contract, there will be a greater role for farmer organisations in the provision of agricultural services. Limited expansion of the non-farm rural economy is expected.

SYSTEM PRIORITIES

Little can be done without increasing the overall water security of the farm family. This generally entails improving the availability of water for drinking and irrigation by repairing existing tanks, improving diversion works from streams and increasing the scale of water harvesting, as well as acquiring more low-lift pumps, tubewells and agro-wells. These improvements will require social mobilisation and participatory planning if they are to be sustainable. Maximisation of moisture and soil conservation through conservation agriculture will also reduce the climatic risk. This approach includes measures such as timely cultivation, minimum tillage, rapid seeding with early-maturing varieties, mulching and – where the low opportunity cost of labour in the dry season and the nature of the soil make it an option – bunding and tied ridging. In this area new technology is being adopted slowly or not at all. More sophisticated methods, such as the use of plastic film for water conservation, are absent altogether. Where drinking water is available that is at least adequate and secure, one good entry point is the improvement in livestock production through planting of fodder grasses and stall feeding. This in turn can lead to a build-up of fertility with consequent better rainfed crops and more arable by-products for animal feed.

Since this farming system depends for its survival on rainfall and possibly groundwater, adequate measures are required in the upper catchments to make sure that tree cover is adequate for it to reduce run-off, and encourage infiltration and percolation that can recharge local aquifers. Improvements to this farming system will need assistance in a spectrum of disciplines, including irrigation engineering, forestry, fodder production, livestock husbandry and horticulture, in addition to mainstream arable crops. Introduction of horticulture and fruit crops is generally constrained by remoteness from markets. This can be overcome in areas where there is some comparative advantage for fruit and vegetable production, if private sector interest in establishing processing plants can be generated. be explained

Some research stations claim to have developed packages of practices suitable for this rainfed farming system. In general, adoption of these recommendations is disappointingly low, but this can be explained by farmer's aversion to risk, or by shortage of labour or other resources to implement improvements. Successful projects or programmes of assistance need to have a wider focus, rather than merely being concentrated on agriculture-related measures. Provision of reliable drinking water is generally the first priority need in these areas; and other social services including health clinics and primary schools, are normally lacking.

The development of markets is less impor-tant than in the Rice-Wheat Farming System. However, access by poor households to land, water and forest resources will be a critical issue. Similarly, access to sources of information is important for the intensification and diversification of these systems.

6 Highland Mixed Farming System

SYSTEM DESCRIPTION

This system is a mixed upland system involving cereals, legumes, tubers, fodder, fodder trees and livestock. It is found in the upland areas of Pakistan, India, Nepal, Bangladesh and Sri Lanka, and covers about 13 percent of the land area of the region. In the more remote areas, where mineral fertilisers are very costly or unavailable and distance to markets is prohibitive, the flow of nutrients to the farm holding is generally only from grazing or cutting of fodder trees from woodland areas at higher altitude. In more accessible areas, such as the central highlands of Sri Lanka, the opportunity for successful vegetable production, particularly potatoes, can result in a highly intensive system of commercial production. Similarly, in the hills of Himachal Pradesh there has been a large expansion in horticulture, particularly fruit orchards. Generally, ruminant livestock are an important part of the system as they provide draught power, milk, manure and cash income.

In most situations the existing communities have always lived in these areas, often as tribal societies that originally practised shifting cultivation. In fact, two thirds of the global indigenous population live in Asia, many of whom reside in the Highland Mixed Farming System zone. Most, however, have now adopted more settled agriculture. In some areas, these original communities have been joined by people from lower down the slope, pushed up by population pressure. In some instances there are also cases of land speculation where forest areas are cleared by 'farmers' with the support of a local landowner or businessman. In most instances farmers in these areas do not have land titles and some communities may well be living inside the boundary of the forest as recognised by the forest department. The most important issue is increased population pressure, both through natural increase and immigration by 'lowlanders', which can make the already fragile system unsustainable.

Total population	82 million
Agricultural population	53 million
Total land	65 million ha
Agro-ecological zone	Moist sub-humid
Arable land in use	19 million ha
Irrigated area	2.6 million ha
Bovine population	45 million
Small ruminants	66 million

BOX 8: A TYPICAL HIGHLAND MIXED FARMING HOUSEHOLD

A typical poor Highland Mixed farm household has 5 family members and owns 0.5 ha of land, of which 0.2 ha is cultivated with irrigated wetland rice followed by a poorly-irrigated wheat crop (both for home consumption), and the remaining 0.3 ha of upland is cultivated with maize for food and millet for the preparation of alcohol. The farm has some fruit trees and produces some vegetables. One ox, one cow and several goats are raised, all of which depend upon herding on overgrazed communal grassland and forest. Some oranges and the offspring of livestock are sold. Vulnerability is high. The only possibility to build up capital is through seasonal migration to the Terai or India for work.

SYSTEM-SPECIFIC TRENDS AND ISSUES

For many of these upland areas, particularly where there has been little development assistance, the trend

has been one of general deterioration in incomes, living standards and the overall environment, as population has increased. Reduction of forest cover on the upper slopes, unimproved agriculture and continuous cultivation on steep slopes – often with thin or poor soils – have led to impoverishment of communities who now barely eke out an existence. They have virtually no cash income and women have to walk ever farther to secure their water and fuelwood needs. Soil and water conservation under these conditions is generally poor, and erosion and the decline of soil fertility can be serious. Generally, there are few local opportunities for young people, who often leave to find work elsewhere leaving an ageing resident population. Many of these problems may be explained by population pressure and the difficulty shifting cultivators have had in changing to settled agriculture. As in some other systems, the situation has not been helped by the general lack or insecurity of land tenure – most families having settled either on common land or within forest boundaries.

In some areas, social cohesion is absent or very poorly developed – each family becoming increasingly a law unto itself, with none of the normal hierarchy of village councils or headmen. This lack of social capital makes it difficult to resolve individual land ownership disputes or to obtain agreement on the use and management of common lands, both of which are pre-requisites for development. They also form the basis for the introduction of improved technology, land use guidelines, and the application of soil and water conservation methods. Several other factors aggravate the lack of social capital, including a low level of education and the paucity of communications facilities.

SYSTEM PRIORITIES

Lessons drawn from the few pockets of successful development provide the basis for strategic directions for future development of the Hills. In scattered areas with reasonable market access or strengthened social capital, for example along the milk collection routes outside major Hill cities such as Kathmandu, intensification of production is evident. To the north-east of Kathmandu, production of fresh vegetables has expanded and the resulting cash injection has increased input use on other crops. In some areas, the extensive planting of farm trees for fodder and timber – substituting for the loss of access to forest resources – is increasing the natural capital of the farms and reinforcing the basis for nutrient recycling through

BOX 9: PROMISING CROP-LIVESTOCK-FORESTRY INTERACTIONS[28]

A case study of this system in Nepal examined a number of innovative interventions that have been successfully tried out on a pilot scale. These could form some of the elements in a strategy to deal with the severe challenges of the overall Highland Mixed Farming System *viz.*: sloping land, poor soils, seasonal moisture stress, limited growing periods, population pressure and fragmentation of holdings (over 60 percent of farms are less than 0.5 ha. in the Nepalese part of the system), as well as isolation from markets. One of the more promising innovations studied was the transition from extensive grazing to zero grazing with cut and carry stall feeding of large ruminants. Stall feeding of livestock had a wide-ranging beneficial impact on labour availability, school attendance of children, adoption of new fodder species, nutrient recycling, the management of crop residues, breed improvement and reduced livestock numbers. A beneficial side effect has been to permit the production of fruit tree seedlings over larger areas. Because of the need to establish livestock development committees to manage the breeding programme, social fencing to protect fodder areas, and veterinary care within the community; community cooperation and the empowerment of local institutions has been fostered. Other promising interventions within the system included: (a) use of farmers' varietal selections, permitting simultaneous selection for a wide range of required characteristics and quicker release of varieties; (b) participatory integrated watershed management for improvement in living standards and encouraging alternative livelihood opportunities; (c) leasehold forestry, involving the hand-over of degraded forest land to households below the poverty line, raising their incomes and improving the ecological conditions in the hills, and (d) community forestry management in which National Forest areas in Nepal are transferred to local community management.

[28] Kiff, L. and B. Pound, 2001, Promising Crop-Livestock-Forestry Interactions for the Highland Mixed Farming System, Nepal, Case Study, Global Farming Systems Study, FAO, Rome.

crop-livestock integration. Other cases have shown how community empowerment improves resource management and incomes, even those of the poorest within a village. This is achieved through communal management of common resources, and group action to increase production through the acquisition of improved germplasm and inputs, plus better marketing[29].

The main plank in the strategy for development in the hill areas should be to arrest land degradation through soil and water conservation, as part of a programme to improve living standards – a strategy that could be termed conservation by stealth. The programme could involve a whole range of measures including integrated crop and livestock husbandry, agro-forestry, introduction of cash crops such as coffee or fruit trees (where this is feasible and markets are available), planting of fodder crops, stall feeding of livestock, community managed animal health services and provision of drinking water. The outcomes of these measures can be further enhanced by undersowing wetland rice with leguminous fodder species such as Egyptian clover (*Trifolium alexandrianum*) before the basin dries out. This would improve livestock feed supply and provide green manure for the following crop as well.

Since remoteness and high transport costs usually make the use of mineral fertilisers difficult or impractical, development of livestock enterprises – with emphasis on improving nutrition, stall feeding and collection of dung – appears to be a good entry point in attacking poverty in upland areas. Where this can be accompanied by introduction of a cash enterprise, such as orchard fruit, vegetables, dairying or goat production, the chances of a significant reduction in poverty are much improved. Finding suitable cash crops for the more remote areas may, however, be difficult or impossible – fruit, vegetables and milk are normally ruled out. Nonetheless, even in these areas there may be opportunities for production of high-value, low-bulk commodities such as vegetable seeds, spices or medicinal plants.

All components of the programme need to be implemented in a participatory manner with the full support of the local community. A supportive policy environment must exist or be created, as this will facilitate local decision-making and allow local development and management of resources – especially in view of the difficulty of communicating with central or even district authorities. Devolution of decision-making authority will also help to build social capital, which is sometimes lacking in hill-dwelling peoples. Participatory research and extension services will be needed to support households and communities during the adoption and adaptation period.

In some instances, rural development interventions must be broader still, in order to include education and health clinics. Establishment of high-quality vocational training schools will foster the remittance economy that often constitutes an important source of rural household income and helps to reduce land fragmentation and maintain viable farm sizes. Projects aimed at development of upland watersheds now stress the importance of full community participation in all aspects of design and implementation. Such projects also include as one of their objectives, helping these local communities to develop the ability to take charge of their own affairs and to manage the land and water resources in their area, while being able to request technical advice from the respective government agencies.

[29] FAO/UNDP Farm level Applied Resource Management Programme.

7 Strategic Priorities for the Region

South Asia's total agricultural population is second only to East Asia and the Pacific, yet it is experiencing a much higher population growth rate. Compared with several other regions, South Asia has relatively little high potential land with fertile soils plus good irrigation or rainfall. The region has a long history of intensive agriculture which has sometimes led to substantial resource degradation. This situation has aggravated the already low availability of resources per capita. During the past 30 years – against all odds – the research and agricultural support services of the system have generated growth in food production in excess of population growth. The continued achievement of this situation is not guaranteed. After decades of protection, the accelerating opening of the region's economies will have profound future effects on farming system dynamics.

The conclusion from the above review of trends in the principal farming systems of South Asia, is that farming systems in the region are likely to evolve rapidly during the coming 30 years – for better or for worse – as technologies, institutions and markets change. The pace of change itself has been steadily increasing and may accelerate further over the next thirty years. Strong policy and investment underpinning for agriculture and rural development will be needed in the decades ahead if this change is to be managed in a satisfactory manner and a successful outcome achieved

NATURAL RESOURCES AND CLIMATE

Population Pressure and Climate Change. Natural resources will come under increased pressure, as a result of the growing demand for additional food and other agricultural produce to meet the needs of the expanding population. Population pressure is likely to be more intense in those farming systems already under severe strain, *viz.* the Intensive Rice, Rice-Wheat and Highland Mixed Farming Systems. If significant climate change were to occur over the next couple of decades, low lying coastal areas would come under intense pressure from storms and flooding, and rainfed semi-arid areas are likely to be seriously affected by increased rainfall variability.

Deforestation. The little forest left in the region will come under ever greater pressure during the coming 30 years. In most countries of the region forest departments have been slow to change their approach to forest management. This lack of progress exists despite ample evidence that sustainable productivity increases can be achieved by a joint system of forest management, which allows benefits to be enjoyed by forest dwelling communities. In many national forest policies, all income from forest products is still considered as national revenue. It seems evident that high priority should be given to re-orienting forestry development policy, and to changing departmental regulations to facilitate the establishment of joint forest management systems. These changes would increasingly empower local communities, while at the same time resulting in more efficient production of forest products. An further change needed in support of such developments is will be the re-definition of forest boundaries. This should be accompanied by decisions concerning optimal management systems for different forest areas, i.e. which areas are appropriate to be managed under some type of joint forest management system and which areas should remain under a more conventional departmental management regime.

Soil Degradation and Watershed Management. Soil degradation is a critical issue in most of the farming systems of the region. Priority needs to be given to ongoing and new participatory research and extension programmes that address these problems, such as those of the Rice-Wheat Consortium for the Indo-Gangetic Plains which has already led to spectacular expansion of zero-till wheat in the Rice-Wheat Farming System. A number of successful participatory, community-based pilot watershed management projects in the Rainfed Mixed and Highland Mixed Farming Systems have provided the methodology and experience to improve the management of the large number of critical watersheds in the region.

Depletion of Water Resources. Conservation of water resources in cultivated areas will require the establishment of mechanisms for the monitoring and regulation of water use; as well as of groundwater levels and water quality. The region's water resources can be further developed through traditional means, such as construction or rehabilitation of tanks and tubewells and improved water management. An important contribution can also be made by large-scale programmes to promote soil moisture conservation by means of mulching, bunding, relay cropping, windbreaks and more general purpose tree planting.

Significant improvements are also likely to result from the introduction of realistic water charges. This will be a question of "when" rather than "if" since the fiscal burden of running irrigation schemes can no longer be borne by governments in the region. Such improvements will include a wide range of improved water management techniques, including laser levelling of irrigation basins, and both sprinkler and trickle irrigation. They will also involve the introduction of more effective techniques of moisture conservation at farm level, through adjustments in cropping patterns, mulching, minimum tillage, relay cropping and water harvesting.

SCIENCE AND TECHNOLOGY

Research. Notwithstanding the existence of a range of technologies which are ready for adaptation and adoption by farmers, there is a continuing need for research efforts that respond to farmers' needs and to a number of strategic priority production problems, including soil degradation in the intensively cultivated systems, continuing germplasm improvement in food crops and, perhaps of greatest importance in the long run, effective biological nitrogen fixation (BNF) to boost cereal productivity. There is substantial capacity in the larger NARs to exploit modern research techniques including:

- the potential of biotechnology, e.g. in the development of new genotypes possessing high yield potential and resistance to biotic stresses;
- the field of animal reproduction;
- value added through new agro-processing technologies.

The germplasm banks held by the NARs will be an important resource for public sector research and are also being utilised in private sector plant breeding efforts. Investments in support of agricultural research and extension – including livestock, forestry and fishery – will pay off handsomely if carried out using a problem oriented, farmer-centred multi-disciplinary approach. Two priority foci would be; (i) maintaining and expanding public research capacity, and (ii) concurrently building partnerships between the public sector, the private sector and farmer organisations.

In many countries in the region, current husbandry practices related to the use of nitrogen fertiliser show considerable scope for efficiency improvement. In the short run, priority should be given to better on-farm nutrient management (INM), combining inorganic and organic nutrient sources, regulatory measures and economic incentives for balanced fertiliser use and reduced green-house gas emissions. The improvements should be combined with technological improvements, such as more cost-effective slow-release formulations in order to reduce losses of plant nutrients. In the long run, breakthroughs in BNF would have a major impact on agriculture.

GLOBALISATION AND MARKET DEVELOPMENT

Trade Liberalisation. The three significant global issues that affect this region are: gaining access to developed country markets in OECD countries; declining terms of trade for agricultural commodities; and the continuation of subsidies for agriculture in developed countries. The terms of trade for rice, wheat and other foodgrains have been declining and the opening of economies exposes farmers to these forces, especially in the Intensive Rice-Based, Rice-Wheat Based, the Upland and the Rainfed Mixed Farming Systems.

Local Markets and Price Information Systems. Notwithstanding all the attention being given to global

issues, functioning local commodity markets and price information systems are of more direct interest to most smallholders. The experience of the recent past has demonstrated that market-led growth does not necessarily lead to benefits for the poor unless strong institutions are in place. Considerable investment is needed in these areas, and especially in the more remote farming systems such as the Highland Mixed and Pastoral Farming Systems. Similarly, further development of rural financial services, including micro-finance and linkages to mainstream banking, are needed for the full potential of farming systems to be realised.

Farm Size. Farms are generally small and fragmented, which limits economies of scale and hinders marketing. For example, the purchase or leasing of machinery for mechanisation in the Intensive Rice-Based, Rice-Wheat Based and Rainfed Mixed Farming Systems, is beyond the capacity of individual small farmers. Moreover, the mechanised services – ploughing, harvesting, threshing – are often too expensive when obtained from a private-sector provider. Likewise, smallholders are at a disadvantage in marketing perishable and minor commodities or purchasing inputs, especially in the more remote areas of the Highland Mixed Farming System. Strengthening of farmers organisations (FOs) and assisting them to enter into commercial activities, by forming farmer companies for example, will help them access some of these services at reasonable rates, and will also give them greater bargaining power in buying inputs and selling their produce.

POLICIES, INSTITUTIONS AND PUBLIC GOODS

Pro-Rural Policies. Most countries in the region have policies that effectively favour the urban areas and the manufacturing sector rather than rural areas and the agricultural sector, i.e. there are national trade and price distortions with a negative impact on the commercialisation of farming systems. For example, the need to maintain food prices within the reach of the increasing, politically articulate, urban population causes some governments to keep inter-harvest food prices artificially low by releasing stocks of grain as prices rise; thus adversely affecting farmgate prices. Because the majority of the poor are located in rural areas, poverty reduction efforts should be targeted towards increased agricultural income. Moreover, successful rural poverty reduction has a positive impact on urban poverty reduction, but the converse is not true.

Strengthening Local Institutions. Decentralisation and performance of local institutions will be key issues in the development of most farming systems. Line departments have already given up some of their functions to the private sector, and plan to hand-over other functions to empowered communities. This trend will become more pronounced in future. However, this handover of functions may not take place very rapidly, and the quality of its implementation will require monitoring – given the close relationship between rural community constituencies and politicians. Yet rural development depends on effective local institutions, including community institutions, for which performance-based incentive schemes will be desirable. Another far-reaching change which is occurring in association with decentralisation and which needs to be encouraged, is the growing role of women in *panchayat* (local council) and district decision making. The growth of public-private partnerships for agricultural development should also be promoted, as they will have far-reaching effects on determining agricultural research priorities.

Socio-economic Research. It is conventional wisdom that vigorous agricultural growth has to be established in order to prime the non-farm rural economy and that both these sub-sectors are interdependent through consumption, production and labour market linkages. However, agricultural policy and development planning will need to take account of the increasing degree to which the roles are reversed. In many cases, off-farm employment is priming the rural farm economy and the growth of agriculture depends on injections of cash directly from this source, as well as from remittances. The return per labour day in agriculture compared to off-farm employment, as well as the seasonality of such off-farm employment, have important implications for labour availability on the farm – particularly at times of peak labour demand. Socio-economic research is needed concerning the impact of this phenomenon on the farm enterprise, as well as to identify the means by which farmer can adjust to the demands of off-farm employment. The policy implications for government also need to be studied, e.g. the need to facilitate the provision of mechanised land preparation and harvesting services by farmer companies or the private sector.

Roads and Educational Services. A high proportion of the increase in foodgrain production during the Indian Green Revolution, occurred in the 10 percent of districts with adequate local infrastructure, especially with regard to water management, transport and electricity for tubewells. On the other hand, agricultural development in many areas of the region has been constrained by a lack of infrastructure. In particular, the shortage of roads in remote and sparsely populated areas pushes up input and product transport costs and the lack of health and educational services reduces labour productivity[30]. Investments in roads and educational services should, therefore, be an essential ingredient of a strategy for increasing agricultural production and rural development.

Water Charges. Supply of irrigation water is traditionally free in many areas and is often seen as a way of supporting farmers and keeping down food prices. Significant improvement in water management will only be possible if realistic water charges are introduced. Better arrangements are required to provide an equitable balance between the benefits accruing to downstream users of irrigation water and electricity, and the well-being of the communities living in the upper catchment above and around the dam.

INFORMATION AND HUMAN CAPITAL

Rural Education. Investment in rural education is required for two reasons: (i) to equip workers with the skills to transfer from agriculture to the non-farm economy; and (ii) to equip the remaining farmers to manage the emerging knowledge-intensive farming systems. The strategic research priorities outlined above call for the training of professionals in research and agricultural support services. Although total labour requirements in agriculture are not likely to increase, improved skills are required to increase efficiency and productivity. These local increases of human capital are needed in order to underpin the development of small-scale local rural industry – perhaps along the lines of some of the more successful examples of rural industry found in China.

Information Services. The shift to commercial knowledge in intensive farming systems requires a greatly improved flow of information concerning technologies and markets, to both farmers and support services. This emerges as a key issue and is a promising area for public-private partnerships.

HIGH POTENTIAL AND LOW POTENTIAL AREAS

Some strategic priorities and interventions will be common to agriculture and rural development across the region, while others will be specific to particular system situations. For example, priorities and interventions will be different for systems in high potential as opposed to low potential areas.

High Potential Areas. Governments are likely to continue, quite correctly, to give greatest attention to the well-watered main cereal producing areas of the Rice and the Rice-Wheat Farming Systems. Governments' priority objective will in most cases be an adequate level of self sufficiency of food supply at acceptable prices. Since there will likely be little scope for price support schemes or subsidies, the main technical strategy will to improve the efficiency of production. This trend is already evident in aspects such as conjunctive use of water, where relatively cheap tubewells provide the needed timely supply of water which the state-managed surface irrigation schemes often cannot meet. Very significant changes will be likely as realistic water charges are introduced. These will involve a wide range of water management techniques including laser levelling of irrigation basins, sprinkler and trickle irrigation; and the introduction of greater moisture conservation, including zero tillage, mulching, windbreaks and relay cropping.

There will also be a need to give considerable attention to soil management. In the Rice-Wheat Farming System, intensive cultivation and unbalanced fertiliser applications have led to a deterioration in soil structure and fertility. Solutions are now being developed to tackle the immediate problem. However, it will be important to develop a range of technologies for sound soil management under highly-intensive continuous irrigated cultivation. The need for precision management of fertiliser nutrients is a closely related issue, not only from the point of view of efficiency in use for grain formation, but also to minimise ground-water pollution. Improved pest management will also be necessary, and it is expected that this will be biologically

[30] Whilst attention to the HIV/AIDS-agriculture linkages has focused on SSA, it is conceivable that AIDS will also cause major suffering and affect agricultural productivity during the coming 30 years elsewhere, including in rural SAS.

oriented for most crops and, increasingly, for livestock. While these areas will remain quite highly specialised in cereal production, there will be a degree of diversification into high value enterprises – including orchard crops and livestock. Household livelihoods will also diversify, and an increasing share of off-farm income is expected for smallholder households.

Low Potential Areas. The Rainfed Mixed, Upland and Pastoral Farming Systems are intrinsically less able than the lowland areas to provide production responses in food crops, but they are likely to see a measure of diversification into high-value produce as market access spreads. In the meantime, the severe poverty prevalent in these areas will probably lead to continuing seasonal and permanent migration, especially of young people. Government initiatives would therefore be undertaken more for social and welfare reasons, than for national food security considerations. However, there are some significant possibilities for development. A community based micro-watershed approach, such as that which is succeeding in parts of India, would form a sound basis for the development of the Rainfed Mixed Farming System. Conservation agriculture should be introduced; including the greater integration of livestock and trees into the farming systems – with fodder trees, catch crops and green manure crops. Such programmes should include the introduction of cash enterprises, such as dairying or orchard crops, wherever market access is feasible. Greater attention to soil and water conservation should also form a vital element in such programmes; including zero tillage, mulching, relay cropping, windbreaks and on-farm tree planting. Development of sound and sustainable agroforestry and forestry operations with participatory management for much of the forest area, will be important in maintaining a good forest cover in the upper catchments, as well as on the large areas of wasteland that currently exist in the Region.

OVERALL REGIONAL CONSIDERATIONS

In both plains and highland areas, government priorities and interventions would include improvements in rural infrastructure – roads, drinking water, schools and health facilities – and also the encouragement of agro-industries and private sector participation in the provision of services to farmers. Government strategies and policies are likely to be focused on realistic pricing for water and power used by farmers; as well as on greater involvement of farmers and the rural population generally, in planning and implementing agricultural programmes. Devolution of the planning and operation of development schemes is likely to increase.

Despite the increasing reluctance of aid agencies to engage in development activities of a sensitive nature, such as large dams and in some cases forestry activities, this type of development will continue to be promoted by governments in the region as a response to internal demands. However, on the basis of experience gained during the implementation of previous projects and the degree of public interest aroused by the issues involved, it is likely that methods will be developed to meet and overcome past criticisms and mistakes. While there will be increasing emphasis on supply of materials and services to farmers by the private sector, there will be a continuing need for government support to research, although the form of this may well change to contracts rather than direct budget subventions. The research focus will also shift from being predominantly focused on production gains, towards emphasising production in the context of more efficient use and co-ordination of inputs. Continued and increased government support for the latter will be crucial in view of the general unattractiveness of these concepts to private sector manufacturers and research institutes.

CHANGING SCENARIOS

This analysis has been largely based on the FAO trends and projections[31], based on recent trends adjusted for expected technology, market and institutional changes. It is worth considering the likely impact of deviations from the FAO projections.

Climate Change. Whilst the existence of global warming is now widely recognized, estimates of the magnitude of change over the coming 30 years vary significantly. A higher level of global warming is expected to lead to changes in the precipitation regime across the region and higher sea levels. The anticipated increase in climatic variability would lead to greater incidence of both droughts and floods, thus

[31] AT2015/2030, FAO 2000.

substantially increasing the risk exposure of a many farmers in the region, especially in semi-arid and flood-prone areas. Welfare and productivity considerations indicate that greater public investment in disaster preparedness and information dissemination would be appropriate. Because the increased variability of crop and livestock production stemming from faster global warming may reduce the attractiveness of some farm inputs and investments, mechanisms to mitigate farm household risk should be considered.

Trade Liberalisation. The impact of different degrees of trade liberalisation would depend upon associated changes in the macro and agricultural policy environments. A roll back of trade liberalisation may have the effects of dampening the instability of farm gate prices and, in the short term, of reducing the deterioration of agricultural terms of trade. Alternatively, accelerated trade liberalisation could lead to dramatic changes in farming systems, with the risk of additional poverty caused during the adjustment process. Whilst the effects on the Pastoral Farming System are uncertain, it is expected that the shift to non-food crops in the Rainfed Mixed Farming System may slow down, and the Rice, Rice-Wheat and Highland Mixed Farming Systems may be forced to rapidly diversity towards high-value commodities, including dairy, aquaculture and fruit production.

Annex: Maps