AGRICULTURAL RESEARCH PRIORITIES IN THE ASIA-PACIFIC REGION - AN APAARI OVERVIEW

ASIA-PACIFIC ASSOCIATION OF AGRICULTURAL RESEARCH INSTITUTIONS
FAO REGIONAL OFFICE FOR ASIA & THE PACIFIC
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FOREWORD

The Asia Pacific region, has lately witnessed a number of paradigm shifts at the global agricultural scenario. These are food security, sustainable agriculture, globalization of agriculture, intellectual property rights regime and concern for sharing the genetic resources for the benefit of mankind. These new challenges demand critical introspection of on-going research efforts and reprioritization among our priorities so as to address these more successfully using available resources both efficiently and effectively.

Besides, APAARI has been fully conscious of the fact that there is a need to define regional and sub-regional research priorities, so as to enable member countries to pursue their goals in a mission-mode, using regional collaboration and partnership approach. APAARI has also actively participated in the CGIAR's transformation process and in the regional needs and requirements on a systematic basis involving NARS and CGIAR leadership by organizing expert consultations on the subject from time to time. This prioritization process would now enable NARS to establish effective linkages among themselves as well as with institutions of excellence and such prioritization process is expected to attract required donor support in order to meet our future challenges successfully.

Towards this process, an Expert Consultation was held in November, 1996 at New Delhi to have research prioritization at the micro-level for its four sub-regions. The summary recommendations were also endorsed by the Fourth General Assembly of APAARI.

The present volume covers the proceedings of the Expert Consultation on Research Priority Setting by NARS in the Asia-Pacific Region. It has brought out over all regional priorities as well as micro-level priorities for the four sub-regions so that appropriate regional/sub-regional programmes are initiated to address the emerging challenges successfully. It is our expectation that the proceedings will draw the attention of all the stakeholders as well as donors to encourage national as well as regional programmes so that Asia-Pacific region continues with a vibrant agricultural growth in the future.

(R.S. Paroda)
Executive Secretary
APAARI

New Delhi
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EXECUTIVE SUMMARY

Above 3.1 billion people, being 56 per cent of the world population, live in the Asia-Pacific region as against only 12 and 9 per cent of the total world population, respectively represented in the Africa and the Latin America among other regions. The region has 30 per cent of the global agricultural land. It is rich in diversity of plant, animal and fish species. It houses 70 per cent of farm households. It has the largest concentration of poor people although it also has eight of the 15 mega cities of the world. Agriculture accounts for 34 per cent to 57 per cent of GDP of most of the countries of the region. The share of labour force in agriculture is approximately 70 per cent over the past few decades. Aggregate agricultural output in the Asia-Pacific region expanded between 1966 and 1992, largely due to increased cropping intensity and better yields. This output has expanded by two to three folds.

Agricultural products and by-products remained the major source of foreign exchange earning of many countries in Asia-Pacific. Total value of agricultural exports rose considerably, from US$2.2 billion in 1966 to US$16.8 billion in 1993 in Southeast Asia alone which was based mainly on traditional commodities, such as, timber and other forest products, palm oil, rubber, copra and coconut oil, sugar and rice. In some countries in the region, a wide variety of non-traditional products, such as, orchids, other cut-flowers, seafood products, fruits and vegetables, coffee, cacao, and spices have also found way into the export markets. Intra-regional trade has expanded rapidly, showing 22 per cent growth rate in the 1970s and 12 per cent, in the 1980s which was respectively higher than the other regions.

Maintaining growth with a high agricultural output is of concern corresponding to the population growth. The agricultural sector continues to serve as a major source of employment and/ or subsistence for a large part of its population. However, natural resource constraints, such as, arable land limit further increase in agricultural output. Ratio of arable land to agricultural population per capita deteriorated from 0.34 ha in 1961 to 0.13 ha in 1993 which is likely to continue further with population expansion, migration, urbanisation and industrialisation. A general slowdown in production growth particularly for major foodgrains has been observed, primarily due to decline in yield growth rates and the efforts to promote further increase in agricultural production in food and other crops with high commercial value need to be geared up.

Increase in production of animals and animal products is equally constrained due to decline in land availability and the increase in future could be made possible from enhanced animal productivity and intensified production. Sustainability in animal productivity is also required which could be attained through a better provision of nutritious feed, improvement of livestock and animal health. Increased production in fish and fish products could be made possible from efficient management of tropical aquatic resource, better understanding of land-water relationships to minimise pollution and habitat destruction and development of more efficient systems in aquaculture farming.

In order to achieve constructive gains, agricultural research has to play a more critical role. Increased production alone is the answer to the challenge for growth in food demand. APAARI has viewed these aspects with concern since 1990 and through various expert consultations and opinion building has identified common research goals and priorities for the region. Efficiency, food self-sufficiency, employment generation, agricultural modernization, global competitiveness, resource conservation/ sustainability; and agricultural diversification have been considered to be the priority research goals.

The emphasis on efficiency is made with respect to various factors, namely, need to achieve global competitiveness, rapid growth in population, decreasing land availability, and deteriorating land quality. Maintaining self-sufficiency in staple foods is of great significance as their adequate supply is often associated with progress and stability. Employment generation in diverse sectors remains important considering the fact that agricultural sector alone remains the largest source of livelihood particularly for rural population. Most countries in the region are fully aware of their respective rich genetic resources and also of the adverse environmental consequences often resulting from agricultural intensification. Yet, sustainability, resource conservation and agricultural diversification are underscored in the Asia-Pacific region and need priority.

Research priorities for various commodities or for broad areas of research, as pointed out by various NARS in the Asia-Pacific region and as deliberated upon and recommended during expert consultancies and meetings, have been pinned up in this report. *High priority has been accorded to* a wide range of commodities, such as, *cereals, coarse cereals, pulses, oilseeds, fruits and vegetables, cattle, poultry, inland and marine fisheries and forestry species.* Further, *flowers, roots and tubers, small ruminants and swine are placed under medium priority.* Resource management and conservation, particularly in relation to soil, water and land use planning were considered to be of high priority as per the broad areas of research. Similarly, agro-forestry, biodiversity conservation, biotechnology, institutional building, human resource development and germplasm enhancement have been considered high priority research areas whereas land use system for rangelands, marginal lands, degraded lands and wastelands have been accorded medium priority. Further, socio-economics, public policy, market research, management research and activities related to processing, product development and value addition have been recommended for a medium research priority for the region.

Agro-ecological commodity research approach was also followed in priority identification; rice, wheat, vegetables and inland aquaculture have been considered high priority research commodities under irrigated agro-ecological regime and rice, coarse cereals, fruits, agro-forestry and livestock under the rainfed areas. In coastal areas, rice and inland and marine aquaculture are high priority commodities whereas in hilly areas fruits, vegetables, spices/plantation crops, agro-forestry and livestock are the high priority commodities.

Several advantages in favour of APAARI and the Asia -Pacific region were clearly observed by Heads of member NARS/countries and other international authorities/experts in relation to the follow up of global research agenda and Action Plan. These included the institutional mechanisms, capabilities of the advance NARS, potentials of the smaller countries to effectively develop their national agricultural research capabilities vis-a-vis systems, abundance of natural resource base and inexpensive manpower, appropriate perception and institution of biotechnologies, availability of model networks and potential for development of other commodity or system based networks/consortia. The APPARI region has been receiving appropriate attention of the international ARIs yet with the transformation of CG system and the upcoming of the global forum, the intra-regional and the regional collaborations have a more demanding role to play. Effective support of the funding agencies and donors has been instrumental in begetting good results in the past. However, scrutiny for the need-cum-merit of the individual cases is a tough task which the APAARI duly appreciates. It has, therefore, drawn out micro-level priorities at the regional level and for the sub-regions so as to help gear the pace of need-based, collective/ collaborative research in agriculture in the region which shall also conform to the global plan of action targets.

Asia Pacific Region

THE BACKGROUND

The Asia and the Pacific is a thickly populated region having more than 55 per cent of the world population housed on just one-fifth of total land area. Its population is predominantly agrarian with over 57 per cent of the 3.1 billion people in the region sustaining on agriculture. Further, nearly three-fourth (72.3%) of the global economic population engaged in agriculture is represented by this region alone (FAO, 1995). An average population growth rate of around 2 per cent was observed in the Asia-Pacific between 1980-92 and the estimated projections for 1993-2000 showed a marginal decline (1.8%) (RAP, 1996).

The Asia-Pacific region represents 20.9 per cent of the world's cultivated area including permanent area under crops. It has recorded nearly two-fifth world production of food crop commodities including cereals, roots and tuber crops, pulses, oilseeds, vegetables and fruits. The proportion of cereal crop production has been impressive (48%) and, in terms of rice alone, this region produced over 91 per cent of total global rice production. The share of agriculture in Gross Domestic Product (GDP) was recorded to be 26.7 per cent in 1994. Some of the countries in the region showing a high percentage were Laos (57.4%), Myanmar (47.1%) and those on the lower side were Republic of Korea (7.2%), Thailand (11.1%), Cook Islands (12.5%), Malaysia (14.8%) and Indonesia (16.6%).

The average annual growth rate for total GDP in the recent past (1990-94) was recorded to be 5.4 per cent, whereas the corresponding value of agricultural GDP was low (2.3%). The IBRD World Development Report, 1996 showed a 3.5 per cent average annual growth rate (1985-94) in the Gross National Product (GNP) but the corresponding figures for average annual rate of inflation (1984-94) were considerably high (9.3%) (RAP, 1996). In terms of other economic indicators, a decline from 11.3 per cent in 1980 to 8.7 per cent in 1994 was observed in commercial food imports in the region as per cent of total merchandise import. Cereal imports registered an increase by over 18 million tonnes, from 62 million tonnes in 1980 to 80.9 million tonnes in 1994. The overview of relative increase in import and export in value in agricultural products showed a 7.8 per cent increase in import between 1984-94 and a corresponding 5.7 per cent increase in export, which is lower.

The Asia-Pacific region is by and large poverty stiken although it houses three developed countries as per FAO reports, namely, Australia, Japan and New Zealand (RAP, 1996) and also several advanced developing countries, such as, China, India, Korea and others. The region has eight of the fifteen mega cities of the world located here. Yet it also sustains largest concentration of poor people and the malnutritioned children. The South Asia sub-region alone houses nearly half of the poor and the malnutritioned children among the developing world. A considerably higher percentage of poverty, in comparison with the mean value for the developing countries (30%) has been recorded in Vietnam (54%), Philippines (45%), Bangladesh (44%) and Myanmar (35%) although data were not available for many other countries in the region.

A limited set of available IBRD data on food aid in cereals for the region showed a declining trend in food aid, from 3.2 million tonnes in 1980 to 1.8 million tonnes in 1994. This *inter alia* could be attributed to an increase by around 20 points in each of the agricultural production and food production indices in 1995 considering 1989-91 as the base (100 points). Figures for the region over the mean world figures in above cases were higher by 9 points each. A simple inference

may, therefore, be drawn; the region gives equal emphasis to production of food crop commodities when compared with total agricultural commodity production, including commercial crops. The agricultural research priorities in the region, have thus to be obviously focused on production of food from agriculture.

The affluence of human resource in the region is well supplemented with plentiful biodiversity and availability of diverse bio-resources. The entire region could be safely placed in the gene rich category although the advanced countries may have a limitation in this regard, A considerable, growth in human population in the region has been suitably matched with increase in food production and the production of other agricultural commodities, thanks to the green revolution and other strides in research in agriculture. However, there shall be a limit to the land and the water resources for

Table 1: Area and the population in the Asia-Pacific region and different sub-regions

Indicators		South Asia	SEAsia	NEAsia	Pacific Is. Countries	S-A Region	World
Total Area	Total	448.2	448.5	1019.5	53.1	1969.3	13422
(m ha)	% of region	22.8	22.8	51.7	2.7	14.7	
Land Area	Total	412.4	435.9	992.2	52	1892.5	12980
(m ha)	% of region	21.8	23	52.4	2.8	14.6	
Arable Area	Total	199.7	61.3	100.3	0.4	361.6	1342.8
(m ha)	% of region	55.2	17	27.7	0.1	26.9	
	% of landarea	48.4	14.1	10.1	.01	19.1	
Permanent Area	Total	5.3	24.6	4.2	0.8	34.9	104.7
under Crops	% of region	15.2	70.6	12	2.2	33.3	
(m ha)	% of landarea	1.3	5.6	.01	.02	1.8	
Per. Area under	Total	19.7	17.4	400.8	0.3	438.3	3361.7
Pasteurs	% of region	4.5	4	91.4	0.1	13	
(m ha)	% of landarea	4.8	4.0	40.4	.01	23.2	
Per. Area under	Total	83.8	227.3	169.5	46.8	527.5	4179.8
Forests & Woodland	% of region	15.9	43.1	32.1	8.9	12.6	
(m ha)	% of landarea	20.3	52.14	17.1	90.0	27.9	
Total Population	Total	1214.1	462.3	1401.8	5.9	3084.1	5630.2
(m)	% of region	39.4	15	45.4	0.2	54.8	
Economic pop.	Total	741.1	220.5	800.6	3	1765.1	2443.1
in Agriculture	% of region	42	12.5	45.4	0.1	72.3	
(m)	% of total population	61	47.7	57.1	50.8	57.2	43.3

agricultural use due to their likely saturation with the inflating population and increased food demand in the next century. Harvesting additional tonnes of animal meat, poultry and fish with increased productivity shall be an equally high priority so as to maintain a balance in food supply relative to energy requirements met from plant and animal products.

Table 2: Area (m ha) indicators for different countries in the Asia-Pacific region

Country/Region	Area		Arable Area		Permanent Area under		
	Total	Land	1978	1993	Crops	Pastures	For.&Wud
Bangladesh	14.4	13.1	8.92	9.45	0.24	0.6	0.9
Bhutan	4.7	4.7	0.1	0.12	0.02	0.27	3.1
India	328.8	297.3	164.59	166.1	3.55	11.4	68.5
Nepal	14.1	13.7	2.29	2.33	0.03	2	5.75
Pakistan	79.6	77.1	19.71	20.79	0.46	5	3.48
Sri Lanka	6.6	6.5	0.86	0.93	0.97	0.44	2.1
Cambodia	18.1	17.7	1.89	2.35	0.05	2	11.6
Indonesia	190.5	181.2	18	18.9	12.09	11.8	111.77
Laos	23.7	23	0.68	0.78	0.03	0.8	12.5
Malaysia	33	32.9	0.99	1.04	3.84	0.03	22.3
Myanmar	68.7	67.7	9.56	9.58	0.51	0.36	32.41
Philippines	30	29.8	5.08	5.52	3.67	1.28	13.6
Thailand	51.3	51.1	16.1	17.6	3.2	0.8	13.5
Vietnam	33.2	32.5	5.99	5.5	1.2	0.33	9.65
China	959.7	932.6	92.27	92.71	3.27	400	130.5
Japan	37.8	37.7	4.34	4.02	0.44	0.66	25.1
Korea	9.9	9.9	2.08	1.88	0.18	0.09	6.48
Korea DPR	12.1	12	1.59	1.7	0.3	0.05	7.37
Fiji	1.827	1.827	0.09	0.18	0.08	0.175	1.185
Papua New Guinea	46.284	45.286	0.017	0.04	0.375	0.08	42
Solomon Is.	2.89	2.799	0.04	0.04	0.017	0.039	2.45
Vanuatu	1.219	1.219	0.017	0.02	0.124	0.025	0.914
Cook's Is.	0.023	0.023	0.001	0.002	0.003	0	0.018
Fdrl. Polynesia	0.4	0.366	0.005	0.005	0.022	0.02	0.115
Tonga	0.075	0.072	0.016	0.017	0.031	0.004	0.008
Westren Samoa	0.284	0.283	0.055	0.055	0.067	0.001	0.134
Kiribati	0.073	0.073	-	-	0.037	0.002	-
Wallis Fut Is.	0.02	0.02	-	0.037	0.002	-	-
Tokelau	0.001	0.001	-	-	-	-	0.001
Tuvalu	0.003	0.003	-	-	-	-	0.001
Region	1969.3	1892.5	355.28	361.64	34.878	438.296	527.476
World	13422	12980	1326.4	1342.8	104.7	3361.7	4179.8

THE APAARI INITIATIVE

APAARI, since its inception in 1990 has been viewing the above facts with concern. Several expert consultations have been held, involving the member countries, other nations in the region, CGIAR institutes and international agricultural research institutions (ARI's) so as to call for a judicious perspective planning for the medium term, 1998-2000, and priority setting for agricultural research by NARS of member countries in a collective and collaborative mode. APAARI has been a keen forum that participated various CG conferences and meetings considering transformation of the CG system and also leading to the Global Forum. In order to translate the proposed priorities to agro-reality, APAARI has also been making fruitful interaction with various funding agencies and mechanisms that would recognize its regional agricultural research priorities for execution in various collaborative modes, such as in NARS-NARS, NARS-APAARI-CGIAR and NARS-APAARI-ARI, at different levels, namely, the regional, sub-regional and country levels.

This APAARI overview of agricultural research priorities in the Asia-Pacific region is primarily based upon CGIAR's framework for classifying research and is synthesized from the four sub-regional reports for the APAARI sub-regions, South Asia, Southeast Asia, Northeast Asia and the Pacific Island Countries. The basic input for the sub-regions and the synthesis was provided by APAARI identified resource persons on the recommendations of one of the Expert Consultations, on NARS-CGIAR partnership, held at New Delhi, 1-2 February, 1996 (APAARI, 1996a) which were thoroughly discussed with several new recommendations given in the Expert Consultation on research priority setting by NARS in the Asia-Pacific Region at New Delhi, 25-26 November, 1996 (APAARI, 1996b). In an IFAD initiative on building NARS-CGIAR partnership held in conjunction with the February, 1996 APAARI meeting, Paroda (1996) presented the APAARI vision towards NARS-CGIAR partnership giving a due emphasis on both crop priorities and 'agro-ecological - commodity research' priorities.

It is, therefore, envisaged to review the information base on selected components/indicators particularly those determining agricultural research priorities in the region/sub-regions/countries, as given above, and to refine and systematically categorize agricultural research priorities, including sub-regional/synthesis reports and Expert Consultations.

SELECTED INDICATORS FOR FOOD AND AGRICULTURAL DEVELOPMENT IN THE ASIA-PACIFIC SUB REGIONS

Population and poverty

The sub-regional data showed that South Asia sustains nearly half of the poor of the developing world and a large majority of them live in rural areas. The rural poor are predominantly landless or small farmers and artisans. 58 per cent of the children were estimated to be malnourished in the sub-region. Bangladesh recorded the highest percent population (44 per cent) under poverty line whereas more than two-fifth of the South Asia's poor lived in India. However, an improvement in poverty situation has been projected through the next two decades because of the anticipated rise in the per capita income in the sub-region.

A majority of the poor in the sub-region Southeast Asia are located in Cambodia, Laos, Vietnam, and Myanmar. About 54 per cent of population in Vietnam and 35 per cent in Myanmar has been under the poverty line. In Thailand, that is considered to be one of the fastest growing economies in Southeast Asia, the incidence of poverty was higher (30 per cent) than in Indonesia (25 per

cent) though its average per capita gross national product has been more than two times higher. In the Philippines, 45 per cent of the population was under poverty line.

The highly industrialized Northeast Asia sub-region did not reflect conspicuous socio-economic indicators for poverty line whereas the Pacific Island countries have been constrained at large with a poor economy due to weak economic sectors sustaining mainly upon the exploitation of their natural resources.

Table 3: Food supply indicators for the Asia-Pacific region and sub-regions

Indicators		South Asia	SEAsia	NEAsia	Pacific Is. Countries	S-A Region	World
Food supply	Total	2177	2488	2937	2734	2584	2718
(k cal/capita/day)	Vegetable	2031	2253	2529	2252	2266	2290
	Animal	161	272	407	483	331	428
Food supply	Total	50.7	57.1	76.1	68.7	63.2	70.8
(protein/capita/day)	Vegetable	43.9	42	52.9	35	43.3	46.2
	Animal	9.6	15.1	30.7	27.9	20.8	24.6
Food supply	Total	42.1	44.1	61.2	92	59.9	68.7
(fat/capita/day)	Vegetable	29.4	26.9	32.6	56.2	36.3	36.2
	Animal	10.3	15.3	28.6	35.9	22.5	32.5

Table 4: Vhanging trends in economic population engaged in agriculture in the Asia-Pacific region and sub-regions

Sub-region		Per cent economical population in agriculture					
	Year	1980	1985	1990	1992	1993	1994
South Asia		73	71.8	69.8	69.2	68.8	68.5
Southeast Asia		61.6	58.4	55.2	53.8	53.3	52.6
Northeast Asia		41.2	36.9	33	31.6	30.8	30.1
Pacific Island Countries		66.3	57.2	53.2	51.5	50.6	49.6
Region		60.5	56.5	52.8	51.5	50.9	50.2
World		50.8	48.7	46.6	45.7	45.2	44.7

Agriculture, economy and sustenance

Most countries in Asia-Pacific are still largely agrarian; the agriculture accounted for a relatively large share in the total gross domestic product (GDP) of South Asian and Southeast Asian countries ranging from 32 per cent in India to 52 per cent in Nepal and from 34 per cent in Vietnam to 57 per cent in Laos. A limited set of available data for other sub-regions showed a range between

Table 5: Per cent economic population in agriculture in different countries of the Asia-Pacific region

Sub-region/Countries		Per cent economical population in agriculture					
	Year	1980	1985	1990	1992	1993	1994
Bangladesh		74.8	71.8	68.5	67.2	66.5	65.8
Bhutan		92.5	91.7	90.8	90.4	90.2	90
India		69.7	68.1	66.5	65.8	65.5	65.2
Nepal		93	92.4	91.8	91.5	91.03	91.2
Pakistan		54.6	52.2	49.7	48.7	48.2	47.6
Sri Lanka		53.4	52.5	51.7	51.4	51.2	51
Cambodia		75	72.8	70.4	69.4	68.9	68.5
Indonesia		57.2	52.8	48.5	46.7	45.8	45
Laos		75.7	73.7	71.6	70.7	70.3	69.8
Malaysia		41.6	36.7	32.1	30.3	29.5	28.6
Myanmar		53	49.8	46.9	45.7	45.2	44.6
Philippines		51.8	49.3	46.8	45.8	45.3	44.8
Thailand		70.9	67.7	64.3	62.9	62.2	61.5
Vietnam		67.5	64.1	60.6	59.2	59.5	57.7
China		74.2	71	67.5	66	65.2	64.4
Japan		11.2	8.5	6.4	5.8	5.5	5.2
Korea		36.4	30.1	24.6	22.7	21.7	20.8
Korea DPR		42.8	38.1	33.5	31.8	30.9	30.1
Fiji		46.2	42.4	39.2	37.9	37.2	36.6
Papua New Guinea		76.3	71.9	67.1	65	64	62.9
Solomon Is.		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Vanuatu		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Cook's Is.		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Fdrl. Polynesia		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Tonga		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Westren Samoa		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Kiribati		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Wallis Fut Is.		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Tokelau		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Tuvalu		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Region		60.5	56.0	52.8	51.5	50.9	50.2
World		50.8	48.7	46.6	45.7	45.2	44.7

12.5-38.8 per cent for the Pacific Island countries, 21 per cent for China, a mere 7.2 per cent for the Republic of Korea and a negligible value for Japan. The overall contribution of agriculture to GDP, however, remained significant although remarkable structural transformation characterized by growing industrialization has been taking place during the past two decades. The percentage of population dependent on agriculture in Bhutan and Nepal was very high, being 90 and 91 per cent, respectively. In the rest of South Asia, it ranged from 50 to 65 per cent. High values were also observed in countries of other sub-regions; Papua New Guinea among the Pacific Island countries recorded 62.9 per cent of its economic population engaged in agriculture in 1994 and the corresponding values for China in the Northeast Asia were 64.4 per cent. In contrast, Japan and Korea, both located in Southeast Asia, had only 5 and 18 per cent of their population respectively engaged in agriculture.

The average share of labour force in agriculture in south and Southeast Asian countries was around 70 per cent. Even in cases where agriculture's share to total GDP has declined over time, a large portion of the respective country's population depended greatly on agriculture; ranging from 27 per cent in Malaysia to 94 per cent in Nepal. A sharp contrast, however, existed in Northeast Asia except China. With the development of national economies in this sub-region, most of the agriculture based population has moved to and concentrated in urban industrial centres. As a result, the farm population in Japan, and Korea has declined sharply due to industrialization and urbanization although total population of these countries has expanded in the last over 20 years. Contrary to the trends in Japan and Korea, the total farm population in China increased from 685.7 million in 1970 to 841.4 million in 1990 which may be partly attributed to the expansion of total population and partly to the slow rate of farm depopulation. The per cent involvement of most Pacific Island countries on agriculture and allied is very high; the bulk of produce is consumed mainly locally or marketed fresh except for in case of a few commodities.

Area, Production, consumption and trade : past trends

Area

Rapidly increased population requires more food availability which means more output per unit area of land and other inputs is essential to cope up with the decrease in cultivated area in several countries in the region. A more intensified land use was adopted in all the sub-regions due to increased population and thereby reduction in per capita land availability yet the Pacific Island countries have been affected the most. Land availability has particularly decreased in some countries in the sub-region, namely, Fiji and Western Samoa whereas an increase was also observed in others, like, Vanuatu. The ratio of agricultural land to agricultural population ranged from 7.63 ha in Samoa to 0.36 ha in Solomon Islands in 1994.

A few countries in Southeast Asia, namely, Indonesia, Thailand and Cambodia also recorded a significant expansion in cultivated area between 1982-1992. In Indonesia, most of the area expansion occurred due to transmigration; the poor and landless farmers from Java and Bali started agricultural development in newly opened areas albeit without much success because several of the transmigration settlements were associated with "problem soils" (AARD, 1994). Land availability is a relatively serious problem in more advanced countries in the region, namely, Japan, Korea and China. Land holdings in these countries ranged from just 0.5 ha to 1.4 ha. Further, the potential for developing uplands for cultivation, particularly in Japan and Korea, is extremely limited.

A rapid deterioration of forest resources has become an important concern and the highlands are also being increasingly placed under cultivation for food due to the inflating population of natives. In the Philippines, The forest cover declined from 75 per cent to 24 per cent over a period of 38 years mainly due to logging and the slash-and-burn cultivation practices. In Indonesia, particularly in Java, shortage of lowland for farming led to the development of land at higher elevation for agricultural purposes.

Table 6: Human-induced land degradation, 1945 to present

Region	Over-grazing	Defores-tation	Agricultural Mismanagement (million hectare)	Others	Total	Degraded area as share share of total vegetated area percent
Asia	197	298	204	47	746	20
Africa	243	67	121	63	494	22
South America	68	100	64	12	244	14
Europe	50	84	64	22	220	23
North & Central America	38	18	91	11	158	8
Oceania	83	12	8	0	103	13
World	679	579	552	155	1965	17

Note : Others includes exploitation of vegetation for domestic use and bioindustrial activities.
Source : "The Extent of Human-induced Soil Degradation," Annex 5 In L.R. Oldeman *et al.* World

Table 7: Potential cropland (million hectares) in the less-developed countries

	Adrica	Asia	South & Central America	Others	Total
Potentially cultivable	789	424	894	48	2155
Presently cultivated	168	387	160	69	784
Uncultivated	621	37	734	0	1392

Source : Table 3.4 in Crosson and Anderson 1992.

Highland farming in the Asia-Pacific region is likely to expand despite the negative environmental consequences. In Southeast Asia as well as in Bhutan, Nepal and parts of India, agroforestry has increasingly become prominent. Most of the highlands in the region are under forest cover and any form of intervention to exploit these resources shall invariably result in deforestation and soil erosion. Further, farmers generally cultivate their land along the slope with little concern for soil conservation. This practice is estimated to affect massive soil erosion at a rate of 9 to 224 t/ha. The fertile top soil at this rate of erosion is likely to be completely washed out in 15 years.

Production

Aggregate production from agriculture in the region recorded an expansion between 1966-92, largely due to the green revolution which was made possible through increase in cropping intensity coupled with improved productivity of new cultivars.

In South Asia, a remarkable progress in agricultural production was achieved despite various constraints experienced during the past 30 years. The near famine conditions prevailing in the early 70's in several pockets in South Asia have largely been alleviated; the cereal production in India increased from about 80 million tonnes in 1965 to 192 million tonnes in 1995; Bangladesh, which imported about 3.5 million tonnes of foodgrains annually during the mid 60's, achieved food self-sufficiency in 1993, despite an increase in its population by more than double during the corresponding period. Taking 1979-81 as the base year, agricultural production index in the sub-region increased by about 60 per cent and the countries, Bangladesh, India, Nepal, and Pakistan registered growth of 32, 66, 69 and 73 per cent, respectively.

The unprecedented increase in agricultural production in South Asia was triggered by the development and diffusion of high yielding varieties, essentially of rice and wheat, in the mid 60s and onward. This was accompanied with increased input of fertilizers, irrigation, and credit facility. Most of the countries concentrated on enhanced production of major foodgrains and their research and technology development policies were also geared up primarily to promote these commodities.

In Southeast Asia, production of major food crops increased by over two-times in two-and-a-half decades, from 94 million metric tonnes in 1966 to 226 million metric tonnes in 1992. Rice production to the tune of 118 million metric tonnes in 1992 accounted for fifty three per cent of Southeast Asia's total food crop production which represented about 25 per cent of Asia's total rice output. Further, rice continued to remain the region's major staple crop and also a major export earner for some countries in the region. Its production increased in the sub-region at a rate of 3.2 per cent per annum during the period between1966 and 1992, reaching its peak in 1976-86. Growth in maize production (3.8 per cent), was also spurred during the same period, mainly due to expanded demand for feed with the rapid growth of the livestock sector. However, use of maize as food has been declining, showing a negative relationship with the economic growth in some countries, such as, the Philippines. Further, a rise in production of cassava was also observed, primarily in response to its strong demand for feed in Southeast Asia and as staple food in the Pacific Island countries as also in other countries of the region, particularly those with poor economy.

Besides significant increase in production of major food crops in the Asia-Pacific region, countries performed well in other agricultural products, such as, fruits, vegetables, and commercial crops. South Asia which produces about 10 per cent of the world's fruit production of nearly 41 million tonnes, registered considerable increase in fruit production during 1984-94. Nepal registered the highest growth rate of about 13.8 per cent in fruit production which was followed by 6.6 per cent in Bhutan. India and Pakistan, the major fruit producers, had growth rates of about 3 per cent. Banana, citrus and mango, being the predominant fruit crops in the region, accounted for about 18, 15 and 23 per cent of the total fruit production, respectively. Of these, citrus and banana registered high production growth rates of about 4-4.5 per cent during 1984-94.

Vegetable production in South Asia also registered an equally remarkable increase. This sub-region accounts for about 70 per cent of the world vegetable production and all countries, except Sri Lanka, experienced considerable production increases for these commodities. The rate of growth during the decade ending 1994 ranged from 2.3 per cent in Bangladesh to 8.3 per cent in Nepal. Production increases in these commodities in Southeast Asia were also significant particularly in the later period. However, unlike the main staples, production growth for many of these crops came primarily from area expansion rather than from improvement in yield.

Shift in production efforts in the region has been largely witnessed from the staple crops to commercial crops. This resulted due to several factors, such as, i) a long-term decline in the price of rice and other major staples which affected farm profitability, ii) a slow down in yield growth of rice and wheat, and iii) a shift, corresponding with economic growth, in demand/preference from staples to high-value products like meat, fish, fruits and vegetables.

Consumption

Cereal consumption trends in Southeast Asia in the past matched with those of production trends. Demand for cereals grew at an average rate of 3.1 per cent per year between 1966-91 but recorded a general slow down in the later period, primarily due to a decline in rice demand. Wheat demand steadily increased with an average growth rate of about 5.6 per cent over the entire period. Per capita consumption of wheat steadily increased over the years while that of rice declined in the more advance countries in the region. This gradual substitution of wheat for rice as staple food corresponds with growth in income and rapid urbanization. Tremendous growth increase observed in maize consumption was mostly for its use as feed. The development of intensive and semi-intensive grain-fed livestock industries mainly accounted for this rapid growth in feed demand. Annual feed consumption rates for the period 1966-90 were very high for some countries; such as, 18.5, 39.0 and 11.3 per cent for Indonesia, Thailand and Malaysia, respectively. A high growth rate of consumption of meat, particularly pig meat and poultry meat was also witnessed. Consumption of other crops in the sub-region, like fruits, vegetables and fish, that was constrained in the past due to several factors, such as, supply, availability and/or relatively high prices, has increased steadily at around 3 per cent per year between 1966-91 and is projected to be higher in the next decade with continued economic growth.

Food self-sufficiency

Asia contributes about 90 per cent of the total global rice output which was estimated at 518.5 million metric tonnes in 1990. Of the total rice production, more than 90 per cent is met from the *Indica* types, that are produced mainly in tropical countries, whereas the rest, less than 10 per cent, comprises of *Japonica* types, produced mostly in Japan, Korea and high elevation areas of other countries in the region. Adequate supply of rice is observed to be often associated with respective country's progress and stability. Rice cultivation is considered one of the most important indicators of its performance in agricultural development undertakings whereas, a shortage of rice could place the concerned government(s) under heavy criticism at large from the media and also the masses.

Some countries of the Asia-Pacific are already self-sufficient in rice. Indonesia, having achieved self-sufficiency for rice in 1984, has placed on utmost priority to sustain the same. Java alone contributed about 60 per cent of irrigated rice to achieve self-sufficiency. Further, the areas outside Java are being given increased attention to ensure maintaining a self-sufficient rice supply. Vietnam too is self-sufficient and even manages to export about 2 million tonnes of rice annually. Prior to 1976, rice production in Vietnam fluctuated from 8-10 million tonnes per year. Remarkable growth, however, has been achieved since then and the current production level in the country has increased by two-fold.

In order to ensure self-sufficiency in rice and generate significant export surplus in Myanmar, the target has been to increase current rice area of 12.3 million acres further, by 0.7 million acres. In the Philippines, self-sufficiency in rice has been an explicit goal following the rice shortage experienced in 1995-96 and a national food security summit held by the government. In Malaysia, the new

agricultural policy highlights a 60 per cent food self-sufficiency target along with main dependence on rice production within the country.

South Asia, with an annual production of 157 million tonnes, accounted for 29 per cent of world' production and nearly one-third of the production of the Asia-Pacific region alone. India and Bangladesh contribute significantly to the rice production, being 75 and 18 per cent, respectively. These countries recorded a substantial growth rate of 2.8 and 3 per cent, respectively, despite poorer average yields as compared with other sub-regions.

Trade

Demand for supply, besides other factors, such as, purchase power, surplus, etc., strongly influence the trade. In South Asia, food demand in the next 5 years is expected to grow annually between 3 to 3.5 per cent which is mainly due to the projected population growth rate of 1.8 to 2 per cent. A 60 per cent increase in population is expected by the year 2020, with a high concentration of poorer people in the region. Further, with an expected income increase of 3 per cent per year in case of the poorer, the food demand is likely to be pushed up further by 1 to 1.2 per cent. Some changes in food packages were witnessed due to, i) increased urbanisation, and ii) new opportunities made possible through economic liberalisation. And the important trends in such changes were, i) the growing demand for animal products, and ii) reduced preference for some food grains due to their diversion for other usses, such as maize for animal feed.

Agricultural products and by-products remained the major source of foreign exchange earning of most countries in Asia-Pacific. The South Asia sub-region is a net exporter of rice and maize. These commodities serve as a good source of earning foreign exchange. The price of rice in Southeast Asia is lower than that in the international market. However, in contrast, the rice prices in Japan and Korea are generally higher than the international market price. Nevertheless, the 'within the region' demand for these commodities is expected to increase in the coming years, primarily due to increase in population. Estimated projections showed that although the net trade in rice in South Asia shall remain positive in the year 2020 yet its level is likely to be much lower relative to that in 1990. In addition, the sub-region will become a net importer of maize by the year 2020. Other commodities likely to be imported in an increased amount in the region are wheat, other coarse grains, soybean, roots and tubers.

In Southeast Asia, total value of agricultural exports rose from US $2.2 billion in 1966 to US $16.8 billion in 1993 (FAO, 1995). Whereas most of the export has been oriented towards the traditional commodities, including, timber and other forest products, palm oil, rubber, copra and coconut oil, sugar, and rice, a wide variety of non-traditional products have also found their way into the export markets in some countries. Orchids and other cut flowers, seafood products, fruits and vegetables, coffee, cacao, and spices constituted some of the current, non-traditional export crops in the sub-region.

Recent trends in total merchandise trade show that many Asian countries are becoming less dependent on sources outside the region, not only for export growth but also for import supply. The Asian intra-regional trade has shown a relatively rapid expansion as compared with other regions; it posted a 22 per cent growth rate in the 1970s. Further, in the 1980s, although the trade within the region was recorded to be much slower (12 per cent) yet it remained higher than the growth rates for any of the other regions.

Table 8: Food (calories) supply in different countries in the Asia-Pacific region

Country/Region		Food Supply k cal/ capita/day (Number)					
		1970			1992		
		Total	Vegetable	Animal	Total	Vegetable	Animal
Bangladesh		2196	2128	68	2019	1961	58
Bhutan		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
India		2082	1980	102	2395	2223	171
Nepal		1912	1774	138	1957	1825	132
Pakistan		2200	1942	258	2315	1981	334
Sri Lanka		2304	2273	104	2200	2166	108
Cambodia		2715	2606	108	2021	1907	114
Indonesia		2118	2062	55	2752	2644	108
Laos		2253	2080	174	2888	2423	465
Malaysia		2469	2174	295	2888	2423	465
Myanmar		2057	1960	96	2598	2496	102
Philippines		1741	1492	249	2257	1986	271
Thailand		2182	1967	216	2250	2074	476
Vietnam		2328	2190	138	2250	2074	176
China		2032	1918	115	2727	2382	345
Japan		2691	2279	413	2903	2273	629
Korea		2818	2705	113	3285	2838	446
Korea DPR		2392	2272	120	2833	2624	209
Fiji		2488	2116	372	3089	2457	632
Papua New Guinea		2183	1989	193	2613	2374	239
Solomon Is.		2286	2040	246	2173	1924	249
Vanuatu		2531	2010	522	2739	2321	419
Cook's Is.		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Fdrl. Polynesia		2849	2218	631	2834	2113	721
Tonga		2647	2419	228	2946	2411	536
Westren Samoa		2260	1930	331	2828	2085	742
Kiribati		2447	2186	261	2651	2327	324
Wallis Fut Is.		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Tokelau		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Tuvalu		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Region (Average)		2329	2123	210	2584	2266	331
World		2464	2083	381	2718	2290	428

FUTURE TRENDS : FACTOR ANALYSIS

Having recorded a remarkable growth in food production during the past three decades, the Asia Pacific region indicated a slow down, between 1986-93, particularly for the major food crops. A sustained growth in terms of production should, therefore, be a high priority. Several other factors, such as demand, purchase power, consumption trends, etc., shall also influence the future production which concern Research and Development. In addition, the changes in the economic and political

Table 9: Food (Protein/Capita/Day) supply in different countries in the Asia-Pacific region

Country/Region		Food supply - Protein/Capita/Day					
		1970			1992		
		Total	Vegetable	Animal	Total	Vegetable	Animal
Bangladesh		46.7	40.5	6.2	42.5	37.7	4.8
Bhutan							
India		52.5	46.8	5.8	58.1	58.7	9.5
Nepal		49.4	42.5	6.9	50.1	42.8	7.3
Pakistan		55.4	42.3	13.1	56	38.3	17.7
Sri Lanka		46.6	37.4	9.1	46.9	38.4	8.6
Cambodia		60.6	53.6	7	50.4	41.8	8.6
Indonesia		43.3	37.9	5.4	60.5	51.2	9.3
Laos		60.7	49.6	11.1	62.8	48.2	14.5
Malaysia		49.6	32.9	16.7	59.9	31.4	28.5
Myanmar		52.8	45.2	7.6	64	56	8.1
Philippines		43.1	23.8	19.4	52.4	31.1	21.3
Thailand		51.4	34.2	17.2	54.3	35.1	19.4
Vietnam		54.1	44.2	9.9	52.1	41.2	11
China		48.7	43	5.7	67.4	51.5	15.9
Japan		81.7	45.4	36.3	97.8	42.1	55.7
Korea		70	62.5	7.5	56.4	53.8	32.7
Korea DPR		70.5	59.5	11	82.7	64.3	18.3
Fiji		59.3	38.4	20.8	74.1	36	38.1
Papua New Guinea		41.6	27.7	13.9	48.9	31.9	17
Solomon Is.		55.1	31.7	23.5	53.1	30.4	22.7
Vanuatu		67.7	32.2	55.5	63.1	37	26,2
Cook's Is.		-	-	-	-	-	-
Fdrl. Polynesia		74.1	36.9	37.2	80.3	36.5	43.9
Tonga		50.3	39.6	10.7	88.2	40.2	28
Westren Samoa		48.6	27.3	21.3	75.6	33.5	42.1
Kiribati		57.5	33	24.5	66	34.6	31.4
Wallis Fut Is.		-	-	-	-	-	-
Tokelau		-	-	-	-	-	-
Tuvalu		-	-	-	-	-	-
World		65.1	43.9	21.2	70.8	46.2	24.6
Region (Average)		56.6	42.0	15.3	63.2	43.3	20.8

environment, continued implementation of sound policies aimed at maintaining and further raising the living standard of people, particularly those below the poverty line are also likely to influence the supply and demand of individual food commodities and thus need to be duly considered while framing R&D priorities.

Economic growth prospects

As a whole, the Asia-Pacific has been one of the fastest growing regions in the world. China lead all Asian countries in 1995 with a 10.2 per cent growth rate in real GDP. Southeast Asian countries,

Table 10: Food (Fat/Capita/Day) supply in different countries in the Asia-Pacific region

Country/Region		Food supply - Fat/Capita/Day					
		1970			1992		
		Total	Vegetable	Animal	Total	Vegetable	Animal
Bangladesh		15.6	11.7	3.9	20.1	16.7	3.4
Bhutan		-	-	-	-	-	-
India		30.4	23.6	6.9	43.8	32.4	11.4
Nepal		25.1	15.6	9.5	28.5	19.4	9.1
Pakistan		34	16.3	17.6	63.1	39.8	23.2
Sri Lanka		50.2	54.5	5.8	55.1	38.8	6.2
Cambodia		22.7	14.4	8.2	20.2	11.8	8.3
Indonesia		29.9	26.5	3.3	50	43.3	7.2
Laos		27.2	13.6	13.6	34.9	15	19.9
Malaysia		54.6	34.9	19.6	99.7	69	30.8
Myanmar		32.4	25.9	6.4	43.3	36.5	6.7
Philippines		33.1	15.8	17.3	37.8	19	18.8
Thailand		30.1	15.5	14.7	43.4	27.3	16.1
Vietnam		21.6	11.4	10.2	23.1	13.5	14.6
China		22.6	12.8	9.8	51.9	21.8	30.1
Japan		53	28.3	24.7	80.4	42	38.4
Korea		24	15.4	8.7	72.1	40.5	31.6
Korea DPR		28.8	20.9	8	40.6	26.4	14.2
Fiji		65	38.3	26.7	109.2	62.5	46.7
Papua New Guinea		33.8	19.5	14.2	69.4	51.6	17.8
Solomon Is.		49.9	34.6	15.3	54.8	38.5	16.3
Vanuatu		88.7	49.7	39	98	67	31.6
Cook's Is.		-	-	-	-	-	-
Fdrl. Polynesia		82.8	36.7	46.1	103.3	48.8	54.5
Tonga		58.4	38.8	19.5	87.6	44.8	42.8
Westren Samoa		91.9	67.4	24.5	114.7	56.9	57.7
Kiribati		94.5	77.6	16.9	99	79.3	19.7
Wallis Fut Is.		-	-	-	-	-	-
Tokelau		-	-	-	-	-	-
Tuvalu		-	-	-	-	-	-
Region (Average)		41.4	27.2	14.6	59.9	36.3	22.5
World		55	26.1	28.8	68.7	36.2	32.5

except the Philippines, closely followed with 7 to 9 per cent rates of growth. A continued success in the implementation of macro-economic and structural reforms significantly contributed for this impressive growth performance and encouraged high rates of investments in the region. Gross domestic investment, measured as per cent GDP was highest in China (10.2%) followed by 7.9 per cent in Southeast Asia and 5.6 per cent in South Asia. The Pacific Island countries, however, showed a negative value of (-) 4.3 per cent in 1995.

Similarly, growth in foreign direct investment (FDI) has been very significant showing a growth rate of 46.4 per cent in China, 23.3 per cent in South Asia and 18.5 per cent in Southeast Asia, in 1993. Cambodia (-17.7%) and the Philippines (-3.3%), among the Southeast Asian countries recorded negative growth in FDI between 1988-93. Whereas China ranked highest in terms of the region's FDI, other countries, such as, Indonesia, Malaysia, Thailand and Vietnam have started to attract substantial inflow. The excellent credit rating of most countries in the Northeast and Southeast Asia has allowed them to regularly tap the international bond markets and this is expected to continue in future as well.

Another major factor that influenced Asian countries' economic growth has been their large advances towards integrating with the world economy. This is particularly evident from the export value, which grew among Southeast Asian countries by more than three fold, from US $48 million in 1981 to US $160 million in 1994, representing an average annual rate of growth of 9 per cent. More recent estimates of annual export growth rates are higher, ranging from 15 to 22 per cent between 1990 to 1995. Much of the trade has, however, been intra-regional. This shift in direction of trade has suggested in favour of a strong economic growth in the region as a whole and also in different sub-regions.

The move towards free trade in agriculture, initiated by GATT and other regional trading arrangements, is likely to have a strong impact on sustainable growth in the region. Increased participation in international trade shall improve resource allocation and enhance efficiency through increased competition, induced learning and technology transfer.

Food demand projections

Additional food demand is imminent as it would correspond with the incremental growth in population. More staple food crop availability should be there in future so as to meet the needs of millions of additional stomachs. At the same time, improvement in individual incomes and also changes in demographic structure of populations are likely to affect changes in food preferences from the tradition. This could increase demand for specific crop commodities. For example, the growing acceptance of wheat as a substitute for rice has been a consequence of urbanisation to a considerable extent. Quite notably, wheat for food demand grew at about 5.1 per cent per annum in contrast with a slower rice demand for food (about 3.1 per cent per annum) during 1966-91. The same factors are also likely to influence in favour of a strong demand for livestock products.

A diversification in food habits has clearly resulted from the overall economic growth. Improvement in income, modernization, and westernization of diets lead to changes in food habits, primarily from the main staples to high-value products like milk, fruits, vegetables, eggs, meat and fish. This trend predominated in some relatively advance countries in the region, such as, Japan, Republic of Korea and Taiwan. The per capita consumption of cereals, particularly rice, in these countries has declined. A similar leveling off in per capita demand of rice and other foodgrains is taking place in India, Thailand and Malaysia. On the other side, the rise in per capita demand of cereals in Southeast Asia comes from the countries having low income, such as, Cambodia, Myanmar, Vietnam, Laos, Indonesia and the Philippines. Further increase in demand for staple food in these countries is likely to take place not only due to population growth but also because of poverty alleviation and improved income.

Food availability prospects

A general slow down for growth in production in the recent past, particularly of major staple crops, may be primarily attributed to a decline in productivity growth rate. Yield ceiling or a plateau is

already reached, particularly in the irrigated ecosystem which mainly contributed towards the overall growth in rice production over the past three decades. The average yields increased from 3.0 to 5.8 tonnes per hectare in irrigated areas. At the same time, a decline in the long term in yield of modern, improved rice varieties was observed following the adoption of intensive monocultures of this crop in the irrigated system. In Japan and South Korea, rice yield remained static at around 6.0 to 6.5 tonnes per hectare after reaching that level as early as in late sixties and mid-seventies, respectively. In humid tropics, maximum achievable yield at the farmer level is lower than 6.0 tonnes because of increased pest pressure, frequent cloudy days with below optimum sunshine, and vagaries like flood, drought and strong winds that strongly affected the actual production in respective years. However, in areas with good irrigation infrastructure, this potential yield level is likely to be reached.

Rice yield levels in the rainfed ecosystem increased only marginally, from 1.4 to 1.8 tonnes/ hectare. This ecosystem hardly got benefit of the green revolution due to non-availability of appropriate high-yielding varieties that could withstand prolonged drought, temporary submergence and other climatic stresses common in the fragile rainfed environments.

Most of the low-income countries in the region have been constrained in respect of natural resource required to increase the overall food production. The Asia, as a whole, is breaching the limits of its arable land. Ratio of arable land to agricultural population per capita deteriorated from 0.34 ha in 1961 to 0.13 ha in 1993 (FAO, 1995). This contraction is likely to continue further with population expansion and migration. Valuable farmland, including irrigated areas, are lost daily to factories, houses and roads as migrants flee from rural to urban areas in unprecedented numbers. Projected estimates calculated using 0.05 ha per capita land use for urban population showed that in the less developed countries of Asia, urban demand for land shall increase from 41 million hectares in 1990 to 155 million hectares in 2025, thereby registering an increase of 75 million hectares in urban land use.

On the other side, the currently uncultivated area with crop production potential is estimated to be only 37 million hectares. The problem is likely to aggravate when more of the prime farm land is urbanized first. Severe soil degradation due to harmful farming practices has further rendered vast stretches of arable land idle. In Asia, estimates show that about 204 million hectares of land has been losing top soil or undergoing other forms of degradation as a direct result of poor agricultural practices. These trends are re-enforced by a strong tendency to shift cultivated area from food to cash and/or export crops. The extent of land degradation in the region is the largest. About 33 per cent of the 2 billion hectares of degraded land area of the world is in Asia. In addition, water, a vital resource for attaining enhanced growth in production and which has been regarded as abundant in the region, is also becoming scarce. Waterlogging and salination has rendered large chunks of irrigated land sterile. In India, about 7 million hectares of land are estimated to have been abandoned because of increased concentration of salts.

The scope of further conversion of the rainfed into irrigated ecosystem is clearly limited; the cost of irrigation has substantially increased since the easy options for development of irrigation systems have already been exploited at large. At the same time, an environmental concern has been growing for the adverse effects of irrigation. A research priority is, therefore, needed for flood control projects on waterlogging, salinity, fish production and the quality of ground water. A decline in investment for the development and maintenance of large-scale irrigation projects in many Asian countries has been already observed. Also a growing competition for water use between the agriculture and the urban sector has become a perplex issue. In absolute terms, however, the annual water

withdrawal is by far the greatest in Asia and agriculture accounts for 86 per cent of total water withdrawal. At the same time, the per capita water availability declined from 40 to 60 per cent between 1955 and 1990and is expected to go further down which is of priority concern to researchers.

Concerted efforts in collaborative mode, and also based upon well thought of regional research priority setting, could help overcome several physical and environmental constraints to production. Yet many countries of the region, particularly in South and Southeast Asia are still likely to face the problem of sustaining farmers' interest in cultivating rice as they continue to prosper. Further, the expansion of the non-farm sector and the rapidly rising labour productivity have pushed up non-farm wage rates which promoted migration of labour from rural areas to cities and affected an increase in agricultural wages. Since traditional rice farming is a highly labour-intensive activity, the increased wage rates shall push the cost of rice production further up and reduce farmers' income and profits. In Japan, Taiwan, and South Korea, the constant outflow of the agricultural labour force has already caused a considerable decline in the farming population. Aging of workers and continued depopulation in remote areas has made it difficult to sustain the existing rural communities in some areas. Malaysia, Thailand, and the coastal provinces of China are likely to face similar trends in near future.

Growth in future supply

Greater food demand resulting from increased population and income growth has to be met by increased production alone, which is achievable primarily from an effective transfer of technology at the farmers' level. This is particularly important because existing land resources have already become a limiting factor. The biggest challenge in the next two to three decades, therefore, shall be to develop more efficient production technology. Efforts need to be geared up in the region, particularly in the developing countries, to promote further increases in agricultural production through farmers' realization of improved yield levels. Growth could be enhanced through development and transfer of low-cost technologies and further through increased investment in infrastructure and enhancing the adoption of technology by the farmers, thereby integrating with the larger economy. Strong linkages between NARS and the international institutions shall be essential particularly in the areas of production, infrastructure building and financing so as to find lasting solutions to these complex problems.

Future growth in productivity, as particularly required in major foodgrains like rice and wheat, is possible through the renewed research efforts for improvement in yield potential of modern varieties and hybrids, in addition to the dissemination of available modern technology as well as expected breakthrough from new science. The research objectives for the region should include: i) prioritizing the development of hybrids/hybrid varieties, ii) new plant types with increased yield potential *per se* coupled with improved stability over diverse environments, iii) improved management practices, and iv) efficient use of the scarce resources. Components of larger research areas should be critically analysed and diligently attended to. A few practical approaches to the applied research and transfer of technology could be envisaged as follows: i) in fertilizer policy, there must be a shift from focus on increasing the level of use of fertilizer to the improvement in the efficiency of nutrient balance, timing and placement of fertilizer application, etc., ii) in irrigation policy, a shift of emphasis is required from investment in new systems of irrigation to improved water use efficiency and productivity in the existing systems, and iii) in crop protection, there should be a shift from dissemination of chemical pesticides to utilization of integrated pest management techniques. There is a need to recognize and integrate individual or joint efforts of public and private sector research in plant improvement to attain an overall growth in productivity.

Increases in animal production could also be constrained due to poor land availability. Therefore, enhanced production of various animal products requires increased animal productivity and also intensified production. The sustainable animal production and productivity, on the other side, could be attained through better provision of nutritious feed, improvement in livestock management and animal health. Higher production in poultry may be ensured through the development of more productive, genetically diverse hybrids to avoid mass scale deaths due to epidemics. Research on vaccine development and production should be a high priority so as to ensure production of healthy and high quality poultry meat. Further, increase in production in fish sector could be attained through an efficient assessment of the status of tropical aquatic resource, more rigid studies on land-water relationship to minimize pollution and habitat destruction, and development of more efficient systems in aquaculture farming.

REORIENTING THE RESEARCH AND MANAGEMENT SYSTEM IN THE ASIA-PACIFIC

A more critical institutional role of APAARI is required to be played in the region so as to strengthen agricultural research in a mission-mode, collaborative approach. More productive forms and technology to meet the future need of increased food demand shall have to be its main target. Besides enhanced production, an increased efficiency and competitiveness in the global market shall also have to be achieved in conjuction. The need to conserve and protect the natural environment also requires considerable research input particularly for biodiversity management, biotechnology and biosafety.

Research goals and priorities

An overview of objectives, common research goals and priorities foreseen by different NARS and for different sub-regions in Asia-Pacific is synthesized below based upon recommendations of various Expert Consultations held by APAARI and keeping in view the CGIAR's framework for classifying research.

Research goals

Various National Agricultural Research Systems (NARS) in the Asia-Pacific region have broad-based research goals at large. Such goals have been drawn by the NARS from respective country's overall development goals in agriculture and also considering other wide range of developmental considerations. NARS tend to have multiple goals, most of which are closely interrelated, some even negatively. For example, efficiency vs sustainable food self-sufficiency is a constrating situation for the development process as a whole and thereby poses enormous challenge to organisations, systems and fora committed to agricultural research.

Seven distinct research goals have been identified from different NARS' reports and recommendations of deleberations held in various APAARI meetings, which are the following :

efficiency,
food self-sufficiency,
employment generation,
agricultural modernization,
global competitiveness,
resource conservation/sustainability, and
agricultural diversification.

The Asia-Pacific is one of the most dynamic regions in the world. Economic policies in the region have shifted from inward-looking to outward-looking and most of the countries in the region tend to have become fully integrated with the global market. Japan and Korea are highly industrialized countries whereas a number of other countries, namely, China, India, Malaysia, Thailand, Indonesia and the Philippines have also recorded a steady, though gradual, shift towards industrialization. With the adoption of an outward looking policy, and also with these countries securing membership of the WTO, it has become imperative for NARS in the region to strive for greater efficiency and achieve global competitiveness in agricultural production and marketing.

Self-sufficiency in basic staples, particularly rice, is among the primary research goals in the Asia-Pacific. Rice has always been recognized as an extremely important food as such that an exemption was sought for the rice-based economies from the GATT Urguay Round so as to enable the countries to pursue an inward looking policy for this commodity.

Production systems in the Pacific Island countries are different from the rest of the Asia-Pacific. Mostly root crops featured under this system although some other commodities, such as, squash in Tonga and rice, ginger and vegetables in Fiji are considered important components in their respective agricultural system. Agriculture in these countries is moderately developed and is characterized by more of the local consumption of their produce, with little export.

Employment generation constitutes an important research goal in agriculture in the Asia-Pacific countries. Whéreas a number of countries in the region have been experiencing rapid economic growth, agriculture remains as the largest source of livelihood, particularly for the rural population. Employment generation in the agricultural sector is crucial. The challenge posed particularly to the advance NARS in the region is to develop capital intensive labour saving technologies designed to improve farm labour productivity, particularly when there is increased tendency of farm labour moving to non-farm activities as a consequence of industrialization.

Table 11: Priority ranking for major research goals/objectives in the Asia-Pacific region

Goal/Objective	SA	SEA	NEA	PIC	A-P
Efficiency	3	1	1	4	2
Food self-sufficiency	2	2	3	1	1
Employment generation	5	4	5	3	5
Agricultural modernisation	6	6	1	5	6
Global competitiveness	4	5	2	4	4
Resource generation/ sustainability	1	2	4	2	2
Agricultural diversification	5	3	3	3	3

Countries in Asia Pacific are fully aware of the fact that area expansion as a strategy to increase agricultural output has little scope and that the use of high yielding monocropped varieties, responsive to high levels of chemical input remains the key to increasing production. This strategy is, however, feared to produce adverse environmental consequences in future in the region. Further, ecologically favourable practices of mixed farming have been adopted on a commercial scale too but the mix of crops and livestock is often not judiciously designed.

Food self-sufficiency, as a research goal in the region, attaines the highest rank followed by efficiency vs resource conservation/sustainability. The South Asian countries have considered resource conservation/sustainability at the foremost whereas the Southeast Asia and the Northeast Asia sub-regional countries accorded highest rank to efficiency as the research goal. On the contrasting side, agricultural modernization, which scored the overall lowest rank in the region, also had the highest priority as a research goal in the Northeast Asia sub-region.

Research priorities

Priority setting refers to the orderly placement of activities envisaged in ways most consistent with the objectives. In the Asia-Pacific region, research priorities have been screened based on several criteria; such as, the degree of importance of a particular research objective, development target, etc. The agricultural research priorities could be identified using a number of quantitative methods, namely i) scoring approach, ii) economic surplus approach, iii) mathematical programming, iv) econometric modeling, and v) simulation method. This would, however, require a large scale data on uniform basis as a pre-requisite. Therefore, research prioritization in the present case has been done for the Asia-pacific region based on informed judgement which is largely subjective.

Priority Research Areas Based on CGIAR's Research Classification Framework

The research priorities have mostly been drawn by NARS based on commodities or across-commodity systems. However, an attempt was also made to determine the major research areas in the region based on CGIAR's framework for classifying research activities. Five major areas, were identified namely, a) increasing productivity, which includes germplasm enhancement and breeding as well as production system development and management, b) protecting the environment, c) saving biodiversity, d) improving policies, and e) strengthening of national programmes. The specific CGIAR definitions for these activities are appended.

Increasing productivity

The two sub-categories under this research activity, as classified by CGIAR, include, i) germplasm enhancement and breeding, and ii) production systems development and management. Germplasm enhancement and breeding include, besides conventional breeding of crops, trees, livestock and fish, activities such as the applied molecular biology. On the other hand, production system development and management includes a wide range of activities, such as, baseline studies, farming system development, plant nutrition, crop protection, seed production, post harvest technology, etc.

An overview of various activities on breeding, being undertaken in some Asia-Pacific countries, showed that the sole objective in most countries was to improve productivity of various commodities, particularly crops and livestock. Considerable differences existed in the type or level of breeding activities being undertaken by countries in the region. Developing countries in South Asia, Southeast Asia and the Pacific Island countries are engaged in conventional breeding activities while the relatively more advanced NARS in the region such as those of Korea, Japan and India have also undertaken high technology pre-breeding activities which have broad genetic application.

Some developing countries in the region, particularly those with relatively larger and advance NARS have been making serious attempts on molecular biology. In India a national centre on Biotechnology and another national research centre on DNA finger printing have recently been established to cater to the research needs of biotechnology, under the aegis of ICAR, which spearheads the Indian NARS, alongwith a limited support from the Department of Biotechnology. In the Philippines,

the Philippine Agriculture and Forestry Biotechnology Agenda (PAFBA) provides support to Biotechnology research in the country. In Indonesia, research on Biotechnology is spearheaded by the R&D Centre for Biotechnology, which includes, among others, genomic mapping to determine the prolificacy traits in the Javanese thin-tailed sheep. Similar techniques should be applied to utilize the genetic potential of indigenous breeds to enhance the efficiency of selection for superior individuals. Development of open nucleus breeding, which is being tested with native chicken, ducks, Javanese fat-tailed sheep and Etawah cross goats should be supported.

Production systems development and management

This priority area, including most of its CGIAR classified sub-categories, is of particular interest to the Asia-Pacific region due to three reasons, as follows, a) countries in this region are either less developed or developing, whereby much of the constraints in agriculture still pertain to production system development and management, b) status of research in this category is still relatively downstream and easy to handle by various NARS in the region, and c) a relatively short gestation period is required to attain a pay-off stage to the research done under this category whereby it becomes more attractive to less developed and developing situations.

The range of research activities shall include, soil management, cultural practices, use of various inputs, harvest and post harvest concerns. Improving overall production efficiency in harmony with the agro-ecosystem would be the major research objective in relation to production system development and management.

Protecting the environment

Protection of the environment and the development of sustainable agriculture are of serious concern in the Asia-Pacific. As mentioned earlier, environmental degradation in the region, that followed the rapid population as well as economic growth, has been alarming and resulted in prompting the governments, in general, and the respective NARS, in particular, to pay serious attention to environmental protection and conservation.

A wide range of research interest for environmental protection and sustainable agriculture is currently being pursued in the region. In India, the priority being given to inventorization, characterization, evaluation and conservation of biophysical resources, generation of technology for resource conservation, development of eco-regional water management planning and amelioration of negative environmental impact of development programmes should be given high priority support so as to *inter alia* develop a model for other countries in the region and also to pursue the same in a collective mode. Further, in India, Nepal and Pakistan, the forest management approach, particularly aimed at reducing the pressure on steep slopes and developing comprehensive afforestation and watershed management programmes, needs a continued emphasis and a liberal funding support as the Himalayan environment has got a special significance in the global context.

Agricultural resource survey and mapping, understanding the bio-chemical dynamics of agro-ecosystem and the environment and the development of alternative strategies for the sustainable utilization and management of resources have been receiving high research priority in Indonesia which should be suitably extended to other neighbouring/regional countries in a collaborative mode. Similarly, consolidating various databases to enable sound decision-making and also the development of a suitable valuation system for environmental resources, ultimately aiming to generate environment friendly technologies should be pursued in an effective mission mode and by using a collaborative approach. Resource management in riverine and reservoirs has received considerable importance

in Laos which is attributed to local needs. APAARI endorses such a priority and recommends to encourage the same, preferably in partnership with other countries with similar requirements. For example, safe exploitation and conservation of water resources has received priority attention in Vietnam also. Thailand's research priorities aimed at protecting the environment, including forest management, silviculture, watershed management and land use. In Pacific Island countries, development of land use policies, soil conservation practices and alternative to slash-and-burn agriculture have been the priority concerns. APAARI stands committed to and recommends to encourage support to activities which enshrine common goals and priorities, such as, in above cases and also those which are specific and critical.

Saving biodiversity

Biodiversity at large and agrobiodiversity in particular have attained important research concern, although relatively recently, in the Asia-Pacific. This has been prompted mainly due to the increasing global awareness for the need to protect the environment and the move towards sustainable agriculture. However, the response of the Asia-Pacific countries, in general, has so far been limited to policy statements and the available information is not clearly indicative of the requirement that 'saving the biodiversity' has become a priority research concern. The Asia-Pacific countries, as also others, are mainly oriented towards high productivity, monoculture systems of agriculture. However, there is a need to integrate the sustainable agriculture into the mainstream of Research and Development through a clearly pinned Action Plan.

Socio-economic, public policy and public management

Studies in this area have been designed to complement current development programmes of countries in the region. Policy analysis and suggesting guidelines appear to have received considerable emphasis, thereby escalating the realization that the governmental policies shall highly influence the developments in agriculture and natural resources, directly or indirectly. Some regional countries have reflected the priorities attached to analysis of the commodity based industry and understanding the socio-economic dynamics in rural areas, and an evaluation of the effect/impact of GATT Urguay Round WTO. However, there is a clear-cut need to attend these issues both as national priorities and also in collective mode to ascertain, specify and safeguard the regional interests.

Evaluation of technology transfer or adoption is also of major interest in the Asia-Pacific. The state of technology adoption in the region appears to be low, in general, as reflected from the wide gap between actual and potential yield of major commodities.

Strengthening national programmes

Strengthening national programmes is undeniably of extreme importance to the region, particularly its developing countries. Support system of NARS in the region consists of human resources, research infrastructure and information resources. Continuous development in respect of these components is crucial to NARS for their effective implementation.

Human resource development, through post-graduate degrees or short training programmes is highly important to the region, particularly with the rapid progress in technology and knowledge related to agriculture and natural resource development. A massive investment in human resource development has already been observed in some countries of the region, particularly during the 1980s, as the number of scientific manpower engaged in various NARS was considerably high, ranging from 1000 to 3000 personnel which was further enhanced. The level of academic background of these personnel was also high, being a post-graduate degree in majority cases. This massive investment in terms of human resource development has improved agricultural research capability

and also placed it at par with the world's best. However, there is a need to refinement and a sutainable human resource development in terms of both career advancement and need-based, on-job, periodic re-orientation training programmes. Elite national agricultural research and education institutes of NARS from advance developing countries, such as, India, China, Japan and Australia, should be encouraged in their attempts to come forward for sharing this important responsibility of human resource development/training through creating regional centres of excellence, seats of eminence in different disciplines and regional professors, besides appropriate funding support for research and training hostel facilities.

The research infrastructures available with the NARS in the region have been observed to consist of national or central research institutes/facilities, regional facilities and provincial or location-specific research stations. The national research facilities included, i) single-commodity or multi-commodity research institutes/stations that catered to the need for agricultural commodities of national importance, and ii) agricultural universities and colleges that were engaged in national R&D programmes. The regional facilities have been often multi-disciplinary in their orientation and have fostered applied research to address the research needs of a major geo-political advance agricultural areas of respective countries. The provincial or location-specific stations were further seen involved in fine-tuning technologies to suit particular needs of the area. In addition, the increased investment in agricultural research during the past few decades has been witnessed to produce an explosion of new agricultural information and knowledge.

It has, therefore, become important for the NARS to carry out careful and deliberate management of information in order to enhance its utility to the research system. The rate at which new research results are generated increases the pressure on fading of previous information or its becoming obsolete within a relatively short period of time. Likewise, the growing complexity of information transfer requires a system that would aid in effective management of increasingly important new resource information.

The recent global developments, including the global Plan of Action require NARS to redefine themselves and include all organisations, non-governmental organisations, universities and other stakeholders in their system set-up. APAARI was particularly appreciative of some of the advance NARS, such as, India, among others, who cater to the research, extension and teaching/training needs of all stakeholders and also include them in policy deliberations. At the same time, the association was equally concerned for some smaller countries who have yet to organise their NARS for providing a definite, institutional mechanism to their agricultural research set-up. The APAARI endorses consultancies and expert deputations to such countries with possible external funding support from FAO, IFAD, ACIAR and other donors so that these member countries are not further kept devoid of the planned agricultural development, sustainable management, conservation of agro-biodiversity and benefit sharing.

REGIONAL RESEARCH PRIORITIES - THE APAARI RECOMMENDATIONS

Research priorities for the Asia-Pacific region have been identified and recommended by APAARI, based on three different aspects, which are the following:

i) commodity or commodity groups,

ii) broad areas of research, and

iii) agro-ecological commodity research approach.

Commodity/commodity group priorities

Cereals, coarse cereals, pulses, oilseeds, fruits and vegetables, cattle, poultry, inland and marine fisheries and forestry are identified as the high priority research commodities in the region, whereas flowers, root and tubers, small ruminant and swine are given a medium priority level. The commodities which should receive immediate priority attention, being elevated from the present low to a high priority are pulses and marine fisheries. Further, the roots and tubers, small ruminants, piggery and inland fisheries, among the food commodities, and flowers among the commercial enterprise, should also receive a high research priority attention as against the medium level priority accorded to them at present

Table 12: Commodity based agricultural research and development priorities in the Asia-Pacific region

Commodity	Regional priority level		Priorities need in sub-regions			
	Current	Needed	SA	SEA	NEA	PIC
I. CROPS						
i Cereals	H	H	H	H	H	L
ii Coarse Cereals	M	H	H	H	H	M
iii Pulses	L	H	H	H	H	M
iv Oilseeds	M	H	H	H	H	M
II. HORTICULTURE						
i Fruits	M	H	H	H	H	H
ii Vegetables	M	H	H	H	H	H
iii Flowers	L	M	M	M	M	M
iv Roots & Tuber	L	M	M	H	M	H
III. LIVESTOCK						
i Small ruminant	L	M	M	M	M	M
ii Cattle	M	H	H	H	H	L
iii Piggery	L	M	M	M	M	H
IV POULTRY	M	H	H	H	H	H
V FISHERIES						
i Inland	L	M	H	M	M	M
ii Marine	L	M	M	H	H	H

Priorities: H = High; M = Medium; L = Low

A further insight into the major commodity research areas would show that the research prioritization at commodity level has been based on relative importance of commodities to the broadly defined research goals. For instance, a high priority has been accorded to food staples when the sole objective was to attain food self-sufficiency. At the same time, a commercial crop has been given a medium to high research priority so as to attain global competitiveness as well as agricultural diversification.

Cereals, are high priority commodities in the Asia-Pacific, comprising about 75 to 80 per cent of total agricultural output in South Asia. Further, among cereals, rice is the most important commodity that secures primary attention to achieve self-sufficiency in most countries in the region. The second most important cereal is wheat in the South Asia and Myanmar among the Southeast Asian countries

Table 13: Broad areas of research based agricultural research and development priorities in the Asia-Pacific region

Commodity	Regional priority level		Priorities needed in Sub-regions			
	Current	Needed	SA	SEA	NEA	PIC
I. Resource Management & Conservation						
i Soil	M	H	H	H	H	H
ii Water	M	H	H	H	H	H
iii Environmental Concerns	L	M	M	M	M	H
iv Land Use Planning	L	H	H	H	H	H
II. Land Use Systems						
i Range and Marginal Lands	L	M	M	M	M	M
ii Agro-forestry	M	H	H	H	H	H
iii Degraded & Waste Lands	L	M	M	M	M	M
III. Biotechnology and Biosafety	L	H	H	H	H	H
IV. Biodiversity Conservation	L	H	H	H	H	H
V. Germplasm Enhancement	L	H	H	H	H	H
VI. IPM	L	H	H	H	H	H
VII. Rice-Wheat Cropping Systems Research	L	H	H	H	H	L
VIII. Exploitation of Hybrid Technology	L	M	M	M	H	M
IX. Processing, Product Development and Value Addition	L	M	M	M	M	H
X. Institutional Building & Human Resource Development/ Strengthening of smaller NARS	M	H	H	H	H	H
IX. Socio-Economics, Public Policy, Market Research, Management Research	L	M	M	M	M	H
XII. Non-conventional/underutilized/ new crop commodities	L	M	M	M	M	H
XIII. Information Management System/ Regional/sub-regional coordinition activities	L	M	M	M	M	M
XIV. On farm water use efficiency	L	M	M	M	M	M
XV. Farmers' Participatory Research	L	M	M	M	M	H

and, further, maize was identified as a common research commodity in the Southeast Asia. Much importance has been advocated in favour of maize for both food and feed purposes, looking into the expected increase in its demand.

The research priority for crop commodities in the Pacific Island countries could vary at large; the root crops which are cultivated along with other food crops such as banana, breadfruit, coconut,

various fruit trees, etc., both in the highlands and in atoll islands, generally under an agro-forestry system, and constitute the major crops of the sub-region, be accorded high research priority. Cassava, sweet potato and Irish potato among the root crops also constitute common commodity research areas in Southeast Asia and South Asia, particularly Bangladesh and parts of India. These commodities, particularly cassava and sweet potato, are generally cultivated in marginal areas by the resource poor farmers. Research interest in these commodities should, therefore, be increased in light of the commitment of countries in the region to address poverty through technological change. This research area should therefore, be given generous funding support. Mungbean, peanut and soybean are likewise the common commodity research areas in the region which should be given a high priority.

Table 14: Research priorities under Agro Ecological-Commodity research approach

Agro-ecological Production Regimes	Crops/Commodities									
	Rice	Wheat	Coarse cereals	Fruits	Vege-tables	Spices/ Plant-ation crops	Agro-forestry	Live-stock	Aqua-culture I	Aqua-culture M
Irrigated	H	H	L	M	H	L	M	M	H	-
Rainfed	H	M	H	H	L	M	H	H	M	-
Deserts	-	-	H	M	L	L	M	H	-	-
Sub-humid (1,000-1,500mm)	H	H	H	H	M	L	H	M	M	-
Humid (>1500mm)	H	L	M	M	M	H	H	L	H	-
Coastal	H	-	L	L	L	M	M	L	H	H
Hills	M	M	M	H	H	M	M	H	L	-

Note: I = Inland; M = Marine ; Priorities: H = High; M = Mèdium; L = Low

Tropical fruits and vegetables also need a major research concern in South Asia, particularly India and Bhutan, and also in the Southeast Asia. Bhutan has a comparative advantage in horticultural products which provide a significant earning to the country from export. The opening-up of world market further strengthens research interest in these commodities. In the Philippines, tropical fruits, such as, banana, mango, durian and pineapple, among others, are identified as high research priority commodities due to their high export potential.

Plantation crops, like the coconut, rubber, sugarcane and tea are considered high priority commodities in the South Asia particularly in Bangladesh, Sri Lanka and India. These commodities earned traditionally high income from export and, therefore, are regarded as among the most important agricultural commodities in the region. Most plantation crops, except cotton are common commodity research areas in Southeast Asia also. These include rubber, palm oil, coconut, tea, coffee, cacao, spices, sugarcane and tobacco. Cotton is of interest to India and Pakistan in the South Asia.

Cattle, buffalo, goat/sheep and chicken are the important commodity research areas in livestock and poultry. Swine is particularly important to the Philippines, Thailand and Vietnam, in the Southeast

Asia. The research on livestock should have a high priority because of increased demand for meat and meat products with increased per capita income.

Broad areas of research:

Resource management and conservation, particularly in relation to soil, water and land use planning, be accorded a high priority as broad areas of research. Also, the agro-forestry, among the land use systems, biodiversity conservation, biotechnology, institutional building, human resource development and germplasm enhancement constitute the high priority areas of research in the APAARI region (Paroda, 1996), whereas land use systems for range and marginal lands as well as degraded and wastelands be considered at medium priority level. Likewise, socio-economics, public policy, market research, management research, and activities related to processing, product development and value addition are the medium priority broad areas of research. It is recommended that the land use planning, which has been receiving a low priority in the region, on an average, at present must be accorded a high research priority. Similarly, the integrated pest management (IPM) and the rice-wheat cropping systems research be elevated from low to high priority broad areas of research.

Table 15: Priority research areasof some selected countries in the region

Country	*Breeding Activities/Genetic Improvement*
SOUTHEAST ASIA	
Indonesia	Improvement of genetic potential of crops, livestock, fish, microorganisms. High priority is given to applied science program and technology program. Molecular biology is also high priority
Vietnam	Employment of high technology to breed and select; Cereal crops: rice with yield of 12-14 mt/ha/crop Fruit trees: segment fruits Forestry: high value trees Breeding Animal: Pig-high lean meat ratio Cattle: dairy and meat
Philippines	Breeding to improve (1) export winners namely; mango, banana, pineapple, durian, papaya and ornamentals; (2) commodities for basic domestic needs such as corn, rice, legumes, vegetables, rootcrops (especially potato and sweet potato); other commodities such as cashew, tobacco, fiber crops, cattle, poultry, small ruminants, forest trees and fish.
SOUTH ASIA	
Bangladesh	Collect, conserve, evaluate and enhance genetic resources of agricultural importance, including fungi and bacteria; germplasm for biofertilizers; genetic upgrading of livestock.
India	Exploration of under-explored and unexplored regions of genetic diversity for collection, *ex-situ/in-situ* conservation, characterization and evaluation of plant genetic resources; acceleration of breeding research for improvement of rainfed crops for higher yield, adaptability to varied water regions and cropping systems,with special emphasis on lowland rice, coarse cereals, cotton, pulses, oil seeds, fruits and vegetables; development of commercially viable hybrid of ideal maturity and plant frame for crop intensification and diversification; development and application of molecular techniques in crop breeding with emphasis on engineering of crop; animal genetic resource conservation and improvement with emphasis on creating and maintaining data bank; molecular tagging and cloning of important genes; superior germplasm production for agro zones through embryo transplant and other biotechnological manipulation; conservation management and cataloguing of fish germplasm and establishmentof gene bank.

Country	*Breeding Activities/Genetic Improvement*
Pakistan	Development and promotion of high yielding drought tolerant varieties of food and fodder crops.
Sri Lanka	Tea breeding for yield improvement; develop clones for the up-country, capable of yielding on a commercial basis about 300 kg/ha, resistant to shot-hole borer, up country live wood termite, blister blight and with high quality at current levels of inputs.
Pacific Island Island Countries	Establish and improve breeding programmes for selected crops, collection and incorporation of native cultivars for breeding purposes and evaluation; collection, introduction and exchange of germplasm of crops varieties appropriate to local conditions; germplasm improvement for root and tuber crops, plantation crops, fruit trees, vegetables, trees and pulses; improve breeding stocks of animal types relevant for island ecosystem.
NORTHEAST ASIA	
Japan	Development of a broad range varieties of rice, wheat, barley, sweet potato, legume, oil crop, etc., improvement of yield and quality, resistance to diseases and pests and tolerance to adverse environment.
Korea	Development of high quality and high yielding cultivars; practical application of biotechnology and preservation and use of genetic resources (e.g. tissue culture, cell fusion and nuclear transfer).
	Production for agro zones through embryo transplant and other biotechnological manipulation; conservation management and cataloguing of fish germplasm and establishment of gene bank.
	Development and promotion of high yielding drought tolerant varieties of food and fodder crops.
	Tea breeding for yield improvement; develop clones for the up-country, capable of yielding on a commercial basis about 300 kg/ha, resistant to shot-hole borer up country live wood termite, blister blight and with high quality at current levels of inputs.
	Establish and improve breeding programmes for selected crops, collection and incorporation of native cultivars for breeding purposes and evaluation; collection, introduction and exchange of germplasm of crops varieties appropriate to local conditions; germplasm improvement for root and tuber crops, plantation crops, fruit trees, vegetables, trees and pulses; improve breeding stocks of animal types relevant for island ecosystem.
	Development of a broad range varieties of rice, wheat, barley, sweet potato, legume, oil crop, etc. - include genetic improvement of yield and quality, resistance to diseases and pests and tolerance to adverse environment.
	Development of high quality and high yielding cultivars; practical application of biotechnology and preservation and use of genetic resources (e.g. tissue culture, cell fusion and nuclear transfer).

Country	*Production systems development and management*
SOUTHEAST ASIA	
Indonesia	Production systems/culture, farming systems; pest and weed control/ management systems; postharvest/agro-industry; agricultural tools and machinery; socio-economics
Vietnam	Land use; seed production for specific agro-ecosystem; postharvest technologies; agricultural mechanization; survey on aquaculture resources; technology development for aqua product storage

Country	*Production systems development and management*
Laos, PDR	Characterization of soil type; crop improvement and management; supply of animal feed resources
Philippines	Appropriate technologies on production management and postharvest handling, integrated pest management; seed production; nutrition, health care and management for livestock and poultry; piloting of community forest management technologies; development of industrial plantations of commercial tree species; development of forestry seed program; determination of harvest cycle for sustained production and development of growth/yield projection for forestry products; socio-economics
Thailand	Cultural practices, cropping systems; soil fertility/fertilizer application; insect and disease control; weed control; farm machinery and equipment; foundation seed production
SOUTH ASIA	
Bhutan	Cropping patterns, pest management and essential oil production; integrated soil fertility management, farm trials on improved productivity of cash crops; input supply improvement; expansion of mechanization in agriculture
India	Strategic research on manipulation of photosynthetic system, effect and mitigation of climatic changes; advanced research on major disease; development of sustainable land utilization systems in farming system framework using modern tools and techniques for different agro-ecological zones; integrated nutrient management system (INMS) with focus on the use of organics; remote sensing, GIS and crop and resource modeling, farm mechanization and energy related technologies; establishment of prototype production centeres in different regions; development of integrated pest management system; non-conventional feed resources for increased nutrient availability; diagnostic and vaccine production for prevalent and emerging diseases; development of suitable mariculture and sea-ranching technologies; development of innovative techniques such as cage culture, periculture, running water aquaculture, integrated farming system with recycling of organic wastes for sustainable fish farming
Pakistan	Balanced use of fertilizer, micro-nutrients and soil amendment, proper on-farm water management
Sri Lanka	Development of alternative techniques for expediting soil reconditioning for tea; development of regional and site-specific fertilizer recommendation; development of irrigation system for tea; development of mechanical harvesting method; formulation of specific pruning styles; identification and development of biological control of related plant diseases
Pacific Island Countries	Develop and improve traditional system with short duration cover crops to improve production including analysis of constraints to production and promote integrated agriculture; development of post harvest technology and agro-processing; pest control for horticulture products; improve and promote traditional production system for livestock; identify animal types suitable both for atoll and non-atoll ecosystem; develop and improve the utilization of coastal ecosystem; development and management of appropriate farming system
NORTHEAST ASIA	
Japan	Development of crop production method and field management system in harmony with ecosystem; development of technologies which may contribute to improve farming efficiency; development of agricultural communication and farm management system; no-tillage planting of soybean, transplanting without land preparation and direst seeding of rice and optimum scheduling of farm operation; development of national systems of rotation of field crops, vegetables and forage crops
Korea	Establishment of innovative cultural practice technique for low production cost and improved yield, diversification of usages of crop products and improvement of agronomic environment for crop production.

Country	*Protecting the environment*
SOUTHEAST ASIA	
Indonesia	Agricultural resource survey and mapping, ecosystem conservation and management; bio-chemical dynamics of agro-systems and the environment alternative for sustainable utilization and management of resources
Philippines	Consolidation of benchmark data base; generation of environment friendly technologies, development of valuation system of environmental monitoring and evaluation system
Loas, PDR	Resource management in riverine and reservoir fisheries
Vietnam	Soil conservation and safe exploitation and conservation of water resources
Thailand	Forest management; silviculture and wood properties; watershed management use studies
SOUTH ASIA	
India	Inventorization, characterization, evaluation and conservation of biophysical resources; evolving technologies for resource conservation and harnessing area-specific advantages of high-rainfall rainfed areas; development of sustainable land utilization systems; eco-regional water management planning for efficient use of water from various resources; assessment of environmental consequences as related to resource management and amelioration of negative impact
Nepal	Reduction of pressure on steep sloped environmentaly fragile land and strengthen biodiversity conservation promotion of community forestry and increase capability in land use planning
Pakistan	Development of comprehensive programme of afforestation, watershed management, rouge management and resource conservation to improve and conserve land and water resources
Pacific Island Countries	Development of policies for land use and development/improvement and sustainable technology and management practices; development of soil conservation practices compatible with farming practices; development of alternative to slash-and burn technique for land clearing; preservation of ecological balance among vegetation, climate and soil
NORTHEAST ASIA	
Japan	Analysis of the characteristics and function of environment resources; utilization of the components of agro-ecosystems and of their function; development and integrated technology for the control and preservation of the environment
Korea	Soil and water conservation; organic farming, optimizing fertilizer application, saving biodiversity

Country	*Socio-economics, public policy and public management*
SOUTHEAST ASIA	
Bangladesh	Commodity analysis, socio-economic dynamics in rural areas; policy analysis (micro and macro); social organization/institutions; monitoring and evaluation of technology adoption

Country	*Socio-economics, public policy and public management*
Philippines	Evaluation of technologies and technology commercialization program; analysis of market potentials, rural industrialization, entrepreneurship for STAND and flagship commodities; socio-economic dimension of sustainable resource management; impact assessment of GATT; policy analysis and advocacy
Thailand	Policy research on agriculture and rural development, macro-economics, natural resources, trade, human resources, social development, science and technology
Vietnam	Policy advocacy on forestry
SOUTH ASIA	
Bangladesh	Develop, adapt and supply problem focused research methods which include farmer's participation to generate socially desirable technologies; technology development and sharing, strengthening of the commercial base of livestock industry by adopting appropriate policies
India	Policy research for sustainable agriculture and poverty alleviation; impact assessment, priority setting and resource allocation; environmental accounting and evaluation of agro-diversity; international trade; socio-cultural organization gender aspect; socio-economic and cultural constraints to adoption of technology; participatory technology generation and development; rural entrepreneurship development; participatory appraisal and intersectoral micro planning
Pakistan	Policy advocacy to provide favorable environment for agricultural production; development of effective linkages and coordination between research, education of extension institutions; extension of training and visit (T & V) system to the entire province of Punjab and Sind
NORTHEAST ASIA	
China	Stabilization of rural policies, protection of cultivated land
Japan	Formulation of policies to overcome the difficulties associated with the decline in self-sufficiency rate in cereals, imbalance between supply and demand in rice and other crops and the decreasing number of people succeeding farming activities
Korea	Development of professional labor forces for agriculture; restructuring agricultural production; improvement of agricultural marketing system; export promotion programme; effective management for agricultural imports

Country	*Strengthening national program*
SOUTHEAST ASIA	
Indonesia	Resource development, education and training, organization and management; research cooperation
Philippines	Strategic human resource development; upgrading of facilities such as laboratories, research equipment and infrastructure; improvement in financial and administrative system; research cooperation
Laos, PDR	Strengthening of research institutions and coordination
Bangladesh	Balance institutional support to private and public entities to sustain agricultural development activities; development of institutions supporting the needs of different classes of farmers

Country	Strengthening national program
Bhutan	Development of human resources by providing much needed training to agricultural and forestry staff
India	Creation of new training laboratory and infrastructure; fostering greater interaction of agricultural scientists; reform in the recruitment and examination procedures; development of lead centers providing regional and natural level training in selected disciplines; ensuring greater inflow of bright, pure-science graduates for teaching courses of ICAR institutes; fostering greater collaboration between scientist of SAU and ICAR
Nepal	Development of human resources to provide trained manpower for the agricultural sector by establishing a separate agricultural university; involvement of local communities jointly with the government in the implementation and identification of rural development schemes
NORTHEAST ASIA	
China	Training of young agricultural scientists; development of exchange and cooperation relations on agricultural literatures and information with counterpart institutions at home and abroad
Korea	Setting up of computer data bases to enhance information dissemination; structural reorganization, e.g. decentralization of extension
Pacific Island Countries	Training of personnel; policy and legislative reforms; infrastructures development; improved access to agricultural information; development of research plans with vigorous screening procedures to address priorities; improved preparation of programmes and better coordination

APAARI has observed, with due concern, that the recent agrobiodiversity related issues, such as, Biotechnology and Biosafety, Biodiversity Conservation and Germplasm Enhancement have all been receiving, on an average, a low priority attention and recommended high priority attention to each of these areas. Institutional building and the human resource development were observed to have received a meidum priority consideration which is insufficient due to the fast changing global scenario and research needs. It was therefore, recommended that these areas, alongwith the strengthening of smaller NARS, must receive high priority. Similarly, both soil and water resource management and conservation areas be elevated to high priority research areas in view of their indispensibility for the agriculture. At the same time, the environmental concerns should also receive more attention than their present low level and be accorded a medium research priority in the region.

Agro-ecological-commodity research approach

Looking into the importance of different commodities in various agro-ecological domains, the APAARI recommends that Rice, wheat, vegetables and inland aquaculture be treated as high priority commodities under irrigated agro-ecological regime whereas in the rainfed areas, rice, coarse cereals, fruits, agroforestry and livestock be the high research priority commodities. For coastal areas, it is recommended that rice, inland and marine aquaculture be projected as high priority commodities whereas for hilly areas fruits, vegetables and livestock be accorded high research priority. In the desert agro-ecology, coarse cereals and livestock need the highest research priority consideration whereas in the sub-

humid ecosystem major and coarse cereals, fruits and agro-forestry could be placed at the top. Further, in the humid ecosystem, having more than 1500 mm rainfall per year, the highest priority for rice, spices and plantation crops, agroforestry and inland fisheries has received APAARI's endorsement in the various expert group consultations.

Other research areas of common interest with collaboration opportunities among countries are, the farming system, soil resources, agricultural engineering, particularly farm power and machinery, aquaculture, artisanal and deep sea fisheries, agro-meteorology, water resources, on-farm research and socio-economics. Biotechnology is accumulating considerable research interest in the Asia-Pacific and be given a high priority consideration for collaboration among NARS and other stake-holders as also a generous funding support by sponsoring/funding agencies, enabling NARS in the region to strengthen from research gains in technology-rich countries besides bringing out useful innovative, inexpensive technology.

THE FOLLOW-UP AGENDA : SOME APAARI ADVANTAGES AND FUTURE DIRECTION

During the interface provided at the Expert Consultations, the heads/senior representatives of NARS of various APAARI member countries and several international authorities and other participants of the FAO, the World Bank, the CG Centres and other ARIs, as also of the past and potential donors, clearly observed several advantages in favour of the region which would effectively help in pursuing APAARI's research agenda and mid-term Action Plan. The foremost consideration for such a follow-up is that the organisation of several national agricultural research systems in the region was up to the mark in the present context. The experts felt that most of the NARS in the region were better organized than the NARS in other regions and also that the smaller countries showed their willingness to pursue the identified research priorities in a collective mode.

The objectives and activities of APAARI were whole-heartedly supported by the representatives of the FAO, IFAD, the World Bank and the CG Centres' at various fora. APAARI's participation in the CG Centres' week (CGW), mid term meetings (MTM) and the Global Forum are considered significant in helping the association project its research agenda, intended in a collaborative mode, at various levels of interaction among NARS - APAARI - NARS, NARS-APAARI-CG Centres and APAARI-CG Centres-Other regional fora.

The advance NARS in the region have shown their capabilities worth demonstration in terms of system-based research, extension, management and teaching programmes, involving all stakeholders and interest groups. This is a positive signal that the Global Forum would use to an advantage in pursuing the Global Action Plan. ISNAR showed particular appreciation for the Indian NARS in having set up a national academy of agricultural research management (NAARM) which can definitely support, like the ISNAR itself, the national institutes of other big countries in the region in their orientation for agricultural research management and also cater to the HRD needs of smaller countries with less organised NARS. The NARS in the northeast Asia sub-region were rather well organised; a tendency was shown to de-centralize powers in favour of grass root level administration in Korea and in the Philippines, appreciable efforts were made in developing an intellectual property protection system.

An early recognition to some research networks in the APAARI region also coincides with the recent global developments in approach towards scientific research. This provides a sure means

of effective and efficient use of resources to address and solve network-specific, common problems under collective mode and to avoid duplication of avoidable efforts. APAARI members in their general Assembly duly endorsed in favour of strengthening some existing networks as its sub-networks, or to provide support through other interested donors. The case of strengthening of TAMNET through effective monitoring, reporting and further improving mechanism of the conduct of international trials was given impetus as CIMMYT agreed to APAARI's persuasion to collaborate with FAO and the forum so as to ensure sustainable functioning of TAMNET. A network approach (Hybrid Rice Task Force) with effective support from IRRI/CORRA and APAARI was felt important as also the strengthening of Rice-Wheat System Research in the region to cope up with the future requirements of Food for Agriculture.

The regional needs to pursue a network approach on coarse cereals and pulses were critically examined and an effective support called for from ICRISAT, AVRDC and ICARDA. APAARI's suggestion to include soybean, mungbean and lentil into the ambit of CLAN was emphatic and its General Body recommended to work out modalities to include these crops and associate other partners with CLAN. Support of CIP, UNDP, FAO, Pacific Island Commission (PIC), ACIAR and APAARI needs to be ensured in helping to develop and strengthen a network on potato and sweet potato, on the analogy of the existing network, ASPRAD, in the region and a network for taro and yarn in the Pacific Island countries. The urgency and priority in terms of the latter was clearly endorsed by APAARI.

Networking of various NARS and CG Centres in the region is vital through active involvement of ISNAR, CABI and APAARI, with a view to activate information dissemination. Effective presence of ISNAR in the region was considered highly critical at this juncture so that both APAARI and ISNAR would extend the much needed support to all concerned.

The APAARI clearly endorses the FAO initiative for its revision of International Undertaking on Plant Genetic Resources for Food and Agriculture and encourages member countries to participate in the Global Plan of Action in a sustainable, cohesive, cooperative, collaborative and time targeted, mission-mode approach.

The regional research and collaboration in research scenario is, quite optimistic. A willingness, which is the basic essential component for positive future developments, was clearly evident among NARS alongwith their willing commitment to the APAARI's cause. The FAO, IFAD, the World Bank and the CG Centres have also whole-heartedly supported the objectives and activities of the forum and they expressed willingness to extends all possible support to APAARI and its constituent NARS. It was, hence, agreed, in principle, that need based, time targetted, collaborative research projects be outlined in mission made based on the identified research priorities for the region and submitted to various donors for funding. Such cumulative research efforts, with a regional perspective are bound to ensure fulfillment of objectives and be put in the right place.

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Annexure

CGIAR CLASSIFICATION FRAMEWORK FOR RESEARCH PRIORITIES — ACTIVITIES AND THEIR DEFINITIONS

Category 1 : Increasing Productivity

1.1 *Germplasm enhancement and breeding*
- Pre-breeding
- Crops
- Livestock
- Trees
- Fish

1.2 *Production systems development and management*
- Cropping systems
- Livestock systems
- Tree systems
- Aquatic systems

Category 2 : Protecting the Environment

Category 3 : Saving Biodiversity

Category 4 : Improving Policies

4.1 *Economic and social analysis*
4.2 *Policy analysis*
4.3 *Governance and management of public systems*
4.4 *Research on organisation and management of institute's*

Category 5 : Strengthening National Programmes

5.1 *Training and Conferences*
5.2 *Documentation, publication and dissemination of information*
5.3 *Institution building/advice to NARS*
5.4 *Networks*

Category 1 : Increasing Productivity

1.1 Germplasm enhancement and breeding

1.1.1 Pre-breeding Activities (including applications of techniques in molecular biology)

1.1.2 Crops : Crop germplasm enhancement and breeding: incorporating primitive and novel germplasm into useful material for breeding purposes, as well as germplasm evaluation and conventional breeding.

1.1.3 Livestock : Breed improvement.

1.1.4 Trees : Tree germplasm improvement: breeding of improved trees including multipurpose trees and shrubs.

1.1.5 Fish : Breed improvement.

1.2 Production systems' development and management

1.2.1 Baseline studies of production systems (including constraint analysis and monitoring of

sustainability) 1: Characterisation of the socio-economic and agricultural aspects of farming systems including analysis of constraints to production and sustainability.

1.2.2 Development and management of farming systems, including socio-economic evaluation of new technology or practices1: Design and testing of farming systems and components for more productive and sustainable systems.

1.2.3 Cropping systems

(a) Plant nutrition - crop and pasture nutrient requirements, the availability, cycling and uptake of nutrients (including the role of mycorrhiza and other symbionts), tillage and fertilizer management.

(b) Plant protection and pest management (diseases, insect pests and weeds)-the economic control of diseases, insect pests and weeds of crop, pasture and tree species during systems for integrated pest management.

(c) Seed production - increase of seed of elite materials, its certification and release.

(d) Postharvest technology - the development of ways of treating commodities to reduce loses in the storage and marketing system and improve the quality and value of foods through processing.

1.2.4 Livestock systems

(a) Livestock nutrition including studies on feeds, pastures and fodder assessment of the nutritional status of livestock in relation to the availability of feed resources.

(b) Animal health - epidemiology, biology, immunology and genetics of animal pests.

(c) Livestock reproduction - reproductive biology of livestock and the reduction of reproductive wastage from reproductive diseases and other causes.

1.2.5 Tree systems

(a) Silviculture and tree production - the management of trees in agroforestry, plantation and natural forest systems to enhance and sustain productivity.

(b) Tree nutrition - tree nutrient requirements, the availability, cycling and uptake of nutrients (including the role of mycorrhiza and other symbionts), and fertilizer management.

(c) Tree protection (diseases, insect pests and weeds) - the economic control of disease, insect pests and weeds of tree species including systems for integrated pest management.

1.2.6 Aquatic systems

(a) Fish reproduction - reproductive biology of fish and the reduction of reproductive wastage from reproductive diseases and other causes.

(b) Fish nutrition including studies on feeds - assessment of the nutritional status of fish in relation to the availability of feed resources.

Category 2 : Protecting the Environment

2.1 Ecosystems analysis, ecological characterisation and environmental concerns - the characterisation, classification, mapping and analysis of aquatic and terrestrial ecosystems, especially in relation to the functioning and use of ecosystems including human use patterns and pressures, climate, hydrology, soil and land form.

2.2 Biology and ecology of useful organisms and pests - study of the distribution, production and dynamics of economically important plants, animals and fish and of the weeds, insects pests and diseases which affect them, the vectors related to hazards to human health.

2.3 Land resources conservation and management - research on the maintenance or improvement of the potential productivity of the land resource base and its components especially the edaphic, climatic, hydrological and biological resources.

a) Soil and land form - research on monitoring, maintaining or improving the physical and biological characteristics as well as chemical fertility of soils.

(b) Water - research on the conservation and management of rainfall and/or irrigation water.

(c) Plants and animals - research on the factors affecting the productivity and conservation of natural vegetation including forests and rangelands, and research to monitor natural populations of wildlife.

2.4 Aquatic resources conservation and management - research on the maintenance or improvement of the potential productivity of the aquatic resource base, including research on the population dynamics of aquatic resources and their exploitation.

2.5 Process and mechanisms of sustainable resource systems.

2.6 Modelling of landscape and watershed level phenomena.

Category 3. Saving Biodiversity

3.1 Germplasm collection, conservation, characterisation and evaluation - collection and maintenance of in vitro (and in situ) germplasm collections and the distribution, characterisation and documentation of collections.

Category 4. Socio-Economic, Public Policy and Public Management Research

4.1 Economic and social analysis

(a) Human nutrition - study of the relationship between such factors as nutritional composition of commodities, food quality, income, price, socio-economic characteristics and the nutritional status of people.

(b) Gender, human health hazards and socio-cultural organisation - analysis of gender, health and socio-cultural organisation in agricultural communities.

(c) Micro-economic and social analysis - research to determine the economic and social effects and implications of technologies or policies as they affect people, by examining farm, household or village data.

(d) Market and trade analysis - research to determine the market level economic conditions that may result from various technologies, institutions or policies and to analyse the impact of trade and macro-economic policy on markets.

(e) Impact assessment and priority setting - research to assess the impact of research including cost/benefit analysis and to improve the analytical basis on which research priorities are set.

4.2 Policy analysis - Research to determine the desirability of alternative policies from the viewpoint of society, taking into consideration productivity, equity, sustainability, and environmental concerns.

4.3 Governance and management of public systems (including irrigation systems) - Analysis of organisations for the management of public systems (including irrigation systems) and the development of innovations to improve their performance.

4.4 Research on organisation and management of institutes - analysis of research and research management processes aimed at the development/enhancement of approaches, methodologies and tools for conducting these processes. The procedures generated relate to biological/

technological research, i.e. technology generation efforts and organisation and management of NARS.

Category 5 : Strengthening National Programmes

5.1 Training and conferences

(a) Training - human resource enhancement including specialised training courses, postgraduate research, study tours, etc.

(b) Conferences and seminars - to foster the build-up of NARS capacities and the effective functioning of international research collaboration; fora for discussion of scientific cooperation among the partners in the global system (IARCs, NARS, specialised institutions); stimulating horizontal transfer of information and technology among national research systems.

5.2 Documentation, publication and dissemination of information - Efforts to use systematically the global knowledge base in areas and disciplines of relevance to centres' research programmes and to make available to NARS relevant information on progress and output of centres' research programmes, through newsletters, publications, electronic media, and abstracting services.

5.3 Institution building/advice to NARS - assisting NARS through the provision of advice and counsel. This covers a range of subjects/topics and includes the biological sciences (conduct of research) and the organisation and management field (organisation and management of NARS). Primary objective : build up of NARS capacities (institution building).

5.4 Networks - Organising, coordinating, managing or backstopping of collaborative research efforts among various partners in the global research systems with the primary objective of building up national capacities. This category does not include activities of research networks.

South Asia

SOUTH ASIA

Introduction

South Asia, comprising Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka, houses a total of about 1.35 billion people, thereby accounting for 21 per cent of the world's population. On the other hand, it occupies only 3 per cent of the world's land area. Thus the South Asian region faces the highest population and development pressures on land and other resources in the world.

Despite the various constraints, the sub-region made remarkable progress in its food and agricultural production during the past 30 years. The near famine conditions prevailing in the early 70's in several pockets of South Asia had largely been alleviated and the sub-region has transformed from a food deficit status to a status of food self-sufficiency. Most of the larger countries in the region attained two or three fold increase in food production. For instance, cereal production in India increased from about 80 million tonnes in 1965 to 192 million tonnes in 1994-95. Bangladesh imported about 3.5 million tonnes foodgrains in the mid 60s, but became self-sufficient by 1993, despite the fact that during this period its population had also more than doubled. Taking 1979-81 as the base year, the agricultural production index in South Asia increased by about 60 per cent and Bangladesh, India, Nepal and Pakistan registered growth of 32, 66, 69 and 73 per cent, respectively. In Sri Lanka, however, the production index increased only marginally.

The unprecedented increase in agricultural production was triggered by the Green Revolution in South Asia through the development and dissemination of high yielding varieties, essentially of rice, and the fertilizers, irrigation and credit. Most of the countries in the Sub-region concentrated on enhanced production of the Green Revolution commodities whereas systems approach, resources management and sustainability aspects, etc., received little attention. This resulted, by and large, in inequity problems and imbalances. A large number of indigenous races and breeds were endangered due to rapid spread of monospecific agriculture. The intensively managed irrigated areas faced retardation in growth in productivity and the rice-wheat system, which constitutes the main food bowl of the sub-region has been getting fatigued.

Food demand in the next 5 years is expected to grow annually by about 3 to 3.5 per cent, mainly due to the projected population growth rate of 1.8 to 2 per cent, resulting in 60 per cent increase in the population by the year 2020, adding about 25 million people every year, to the already overcrowded sub-region. Further, the expected income increase of 3 per cent per year is likely to further push up the food demand by 1 to 1.2 points. Other important trends such as the growing demand for animal products and the need for diversion of food grains for animal feed, the changing food package particularly with the increasing urbanization, the new opportunities arising through economic liberalisation and possibilities of promoting non food crops for sharing the global market would greatly influence the future priorities of agricultural production, including the balance between food self-sufficiency and food self-reliance.

The national level food securities achieved in the various South Asian countries also mask large pockets of malnutrition. The gap between the national and household level food security is essentially due to the poor economic access to food on the part of the poor. Although the trends in reduction in poverty in the sub-region, are quite evident yet by the year 2020 South Asia is estimated to house half of the world's poor people. The unholy alliance among poverty, food insecurity and environmental degradation needs to be broken.

The South Asian economies, despite a reduction in the level of contribution of agricultural GDP to the total national GDP, are still largely agrarian in nature and the share of agriculture in their national GDP ranged between 26 per cent and 60 per cent. In employment sector, agriculture accounted for even higher shares. In most South Asian countries, agriculture contributes significantly to national exports and its importance is further increasing.

Food and agricultural production in South Asia consume highest proportion of land resources as against other land use patterns. A considerable enhancement was observed in the consumption of Technological input in agriculture in the South Asia. Consumption of NPK in Bangladesh, India, Nepal and Pakistan increased by 6 to 9 per cent per annum during the decade ending 1993. The Asian region as a whole accounts for about 61 per cent of the world's irrigated land and more than 32 per cent of the region's agricultural land is irrigated against only about 10 per cent in the rest of the world. The proportion of irrigated land to total land in South Asia was fairly high, ranging from 25 per cent in Bhutan to 81 per cent in Pakistan. Further, in terms of mechanisation, the number of tractors in South Asia has been increasing at a high rate, particularly in India and Pakistan. India is the largest producer and user of tractors in the world.

Table 16: Fertilizer use, Irrigation, and Tractor availability in South Asia in 1993 and Growth Rates during 1983-93 in South Asia

Use/growth	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
NPK (kg/ha of crop land)	97.8	0.7	72.8	30.9	101.0	110.6
Growth rates (per cent)	7.1	-6.3	6.7	8.4	5.5	0.4
Per cent of crop land Irrigated	32.0	25.4	28.3	36.1	80.5	28.9
Growth rates (per cent)	6.1	1.6	1.6	2.4	1.0	-0.5
Tractor numbers	5300	—	1195013	4600	283300	33000
Growth rates (per cent)	1.2	—	9.5	6.5	8.7	2.6

The impressive growth in the inputs led to an equally impressive growth in agricultural production. However, this progress was often not associated with appropriate management of resources. The rice-wheat system is already showing fall in total factor productivity. Both short and long term problems of unsustainability are likely to arise due to several factors, such as, the deteriorating soil structure, soil nutrient depletion, build up of insects, weeds and diseases affected by the intensive cropping. With the growth in irrigation, ground water is receding at an alarmingly high rate in western India and other intensively cultivated areas in the sub-region. Problem of water logging and salinisation have also resulted from irrigation, on the other side.

In India, 7 million hectares of land was abandoned and productivity reduced on another 20 million ha due to excess salts. In Pakistan, lack of proper flushing of soils and poor drainage led to water logging and salinity in an estimated 3.5 million ha which is 25 per cent of the total irrigated land and another 8 million ha were vulnerable to water logging because of high water table. The use of pesticides was observed to be on an increase and the integrated pest management (IPM) has not been promoted in South Asia with the same vigour and success as in parts of Southeast Asia. The production and distribution of high quality seeds also increased. More than 90 per cent of the wheat acreage increased under the high yielding varieties and in rice, more than 60 per

cent of the area in the region are under high yielding varieties and its coverage is further on an increase. However, the genetic diversity at the farmers' fields has been shrinking; the HYVs having pushed out the veritable land races which provided wide spectrum of genetic variability, often free from pests and diseases and high sustainability, although usually not as high yielding.

AGRICULTURAL PRODUCTION AND PRODUCTIVITY

Food Crops

Cereals : Area under cereals has been on a decline in Bangladesh, Bhutan, India and Sri Lanka during the past ten years whereas in Nepal and Pakistan it increased annually by 1.7 per cent and 0.8 per cent, respectively. Cereals comprise about 75 to 80 per cent of the total agricultural production in South Asia. The six countries taken together, with a total production of over 270 million tonnes of cereals accounted for about 14 per cent of the world total cereal production. The average cereal yield in the sub-region was 2.1 tonnes per hectare against 2.8 tonnes per hectare in the world. However, the yield growth rate in the region (2.8 per cent) was more than double of that of the world's growth rate (1.3 per cent). India scored highest growth rate of 3.4 per cent followed by 2.8 per cent in Bangladesh, whereas Bhutan registered negative growth rate. Sri Lanka recorded the highest average yield of about 3 tonnes per hectare, followed by 2.7 tonnes in Bangladesh, 2.1 tonnes in India and less than 2 tonnes per hectare in the remaining countries.

Rice Paddy : With an annual production of more than 157 million tonnes of rice paddy, the sub-region accounted for about 29 per cent of the world's rice paddy production although its average yield is only 2.8 tonnes per hectare as against about 3.5 to 7.0 tonnes per hectare in several of the developing countries in the Asia-Pacific region.

Wheat : With an annual production of about 76 million tonnes the region accounted for about 14.4 per cent of the world's wheat production. India and Pakistan are the major wheat producing countries in the region wherein the production during the last ten years increased steadily. Bangladesh took to larger scale wheat production about 25 years ago and crossed the one million tonnes mark by the mid 80s. However, its production during the last 10 years remained stagnant and the yields also declined. Nepal, is traditional wheat growing country and its production has also increased steadily whereas Bhutan is a marginal producer and its production has declined over the last ten years.

Maize : South Asia's share in the world maize production is a meagre 2.3 per cent. India, with about 10.5 million tonnes of annual production, accounted for about 80 per cent of the region's maize production and a high yield growth rate of 3.4 per cent. Maize yields in the sub-region are generally low, ranging between 1 to 1.8 tonne per hectare as against 4.3 tonnes per hectare in the world as a whole.

Roots and Tubers : South Asia with a production of over 26 million tonnes of roots and tubers, essentially potato, accounted for about 5 per cent of the world's production and has registered an average yield of about 14.4 tonnes per hectare against about 12 tonnes for the world as a whole. India's share to the regions production was 82 per cent and its yield of 16 tonnes per hectare was one of the highest in the whole of Asia-Pacific.

Pulses : South Asian countries accounted for about 40 per cent of area and 27 per cent of the world's pulses production. More than 87 per cent of the production came from India alone, with

an annual production of about 16 million tonnes. The average yield was only about 600 kg per hectare against 847 kg per hectare at the world level. The yield gains have generally been low, ranging from 0.3 per cent in Bangladesh to 2.1 per cent in Sri Lanka. Pakistan had registered a yield decline of 2.6 per cent per annum during the decade ending 1994.

Oil Crops : In terms of oil equivalent, South Asia accounted for about 11 per cent of the world's vegetable oil production with an annual production of 9.6 million tonnes. India accounted for 90 per cent production and registered a very high growth rate of 6.6 per cent during 1984-94.

Fruits : South Asia produced about 41 million tonnes of fruits (excluding melon), which was about 10 per cent of the world's production. Although from a small base level, Nepal registered the highest growth rate of fruit production of about 13.8 per cent, during 1984-94, followed by 6.6. per cent in Bhutan, India and Pakistan, registered growth rates of about 3 per cent. The production in Bangladesh remained static and it declined in Sri Lanka. Banana, citrus and mangoes were predominant fruits in the region accounting for about 18 per cent, 15 per cent and about 23 per cent of the total fruits production. Of these, citrus and banana registered high growth rates of about 4 to 4.5 per cent during 1984-94.

Vegetables : The South-Asian sub-region, with an annual production of about 73 million tonnes of vegetables, accounted for about 70 per cent of the world's total vegetable production. All the countries witnessed considerable increases in vegetable production, except Sri Lanka, and the rate of growth during the decade ending 1994 ranged from 2.3 per cent in Bangladesh to 8.3 per cent in Nepal.

Industrial Crops

Jute : With an annual production of about 2.3 million tonnes, mainly from India (1.5 million tonnes) and Bangladesh (about 0.8 million tonnes), the South Asian sub-region accounted for about 76 per cent of the world's production of jute and jute like fibres. Area under jute in the two countries has declined considerably, however, the corresponding yield increased steadily.

Cotton : India and Pakistan, with an annual production of 6.9 and 4.1 million tonnes of seed cotton, respectively, together accounted for about 21 per cent of the world's seed cotton production. The production in these two countries during the year 1984-94 increased annually by 5.5 and 3.1 per cent respectively. The average yield of the region was only 1045 kg/ha against 1711 kg/ha for the world as a whole, however, the region's yield during the decade ending 1994 increased at a much faster rate (3.2 per cent against 0.9 per cent). India showed a high growth rate of 4.9 per cent.

Sugarcane : South Asia with an annual production of about 285 million tonnes of sugarcane accounted for about 26 per cent of the world's production. India (231 million tonnes), Pakistan (44 million tonnes) and Bangladesh (7 million tonnes) were the major producers. India's average yield of about 65 tonnes per hectare, the highest in the region, exceeded the average of the world by about 4 tonnes/hectare. The average yield in other South Asian countries was, however, low, ranging from 30 to 45 tonnes per hectare.

Tea : South Asia accounted for about 39 per cent of the world's tea production, India and Sri Lanka with an annual production of over one million tonnes were the highest tea producers in the world. Yields were also fairly high (1.6 tonnes/ha) in India. Of late Bangladesh has increased its tea production to around 50,000 tonnes.

Livestock

With an annual production of only 7.6 million tonnes of total meat, 1.33 million tonnes of poultry meat, and 2.2 million tonnes of hen eggs, the share of the sub-region in the total world production has been rather small, being, 3.0 per cent, 2.0 per cent and 5.5. per cent, respectively. However, the production was rather substantive (16 per cent; over 87 million tonnes). The average rate of growth of the various animal products however, generally far exceeded the corresponding rates of growth at the world level. Total meat production in Pakistan, Bangladesh and India increased annually by 6.3, 3.9 and 3.2 per cent, respectively, as against 2.7 per cent in the world as a whole. Poultry meat production increased at a much faster rate than other animal products and the growth rate in the South Asian countries ranged from 5.8 per cent in Bangladesh to 12.5 per cent in India. India's milk production increased by about 22 million tonnes, registering a high growth rate of 4.7 per cent. In Pakistan, the production increased by about 6.5 million tonnes showing a growth rate of 5.4 per cent. Bangladesh also registered an increased milk production, from 1.3 million tonnes in 1984 to 1.9 million tonnes in 1994, with an annual growth rate of 4 per cent. All countries in the sub-region recorded high growth rates for hen eggs. Bangladesh registering the highest growth rate of 7 per cent, followed by 5.7 per cent in India, 4.9 per cent in Bhutan and 4.2 per cent in Pakistan.

An annual production of about 2.7 million tonnes of inland fisheries was recorded in 1993. This accounted for about 16.5 per cent of the world's production. India (1.84 million tonnes), Bangladesh (0.74 million tonnes) were the major inland fisheries producers. In the recent years, however, the production also picked up in Pakistan and Nepal, registering high annual growth rates of 7.3 to 13.6 per cent, respectively. India also showed a high growth rate of 6.4 per cent whereas a decline of 6.7 per cent per annum was observed in Sri Lanka.

In case of marine fisheries, India produced about 2.5 million tonnes, followed by about 0.5 million tonnes by Pakistan, 0.31 million tonnes by Bangladesh and 0.2 million tonnes by Sri Lanka. This altogether accounted for about 4.0 per cent of the world's production.

Aquaculture production in the region during the recent years neared about 2 million tonnes, increasing at a high annual growth rate of over 12 per cent during the last decade. India (84 per cent) and Bangladesh (14 per cent) together accounted for 98 per cent of the region's aquaculture production, and the two countries had maintained high growth rates of 13.1 and 8.5 per cent, respectively. Although from very small base levels, Sri Lanka and Nepal also increased their acquaculture production at very high rates, 34 and 14 per cent, respectively.

Rice-Wheat System in South Asia

Rice and wheat together account for about 90 per cent of South Asia's total cereal production and are the backbone of the region's food security. A projected growth rate of 3 to 2.5 per cent of production of these crops will be essential to meet the food demands towards the year 2020. During the early part of the 21st century, South Asia's preparedness to meet the food challenges will greatly depend on the growth and production of rice and wheat.

The rice wheat cropping system in South Asia is mainly concentrated in Indo-Gangetic and Brhamaputra flood plains and the foothills of the Himalayas. This system covers about 12 million hectares of the most fertile land of the region; accounts for about 32 per cent of the total rice area and 42 per cent of the total wheat area, which also includes legumes, oil seeds, fodder crops,

vegetables and sugarcane besides the livestock production, which is also intimately linked with this crop production system.

Table 17: Area under rice-wheat cropping systems in South Asia, 1988

	Total rice + wheat area (million ha)	Total rice + wheat production (million t)	Percentage of wheat area located on land where rice is grown (per cent)	Percentage of rice area located on land where wheat is grown (per cent)
Bangladesh	0.50	2.03	85	7
India	9.12	38.58	42	33
Nepal	0.49	1.74	85	34
Pakistan	1.63	6.67	22	80
South Asia	11.74	49.02	42	32

During the Green Revolution period, both yield and area enhanced simultaneously and synergistically under the rice-wheat production systems. However, in recent years growth in area planted to rice and wheat in South Asia slowed down considerably. The production average rice and wheat yields increased at 2.7 and 2.5 per cent, respectively during the decade ending 1994. However, in the recent years a decline was noticed in the rate of growth. Considering that there is negligible scope for area growth, and there is a need to maintain a production growth rate of about 2.5 per cent well into the next century, the future production gains shall have to be achieved mainly from yield increase.

Most of rice-wheat area is irrigated and with the slower rate of extension of growth in irrigated area, there is limited scope for expanding irrigated rice wheat areas. Further, fertilizer application to rice wheat has also increased steadily and the average application of more than 100 kg of NPK per hectare to rice and wheat in the rice-wheat areas is not uncommon. The use of seed of high yielding varieties, is also fast approaching the saturation point.

Table 18: Trends in total factor productivity for rice-wheat cropping systems in Pakistan, 1970-79 and 1980-89

Province	1970-79	1980-89
Punjab (per cent annual growth)	-2.00**	-2.90**
Sind (per cent annual growth)	-0.24	-2.60*

Source: Ali and Velasco (1994).

Note: ** and * indicate significance at the 5 per cent and 1 per cent levels, respectively.

The factor productivity is reported to be on a decline and concerted efforts are needed to find out its reasons. Soil fertility and soil structure are considered among the possible causes. The nutritional balance of the rice-wheat soils has been disturbed, particularly the deficiency of micronutrients is seen. Different types of soil preparations are needed for the two crops; puddling in rice particularly aggravates physical properties of the soil. Poor control on water and increasingly poor quality of irrigation water also have affected productivity. In the intensive cropping districts the water table has receded greatly and problems of salinity and sodicity are not uncommon.

Trade

Trade policies, nature and magnitude of trade have great bearing on food security, economy and direction of research and technology development. In recent years South Asian countries have initiated economic reform programmes, including trade policies and practices intending to expand trade regimes. The countries of South Asia through the South Asian Association for Regional Cooperation (SAARC) have agreed to create an area-wide trading bloc, to be known as the SAARC Preferential Trading Arrangement (SAPTA) like the "single market" of the European Union and the North American Free Trade Agreement.

Table 19: Trends in input, output, and total factor productivity for rice in India, 1971-72 to 1988-89

	Total input	Total output	Total factor productivity
Region			
Eastern	1.81*	2.17*	0.36**
Western	1.74**	0.76	-0.98
Northern	6.03*	6.79*	0.76*
Southern	1.12*	2.97*	1.85*
All India (excluding Western Region):			
1971-80	2.99*	4.30*	1.31*
1981-88	2.13*	3.10*	0.97*
1971-88	2.49*	3.52*	1.03*

Source: Kumar and Rosegrant (1994)

Note: ** and * indicate significance at the 5 per cent and 1 per cent level, respectively. Eastern Region comprises Assam, Bihar, Orissa, West Bengal; Western Region comprises Gujarat, Maharashtra, Madhya Pradesh, Rajasthan; Northern Region comprises Punjab, Haryana, Uttar Pradesh; and Southern Region comprises Andhra Pradesh, Tamil Nadu, Karnataka and Kerala.

The merchandise exports of the countries in the region are concentrated in manufactures, particularly the labour intensive and other light manufactures. Primary commodities export is quite significant particularly for India, Pakistan and Sri Lanka. Imports of agricultural and other primary commodities constituted between one-third and one-half of the imports of Bangladesh and India and one-third of the imports of Pakistan and Sri Lanka. Imports of food are substantial, accounting for 10 per cent of the total imports for India, 15-20 per cent of Pakistan and Sri Lanka and 30 per cent of Bangladesh.

Trade of individual agricultural commodities showed that the South Asia's net import of wheat in 2020 is likely to increase to 21.3 million tonnes from 3.3. million tonnes in 1990, and the bulk of the import will take place in Pakistan (15.5 million tonnes), followed by Bangladesh (4.5 million tonnes). For rice, the net trade will be negligible. For soybeans the projected net import will increase to 4.03 million tonnes, the major net importers being India and Pakistan. The region may become a net importer of 2.2 million tonnes of roots and tubers, 1.03 million tonnes of maize and 0.41 million tonnes of other coarse grains toward the year 2020.

Development plans

An equitable and sustainable development, poverty alleviation and further enhancement in production and productivity are the core elements of national development plans. This requires growth-oriented macro-economic policy framework and structural reforms in agricultural sector. A comprehensive

package of agriculture sector policy reforms consisted of withdrawal of input subsidies, dismantling of expensive public food distribution systems and removal of subsidised credit and protective tariffs as well as other barriers. It also included freeing import restrictions, encouraging private sector participation and investing in infrastructure to promote that efficient operation of market mechanisms. Such reforms are carried out selectively and sequentially giving due consideration to the socio-political realities of the individual countries concerned.

Expenditure on agriculture

Table 20: Central government expenditure on agriculture in South Asian countries (late 1980s)

Country	Agriculture as per cent of GDP	Spending on agriculture as percent of all expenditure
Bangladesh	44.3	12
India	31.7	8
Nepal	58.7	8
Pakistan	26.6	1
Sri Lanka	26.0	8

Source :Gerard J. Gill, 1995

Note : Agriculture here includes forestry, fishing and hunting.

a. State governments in India and provincial governments in Pakistan also spend considerable amount on agriculture, but this figures are not included as they were not available at present.

Domestic expenditure on agriculture by central governments in South Asian countries showed that although the agriculture is much important to South Asia, yet very little is spent on it. Moreover, the relative proportion of the agricultural GDP spent on agricultural research is very low and that too has been declining. This needs to be reversed in light of resource depletion and degradation, together with increased food demand. Scenario in individual countries in the sub-region is discussed below:

India

The process of economic planning began in early 50s with the implementation of the First Five Year Plan (1951-1956) which was formulated against the backdrop of an influx of refugees after the partition of the country, acute food shortages, mounting inflation and the general disequilibrium in the economy as a fallout of the country's partition and the Second World War. Hence the objectives of the First Plan were the rehabilitation of refugees, rapid agricultural development to achieve food self-sufficiency and controlling inflation. A 31 per cent share of agricultural sector was given in the total plan outlay. The share of agricultural sector in the total outlay during the Second Five Year Plan (1956-61) declined to 20 per cent although the total allocation was increased by more than 50 per cent.

The first two plans helped to create an institutional structure required for rapid economic progress and the agriculture was once again given top priority in the Third Five Year Plan (1961-66). Adequate emphasis was also given to the development of basic industries. Two successive years of drought, forced *inter alia* devaluation of the rupee, and other inflationary pressures. The Third Plan was, therefore, followed by three Annual Plans (1966-69). The Fourth Plan (1969-74) projected two basic

objectives; i.e., growth with stability and progressive achievement of self reliance. Agriculture was given due consideration accounting for 24 per cent of the total plan outlay.

The Fifth Five Year Plan (1974-79) also stressed on attainment and removal of poverty of self reliance through a higher rate of growth, better distribution of income and increased rate of domestic savings. Of the total plan allocation, agriculture and industry received 22 and 26 per cent share, respectively.

The Sixth Five Year Plan (1978-83) sought to enlarge the employment potential in agricultural and allied sectors, encourage mass consumer goods producing household and small industries and raise the incomes of the lowest income groups through a minimum needs programme. A mid-term revision presented a new Sixth Plan (1980-85) which aimed at bringing about significant increase in the rate of economic growth through resource use efficiency and enhanced productivity, modernisation of the economy and technological self-reliance, development of indigenous energy, reduction in income inequalities and regional disparities and improving the quality of life, at large, especially of the weaker sections. Although energy, science and technology also received a high priority in the Sixth Plan, yet one-fourth of the total plan resources were allocated to agriculture, irrigation and flood control.

The further plan focus, during the Seventh Five Year Plan was made on food, work and poverty. It also aimed at accelerating the rate of growth in foodgrain production, increasing employment opportunities and raising productivity complemented by expansion in the economy, particularly the agricultural sector. The Plan also sought to ensure the growth in employment opportunities production of foodgrains, edible oils, sugar, textiles, cooking fuel and other items of mass consumption. The proposed outlay on agriculture was around 22 per cent of the total outlay in this plan and the agricultural sector was estimated to grow at the rate of 4 per cent during this plan.

The Eighth Five Year Plan (1992-97), formulated in an economic environment of growing fiscal deficits, depleting foreign exchange resources and an adverse balance of payments (BOP) position, high rate of inflation and industrial recession, attempted to affect a turn-around in the economy and also tackle the persisting socio-economic problems of poverty, hunger, illiteracy and unemployment. Growth and diversification of agriculture was sought to achieve self sufficiency in food and generate surplus for exports, besides strengthening of infrastructure (energy, transport, communications, and irrigation) in order to support the growth process on a sustainable basis.

The agricultural sector has received priority in almost all the Five Year Plans of the country as it is recognised that the economic and social development of the country rests on the development of this sector. The outlay on agriculture, rural development and irrigation went up from a mere 600 crore rupees in the First Five Year Plan to 93,680 crore rupees in the Eighth Plan although the share of agriculture in total outlay was the maximum in the First Plan (31 %) which declined in the subsequent plans, ranging from 20 to 25 %.

Agricultural production over the different plan periods increased considerably, making the country self-sufficient in foodgrains production. During the early years, the increases in production were realised from expansions in crop areas whereas after 1960-61, increased productivity complemented by increases in supply of essential inputs were the main factors responsible for enhanced production. Creation of infrastructure to expand the markets for agricultural products, irrigation development,

soil conservation, dry farming, land reclamation, increased inputs supply and the promotion of scientific agricultural practices, institutional reforms also contributed substantially to achieve the same.

Table 21: Pattern of government outlay on agriculture in the plans

(Rupees Crores)

Plan	Total plan outlay	Outlay on agriculture & irrigation	Share of& agriculture in Total
First Plan (1951-56)	1960	600	31
Second Plan (1956-61)	4600	950	20
Third Plan (1961-66)	8600	1750	21
Fourth Plan (1969-74)	15780	3670	23
Fifth Plan (1974-78)	39430	8740	22
Sixth Plan (1980-85)	109290	26130	25
Seventh Plan (1985-90)	218730	48100	22
Eighth Plan (1992-97)	434100	93680	22

Source : GOI, Five Year Plans (various issues)

Note : Figures for all plans except for the Eighth Plan are actuals. The Eighth Plan figures are projected outlays.

Table 22: Required yield (kg/ha) target by crops at the end of Ninth and Tenth Five Year Plan in India

Items	Achieved	Required yield level	
	TE 1994-95	2001-2	2006-7
Rice	1851	2229	2454
Wheat	2420	2885	3213
Coarse cereals	979	1062	1121
Jowar	888	989	989
Bajra	688	712	712
Maize	1590	1863	2157
Pulses	593	839	968
Gram	774	1087	1256
Arhar	688	962	1108
Oilseeds	815	1104	1646
Groundnut	1007	1228	1471
Rapeseed & Mustard	849	1005	1209
Soybean	963	928	1111
Cotton	255	343	415
Sugarcane	67354	80054	95094
Vegetables	17915	17727	20966
Fruits	10281	16781	22031

The outlay of the Indian Council of Agricultural Research (ICAR) which is the nodal organisation of Indian NARS increased around fourteen times between the Fourth and Eighth Plans, and from 3.9 per cent in the Fourth Plan to 5.8 per cent in the Eighth Plan.

The technological advances made during the VIII Plan helped achieve the agricultural production targets in the country. More than 550 high-yielding varieties of different crops were developed. Also, a number of improved breeds of cattle and poultry, such as, Frieswal and CARI-GOLD were evolved. In fisheries sector, all round development continued with a compound growth rate of more than 10 per cent in inland fisheries production. In farm implements and machinery, a number of improved prototypes were developed which have gone into commercial production.

Future increases in the production of food and non-food agricultural commodities have to be essentially achieved through increases in productivity as possibilities of area expansion are minimal. A 2-3 per cent growth rate is envisaged for most of the food crop commodities whereas a higher growth rate of 5-6 per cent is required in oilseeds, fruits and livestock products. It is important to prioritize plan allocation of individual crop commodities in their respective priority states.

Table 23: Per cent targeted annual growth in yield/production to attain self sufficiency in food during the Ninth and Tenth Five Year Plans

Item	Growth achieved			Target growth	
	1980-90	1990-94	1980-94	2001-2	2006-7
Crops					
Rice	3.70	1.79	3.06	2.35	2.19
Wheat	3.28	2.23	2.93	2.22	2.20
Coarse cereals	2.52	2.71	2.58	1.01	1.04
Jowar	2.08	2.89	2.35	1.36	0.83
Bajra	2.08	1.47	1.94	0.43	0.26
Maize	3.70	1.23	2.42	2.00	2.37
Pulses	2.01	0.83	1.46	4.45	3.86
Gram	0.97	2.36	1.44	4.34	3.79
Arhar	0.64	-1.58	-0.61	4.28	3.73
Oilseeds	3.58	1.19	2.33	3.88	5.56
Groundnut	2.67	0.80	2.04	2.51	2.96
Rapeseed & Mustard	5.91	-0.69	3.50	2.13	2.76
Soybean	3.57	1.77	2.60	-0.46	1.11
Sugarcane	1.40	1.30	1.36	3.07	3.20
Cotton	4.58	3.08	4.10	3.78	3.82
Vegetables	na	na	na	3.53	3.20
Fruits	na	na	na	6.04	6.04
Livestock products					
Milk	5.31	4.26	4.95	5.54	5.37
Fish	5.56	4.27	5.96	6.25	5.98
Meet & eggs	8.55	4.55	6.90	5.54	4.95

na: not available

Table 24: Policy scenarios

Commodities	Target growth per cent	Priority States	Percent share of priority States in total crop area
Rice	2.35	BH, OR, AS, WB, UP	66
Wheat	2.22	UP, MP, BH, RJ	68
Jowar	1.36	MH, KN, MP, AP	82
Bajra	0.43	RJ	47
Maize	2.00	BH, UP, MP, RJ	60
Gram	4.34	MP, RJ, UP, MH	83
Arhar	4.28	MH, GJ, KN, AP, MP	72
Groundnut	2.51	AP, GJ, KN, MH	76
Rapeseed & Mustard	2.13	RJ, UP, MP,WB	74
Soyabean	1.11	MP, RJ	83
Cotton	3.78	MH,GJ,KN,RJ,AP	74
Sugarcane	3.07	UP	51

AP: Andhra Pradesh, AS: Assam, BH: Bihar, GJ: Gujrat, HP: Himachal Pradesh, KN: Karnataka, MP: Madhya Pradesh, MH: Maharashtra, OR: Orissa, RJ: Rajasthan, UP: Uttar Pradesh, WB: West Bengal.

Bangladesh

Bangladesh was among the poorest countries in the world with estimated per capita GNP of US $225 in 1992. It is densely populated. The economic policy reforms, human resource development and poverty alleviation remained top priorities in the country. Over the years, floods, droughts and cyclones have hampered the efforts to stimulate growth and reduce poverty. Despite all these, Bangladesh made significant economic progress over the past decade and initiated a number of structural reforms in the industrial and financial sectors, public enterprise and trade. Trade policy shifted from import substitution to export promotion. Agricultural sector was the largest source of income, employment, savings and investment. Agriculture accounted for about 40 percent of GDP and more than 60 percent of employment. Rice dominated all other agricultural products, and economic activities. Production, trade, processing and transportation of rice amounted to more than 25 percent of the country's GDP. It represented 75 percent of the cropped area, 95 percent of foodgrain production, about 80 percent of calorie intake, 60 percent of protein intake and about 30 percent of total household expenditure. Agricultural policies and projects have expanded the use of high-yielding variety rice seeds, fertilisers and shallow tube wells for irrigation. As a result, overall economy improved and rice production increased by more than 40 percent in the past one decade. In addition to rice, the fisheries sector contributed significantly to the country's social and economic development.

Bangladesh is a predominantly agrarian economy and the agricultural sector continues to be a major focal point for programmes of income and employment generation, poverty alleviation, human resource development and food security. Agricultural development strategies during the Third Five Year Plan sought to promote HYV technology and expand rain-fed crop development and appropriate crop diversification. Although sizeable gains have been realised in grains production, population growth has adversely affected self-sufficiency. Being essentially an agrarian economy, Bangladesh must necessarily adopt an agriculture-led development strategy. However, growth in the

agricultural sector during the Third Five Year Plan remained below the targeted rate. Production targets for both rice and wheat could not be achieved, mainly on account of the shortfalls in achieving both area and yield targets. Diffusion of HYV technology has been slow as there appears to be a decline in the profitability of cereals including irrigated rice though they are still more profitable than non-cereal crops. Natural factors, like floods, also contributed to the low rate of growth of agriculture.

The Fourth Five Year Plan of Bangladesh sought to achieve technological transformation in the agricultural sector and self-sufficiency in food grains leading to an improvement in nutritional status and food security for the rapidly growing population. Its main objectives were to, (a) attain self-sufficiency in food along with increased production of other nutritional crops (b) ensure sustained agricultural growth through more efficient and balanced utilization of country's land, water and other natural resources, (c) promote rapid and appropriate technological transformation, (d) diversify agricultural production especially along nutritional lines, (e) contribute to increased foreign exchange earnings through agricultural exports, (f) contain areas under cereals (especially rice) within limits of soil and ecological balance in order to progressively release land for other crops, especially legumes and fodder crops, and achieve cereal production targets through increases in per hectare output (g) reduce rural poverty and promote income equality over socio-economic groups/regions, and (h) promote economic and employment opportunities and access to resources such as credit for landless and small farmers and other disadvantaged groups especially in backward regions.

Bhutan

This small, mountain kingdom is a country of rural communities with very few urban centres. On account of the significant differences in altitude, rainfall and topography, Bhutan offers diverse agro-climatic conditions.

Agriculture is the mainstay of the people with integrated farming, including arable agriculture, animal husbandry and forest production. This sector, mainly constitutes the Renewable Natural Resource Sector of Bhutan, provides livelihood for 90 per cent of the population. This accounts for nearly half of the GDP. Between 1985 and 1991, the output of this sector is estimated to have grown at the rate of 3.4 per cent. Development of the agricultural sector faces many problems on account of the remoteness and isolation of the agricultural holdings besides their very small average size and alienation of rural economy from the monetary economy with around 90 per cent of the production being locally consumed. Only a small area is estimated to be farmed, ranging between 3 to 16 per cent due to arable agriculture being highly dependent on rain. The spread of irrigation, mechanisation and high yielding varieties and the associated improved cultivation practices has been slow. The major foodgrain crops are maize and rice, accounting for 55 and 33 per cent of foodgrains production. Oranges, cardamoms, apples and potatoes are grown for exports. Bhutan has a comparative advantage in horticulture and the horticultural commodities provide significant export earnings to the country.

The broad objectives of Bhutan's Sixth Year Plan (1988-92) were, promotion of national self-identity and economic self-reliance, human development and improvements in rural condition. In the agricultural sector, the objectives of the Sixth Plan were (i) to improve self-sufficiency in staple food, (ii) improve the per capita income of rural people, (iii) enhance productivity and output and (iv) conserve soil and water. The Seventh Five Year Plan (1993-97) aimed to pursue the same broad objectives and goals as the Sixth Five Year Plan, alongwith an increased emphasis on education and training. The Seventh Plan envisages to promote, i) sustainable agriculture, through the protection

of soil fertility, in order to improve rural incomes, living and nutritional standards and also improve food security through increased production of staples and horticultural crops in which the country has a strong comparative advantage, ii) an attempt to integrate agriculture, forestry and livestock in the regional development programmes.

Nepal

Nepal's economic performance during the past three decades has not been very encouraging. Gross domestic product has grown at a slow pace. Population has grown rapidly and this has resulted in only marginal increases in per capita income. A large number of people have been pushed below the poverty line on account of growing disparities in income. Population growth has been higher than the growth in food production leading to a decline in per capita availability of food grains.

Agriculture is the main occupation of the people with nearly 90 per cent of the labour force engaged in it . This sector accounts for around 60 per cent of the GDP. Productivity in agriculture has been low and the whatever low growth has been achieved in food production has come from area expansion. An important reason for this state is the dependence of agriculture on rainfall.

Improving the socio-economic conditions of the people through reduction in economic stagnation and poverty, structural distortions, environmental degradation and population growth, is the broad policy being pursued by Nepal. The main objectives of its Eighth Five Year Plan (1992-97) are:

(i) Achieving a higher sustainable rate of economic growth through increased productivity in all fields, greater community efforts and participation of private sector, increased labour productivity, infusion of improved technology, adoption of institutional innovations and reduction in population growth.

(ii) Alleviation of poverty through the creation of productive employment opportunities and expansion of social services like health and education, vocational training and other target oriented programmes.

(iii) Rural development and regional balance through the provision of services, development of infrastructure and proper exploitation of agricultural and industrial advantage of different regions.

Pakistan

Agriculture continues to be a major sector in Pakistan with around 50 per cent of the population being dependent upon it for livelihood. The share of agriculture in GDP has, however, declined in the past few years on account of significant developments in industry and infrastructure, and it is currently around 23 per cent. This sector also provides around 70 per cent of the country's exports earnings. Over the past two decades, agricultural production has increased at an average rate of 3.3 per cent. The Sixth Five Year Plan had targeted the agricultural sector to grow at 4.9 per cent but the rate achieved was only 3.8 per cent. Nevertheless, Pakistan achieved self-sufficiency in foodgrains although the desired diversification towards high value crops and non-traditional oilseeds registered only modest increase.

The objectives of the Seventh Five Year Plan were based on recommendations made by the National Commission on Agriculture which proposed broad-ranging measures to consolidate the gains achieved and further improve the agricultural sector. A growth rate of 4.7 per cent was set for the agricultural sector during the Plan. The objectives have been framed keeping in view the need

to increase and sustain growth rates and generate additional employment opportunities in view of the rapidly growing population. The specific objectives were,

i) the acceleration of the modernization of the agricultural sector to achieve a growth rate substantially higher than that of the population so that the sector can generate resources for sustained development of the economy with a high degree of self-reliance,

ii) increased agricultural productivity mainly by vertical expansion to effectively override the constraint on area expansion imposed by the limited available irrigation water supplies,

iii) consolidation of self-sufficiency in sugar production and reduced dependence on edible oil imports,

iv) diversification of agricultural production and rural employment opportunities, giving more attention to high-value products like fruits, vegetables, oilseeds, meat, milk and poultry and increase their share in GDP,

v) strengthen institutional support and provide incentives to generate export surplus by encouraging crop specialization in areas which have a comparative cost advantage.

vi) improve the support price system and the market mechanism in order to make the system responsive to the needs of small farmers with the ultimate objective of increasing their earning,

vii) bring about a major transformation in the productivity of the livestock sector to meet the growing demand for milk and meat and to contribute to the well being of the less developed areas,

viii) develop policy framework to solve fodder and feed deficiencies and improve the genetic make up of livestock,

ix) evolve programme for integrated development of rainfed riverine and mountainous areas as a part of a long-term programme to arrest environmental degradation and conserve the country's forest, land and water resources.

Sri Lanka

Sri Lanka endured progressive social welfare policies, viz., food subsidy, an entirely free education system and free universal health care. The country ranked high among both developed and developing countries in terms of wide range of human development indicators. However, the performance in economic growth was not as bright. The country's inability to generate budget and trade surplus limited the public and private savings, resulting in a low rate of investment. Over the time, high unemployment, high inflation, balance of payments deficits and economic stagnation made it more and more difficult for successive governments to pay for the country's food, health and education programmes. In 1970s, import-substitution policies were pursued which also failed to generate enough growth in income and employment. In 1977, some fundamental changes were introduced to the country's economic policy and economic development strategy, shifting from an inward-looking, state controlled economy to an export and market oriented system. The economy responded impressively to this new policy environment for nearly a decade. The GDP, which was less than 3 per cent per year between 1970 and 1977, grew to more than 6 percent on an average between 1978 and 1986. This growth was also balanced, wherein agriculture, industry, services and international trade, performed well.

The economy was, however, unable to build on or sustain the momentum, with the result that slow economic growth, high unemployment and poor agricultural sector performance recurred during the late 1980s. The economy faltered for a number of reasons, such as, the diverted public resources and discouraged foreign investment, bad weather, including periodic droughts which hampered

agricultural production and exports. The stabilisation policies, aimed at containing the fiscal deficit and controlling inflation, suppressed demand and slowed economic growth. Also, the policy-makers remained focused on key macro-economic aggregates whereby the important sectoral reforms were neglected. Since 1989, the government has focused much attention on sectoral reforms, for taxation, tariff, public administration, public sector enterprises, the banking system, private sector management of tea estates and agricultural diversification. The agricultural sector, in particular, has undergone noteworthy changes. In the last several years, the economy has grown at a relatively strong pace.

In the five year period preceding 1990, the performance of Sri Lankan economy was not very encouraging with three successive bad years retarding the growth of the economy. In 1990, there was an increase in both agricultural and industrial production along with improvement in external trade and balance of payments position. In 1994, a 5.4 per cent growth in GDP was achieved. Share of agriculture in GDP is very high. Sri Lanka is a net exporter of agricultural products; the agricultural exports constitute around 22 per cent of total exports.

Important policy reorientation in the sector included measures taken to open seed multiplication and distribution to the private sector, government sponsored farmer organizations given the legal instruments to conduct their affairs more independently, reforms in the Agrarian Services Act enabling wider crop choices in lands where, by law, only paddy cultivation was permitted. Several government agencies performing commercial operations were divested. Other institutional reforms aimed at scaling down government involvement.

Incipient export markets for many varieties of vegetables, which were primarily grown for domestic consumption, have been developed thereby increasing export volumes, although still small. Some crops, such as gherkins, have been introduced exclusively for export with considerable success.

Preparedness in agricultural research

During the last 25 years the South Asian countries have taken important policy decisions to strengthen their agricultural research systems. An important feature has been the establishment of autonomous Research Councils with primary responsibility for research policy, planning and coordination. This initiative has been fairly successful in organizing research, generating appropriate technologies and transferring the technologies to the farmers. Another important feature has been the establishment of collaborative linkages between the National Agricultural Research Systems (NARS) and the International Agricultural Research Systems (IARC), like ICRISAT, CIMMYT, IRRI and others, and large scale adaptation of IARC technologies in different countries of the region. The composition and management styles of different NARS in the region differ as briefly summarized below:

India : The Agricultural Research Management System in India is one of the largest, and of its kind, in the world. About 95 per cent of the total funding support to the system comes from within the country, 60 per cent of the funds coming from the Federal Government. The Indian Council of Agricultural Research (ICAR) is the apex research organization in the country and has enormous powers as a semi-autonomous body not only to plan and coordinate research nationally but also as the main funding and executing agency for research. It functions through its National Research Institutes, National Research Centres, Project Directorates, Bureaus, All India Coordinated Research Projects besides State Agricultural Universities. Apart from the isolated single crop and commodity approach for tackling crop and commodity oriented research programmes, the Council has, in the recent years increased its emphasis on system-based approach and programme-based research. It is a "managing" kind of Council performing a variety of functions including determination of research

policy and priorities, linking them with government's development objectives, establishing and managing a large network of research institutes and centres and coordinating research in the federal and state institutions. The Director-General of the Council is also Secretary of the Department of Agricultural Research and Education in the Ministry of Agriculture and reports directly to the Minister. This arrangement has ensured effective linkage among policy, planning, priority setting, development and other concerned ministries and programmes.

Pakistan : The mandate of its apex research organization, the Pakistan Agricultural Research Council (PARC) is to undertake, aid, promote and coordinate agricultural research, arrange the expeditious utilization of research results; establish new research institutions as needed; promote development of scientific manpower; maintain a reference and research library; and to generate, acquire and disseminate information relating to agriculture. PARC as an agricultural research system in the country is, however, not fully integrated and does not function as the main funding and executing agency for the country. All federal research institutions are also not under the direct administrative control of PARC. The provinces continue to have independent research infrastructure of their own, funded largely from their respective resources. However, an independent Research Coordinating Board has been established to improve the planning, coordination and funding of research in the provinces.

Bangladesh : The Government of Bangladesh, established ten major research institutes in the seventies which constitute the core of the national agricultural research. These include the Bangladesh Agricultural Research Institute, the Bangladesh Rice Research Institute, the Bangladesh Jute Research Institute, the Bangladesh Livestock Research Insfitute, etc. Of these ten institutes, eight were established as autonomous institutions each headed by a Director-General who reports directly to the concerned Ministry. In addition of these Institutes, agricultural research in Bangladesh is carried out by a number of universities. In order to integrate the activities of the various institutes, as in some other South Asian countries, the Government of Bangladesh has created the Bangladesh Research Council (BARC) as an apex organization. The BARC's specific role is strategic planning, priority setting, monitoring, evaluation and the overall coordination of agricultural research in the country. It may be emphasized that BARC has no role in the direct management or execution of research programmes as it does not have any formal administrative or institutional links with different research institutes. BARC reports to the Ministry of Agriculture through Permanent Secretary of Agriculture.

Sri Lanka : Sri Lanka's agricultural research system is characterized by a series of commodity research institutes which function in a multi-disciplinary manner, are generally well funded and managed and are organized as autonomous bodies. These have their own Board of Governors who advise the Director and the senior staff. The funding comes in the form of cess levied by the Government on exports. The Department of Agriculture also has its own research division and research centres on specific food and other agricultural crops. Recognizing the need of coordination among the various agricultural research establishments in the country, in the late 1980s the Government of Sri Lanka established a Council of Research Policy with the major objective of coordinating the work of different organizations. The Council has developed national research plan and evolved policy guidelines for the concerned ministries and agencies and is advising the Government on the development of further infrastructural and resource requirements to meet the national research goals in an integrated manner. The Director-General of the Council is of the status of a Permanent Secretary and the Secretaries of all the concerned ministries sit on its Board.

Sri Lanka's economy relies mainly on four crops - tea, rubber, coconut and rice. Tea remains the dominant agricultural export. Rice is grown in small farm sector on 40 percent of the agricultural land. Before the 1977 reforms, rice production and distribution were strictly regulated by the government.

The improved markets and increased real producer prices had positive impact on rice production, which grew at a rate of well over 10 percent per year between 1977 and 1980. From 1978 to 1986, rice production rose from 1.7 million to 2.7 million tonnes and its productivity from 2500 to 3500 kg per hectare. This was an important accomplishment for Sri Lanka's economy because the country imported from 40 to 50 percent of its total rice consumption during the 1960s and most of the 1970s. From 1970 to 1977, the country's rice imports averaged 0.4 million tonnes per year, then fell to 0.15 million tonnes between 1978 and 1985. By the mid 1980s, the country had attained more than 90 percent self-sufficiency in rice. The estate sector has also undergone significant structural changes over the past two decades. For instance, tea no longer accounts for 80 percent of total exports as it did in the early 1970s. Textiles have overtaken tea as the island's principal export, accounting for some 40 percent of total export earnings. The primary export crops (tea, rubber and coconut) have dropped to below 30 percent of total export earnings. The privatization of plantation management, combined with substantial investment in rehabilitating estates and new planting in recent years, is likely to improve short-term agricultural prospects. Agricultural sector has a limited capacity to absorb labour and all of the agricultural land has already been developed. Without access to more jobs in agro-industrial and agro-processing enterprises, Sri Lanka's rural population may be forced on to economically marginal and environmentally fragile lands.

Nepal : During the last 10 years Nepal has succeeded in establishing an effective Nepal Agricultural Research Council (NARC) which is controlled by an Executive Board and has a mandate to define the research policy, determining national priorities, allocating resources and evaluating research results. The Minister of Agriculture is the Chairman of the Executive Board of the Council and the Executive Director of the Council is the Member-Secretary of the Board. The Council is currently busy in establishing a number of national agricultural research institutes in different fields of agriculture and has established a National Agricultural Research Institute and a National Animal Sciences Institute. The Council collaborates with other concerned institutions such as the Tribhuvan Agricultural University and the Institute of Forestry.

Bhutan : In the recent years, with the establishment of the Research Extension and Irrigation (REID) in the Department of Research, Technology Transfer and Training under the Ministry of Agriculture, the country aims to bring together scientists from all the concerned departments including agriculture, animal husbandry and forestry and integrate them with the extension services. REID is headed by the Director-General and is organized into three sections: Research, Extension and Irrigation. Bhutan is organizing its research programmes not along disciplinary or commodity lines, as common in many countries, but along production systems. Three major production systems have been identified based on land use patterns: dry and wetland plantations; pastoral forest-based; and shifting cultivation. This effort of Bhutan is innovative and exemplary as a way of organizing a small and need based national research system.

AGRICULTURAL RESEARCH PRIORITIES

Research in the sub-region has been effective; the technologies generated and adapted have been instrumental in achieving impressive growth in agricultural production. However, a good number of the technologies were observed to be sitting on shelves and there were serious technology transmission gaps. Sometimes the research priorities have been misplaced; the countries generally lacked systematic priority setting mechanisms.

Generally, research priorities at national levels in most of the Asian countries were set based on informed judgement, experience, national and regional goals, international scenarios, actual and apparent opportunities, existing capabilities, and, above all, people's aspiration and expectations. Formal methods of priority setting, have usually not been followed, although lately they are being used increasingly. Of the various methods, the scoring approach has been most commonly used, like in other sub-regions.

Bangladesh

Based on scoring and economic surplus analysis, research priority ranking were provided by commodity and by research problem area. Priority setting in Bangladesh has taken into account the multiple research objectives, viz., improved agricultural productivity, efficiency, providing employment, improved nutrition, conservation and increasing sustainability. These objectives were used to derive commodity priority rankings. A second set of criteria incorporated included to derive priorities for research problem areas, the number and severity of research problems, the effect of research on the farmers need for capital, complementarily with research which can be borrowed from other countries, current manpower emphasis in research, research cost, effect of research on the quality of natural resource environment, and the effect of research on annual variability of production.

Priorities by research problem areas for each of the major commodity groups are worked out. Plant breeding and genetics, pest management, production practices, and soil science receive a high ranking for many of the commodity groups (e.g. oilseeds and other cereals). For a couple of commodities (e.g., tea and forestry) post-harvest technologies are important. Water control and socio-economy tend to be of intermediate importance for many commodities. For livestock and fisheries, animal health, nutrition, and management tend to be the most important research areas. Animal breeding and genetics and post harvest technologies come lower on the list. Among the high priority commodities, rice is number one ranked commodity, followed by freshwater fish, potato, sugarcane, eggs, meat, jute, sweet potato, milk, wheat, wood products, mustard and rape seed. Among the medium priority commodities, banana is at the top followed by cattle and buffalo, brackish water fish, lentil, riverine fish, bamboo, brinjal, tea, onion, tomato, chilli, marine fish, turmeric, cotton, groundnut gram and radish. The other commodities, viz., cucurbits, garlic, maize, cauliflower and cabbage, tobacco, other fruits and vegetables and coarse cereals fall under low priority commodities.

Bhutan

Bhutan has a comparative advantage in horticulture and horticultural commodities. Agriculture is the mainstay of the people with integrated farming, including arable agriculture, animal husbandry and forest production. The major foodgrain crops are maize and rice whereas oranges, cardamoms, apples and potatoes are grown for exports.

The research and extension efforts include strategies of regional development programmes, with focus on: a) Cropping patterns, pest management and essential oil production, b) Integrated soil fertility management through the promotion of suitable agricultural practises compatible with the continued use of land for arable agriculture, livestock, perennial crops and forestry and proper soil conservation and watershed management practises, c) improved productivity of cash crops, d) improvement in input supplies, e) improvement in livestock breeds and artificial insemination to improve productivity of cattle in contrast with an increase in cattle population which causes forest degradation through over grazing, f) Provision of animal health services, g) Agro-forestry and community forest development with a high priority on conservation than on commercial exploitation. Only 40 per

cent of the forest area has been legally earmarked for the latter, h) Development of human resources by providing much needed training to agricultural and forestry staff and developing qualified agronomists, foresters and extension workers, and i) Expansion of mechanization in the agricultural sector.

India

Using the scoring approach, relative research priorities were worked out in terms of regions and individual commodities. Value of output (VOP) shares, concerns of poverty alleviation, sustainability, and export orientation were considered in determining such priorities. The regional research resource allocation indicated in favour of some readjustments in VOP-based allocations. The eastern region comprising the states of Assam, Bihar, Orissa and other North-Eastern states, required about 4 percent (Rs. 520 million) higher research resources as compared to the VOP-based allocation. The predominantly dryland states of Andhra Pradesh, Madhya Pradesh and Karnataka also needed adjustment of a similar magnitude. The northern states of Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir and the states of Gujarat, Kerala and Goa could spare some of their additional resources.

The commodity-based priority setting indicates that 25.6 percent of research resources should go to cereals, 22.7 percent to livestock, 13 percent to fruits and vegetables and about 10 percent to oilseeds. Fisheries, plantation crops and pulses would require 7-8 per cent each. In terms of shift between efficiency and a comprehensive goals structure, namely, equity, sustainability, and export orientation, cereals and sugarcane need to forego some resources so as to provide additional research support to pulses, fibers, oilseeds, fruits and vegetables; spices and agro-forestry. Trade liberalisation has to be accorded a high consideration in determining the commodity-based priorities. Priority for growth oriented research in agriculture will continue with greater emphasis on diversification of agriculture to include livestock, fisheries, horticulture and agro-forestry. In the light of available irrigation potential, rainfed farming research needed a high priority. In addition to these, major focus of research included natural resources, management i.e., of land, water, climate, flora and fauna management. Since agricultural development can not subsist on a deteriorating natural resource base, it is imperative to develop strategies for conservation and improvement of resources.

Priorities related to crop improvement included, exploration of under-explored and unexplored regions of genetic diversity for collection, ex-situ/in-situ conservation, characterization and evaluation of plant genetic resources, consolidation of the harvestable component of the potential yield in currently available high-yielding varieties of major food, non-food and horticultural, including the medicinal and aromatic plants, crops under irrigation ecology by insulating them with desired level of resistance to biotic and abiotic stresses, Acceleration of breeding research for improvement of rainfed crops for higher yield, adaptability to varied water regimes and cropping systems, with special emphasis on lowland rice, coarse cereals, cotton, pulses, oilseeds, fruits and vegetables, intensification of research towards development of commercially viable hybrid technology for new yield thresholds in prospective non-traditional crops and harsh ecologies, tailoring varieties and hybrids of ideal maturity and plant frame for crop intensification and diversification, development of value-added crop varieties for domestic and export markets, development and application of molecular techniques/tools in crop breeding, with emphasis on engineering of crop-plants with novel genes for improvement of productivity, stability and quality, and development and standardization of selected species, strategic research on manipulation of photosynthetic system, effect and mitigation of climatic changes, apomixis in crop improvement and monitoring of variation in strains of pests and pathogens; advanced research on major diseases, such as, viruses in vegetables and pulses, rust, leaf blight and Karnal Bunt in wheat, blast and blight

in rice, malformation in mango, guava wilt, citrus decline and *'Phytophthora'* diseases in fruits, production and supply of nucleus-breeder seed with added emphasis on hybrid crops, and protected cultivation particularly of flowers and other horticultural crops oriented towards export.

Priorities related to natural resources included inventorization, characterization, evaluation and conservation of biophysical resources (soil, water, climate, flora and fauna) in different agro-ecological regimes, evolving technologies for resource conservation and harnessing area-specific advantages of high-rainfall, rainfed areas, problem areas (flood-prone areas, acid soils and degraded lands) and fragile ecosystems (mountainous, coastal and island ecosystems), development of sustainable land-utilization systems in farming-system frame using modern tools and techniques for different agro-ecological regions/sub-regions/zones, considering not only biophysical aspects but also socio-economic aspects, eco-regional water management planning for efficient use of water from various sources and of varying quality, micro-irrigation systems for efficient water and nutrient use, integrated nutrient management system (INMS) with a focus on the use of organics, assessment of environmental consequences as related to resource management and amelioration of negative impacts, remote sensing, GIS and crop and resource modelling for sustainable natural resource management and diversification with a special reference to rainfed dryland agriculture, farm mechanisation and energy related technologies for management of natural resources and development of rural enterprises; design and development of equipment for handling pre- and post-harvest operations for selected commodities with special focus on efficiency and comfort of women farmers, hill agriculture and dryland agriculture, establishment of prototype production centres in different regions of the country and establishment of national networks on mechanisation of selected agricultural production systems, strengthening basic research in ecological and environmental sciences for sustainable management of water, soil, and ecosystems and development of integrated pest management system (IPM) with emphasis on resistant/tolerant varieties, biocontrol agents and biopesticides.

The priorities related to livestock sector enlist the animal genetic resource conservation and improvement with emphasis on creating and maintaining data bank of the breed characteristics; identifying, evaluating, and characterising draught breeds of livestock; evolving modalities for *in-situ* and *ex-situ* conservation specially of rare and endangered breeds; and molecular tagging and cloning of important genes of utility, superior germ-plasm production for agro zones through embryo transplant and other biotechnological manipulations with focus on production of superior males for livestock using embryo transfer, non-conventional feed resources for increased nutrient availability including screening and identification of new agro-industrial byproducts, improving quality of poor quality feed resource with various treatments; identification and quantification of anti-nutritional factors and biotechnological interventions for improvement of nutrient utility value of feed resources, diagnostic and vaccine production for prevalent and emerging diseases with focus on efficiency and diagnostic methodologies and vaccines; development and evaluation of newer generation of diagnostics and vaccines using molecular approaches and biotechnology under field conditions; development of synthetic vaccines and their testing; and creation of comprehensive data base on animal diseases and their management including development of forecasting models, and meat processing for value addition with focus on export market, introduction of quality standards and modernisation of small and large scale meat industries.

In the fisheries sector, priorities be accorded to technologies for semi-intensive and intensive aquaculture in fresh water and brackish water ecosystems which are sustainable environmentally, socially and economically, research support through studies on nutrition, reproduction, disease control

and broodstock management with innovative biotechnology, development of suitable mariculture and sea-ranching technologies, development of value-added products from low value fishes and improved packaging techniques with use of biotechnology, microbiology and engineering, conservation, management and cataloguing of fish germplasm resources and establishment of gene bank, investigations on biological response to ecological changes in selected river systems, estuaries and wetlands, and development of innovative techniques such as cage culture, penculture, running water aquaculture, integrated farming systems with recycling of organic wastes for sustainable fish farming.

The socio-economics and technology transfer research priorities may be accorded on, policy research for sustainable agriculture and poverty alleviation, impact assessment, priority setting and resource allocation with special reference to food security, environmental accounting and evaluation of agro-biodiversity, international trade, socio-cultural organization and gender aspects, socio-economic and cultural constraints to adoption of technology, participatory technology generation and development, rural entrepreneurship development, and participatory appraisal, inter-sectoral micro planning.

The human resource development priorities included the creation of new training and laboratory infrastructure; fostering greater interaction of agricultural scientists in India with those in the developed countries; reform in the recruitment and examination procedures to overcome problem in inbreeding in the ICAR Institutes and SAUs; development of lead centres for providing regional and national-level training in selected disciplines; and redefining the mandate of ICAR Institutes to organise degree and non-degree training programmes for the scientists of the SAUs, creation of a cell in the Education Division of the ICAR to take up statutory responsibility for assisting SAUs in the improvement of their courses, examination systems and monitoring their progress in this regard. The ICAR will perform the same supporting and monitoring function for the SAUs which the UGC does for general universities, and ensuring greater inflow of graduates for teaching courses of the ICAR Institutes and SAUs to provide the leadership for the more modern technologies based on basic sciences; fostering closer collaboration between scientists of the SAUs and the ICAR Institutes with the scientists of the country's major universities through joint research programmes and other forms of collaboration; and establishing a National Library and Networking between the SAUs and the ICAR Institutes.

Nepal

The priority setting in agriculture in Nepal has been guided by three principal objectives, namely, sustainable economic growth, poverty alleviation and a reduction in regional imbalance. Agriculture perspective plan (APP) of Nepal proposes limited number of priorities. In the past, too many priorities depending upon donors interest and the populist slogans have resulted in several small scale projects, with little impact. The available resources were scattered and failed to show any significant impact in agricultural productivity or overall economic growth in the country. The APP, therefore, concentrated on only a small number of priorities, charted on the proven experience of the successful strategies followed in the fast growth economics of the countries in south and south-east region: Taiwan, Thailand Indonesia, Malaysia and (Punjab and Himachal Pradesh states of) India. The priorities identified have been as follows:

Priority Inputs : Irrigation, fertiliser, technology, roads and power.

Priority outputs : Livestock, high-value crops, agribusiness and forestry.

Public Policy : To encourage an efficient, competitive private sector; public investment in priority inputs; macro economic policies-price and exchange rate and the land tenure, viz., reforms with a provision of land consolidation.

Key Institutions : The implementation/coordinating shall be spearheaded by the National support committee with independent analytical unit and district-level sub-committee for APP implementation; development of agricultural roads; agricultural development bank, agricultural input corporation; Nepal agricultural research council; department of agriculture development; department of irrigation and department of forestry.

Implementation Mechanism : Prioritized productivity package; harnessing complementary relationship between the hills, mountains and the tarai.

The specific priorities are as follows:

Agricultural intensification and diversification to broaden the agricultural base and achieve rapid growth. Accessible areas having irrigation facilities be targeted for intensive agriculture with a focus on cereals and adequate support services provided. At the same time diversification into cash and horticultural crops and livestock be encouraged to raise income, employment and export opportunities. Research on development and production of high quality fodder to promote livestock industry. Among horticultural crops, emphasis should be on citrus throughout the mid-hills, apple in the inner Himalayan zone, off-season vegetables in the hills and the Tarai, vegetable and flower seed in the hills and mountains, bee keeping products in the hills and mountains and raw silk in the mountains. Development of rural infrastructure especially transport and communication. Reduction in population growth to promote economic growth and increase income. Employment generation through human resources development. Energy development, promotion of IPM. Development of suitable agricultural technology given the agro-ecological conditions, resource endowments and access to markets, with particular emphasis on rainfed agriculture. Reducing the pressure on steep sloped environmentally fragile land and strengthening biodiversity conservation. To promote community forestry and increase capability in land use planning. Development of human resources to provide trained manpower for the agricultural sector by establishing a separate agricultural university. Reorientation of agricultural extension system to provide an integrated service covering arable agriculture, livestock, horticulture and fisheries and to strengthen extension activities at the grassroots level. Improved agricultural support services. Institutional and agrarian reforms to lend support to non-price instruments for effective agricultural development. Promotion of private sector in market-led development without sacrificing the goals of self-sufficiency in foodgrains production. Reduction in fertiliser subsidies along with the strengthening of fertiliser distribution system and establishment of fertiliser production facilities. Adoption of people oriented, decentralised and participatory district level agricultural planning keeping in view inter-sectoral linkages and area needs. Involvement of local communities jointly with the government in the implementation and identification of rural development schemes. Local procurement of foodgrains for public distribution to reduce transport costs and help phase out transport subsidies and at the same time provide price incentives to local producers. Integration of agriculture and irrigation programmes to maximise yields, gainfully utilise locally available resources, and involve local communities.

Pakistan

Pakistan continues to rely heavily on agriculture sector which accounts for approximately 24 percent of the country's GDP. Nearly 72 percent of Pakistan's total population directly or indirectly draws sustenance from this sector. As population growth is high, and shows no sure sign of declining significantly, the need for food security has attained a new urgency. Rice and cotton are the major foreign exchange earners and research emphasis is needed to maintain the export status of these commodities. Data indicate that Pakistan, attained near self-sufficiency in wheat during early eighties

but the trends in wheat production declined since then. Increased investment in irrigation and infrastructure is likely to ensure surplus production of rice in the next 25 years.

Specific research priorities in agriculture include, balanced use of fertilizers, micro-nutrients, and soil amendments, proper on-farm water management, distribution of certified seeds, promotion of improved agricultural practices and integrated pest management for increased agricultural productivity. Orientation of research efforts towards development of high yielding, disease resistant varieties of crops, particularly sugarcane, rice and oilseeds. Development of effective linkages and coordination between research, education and extension institutions to minimize the time between acquisition and dissemination of improved technology. Upgradation creation of research institutions to ensure a speedy flow of new varieties and other technology to support desired growth in agricultural production. Emphasis be given to the production of non-traditional oilseeds, in order to increase edible oil production, to promote crop specialization based on natural endowments of various agro-ecological zones; to attain diversification towards fruits, vegetables and other crops having a comparative advantage. To ensure support price system and procurement targets for important crops, particularly rice and vegetables. Concentration of research efforts for the development of superior livestock breeds using conventional and modern technologies, complemented by efforts to provide herd immunity and a disease free environment alongwith a progressive reduction in the number of inefficient animals so as to maintain equilibrium between supply of feed and fodder and number of animals. A comprehensive programme of afforestation, watershed management, range management, resource conservation social forestry and energy plantation to improve and conserve land and water resources. Initiation of institutional reforms to provide a favourable environment for agricultural production.

Sri Lanka

Three priority setting methodologies were used, viz., (i) Weighted Criteria Method for Commodity Prioritisation, (ii) Alternative Methodology of Ranking, and (iii) Composite Approach in Decision Making in Agriculture (CADMAR). The Council for Agricultural Research Policy (CARP), using the Weighted Criteria, identified about 40 crops and commodities in 3 priority groups as given below :

Priority Group I : Banana, Coconut, Dairy Cattle, Fish, Forest Products, Poultry, Rice, Rubber, Sugar and Tea.

Priority Group II : Cashew, Chilly, Cinnamon, Cocoa, Coffee, Cowpea, Gingelly, Grape (Table), Green Gram, Goat, Maize, Mango, Manioc, Passion Fruit, Pineapple, Potato and Woodapple.

Priority Group III : Arecanut, Bean, Cardamom, Citrus, Clove, Ground Nut, Kurakkan, Onion, Papaya, Pigeon Pea, Soybean, Sweet Potato, Tomato and Vanilla.

The commodities within a group could not be ranked as per limitation of the Weighted Criteria Method used. Therefore, by using the Alternative Methodology of Ranking, the following crop/ commodity priorities were identified.

Plantation Crops : Coconut, Tea, Rubber, Sugarcane

Field Crops : Rice, Maize, Chilly, Green Gram, Cowpea, Cassava, Black Gram, Gingelly, Ground Nut.

Fruit Crops : Banana, Mango, Lime

Vegetables : Plantain, Brinjal, Okra, Beans, Red Pumpkin

Fisheries : Near-shore fisheries, Off-shore fisheries, Deep-sea fisheries, Inland fisheries.

Animal Products : Meat Cattle, Beef Cattle, Buffaloes, Layer Chicken, Broiler Chicken, Meat Goats, Milk Goats, Swine, Goats, Sheep.

Forestry : Forest Plantation Trees, Multi-purpose Trees, Non-wood Products.

Export Agricultural Crops : Cinnamon, Pepper, Arecanut, Clove, Cardamom, Cocoa, Vanilla, Coffee, Betel, Nutmeg.

Further, the Composite Approach in Decision Making in Agriculture (CADMAR) was used, the outcome of which is not fully consolidated. As regards non-commodity research priorities, the following areas were identified, natural resources base-soils, irrigation, drainage, pollution, meteorology and agricultural production inputs; agricultural machinery, structures and food processing; marketing, economics, sociology and policies which are not concerned to the specific crop, and agricultural statistics and research methodology.

The non-commodity research being the characteristic of basic research is likely to support commodity production through the non-commodity research.

The research priorities often relate to development of high yielding varieties adapted to varying agro-ecological conditions and tolerance to common biotic and abiotic stresses. The country also gives a high priority to plant genetic resource activities. Socio-economics research should cover on priority, studies/analyses on impact of alternative policy options on agricultural development; off-farm employment on adoption of technology, agricultural productivity and family income; international trade agreements on various agricultural commodities; demand and supply analysis; socio economics aspects of available and potential technologies, analysis of prospects of value addition and export.

The appropriate research priorities need to be identified and development strategies need to be reoriented to improve the quality of human life in the sub-region. This calls for sustainable agriculture and rural development for ensuring sustainable food and nutrition security by physical and economic access to balanced diet and safe drinking water at the level of the individual households.

Common research priorities

The common research priorities for South Asia should include the following : i) Managing Rice-Wheat System, ii) Enhancing yield of major commodities, iii) Conservation and utilisation of agro-biodiversity. South Asia is a major centre of agro-biodiversity, encompassing rich genetic resources of plants, livestock, fisheries and microbes. The variability obtained in the region includes genotypes which are suited to varying agro-ecological conditions and are adapted to biotic and abiotic stresses. However, the variability has been eroding at a fast rate in all the countries and there is an urgent need for arresting the erosion. Each country should give highest priority for prospecting, collection, characterisation, cataloguing and utilisation of the indigenous agro-biodiversity, iv) Post-harvest handling and value addition, v) Increasing income growth for promoting food self-reliance. Besides developing technologies for promoting intensification, NARS in the region should give greater attention to the development of technologies which will facilitate agricultural diversification particularly towards intensive production of fruits, vegetables, flowers and other high value crops which are expected to increase income growth and generate effective demand for food, let alone distribution of risk and capturing of new opportunities. In order to increase international market share, due importance should be given to quality and nutritional aspects in order to sharpen the cutting edge of credible technologies

and commodities following emphatic impact and demand, both domestic and global. While maintaining the thrust on production technologies, the NARS should give additional support to development of products to enhance their country's share in international market. vi) Non-conventional feed resources utilisation for increased nutrient availability, vii) Diagnostics and vaccine production for management of major prevalent and emerging diseases, viii) Differentiating natural resources, agricultural potentials and technological opportunities, ix) Integrated management of biotic and abiotic stresses, x) Integrated management of natural resources, xi) Technology led promotion of productivity of rainfed areas and of equity, xii) Systems research, xiii) Strengthening biotechnology and other basic research, xiv) Socio-economic and policy research, research on priority setting mechanisms to take into account various interacting biophysical, agricultural, political, social and economic factors in arriving at appropriate research priorities must receive high attention, xv) Participatory technology assessment and transfer, and xvi) Human resources development.

Priority research areas based on CGIAR's research classification framework
The following priority areas could be identified :

Increasing Productivity-Germplasm Enhancement and Breeding
More than 50 important food and non-food crops, horticultural crops, and speciality crops are grown in the region. In each of these crops germplasm enhancement and breeding programmes are taken up in the different countries at varying intensity from crop to crop and country to country. Conventional breeding of crops, livestock and fishes is the predominant agricultural research activity throughout the region. Breeding of improved varieties of rice suitable for different production regimes such as irrigated, rainfed lowland, rainfed upland and deep water flooded, and resistant to common diseases and pests has been the preoccupation. In India and Pakistan, development of improved varieties of aromatic rice is a priority programme. Of late, hybrid rice and development of new plant type with very high yield potentials (12-15 tonnes/ha) are being researched in India, Bangladesh and Sri Lanka. Aggressive breeding programmes include production of pest resistant varieties, particularly against brown plant hopper, green leaf hopper and lately white plant hopper. Research on sources of resistance against blast and blight is highly required. whereas in respect of abiotic stresses, several rice varieties suited to saline conditions, rainfed upland settings and deep water and flooded conditions are being developed.

In wheat, the second most important crop in the region, strong breeding programmes exist in India and Pakistan. The wheat varieties developed within the region have been shared by the regional countries, viz., Bangladesh, Nepal and Bhutan. In the Annual Indian Wheat Workshops wheat breeders and other wheat scientists from the neighbouring wheat-growing countries have been to identify useful cultures and breeding lines participating which have freely been supplied to them.

In addition to the ongoing efforts for consolidation of yield gains for still higher productivity in wheat genotypes suitable for distinct agro-ecological settings such as irrigated (timely and late sown) and rainfed (timely and late sown) of varying temperature regimes (in context of length of cooler period) and mountainous region, the current and near future wheat germplasm enhancement and breeding priorities should concentrate on deployment of genes for management of rust (especially after the Breakdown of Yr 9 against a virulent race of yellow rust in the western part of the region) and development of varieties resistant to foliar diseases and Karnal Bunt. Horizontal resistance breeding should assume higher priority than in the past. Greater cooperation is needed in tracking the pathotypes and races and the genes for resistance. Wheat is expanding in warmer and shorter growing-period

regimes, hence germplasms and breeding materials possessing tolerance to high temperature both during sowing and ripening periods should be augmented and classified. Additional genetic enhancement work is called for tolerance to saline/alkaline and acid soils. Increased emphasis be placed on genetic improvement of quality as well as for product diversification.

Unlike rice and wheat, maize productivity, despite being the first crop in which hybrid varieties were commercialised at a large scale in the sub-region, remained low. Considering that the demand for animal feed, particularly poultry feed where about 40% of the feed comes from maize, the demand for maize in the region is expected to grow rapidly. Despite significant improvement in yield potential of hybrid varieties, most of the sub-regional countries until recently were growing open pollinated composites or local varieties. However, lately, emphasis on hybrids has also increased. There is an increasing demand for producing early maturing hybrids with high yield and pest resistance which could fit into maize-wheat, maize-potato, maize-mustard rotations. Aggressive breeding programmes in several countries have been initiated. Germplasm and breeding lines of medium and long maturing durations possessing very high yield potential of upto 01-12 tonnes per ha have been identified and being adopted in appropriate agro-ecological zones. In the eastern part of the region, winter maize is being popular and aggressive germplasm enhancement programmes have been initiated in India and to some extent in the adjoining tarai area of Nepal. The spill over impact of this initiative is yet to be felt in Bangladesh, but the prospects are certainly good. Against biotic stresses, comprehensive breeding programme for managing downy mildew and corn borer are in progress in some of the countries. For the hilly/mountainous region including major parts of maize growing areas of Nepal and Bhutan, there is increasing emphasis for generating genotypes possessing cold tolerance. Furthermore, in order to render maize production more competitive, veritable germplasms possessing diverse quality and industrial traits and uses be developed.

Millet and sorghum are other cereals which have witnessed rapid increase in their productivity through germplasm enhancement and breeding activities, particularly in India. In these two crops the emphasis is on development of hybrid varieties, although improved composites are also common in pearl millet. Diversification of the female lines and incorporation of genes for resistance to drought and other abiotic stresses and to diseases (downy mildew and ergot in pearlmillet) and pests (shoot borer in sorghum) have been achieved. Future thrust areas for genetic improvement of these crops include development of new sources of male sterility suitable for rainfed as well as restricted irrigated conditions. For sorghum, like maize, genotypes suitable for post-rainy season are important.

Increased use of a system approach requires to develop rice and wheat varieties for the different agro-ecological settings which may fit in rice-wheat rotation. These varieties have necessarily to be short duration and photoinsensitive. The wheat varieties particularly have to be suited to establish under high temperature conditions during sowing period. A Rice-Wheat Consortium constituted recently, jointly by the World Bank, IRRI, CIMMYT and ICRISAT is operational in the sub-region. Exchange of desirable enhanced germplasm and breeding materials of both crops for wider testing under varying rice-wheat systems shall be highly required.

Among roots and tubers, significant progress has been made in the genetic improvement of Irish potatoes. Several of the varieties developed in India are being grown in adjoining countries. Through varietal improvement, the production of potatoes has been greatly extended due to availability of varieties of varying duration and tolerance to varying temperature regimes. True Potato Seeds (TPS) technology has been standardised and is being widely used in the region on commercial scale.

As regards disease management, through distant hybridization, resistant genes for blight as well as other diseases have been transferred. For diversifying the use of potato, new hybrids and varieties suitable for potato chips and French fries have been developed.

Among pulses, chickpea and pigeonpea and cowpea are important crops in the region both as a major source of dietary protein for majority poor people and a soil ameliorating element in intensive cropping systems. Comprehensive breeding programmes in progress, such as, with ICRISAT, on chickpea in India, Pakistan, Bangladesh and Nepal on pigeonpea in these countries plus Sri Lanka need to be pursued. For cowpea extensive germplasm enhancement and breeding programmes are in progress in India and Sri Lanka. The main problem encountered in pulses has been their low yields. Most of the breeding programmes have been trying to consolidate the yield genes, but with limited success, although promising better yielding chickpea varieties of different grain sizes and possessing tolerance to common diseases such as blight and wilt have been developed. The major bottleneck in production of chickpea and pigeonpea is high incidence of pod borer (*Heliothis* sp.). So far no resistance source against this menace has been detected. However, distant hybridisation is in progress in both the crops in selected countries and it is hoped that some promising material will be available in the near future. Recently, the success of crossing *Atylosia platicarpus* with *Cajanus cajan* has given new hopes for creating breeding materials possessing resistance to pod borer as well as to several diseases. New genotypes of pigeonpea, including hybrids, which are extra short duration and can be fitted into pigeonpea-wheat cropping system are assuming importance. A large number of crosses to generate appropriate breeding materials combining resistance to Sterility Mosaic Disease, Fusarium wilt, Phytophthora blight and to waterlogged and drought conditions have been made and are being handled in the national programmes of India, Nepal, Bangladesh, Pakistan and Sri Lanka.

All South Asian countries, barring Bhutan, have breeding programmes on moongbean, a pan-Asian crop, and are in process of developing high yielding virus resistant bold grain type varieties suitable for various cropping patterns. Development of extra early varieties of moongbean is a high priority in the countries where moongbean can be taken as a catch crop between wheat and rice.

In the livestock sector, buffaloes are the monopoly of this region. Much success has been attained in improving yield and milk quality of buffaloes through breeding. In the recent years, through the use of embryo transfer, high performing buffaloes populations are being created in India and Pakistan. Further, an aggressive cross breeding programme involving local and exotic breeds of cattle is being practiced throughout the region. Fish breeding using hormonal manipulations, has high priority in India, Bangladesh and Sri Lanka.

Increasing productivity-production system development and management

Integrated farming system : South Asia is a region of small farmers and the small farms are the main source of livelihood of the populace. Mixed farming is the rule, but often the blends of crops and animals are not judiciously designed. Having recognised the ill-effects of monocropping, greater attention is now being paid to system approach for designing appropriate farming systems integrating crops, livestock and even fish in certain settings. Agroforestry, especially in hilly and sloppy lands and rainfed areas is getting prominence in Bhutan, Nepal and parts of India. Watershed approach of integrated and participatory management of land, water, inputs, biodiversity, crops, livestock and human resources is gaining popularity in rainfed areas. For livestock and fisheries production special attention is being paid to the development of non-conventional feed resources. To protect against

diseases, the countries are strengthening their capabilities in producing diagnostic kits and recombinant-DNA vaccines.

Integrated nutrient management system : To ensure synergistic interaction among organic fertilizers, including bio-fertilizer and chemical fertilizer, interdisciplinary research involving agronomists, soil scientists and water management technologists are in progress in India, Pakistan, Bangladesh and Sri Lanka. Isotopic studies in understanding the dynamics of soil, water and nutrient relations are in progress in these countries and techniques for judicious utilisation of various sources of nutrients to increase overall efficiency of production inputs to render the systems sustainable are in progress in India, Bangladesh and Pakistan. This area of research should be pursued at a high priority.

Integrated pest management : All the South Asian countries give high priority to integrated pest management and therefore national as well as international efforts, particularly the FAO programme on IPM, have strengthened their research capabilities in this area. Researches in IPM are being intensified to reduce the use of chemical pesticides and to improve the overall pest management scenario. The countries are actively involved in developing bio-control agents, which through appropriate mechanisms could be shared among them.

Alleviating adverse effects of irrigation : High priority is being assigned to management of irrigation-related problems such as soil salinity and water logging, particularly in Pakistan and India, and several new technologies and crop varieties have been developed to alleviate this malady. Micro-irrigation and fertigation research is gaining importance.

Post harvest technology and energy management : All countries in the region are strengthening their post-harvest technologies and value addition programmes to increase competitiveness in the liberalised global market. Farm mechanisation and renewable energy researches are gaining importance in all the countries to reduce the cost of production, to improve quality of products and to save energy. Because of the increasing interest in export of cut flowers and other horticultural products as well as with increasing indigenous demands for these products, adaptive and strategic research in protected horticulture is a high priority in most countries of the region.

Flow of quality seed : Research on production and distribution of quality seeds and mechanism of ensuring smooth flow of pure seed from breeder's plots to farmer's fields have been strengthened in all the countries. Bhutan and Nepal are particularly strengthening their capabilities in production of TPS, vegetable seeds and cut-flowers as well as production of medicinal and aromatic plants.

Protecting the Environment

Environmental protection and sustainability are now major interventions in the overall planning for agricultural growth and development. Although the high yielding varieties of rice and wheat are considered instrumental for causing environmental degradation, through increased use of chemical inputs, yet these varieties had saved millions of hectares of forests from being cleared to produce food to feed the burgeoning population. For instance, in India alone, the high yielding varieties of wheat have saved about 45 million hectares of forest cover being brought under cultivation. Given below are the priority researches in the region in the field of environmental protection :

— Development and management of agro-chemicals, including neem products.
— Strengthening of IPM and IPNS for reducing the use of agro-chemicals without compromising with yield enhancement.

— Monitoring of climate change and its impact on agricultural productivity and sustainability; some of the countries are regularly monitoring methane emission from rice paddy fields as well as from aquatic bodies and are devising technologies to minimise the release of green house gases from agricultural fields into the atmosphere.

— Ecological and environmental studies through GIS and remote sensing.

Saving agricultural bio-diversity

The rich agro-biodiversity in the sub-region has been eroding fast. To check it all the countries have constituted National Gene Banks and established national programmes on germplasm. Some of the countries have advanced research in the field of conservation and characterisation of the genetic resources. A greater emphasis should be placed on conservation, evaluation and utilisation of agro biodiversity in the region with increased funding support. Besides research, the countries should also develop appropriate *sui-generis* system of variety and germplasm protection so as to take note of the farmers rights and the countries NARS should evolve methodologies for implementing these rights. Agro biodiversity within the region has already contributed several important genes to the world agriculture but a lot more is unknown, specially in case of microbes.

Improving policy

Non-technological elements are equally important as the technological elements in bringing about wholesome development in agriculture. Generally, in South Asian countries policy analysis and scientific priority setting in agriculture had received inadequate attention. Often, School of socio-economics in agricultural organizations are not well organised and are involved mostly in routine teaching and research. Moreover, the linkages of agricultural systems with so called "pure" economics and policy planners have been rather weak. However, all the countries in the region are presently strengthening their socio-economic and policy research. For instance ICAR has recently established a Policy Planning Cell and also a National Centre for Agriculture Economics and Policy Research (NCAP). This growing realisation for countries future growth and development in agriculture, must aim for congruence among productivity, sustainability, profitability and equity, should be based on a judicious inter play of technical and non-technical elements. The following policy research areas are being presently persued in the region :

— Policy research for sustainable agriculture and poverty alleviation.

— Technology impact assessment, refinement and priority setting as well as allocation of resources to meet national goals and to ensure food security.

— Research and development of methods for environmental accounting and evaluation of agro-biodiversity.

— Policy research on international markets, comprising intellectual property regimes and sharing of technologies.

Strengthening national agricultural research systems

There was a considerable expansion of international and national support for agricultural research during the past three decades. However, annual growth in real total research expenditure in Asia declined from 7.4 per cent in the 1961 to 1980 period, to about 4.6 percent during the 1980s. Expenditures per researcher have nearly remained constant over this period, and are very low in Asia. Relatively low spending per researcher is a cause for additional concern in the light of fast growing population and demand for food inspite that investment in research have been among the

most socially profitable avenues for public investments. Moreover, the available date showed that the rate of return to agricultural research have been maintained in the 1980s, despite the deceleration in the growth in total factor productivity due to the failure to introduce new varieties that increase potential yield for most of the agricultural commodities. The effective use of maintenance and adaptive research has sustained the rate of return to research. Continued reductions in research expenditures will, therefore, increase the difficulty of sustaining agricultural productivity growth.

The NARS in the region have been evolving to meet the challenges and opportunities of agricultural development. Even though the countries recognise that research is the engine of growth of agriculture and, the allocation of resources to agricultural research by the national governments had declined in real terms. The overall external assistance to NARS has also declined. On the other hand, the complexities of problems to be solved are aggravating and there is a greater demand for system based and problem-solving research. The countries have realized this shortcoming and in their next development plans most have sought 3 to 4 times increase in research allocations, raising the level to at least 1 % of the agricultural GDP.

In some of the countries fairly elaborate NARS have been established and there is a need for consolidation of efforts in terms of strengthening human resources, providing additional operational support, instituting and fostering appropriate linkages, reforming recruitment and examination procedures and providing incentives to promote creativity. Nepal, is now establishing an agricultural university of its own. Smaller countries like Bhutan have also recognised the importance of an effective research system and the country is emphasising system based research and is establishing effective linkages between research and extension. Smaller countries in the region can always benefit from researches and technologies generated in the neighboring larger countries, as already demonstrated by sharing of India's wheat and potato varieties and production techniques by Nepal, Bhutan and Bangladesh.

The Agricultural Research Councils in Bangladesh and Pakistan, are striving to increase their effectiveness in coordinating the national agricultural research system through full integration of the state and federal level institutions. The management and organisational structures of some of these Councils may have to be restructured to render them efficient and effective. All the countries in the region are strengthening their informatics and database and can now easily be interlinked with each other. The SAARC countries on the basis of their identified common priorities and commitment should constitute selected networks of research, technology assessment, and transfer to facilitate sharing of existing and future technologies.

Conclusion

If existing trends in high population growth, low agricultural development, large disparities in income, high environmental degradation, and high incidence of poverty continue, South Asia's food, agriculture, environment, and quality of human life will be seriously threatened in the coming years. Poverty and malnutrition will remain the major problems. Pressures to produce more food and to use more natural resources, brought about by the changing composition and growth of the population and the unequal distribution of income, will harm the environment.

While the total eradication of poverty, malnutrition, and environmental degradation are desirable goals, policies should be framed in the context of what can be achieved with given resources-natural and human-and within given time horizons. Therefore, the 2020 vision for South Asia should aim to significantly reduce the proportion of the population that is below a specified level of poverty,

to reduce the number of malnourished children, and to decrease maternal, infant, and child mortality by the year 2020.

Such identified research priorities and strategies for South Asia over the next 25 years are likely to create conditions that will allow continued and sustainable growth in agricultural output and thereby improve the livelihood of folks and the overall socio-economic conditions.

Southeast Asia

SOUTHEAST ASIA

Meeting the growing demand for food continues to be the highest priority particularly of the developing countries although several of them are still agrarian. The sub-region faces this challenge from two fronts, namely, i) increased production corresponding to the growth in population, and ii) poverty that abounds in many parts of the region. A majority of the poor in the sub-region are located in few countries, namely, Cambodia, Laos, Vietnam, Myanmar. About 54 per cent of Vietnam and 35 per cent of Myanmar population are under the poverty line. The more rapidly growing countries also face this problem to a considerable extent. For example, Thailand, which is one of the fastest growing economies in Southeast Asia, has a higher incidence of poverty (30 per cent) than Indonesia (25 per cent) even though its average per capita gross national product (GNP) is recorded to be more than two times higher. Further, in the Philippines, 45 per cent of the population are estimated to be under the poverty line.

Agriculture, remains an important sector in the sub-region and it plays the dual role of providing enough food to meet the growth in demand and to sustain the buoyant economic growth. Agriculture accounts for a relatively large share in the total gross domestic product (GDP) of Cambodia, Laos, Vietnam and Myanmar, ranging from 34 per cent in Vietnam to 57 per cent in Laos. The share of labour force in agriculture in these countries has been relatively unchanged, at approximately 70 per cent, over the past decades. The other Southeast Asian economies also show large portion of their population greatly dependent on agriculture, ranging from 25 per cent in Malaysia to 63 per cent in Thailand even though their agriculture's share to total GDP has declined over time. For many countries, there are no alternative sources of employment. Their land holdings are small, and becoming even smaller over time thereby leaving no opportunity to reinstate the soil fertility by following the practices of fallow land across intervals. Agricultural exports have been vital source of foreign exchange earnings in the sub region. All Southeast Asian countries except for Cambodia, have shown an increasing ratio of agricultural exports to imports over the period 1961 to 1993. The heightened interest in the promotion of regional cooperation and market integration provides new opportunities for further trade expansion and overall development. However, the capacities to take advantage of these opportunities have to be developed through enhanced capabilities to make technological progress. Research has thus the central role to play through the complex changes that are taking place in the field of technologies. The new technologies which for example, are aimed at further increasing agricultural productivity also have added dimension of sustainability. The growing concern for resource and environment protection, the changes brought about by structural reforms, and the new developments in the international arena together strongly influence the agricultural research agenda. The changing focus of agricultural research in southeast Asia as in other sub-regions needs to be redefined. Research goals and priorities should aim at the more complex issues brought about by changing trends in commodity supply and demand as influenced by diverse factors, such as, population, greater urbanisation, growing demands for natural resources and changing trade environments. The present study covers the sub-regional countries of Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand and Vietnam and is based on reports obtained from their respective NARS and supplementary information review from literature on the research agenda of other national and international research institutions.

Table 24: Indicators for economic growth

	GDP Growth rate (%)		Merchandise Exports (US$ mil)		Foreign Direct Investment (US$ mil)	
	1981-90	1995	1981	1994	1988	1990
NIE 1	9.8	7.6	86580	436702	1096	39
China	10.4	10.2	22007	104607	2344	231
Southeast Asia	6.4	7.9	47698	160016	3551	98
Cambodia	1.23	7.5	35.5	303	110	
Indonesia	60	7.6	22260	39497	576	20
Laos	6.73	7.1	23	290	29	
Malaysia	5.2	9.3	11765	58147	719	52
Myanmar	-0.1	7.7	462	794		
Philippines	1	4.8	5655	12124	936	7
Thailand	7.9	8.6	7031	45061	1081	14
Vietnam	7.1	9.5	467	3800	100	3

Notes:

1. Includes Hongkong, South Korea, Singapore and Taiwan.
2. Includes East and Southeast Asia
3. Figures are for 1990
4. World Bank, 1996
5. Figure is for 1986
6. Increases are primarily for Singapore. Other NIEs showed negative FDIs during the periods reported here.
7. Cambodia's FDI has been increasing gradually in the 1990s.
8. This is significant improvement from 1992 which was only US$ 228 million.
9. Figures do not include India and Nepal.

Sources : ADB, 1995; World Bank, 1996.

PAST TRENDS IN PRODUCTION, CONSUMPTION AND TRADE

The aggregate production from agriculture in the sub-region expanded between 1966 and 1992 largely due to increased cropping intensity and better yields. Production of the major food crop more than doubled in 27 years, increasing from 94 million metric tonne in 1966 to 226 million metric tonne in 1992. The commodity composition of the region's production reflects the dominance of rice which showed tremendous increase in production and accounted for fifty three per cent of Southeast Asia's total food crop production in 1992, figuring at 118 million metric tonne. This also represented about 25 per cent of Asia's total rice output. Rice is the major staple crop of the sub-region and a major export earner for some countries, such as Thailand and Vietnam. Its production increased at the rate of 3.2 per cent per annum during the period, 1966-92 reaching its peak during 1976-86 but it has shown some decline in subsequent years. Production growth rate for maize was also high, being 3.8 per cent per year in 1966-92. This growth has been spurred by expanded demand for feed as its use as food in some countries like the Philippines declined with the economic growth. Thailand has been growing maize in significant quantities mainly for export as feed but more recently, its demand for domestic use as feed has also increased due to rapid growth in livestock sector. Production of cassava also recorded an increase, primarily in response to a strong demand for feed in the European countries during the period late 1960s to late 1980s. The bulk of this demand was met by Thailand and Indonesia.

Besides major food crops of the sub-region, Southeast Asia also performed well in other agricultural products including meat. Significant production increases were recorded in fruits, vegetables, and

other commercial crops particularly in the later period. But unlike the main staples, production growth for many of these crops came primarily from expansion in area rather than from improvement in yield. Shifts in cultivation trends were mainly observed from commercial crops mainly due to a long-term decline in the price of rice and other major staples which affected farm profitability. Besides, a slowdown in growth in productivity of rice and wheat and shift in demand preferences with economic growth from the staple foods to high-nutritional value products like meat, fish, fruits and vegetables constituted the other important factors.

Total meat production in Southeast Asia increased by almost three fold, from about 2 million metric tonnes in 1966 to 6 million metric tonnes in 1992, at the rate of about 4 per cent per annum. Pig meat and poultry meat registered the highest rates of increase, i.e., 3.8 per cent and 6.3 per cent, respectively, due to their preference in trade and commerce.

Past trends in cereal consumption were similar to those of production. The average rates of growth in consumption grew by 3.1 per cent per year between 1966 to 1991, and a general slowdown was further noted, during later period. This retardation in growth was mainly attributed to the decline in rice demand. Wheat demand remained strong with average growth rate of about 5.6 per cent over the entire period. Per capita consumption of wheat steadily increased over the years whereas that of rice declined, particularly in the more advanced countries like Malaysia and Thailand. This gradual substitution of wheat for rice as a staple food was mainly due to growth in income and the rapid urbanisation. The low growth rate of wheat consumption in 1976-86 was mainly due to a big cut in the Vietnam's demand.

Growth in maize consumption increased tremendously but mostly due to its use as feed and the setting up of several intensive and semi-intensive grain-fed livestock industries. Annual feed consumption rates for 1966-1990 for Indonesia, Thailand and Malaysia were 18.5, 38.0 and 11.3 per cent, respectively (FAO 1992). The rate of feed demand growth in other countries was however, lower, i.e., around 4 to 5 per cent but are expected to increase in future with further expansion of the livestock sector in response to strong demand for livestock products. The use of maize for human consumption is likely to further decline. Some countries such as the Philippines which still use maize as the main staple have started the shift in demand towards more rice and wheat.

Consumption of other crops like fruits, vegetables and fish in the past have been primarily due to factors like poor availability and relatively high prices. The latter have steadily increased at around 3 per cent per year between 1966-91 and are projected to be further higher in the next decade with the continued economic growth in the sub-region.

Agricultural products and by-products earn a major sum of foreign exchange in most countries of the Southeast Asia. Total value of agricultural exports rose from US $2.2 billion in 1966 to US $16.8 billion in 1993 (FAO, 1995). Whereas most of these were the traditional export commodities, including timber and other forest products, palm oil, rubber, copra and coconut oil, sugar and rice, yet a variety of non-traditional products, such as orchids and other cut flowers, seafood products, fruits and vegetables, coffee, cocoa and spices also found way into the export markets in some countries.

The share of agriculture in Thailand's exports is about 60 per cent; the bulk of it being rice, but the share of non-traditional export crops is also increasing. In the Philippines, agriculture accounts for 30 per cent of total exports dominated by fresh shrimps and prawns, banana and crude coconut oil. The country has been the world's biggest supplier of coconut products. From the 1970s, however, it increased exports of mango, pineapple, coffee, cocoa and black pepper. Malaysia, Indonesia and Thailand account for about 75 per cent of the world's rubber exports while large portion of palm oil exports come solely from Malaysia. In Indonesia, export crops, namely cocoa, pineapple, bananas,

Table 25: Baseline projection of production, demand and trade of major food crops in Southeast Asia, 1990-2020

Countries/ Regions	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
WHEAT						
Indonesia	0	1791	-1791	0	3587	-3587
Thailand	0	295	-295	0	565	-565
Malaysia	0	701	-701	0	1619	-1619
Philippines	0	1437	-1437	0	3261	-3261
Other SE Asia	126	471	-345	170	965	-795
SE Asia	126	4695	-4569	170	9997	-9827
MAIZE						
Indonesia	6445	6449	-4	11520	11689	-168
Thailand	4263	3057	1206	6759	8864	-2105
Malaysia	35	1340	-1305	68	3243	-3175
Philippines	4677	4787	-110	8203	9271	-1067
Other SE Asia	1021	1058	-37	1814	2134	-320
SE Asia	16441	16691	-250	28365	35200	-6835
OTHER GRAINS						
Indonesia	3	30	-27	5	35	-30
Thailand	250	244	6	307	602	-295
Malaysia	0	72	-72	0	161	-161
Philippines	0	251	-251	0	360	-360
Other SE Asia	392	184	208	539	413	126
SE Asia	645	781	-136	851	1572	-720
RICE						
Indonesia	29163	29262	-99	51872	51806	66
Thailand	12667	8476	4191	17081	9783	7298
Malaysia	1200	1668	-468	1945	2283	-338
Philippines	6050	6388	-338	12023	11491	533
Other SE Asia	23188	21800	1100	44727	40763	3964
SE Asia	72268	67594	4386	127647	116125	11523
SOYBEAN						
Indonesia	1450	1803	-353	2840	5431	-2591
Thailand	618	618	0	831	2425	-1594
Malaysia	0	398	-398	0	1527	-1527
Philippines	6	30	-24	9	94	-85
Other SE Asia	130	74	56	218	193	25
SE Asia	2204	2923	-719	3898	9670	-5772
ROOTS/TUBERS						
Indonesia	19229	15085	4144	24963	22678	2285
Thailand	21975	488	21487	26873	1004	25869
Malaysia	521	541	-20	726	945	-220
Philippines	2748	2716	32	4365	4320	46
Other SE Asia	6883	6823	60	10988	11773	-785
SE Asia	51356	25653	25703	67914	40720	27194

Source : Rosegrant, Sombilla and Perez, 1995

Table 26: Baseline projection of production, demand and trade of livestock products in Southeast Asia, 1990-2020. (in thousand metric tonnes)

Countries/ Regions	1990			2020		
	Production	Demand	Net Trade	Production	Demand	Net Trade
BEEF						
Indonesia	181	297	-116	579	1214	-636
Thailand	226	228	-2	551	898	-347
Malaysia	11	66	-55	21	271	-250
Philippines	81	97	-16	189	324	-135
Other SE Asia	220	391	-171	411	1078	-667
SE Asia	719	1079	-360	1752	3786	-2034
PIGMEAT						
Indonesia	286	283	3	1059	963	97
Thailand	335	334	0	1132	1104	28
Malaysia	226	193	33	610	653	-43
Philippines	687	690	-3	2236	2207	29
Other SE Asia	919	922	-3	2524	2494	30
SE Asia	2453	2422	30	7560	7420	140
SHEEP MEAT						
Indonesia	84	80	4	243	270	-27
Thailand	1	1	0	1	3	-2
Malaysia	0	8	-8	0	27	-27
Philippines	0	23	-23	0	58	-58
Other SE Asia	92	34	58	99	79	20
SE Asia	177	146	31	343	438	-94
POULTRY MEAT						
Indonesia	451	450	1	1758	1714	44
Thailand	667	497	170	1896	1749	146
Malaysia	340	336	4	813	1157	-344
Philippines	233	241	-8	572	692	-119
Other SE Asia	229	322	-93	655	866	-212
SE Asia	1920	1846	74	5694	6179	-485
EGGS						
Indonesia	486	486	0	1927	1783	144
Thailand	249	240	9	947	891	57
Malaysia	193	172	21	624	682	-59
Philippines	322	323	-1	1041	1020	21
Other SE Asia	209	205	4	535	561	-26
SE Asia	1459	1426	33	5075	4938	137

Source : Rosegrant, Sombilla and Perez, 1995

spices and other horticultural products have gained significance as a means of diversifying Indonesia's economy.

Agricultural trade in Southeast Asia did not only expand in volume and composition but has also changed trade directions. Recent trends in total merchandise trade show that many Asian countries are becoming less dependent on sources outside the region, not only for export growth but also

import supply. Asian intra-regional trade has expanded rapidly as compared with other regions. It posted a 22 per cent growth rate in intra-regional trade in the 1970s. The rate was much slower (12 per cent) in the 1980s yet higher than anyone of the other regions.

Factors affecting future production and consumption

Southeast Asia has shown quite a remarkable performance in food production in the last three decades. The question now is whether this performance could be sustained in future? The time profile of both production and consumption, particularly of the major food crops, over the period, has indicated a general slowdown in growth particularly between 1986-93. Several factors influenced these trends which need to be deliberated and appropriate measures taken to attain suitable growth rate.

Demand prospects

Growth in population, improvement in income and changes in demographic structure of the population together influenced trends in food demand. The last two factors accounted mostly for the alteration of traditional food preferences. The growing acceptance of wheat as a substitute for rice, for example, has been to a considerable extent, a consequence of increasing urbanisation. Its demand for food use grew at about 5.1 per cent per annum as against rice demand which grew only by about 3.1 per cent per annum during 1966-91. The same factors influenced in favour of a strong demand for livestock products.

Prospects for further economic growth

Asia as a whole remained the fastest growing region in the world. China led all Asian countries with a 10.2 per cent rate of growth in real GDP in 1995. The Southeast Asian countries, however, closely followed with rates of growth ranging from 7 to 9 per cent.

One major factor for this impressive growth performance was the continued success in the implementation of macroeconomic and structural reforms which encouraged high rates of investments in the region. Gross domestic investments, measured as per cent of GDP, rose in most Asian countries. Similarly, growth in foreign direct investments (FDI) has been very significant, particularly in the Southeast Asian nations. While China received the lion's share of the region's FDI, Indonesia, Malaysia, Thailand and Vietnam have also started to attract substantial inflows. The excellent credit ratings of most countries in the sub-region have allowed them to tap international bond markets regularly, which is expected to continue in future also.

Another major factor that influenced Asian countries' economic growth has been their large advances towards integrating with the world economy, particularly a strong growth in merchandise exports. Export value in these countries grew by almost four-fold from US $48 million in 1981 to US $160 million in 1994, representing an average annual rate of growth of 9 per cent. More recent estimates of annual export growth rates are higher, ranging from 15 to 22 per cent between 1990 to 1995. Much of this trade has been undertaken intra-regionally which is significant.

Remarkable export performance and strong investment will continue to underpin Southeast Asia's growth. World Bank projects that GDP in these countries will continue to increase @ closer to 8 per cent, given an appropriate follow-up for sound policies and institutions including for the agriculture sector.

The move towards free trade in agriculture, initiated by GATT and other regional trading arrangements will have a big impact on the sustainability of growth in the region. Increased participation in international trade could improve resource allocation, enhance efficiency by increasing competition, and induce learning and technology transfer.

Population growth and urbanisation

Southeast Asia's population is estimated by about 40 per cent between 1995-2020, from 447 million in 1995 to 665 million in 2020 (UN, 1992). Along with the rise in population, some changes are expected in other demographic characteristics, such as, the rate of urbanisation. Urban population as per centage of total population increased from 26 per cent to 34 per cent between 1985 to 1995. This represents a growth rate of about 4 per cent per year. It has been clearly noted that urbanisation will accelerate dietary transition, from the basic staples to more convenient and processed foods.

Recent estimates showed that demand for cereals in Southeast Asia will almost double from about 90 million metric tonnes in 1990 to 163 million metric tonnes in 2020 thereby registering a yearly rate of growth of 2 per cent. Rice will still consist the bulk of total cereal demand but its annual rate of increase may be slower, i.e., only at 1.8 per cent per year. Although the per capita demand for wheat will still be lower than bulk of the other Asian countries, the rate of increase would be rapid, at about 2.6 per cent per year. Maize demand will also grow at almost similar rate. Thus,. the sub-region may increase here to its cereal imports to about 6 million tonnes in 2020.

Domestic supply of meat, fruits, vegetables and other high-value food products have been largely supplemented by imports, which is likely to continue. Meat demand for the sub-region will increase by more than three-fold, from the 1990 level of about 5.5 million metric tonnes to about 17.8 million metric tonnes in 2020, leading to meat imports from 224 thousand million metric tonnes to 2.5 million metric tonnes by 2020. Fruits and vegetables, including citrus, apples, grapes, and raisins, are the third largest category of Asian agricultural imports and one of the fastest expanding areas for U.S. exports. More rapid increase in demand is expected in these commodities with further improvement in income.

Greater food demand resulting from population and income growth must be met by food production increases. As indicated earlier, opportunities for food production increases from existing resources particularly land is becoming very limited. This implies that future output increases must come primarily from higher yields. Thus, the biggest challenge in the next two or three decades is the development of more efficient production technologies. Efforts are now being undertaken, particularly in developing countries, to promote further increases in agricultural production. Prospects for growth are being initiated from cost-reducing technological change which is fully integrated into the larger economy through increased investment in infrastructure and services that permit farmers' adoption of the technology. Solutions to these problems are complex. They involve the foundation of a strongly linked national and international institutions in the areas of production, infrastructure building, and financing.

Future growth in rice and wheat productivity in developing countries in Asia, for example, will come from the renewal of improvement in yield potential of modern varieties (through hybrid and new plant structures for rice, and through continued generation and adoption of wheat varieties which generate evolutionary increases in yield potential and improved stability in many environments); and, more important, from improved management and efficiency of use of the scarce resources utilised in rice production, in contrast to rapid dissemination of modern technology which has been dominant in the past. Thus, in fertilizer policy there must be a shift from a sole focus on increasing the level of use of fertilizer to also improving the efficiency of nutrient balance and the timing and placement of fertilizers; in crop protection there should be a shift from dissemination of chemical pesticides to utilisation of integrated pest management techniques and in irrigation, a shift of emphasis from investment in new systems to improved water use efficiency and productivity in existing systems. Yield growth in maize is also expected with the spread of well-adapted modern varieties evolved

both from public and private research. Maize and other grain sectors will also benefit from reforms described above for wheat and rice.

Land constraint will also pose a problem to achieve further increases in animal production, which could come principally from increased animal productivity and intensified production. Sustainability in animal productivity will come from better provision of nutritious feed and improvement of animal health, genotype and livestock management.

Increased production in other crops, especially those with high commercial value, will come from development of new seed strains and varieties which are high-yielding, resistant to pests, insects, and diseases, and well adapted to different environmental conditions, improvement in natural resource management practices, increased efforts towards the dissemination of information and farmer education and infrastructure and market development. Fish sector production increases would be achieved through efficient assessment of the status of tropical aquatic resource, more rigid studies on land-water relationship to minimise pollution and habitat destruction, and development of more efficient systems in aquaculture farming.

Reorienting the research and management system

Agricultural research obviously needs to play a more critical role. The challenge lies in increased production to meet the growth in food demand. This has, however, to be achieved within the context of efficiency, considering the need to conserve and protect the natural environment as well as to promote competitiveness in the global market.

National Agricultural Research Systems (NARS) in Southeast Asia formulate research goals based on the respective country's overall development goals and on a wide range of other development considerations. With the formulation process being broad based, NARS tend to have multiple objectives, most of which are closely interrelated but some are conflicting (e.g. efficiency versus self-sufficiency in food production). This multiplicity suggests the complexity of the whole development process and the enormous challenges being faced by the NARS in the sub-region.

Agricultural research goals for Southeast Asia

Seven major research goals were identified from the various reports of NARS in the sub-region, namely, 1. production efficiency, 2. food self-sufficiency, 3. employment generation, 4. agricultural modernization, 5. global competitiveness, 6. resource conservation/sustainability, and 7. agricultural diversification.

Most of the countries/NARS in the sub-region have prioritized efficiency followed by resource conservation/sustainability as their major research goals. Although these goals appear conflicting in their attire yet these are complementary to the real needs of agricultural development of the present and the future. Food self-sufficiency and diversification follow next with ninety per cent common agreement to these priority goals. Agricultural modernization and employment generation is agreeable to only 50 per cent cases, which is still important whereas a higher acceptance (per cent) was agreeable in favour of global competitiveness.

The pre-occupation of the sub-region with self-sufficiency in rice production has understandably diverted resources from production of high-value and export crops. Declines in rice production profitability and farmers' incomes as well as demand shifts from the staples to high-value commodities associated with income growth have aroused increasing appeal to diversity farming systems. The move towards this direction was realised earlier in some countries like Japan, Thailand, Taiwan, etc. (Bhargouti, 1992). Thailand has in recent years adopted a free-wheeling market oriented approach to diversification within the agricultural sector. Agro-horticultural systems were observed to be most appropriate because Thai agriculture was predominantly (over 80 per cent) rainfed. Fruits and processed fruit products

as well as cassava and fibers were being promoted because of their great potential as foreign exchange earner in the country. However, in the Philippines, Indonesia and some South Asian countries, cropping pattern changes were less flexible because of the need to increase foodgrain rice production to cope with burgeoning population. Many farm areas were still primarily cultivated with rice but under double or triple-cropping, where it is possible to grow only one to two upland crops (APO, 1991).

Design and implementation of policies and investment strategies to foster rural diversification was complicated issue. A successful diversification strategy would determine the right balance between the production of staple and non-staple crops, on other hand, and increasing potentials of small and medium scale rural industries, marketing, construction and other labour-intensive services versus industrial development in cities and other urban areas.

Research focus in agricultural diversification should be on the identification of appropriate farming systems which include crop selection, proper application of fertilizer and other soil amendments, improved water control, etc. The most crucial factor was the role of investment because such investments blaze the trail along which gradual adjustments in cropping patterns and resource allocation must follow.

Table 27: Major research goals/objectives in Southeast Asia

Countries	Agricultural Modernization	Efficiency	Food Self-Sufficiency	Employment Generation	Conservation/ Sustainability	Diversification
Indonesia	x	x	x	x	x	x
Malaysia	x	x	x		x	
Philippines	x	x	x	x	x	x
Thailand	x	x			x	x
Vietnam		x	x	x	x	x
Lao, PDR		x	x	x	x	x
Myanmar		x	x		x	x
Cambodia		x				

Research priorities

In Southeast Asia, research priorities were fixed using several criteria derived from degree of importance in reaching an objective and the development targets.

Research prioritization in Southeast Asia has been generally subjective. Some countries, however, made serious attempts to employ more objective processes.

Major commodity research areas

Major commodity research areas in Southeast Asia were classified based on whether they were (a) common to all or majority of countries; (b) important only to few countries; and (c) unique to a particular country.

Rice and corn are priority commodities in all the Southeast Asian countries. The priority given to rice underlies the primary goal of most countries in the region to achieve self-sufficiency in food vis-a-vis this commodity. Corn is another research commodity in the Southeast Asia as this commodity also serves as a staple food of a significant portion of the population in the region. Corn is also a major feed ingredient too.. The demand for this commodity is expected to escalate further with the increasing demand for meat and meat products due to increasing population and per capita income in the region.

Among the cereal, wheat is a major commodity research area only in Myanmar. Except Myanmar, all countries in the sub-region import their wheat requirements. Cassava, sweet potato and Irish potato are common commodity research areas in Southeast Asia. These commodities, especially cassava and sweet potato are generally cultivated in marginal areas by the resource-poor farmers. Research interest in these commodities therefore, reflect the commitment of countries in the region to address poverty through technological change. Mungbean, peanut and soybean are likewise common commodity research areas in the region. Tropical fruits and vegetables also have a major research concern in the Southeast Asia, particularly with the opening-up of world market. Tropical fruits such as, banana, mango, durian and pineapple, among others, are among the top research priority commodities in a few countries. Most plantation crops, except cotton, provide common commodity research areas in the Southeast Asia. The rubber, palm oil, coconut, tea, coffee, cacao, spices, sugarcane and tobacco together fetch traditional dollar earnings, and are, thus, regarded as among the most important agricultural commodities in the region.

Cattle, buffalo, goat/sheep and chicken are the important commodity research areas among the livestock and poultry. Swine is important but only to Philippines, Thailand and Vietnam. The research interest in meat products shall undoubtedly increase as demand for these commodities is projected to rise considerably with increasing population and per capita income.

Other research areas common among the Southeast Asian countries are the farming system, soil resources, agricultural engineering, particularly farm machineries, aquaculture, artisanal and deep sea fisheries, agro-meteorology, water resources, on-farm research and socio-economics. Biotechnology is increasingly gaining considerable research interest in Southeast Asia especially in Indonesia, Malaysia, Philippines and Thailand.

Priority research areas based on CGIAR's research classification framework

Research prioritization in Southeast Asia is largely commodity-based. Thus, most information on research priorities found in available references are limited to "across-commodity" level. However, the major research areas in the region based on CGIAR's framework for classifying research may be as follows:

Increasing productivity

Most countries in Southeast Asia are engaged in breeding activities to improve the productivity of various commodities, particularly crops and livestock. These breeding activities, however are largely of the conventional type. Work related to high technology pre-breeding activities is still limited. Serious attempts on molecular biology are being made, especially in the large and advanced NARS of developing countries in the region, including the Philippines and Indonesia.

Production system development and management

Most of the sub-categories under production system development and management are of research interest to Southeast Asia, due to three reasons, namely, (a) countries in this region are either less developed or developing, thus much of the constraints in agriculture are still on production system development and management; (b) research in this category is still relatively of the "downstream" type thus could easily be handled by the NARS in the region; and (c) pay-off to these researches relatively have short gestation period, thus are more attractive to less developed and developing countries.

Protecting the environment

Protection of the environment and the development of sustainable agriculture are given serious concern in the sub-region. The environmental degradation, especially following the rapid economic growth as well as population growth in the region, has been alarming, prompting the government, in general,

and the respective NARS in particular to pay serious attention on environmental protection and conservation.

A wide range of research interest on environmental protection and sustainable agriculture are currently being pursued in Indonesia, Philippines, Laos, Vietnam, and Thailand which should be pursued in a collective mode to ensure more lasting results.

Saving biodiversity

Saving biodiversity is an important research concern in Southeast Asia. This, however, is of relatively recent interest prompted largely by the growing global awareness on the need to protect the environment and a move towards sustainable agriculture. In general, however, the response of Southeast Asian countries is still limited to policy statements and available information so far have not made explicit indication of saving biodiversity as a priority research concern. Rather, the sub-regional countries are still oriented towards high productivity and income in monoculture systems. Sustainable agriculture needs, however, to be fully integrated into the mainstream of development activities.

Socio-economic, public policy and public management

Studies in this area are designed to complement current development programme of countries in the region. Policy analysis and advocacy appear to receive considerable emphasis which indicates the growing realisation that much of the developments in agriculture and natural resources are the results, directly or indirectly, of the governmental policies.

Evaluation of technology transfer programs or technology adoption is also of major interest in Southeast Asia. Technology adoption in the region is still generally low as reflected in the wide gap between actual and potential yield of major commodities. Understanding the various constraints to adoption is, therefore, crucial.

Strengthening national programmes

Strengthening national programmes is of extreme importance to the sub-regional countries. Support system of NARS consists of human resources, research infrastructure and information resources. Continuous development of these resources is crucial for NARS to be able to effectively carry out their mandates.

Human resource development either through advance degrees or short training programmes is important especially with the rapid progress in technologies and knowledge related to agriculture and natural resources development. Massive investment in human resources development had actually been made by various Southeast Asian countries during the 1980s. The number of scientific manpower among the NARS in Southeast Asian ranged from 1000 to 3000 personnel. To date it is estimated that the scientific manpower of most NARS in the sub-region has doubled in number.

The research infrastructure among the NARS in the sub-region consisted of national or central research facilities, regional facilities and provincial or location-specific research stations. The national research facilities included single-commodity or multi-commodity research that would cater to the needs of agricultural commodities of national importance as well as agricultural colleges and universities that are engaged in national R&D programs. Regional facilities are those that conduct applied research to address the research needs of a major geo-political area of a country and are often multi-disciplinary in orientation. Provincial or location-specific stations are involved in fine-tuning technologies to suit the needs of specific area.

In addition, the increased investment in agricultural research during past decades has produced new agricultural information and knowledge. It is important for NARS, therefore, to carry out a careful and deliberate management of information in order to enhance its utility to the research

system. The rate in which new research results are generated increases the pressures of previous information becoming obsolete within a relatively short period of time. Likewise, the growing complexity of information transfer requires a system that would aid in the effective management of this increasingly important new resource information.

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Northeast Asia

NORTHEAST ASIA

The agricultural situation is across the globe is likely to change rapidly doe to a growing free trade movement since the advent of the World Trade Organization (WTO) in 1995. The emerging new forms of cooperation and unlimited competition in all sectors, including agricultural, are likely create unprecedented pressure on Asian agriculture. At the same time, the evolution and spread of agricultural research has been rapid during the past few decades; the improved varietal technology has also necessitated the application of higher inputs to realize the increased productivity in the farmers' fields. This trend has, however, also resulted in unanticipated and unintended problems which could hinder further agricultural development. This growing awareness has caused genuine interest in the sustainable agriculture.

Thus, the present dimensions of agricultural research include, contrary to the productivity-linked objectives at large, a few decades ago, a changed, socio-ecological sustainability, in addition to maintaining growth in productivity. Realizing this mission, in the region, most Asian countries, particularly the Northeast Asia sub region, namely, China, Japan, and Korea, have recently restructured their national agricultural research systems (NARS) based revised agricultural research priorities.

Agricultural situation in relation to farming structure

Asia covers one-fifth of the total area under agriculture in the world and houses 3.1 billion people which is nearly 60 per cent of the total global population. The population density in the region is three times higher than that of the world. A traditional dependence of relatively higher population on agriculture is evident in this region. Indeed, over 75 percent of the agriculture dependent population of the world is located in Asia. Above that, the cultural realization of the importance of agricultural development for the economic development and farmer's prosperity in the sub-region has a long history.

Table 28: Change in total and farm population (in thousands) over years in Northeast Asian countries

Country	Year	Total population	Farm population	Farm/total population (per cent)
China	1970	82,992	68,568	82.6
	1980	98,705	79,565	80.6
	1990	114,333	84,142	73.6
Japan	1970	10,732	2,659	25.3
	1980	11,706	2,137	18.3
	1990	12,361	1,729	14.0
Korea	1970	3,145	1,442	45.9
	1980	3,744	1,083	28.9
	1990	4,350	666	15.3

However, with the development of national economies, majority of the population depending on agriculture moved to and concentrated in the urban, industrial centers. Whereas the total population of China, Japan, and Korea expanded rapidly in the last 20 years, the farm population has declined sharply in Japan and Korea, particularly since the 70s, mainly due to industrialization and urbanization. Contrary to this, the total farm population in China increased from 685.7 million to 841.4 million during the period 1970-90. This is attributed partly to the expansion of total population and partly to the slow rate of farm depopulation in this country. However, China is also likely to face a sharp

decline in the total farm population with the further development of its national industry. The proportion of farm population to total population has decreased in all three countries during 1970-90. The Labour force employed in agriculture in 1990 accounted for 14.0 per cent, 15.3 per cent and 73.6 per cent of the total population in Japan, Korea and China, respectively.

In the past, agriculture in Northeast Asian countries was characterized by small scale farming with low crop productivity. The land holdings in China, Japan, and Korea, have been only about 0.5 to 1.4 ha (Table 2) as against average farm household areas in Australia and U.S.A. of 2,800 ha and 182 ha, respectively. The labour productivity of agriculture in these three countries has been obviously lower than that in the western countries. The potential for further developing land area for agriculture is also extremely limited in Japan and Korea. Of the 2.1 million ha cultivated area in Korea, about 64 per cent (1.3 million ha) are covered under paddy for production of rice which comprises the principal staple crop. In Japan, 54 per cent of total cultivated land is used as lowland whereas remaining 36 per cent cultivated area in Korea and 46 per cent in Japan are uplands.

Table 29: Total farm land and average household farm size in the NE Asia sub-region

	China	Japan	Korea
Total area (1,000 ha)(A)	959,700	37,774	9,926
Farm land (1,000 ha)(B)	95,700	5,243	2,109
Lowland	25,700	2,846	1,345
Upland	69,900	2,397	764
B/A(per cent)	9.97	13.9	21.2
Farm size (ha/household)	0.49	1.37	1.19

Table 30: Production of major crops (million metric tons) in Northeast Asia

	Rice	Soybean	Wheat	Maize	Barley	Potato
1980						
World(A)	490.6	15.9	506.9	400.3	167.3	271.2
Asia(B)	447.1	7.8	184.5	112.9	22.0	62.9
Ratio(B/A, per cent)	91.1	48.8	36.4	28.2	13.1	23.2
China	145	8	59	60	3	25
Japan	13	0.2	0.6	**	0.4	3
Korea	6.7	0.2	**	0.1	1	0.4
1990						
World(A)	518.5	16.3	595.2	475.4	180.4	269.6
Asia(B)	478.7	8.0	198.7	123.3	18.4	64.9
Ratio(B/A, per cent)	92.3	49.0	33.4	25.9	10.2	24.1
China	191	11	98	97	3	32
Japan	13	0.2	0.9	**	0.3	0.2
Korea	8	0.2	**	0.1	0.4	0.3

** : less than 0.1

In China, a relatively lower proportion of lowland to upland fields has been observed. About 27 per cent of the cultivated land is used for the production of rice crops. It may be safely stated that

farming in the entire Northeast Asia sub-region is primarily agriculture based, particularly the rice production. In 1990, the global production of major crops reached 2,112 million tons, 43.6 per cent of which came from the Asian region. In rice alone, the-Asian region, contributed 90 per cent of the total production in the world and the trend in the total production has been further increasing.

Of the two main groups of rice varieties, namely, Indica and Japonica types, the Indica types are mainly produced in tropical areas, and account for over 90 per cent of total rice production whereas the production of Japonica types is less than 10 per cent. The latter are mainly produced in Japan, Korea, and other high elevation areas. Under the open market system the Indica form land types get good returns. However, the case is not the same with Japonica types. This poses a serious problem in Japan and Korea because the price of rice in Southeast Asia is lower than that of the international market but in the domestic market it is higher by five to seven times than that of the international market.

Research system

Remarkable changes have recently been witnessed in terms of agriculture, forestry, fisheries, and the food industry in the sub-region, which are primarily attributed to varying consumers' needs and the technical achievements for improvement of productivity and food quality to meet the consumers' demand. In this context, the national agricultural research systems in China, Japan, and Korea have played important role, in collaboration with provincial governments and private research organizations and universities, particularly to overcome the trade liberalization.

The first agricultural experiment station in China was established in 1902 in the Hebei province, followed by another one in Beijing in 1906. A number of agricultural experiment stations and universities were subsequently established and the Central Experiment Institute was founded near Nanjing, in 1932. A renewed focus on the development of the country's agricultural research was given after 1949, by the new government and the Chinese Academy of Science (CAS) and the Chinese Academy of Agricultural Sciences (CAAS), and several local-level bodies on agricultural sciences were established. Further, reorganisation of many research institutes was extensively done after the government at the end of cultural revolution in 1979.

Presently, there are about 1,142 agricultural research organization institutes in China out of which 60 organizations are engaged in applied and basic research at the national level. The crop based research institutes numbered 688, in all; and the corresponding numbers for the reclamation research, and the agricultural mechanization research were 121, 115, 63 and 175, respectively.

In Japan, the Agriculture, Forestry and Fisheries Research Council (AFFRC), under the Ministry of Agriculture, Forestry and Fisheries (MAFF), leads the boundry's NARS. Among the National Research Institutes, affiliated to the MAFF there are 29 research organizations in all; 19 for agriculture, 1 for forestry and 9 for fisheries. Further, out of the 381 local research institutes in Japan, 208 are engaged on agricultural research, 53 on forestry research, and 85 on fisheries research.

Organized agricultural research started in Korea in 1905 with the establishment of an agricultural demonstration farm in Seoul. The following year, this farm was shifted to Suweon, which was expanded and renamed as the Agricultural Experiment Station in 1929. Several branches at different locations were also established. After the Second World War, the station was again renamed, as the Central Agricultural Experiment Station and re-organized as the Office of Rural Development (ORD), in 1962. In the 1970s, ORD was renamed as the Rural Development Administration (RDA). The RDA, under MAFF, holds the national leadership of the Korean NARS.

Recently, with the rapidly changing national and international scenario, other important reforms the restructuring of RDA organizations and the adjustment of research projects in 1994. Presently,

the RDA is composed of five bureaus (Planning and Management, Research Management, Extension Services, Farm Management, International Technical Cooperation Centre), 12 national research institutes one National Seed Production and Distribution Office, a Korea National Agricultural College, 32 region-specific crop experiment stations, and the provincial RDAs (PRDAs). In addition, some other institutes both in the public and private sectors participate in the agricultural research. In Korea, there are 20 national research organizations and 50 local stations out of which are 55 carry out the agricultural research, 2 are engaged on forest research, and 12 on fishery research.

Research budget

The NARS in all the three in the sub region countries are exclusively supported by the central and provincial governments. In addition, participation by the private sector in agricultural research has become substantial although their exact contributions are not known.

The research budgets were the highest in Japan; the total expenditure in 1993, being 2,411 million dollars, out of which 1,560 million dollars were allocated for agricultural research (64.7 per cent), 232 million dollars for forestry research (9.6 per cent), and 619 million dollars for fisheries research (25.7 per cent). China invested 49 million dollars for agricultural research out of the total investment in national scientific research to the time of 279 million dollars. It is expected to increase expenditures on the agricultural research in the near future. In Korea, RDA budgets for research and extension have increased steadily but the proportions, as compared to the total budget of MAFF and the nation, have levelled off; the research budget increased 10 times but the proportion of research to total budget of MAFF declined from 2.62 per cent to 1.46 per cent during 1980-1993. The budget for agricultural research was about 73 million dollars out of total research budge of about 83.4 million dollars which included research on crops (69 per cent), advanced technology (14 per cent), production environment (7 per cent), farm management and international cooperation (2 per cent), and general support for research institution (8 per cent). Also, a sum of 3.4 million dollars was provided for forest research and 7 million dollars for fisheries research. More investment in the technology development for the advancement of agricultural industry is envisaged, in near future.

Agricultural research scientists

The number of research scientists engaged in agriculture and forestry in China are approximately 74,000 and 1,800, respectively. Of the total research scientists in Japan (10,793), 69.4 per cent are engaged in agricultural research (7,490), 11.0 per cent in forest research (1,190), and 19.6 per cent in fishery research (2,113). The administration, coordination, research assistance staff that assists the agricultural research in Japan is nearly 10 thousands. Of the total 2,475 persons engaged in research in Korea, 81.6 per cent have been working on agricultural research (2,019), 7.5 per cent on forest research (185), and 10.9 per cent on fishery research (271). The number of research scientists in RDA, the main national agricultural research institutes in Korea, increased from 357 to about 2,000 persons during the past three decades which is still insufficient.

Research priorities

Common research priorities

Enormous increase in crop productivity has been achieved during the last three decades. This was mainly due to the improvement of varieties and cultural practices adapted for the new high yield varieties, innovative cultural practices such as mechanization, polyethylene film mulching and tunneling, or seedling nursery techniques, technology for increasing efficiency of fertilizers agro-chemicals and the quality control of crop production, in addition, active research has also been undertaken on livestock, forest, and fisheries.

The common research priorities in China, Japan, and Korea share several aspects, such as, of quality improvement, biotechnological innovations, sustainable agriculture, etc. Keeping in view, the

common agricultural situation which is characterized by small scale farming systems, much emphasis has to be placed on the increase on agricultural production per unit area. Specific factors needing priority research attention across the sub-region, in China, Japan and Korea, may be focussed on the following areas :

1) Diversified and high quality oriented development of agriculture, forest, and fisheries products.
2) Stable production of grain crops.
3) Biotechnological innovations to create extra revenues in agricultural, forestry, and fisheries products, and introduction of new technologies to improve physical and nutritional quality.
4) Technical support for organising suitable local export markets based on enhancement of activity in rural fishermen communities in Japan and Korea. However, in China, banks and rural credit cooperatives have been providing such support at the local level.
5) Low-input, sustainable development of agriculture, forestry, and fisheries compatible with the preservation of environmental resources and natural eco-systems.

Country-specific research priorities

Some salient important specific research priorities specific to countries within the sub-region could be drawn from the comparative picture of national economy, agriculture and its role in the national economy of individual countries. Japan is a highly developed state of national economy, but it is geographically composed of many islands showing limitation of land for cultivation. Korea is fairly developed, but its agricultural resources are also very limited. China, on the other side, has good potentials for developing its agriculture because of natural factors.

Much research has been focused on the utilization of rice heterosis in China eversince the report on the phenomenon of rice hybrid heterosis in the 1920's. The achievements could be largely divided into five areas, namely, as

(1) development of a group of rice male sterility lines utilizable in production;
(2) development of superior high-yielding hybrid rice cultivars;
(3) production of hybrid seed and multiplication of sterility lines;
(4) creation of the patters of high-yielding cultivation; and
(5) detailed research in the area of biological background of rice male sterility, genetic patterns of three line composition and cultivation properties.

Besides, hybrid research has also been conducted on maize for the development for new varieties with high yield, above 75000 kg/ha, high oil and lysine content. Recently, computerized cultivation technologies have been developed through the control and coordination of crop growth.

In China, particularly high research priority may be give to the following :

i) production and utilization of hybrid seed,.
ii) physiological basis of storage of horticultural produce,
iii) effect of climatic change on the crop production,
iv) forecasting of crop production through remote sensing,
v) diversification of forest lives,
vi) greenhouse effects on the forestry production, and
vii) increase in soil fertility of artificial forests.

Agricultural research objectives

China

* Development of under-exploited regions and establishment of stable yield and commodity production bases
* Protection of the farm environment
* Intensification of basic researches
* Development of efficient storage techniques and prevention of post-harvest losses
* Intensification of germplasm conservation
* Analysis of socio-economic aspects of various production systems

Japan

* Promotion of consumers-oriented research and development for diversified and high quality agriculture, forestry, and fisheries products
* Development of agriculture, forestry, and fisheries by means of development of bio-functions
* Development of agriculture, forestry and fisheries, based on the individuality of each region, and enhancement of activity in rural and fishermen communities

Korea

* Contribution to the development of agriculture, forestry, and fisheries, and to solving environmental issues, on a global basis
* Replenishment of generic research for supporting researches relating to agriculture, forestry, and fisheries
* Development of stable, cost-down, and labor-saving production system of major grain crops
* Improvement of quality and development of cost-efficient production system of cash crops and livestock
* Development of safe and pollution-free crop production and adequate pest management
* Creation of extra revenues by exploiting and adopting high-technology agriculture
* Technical support on the production for special local or export markets
* Development of sustainable agriculture

Agricultural research in Japan has been mainly oriented towards the following points which need for the priority attention:

i. development of better-quality, high-yielding crop varieties of rice, wheat, barley, sweet potato, legumes and oil seeds and of their food processing systems,

ii. development of environmental friendly crop production systems and management for sustainable agriculture through development of soil management techniques and methods of diagnosis of crop nutrients compatible with preservation of environment and sustainable production,

iii. development of biological and ecological control of insect pests, pathogens and weeds in harmony with ecosystem, and

iv. development of low cost and sustainable production techniques for crops,

v. development of large scale, mechanized and intensive land use based farming systems, energy saving production techniques for staple crops, such as no-tillage planting of soybean, transplanting without land preparation and direct seeding of rice and optimum scheduling of farm operations, rational systems of rotation of field crops through analyses of biological functions of crops for soil improvement and control of soil born diseases and pests, effective utilization of land and water resources,

vi. natural resource management for sustainable agriculture,

vii. marketing strategies and development of new production centers,

viii. farm-management systems for field crops, vegetables, fruits, livestock, and sericulture, and

ix. research on sustainable and environment friendly rural development, and optimizing the use of rural resources such as manpower, natural resources, and capital.

Particular research attention has been accorded in Korea to the development of high quality and high yielding cultivars of rice and other cash crops, such as, sesame, peanut, and medicinal plants, establishment of innovative cultural practices/techniques for enhanced production and low production cost, such as, infant rice seeding, direct seeded rice, no-tillage rice seeding production, development of a combine harvester for sesame, large grain cultivars for peanut, cropping techniques for improved quality medicinal plants suited to overseas demands, and bottle cultivation and year-round production systems for mushroom, improvement of cropping practices has also been focused for the mechanization and low-cost production for their end-use quality in upland crops, diversification of usages of crop products and improvement of agronomic environment for crop production, such as, pests control/ prevention, soil environment of crop, and integrated weed management, practical application of biotechnology for gene manipulation and collection, preservation and use of genetic resources, for safe conservation and sustainable use of plant genetic resources, about 20,000 seed samples have been preserved or duplicated, about 14,000 seed samples preserved at -18°C for breeding, and the germplasm bank with more than 130 thousand accessions of local and world collections established.

Specific agricultural research priorities, in Korea include

i) direct-seeded rice cultures,

ii) breeding of "Super Rice" with a productivity potential of (+) 7.1t/ha,

iii) mass-production system for seed-potato, using hydroponic system, Shift change

iv) high value-added sericulture industry through commercialization of a silkworm-based blood sugar suppressive, For Livestock,

v) a new breed of dairy cow with high milk production potential, and vi) technology to reduce agricultural pollutants to conserve environment.

Livestock

Research attention on animal sciences in China included the livestock production management for swine, poultry, and dairy cattle animal genetics and breeding, forage production, animal nutrition and production. The main achievements in the past, were as follows :

(1) development of a three-bred crosses and a complete set of feeding and management technology for lean pork production,

(2) development of a technique on the artificial insemination with frozen ram semen,

(3) general survey of selenium contents in the feed-stuff to help control the selenium deficiency in animal production,

(4) determination of the composition and nutritive value of home-made feedstuff for swine, poultry, cattle and sheep, and

(5) general survey of the Chinese animal genetic resources. Recently, research on the animal production has been directed to improve individual and group production of livestock, to develop forage crops, and to determine the best scale of animal husbandry for stable animal production.

In Japan, research on livestock included cattle, pig, chicken, sheep, goat, rabbit, quail, honeybee and small experimental animals. During the past forty years, production and consumption of domestic

animals has progressed both in quantity and quality. Future thrust, as proposed by the National Institute of Animal Industry (NIAI) includes diverse topics, such as,

(1) genetic basis of biological functions of domestic animals and application to breeding;
(2) reproductive mechanisms in animals and development of proliferating techniques;
(3) physiological and productive functions behavior in domestic animals in relation to behaviour.
(4) metabolic functions in domestic animals and their effect on utilization of nutrients in feeds;
(5) production of good and safe products;
(6) high and stable yield over environments; and
(7) promotion of basic research.

The main research areas covered in Korea aimed to improve the international market compatibility of livestock production and development production technology of high quality animal products, animal breeding and genetics, reproductive physiology, and biotechnology. Hanwoo calves were first produced by the transfer of embryos fertilized *in vitro*. Animal product utilization research included cutting methods, proper storage methods, shelf life, vacuum packing, etc.

The Chinese Academy of Fishery Science CAFS have been i) technology for fishing and aquaculture, ii) quality standard, iii) fishery machinery, iv) development of aqua-product processing systems, v) protection and management of aquatic wildlife, vi) development of tele-communication and navigation systems, vii) extension of distant water fishing, viii) marketing information system for fisheries products, and ix) International technical cooperation.

The National Research Institutes of Fisheries in Japan have been engaged in research on fishery resources, fish culture, acceleration of development of ocean fishery resources, fishing ground protection in coastal fishery, ecological studies of fishes, far sea fisheries, aquaculture, and fisheries engineering.

The National Fisheries Administration (NFA) is involved in executes fishery policies and directs research activities in Korea at the national level. The agricultural sector fisheries industry has been felt important and therefore, artificial breeding and certain regulations were enforced for its promotion; Uncontaminated water areas along with fishery preserves should be managed to protect coastal fishing grounds from pollution. Modernizing processing facilities, long-range ocean study by remote sensing, movement and ecology of coastal fisheries resources, their movement and distribution.

The main research fields on forestry in China include silviculture, wood industry, chemical processing of forest products, and forest economics and information whereas in Japan, the fields of research interest in this include, (i) development of multiple use of forest, (ii) techniques for forest production and forestry efficiency improvement, (iii) activation of regional forestry and forest products industries, (iv) improvement and development of technology for wood resources utilization, (v) innovation for forest bio-resources development and utilization, and (vi) promotion of international research cooperation and contribution to the overseas forestry development.

The main research subjects in Korea were as follows: (i) research of forest policy and forest management structure, (ii) advanced utilization of forest resources and alternate uses of forest products, (iii) conservation of forest environmental function, (iv) development of short-term income sources of forestry, (v) improvement and cost saving, and (vi) forest protection against pests to conserve the forest ecosystem.

Environmental protection

The environmental components of agriculture include soil, water, meterological factors, living organisms, farm chemicals, energy, etc, mainly related to the cultivation of crops and animal production. The

complexity of the interactions among these factors results in the matter and energy cycle. The analysis of the interactions and mechanisms controlling the agro-ecosystem is an important research objective related to the agricultural environment.

The intensification and expansion of industrial and human activities have exerted a detrimental effect on the agricultural environment. The modernization of agriculture associated with use of farm chemicals and large machines has contributed significantly to the reduction of manpower and increase of productivity but at the same time has profoundly affected the agro-ecosystems. There is a growing concern for various phenomena that affected eco-systems worldwide, such as, the desertification process, increase of the concentration of carbon dioxide in the atmosphere, destruction of the ozone layer, and acidic deposition, etc. It has, therefore, become extremely important to preserve the environment in maximizing the use of beneficial functions in agriculture.

Agriculture in China is characterized with intensive farming which ensures high yields to support large population. Besides population, other resources, including finances may be a limiting factor. Every year industry and cities of the country dump and release 40 billion tons to wastage water, 800 million cubic meters of waste gas or steam, over 400 million tons of industries waste residue and 73 million ton of garbage. But the ability to dispose and retrieve there wastes is fairly low. Accordingly, the agricultural environment has been polluted. In addition, the degeneration of natural vegetation resulted in soil erosion and expansion of the desert area in China.

Biological diversity may have also reduced over years. Some 2,000 plant species are believed to have been extinct, with an estimated 5,000 species becoming endangered as a result of deforestation. The fundamental solution to polluted agricultural environments, worsened ecological conditions and loss of biological diversity emphasized on the new developmental model and new technological system for protecting the environment.

About 80 per cent of the surface area of Japan consists of farmland, pastures and forests. Agricultural activities do not aim solely at producing and supplying a sufficient amount of food products of food quality but also contribute to the preservation of greenery and water resources and to the purification of air pollutants in order to secure comfortable living conditions for the 120 million odd population of Japan. A highly productive agriculture is envisaged in harmony with the natural ecosystems through the development of integrated technology for the control and preservation of the agricultural environment.

The agricultural research trends in Korea has been shifted from input responsive, high production technologies to exploring means to achieve the desirable productivity of agriculture with the lowest possible input and minimal disturbances to agricultural environments, integrated management of soil resources, improvement in the efficiency of chemical fertilizers, recycling organic waster, integrated pest management, monitoring of environmental and climatic changes, etc.

Saving biodiversity

Genetic diversity has becomes more important to feed the increasingly thickly populated world. Rich and diverse genetic resources are prerequisite for successful crop improvement programs. Therefore crop plant species germplasm management, such as, in terms of field conservation, multiplication, characterization, rejuvenization, documentation and distribution, has become of utmost importance.

In China, Institute of Crop Germplasm Resources were established on 1978 in Beijing as national center for conservation and research on crop species germplasm. This Institute has contributed to the successful assemblage of 124,280 samples of different crops, including wheat and barley, 15,375 rice 40,564 and food legumes 36,188.

Table 31: Estimates of germplasm holdings in national centers of three countries

Crop	Number of accessions		
	China	Japan	Korea
Wheat and Barley	15,375	55,206	38,638
Rice	40,564	28,114	21,689
Food legumes	36,188	14,882	25,336
Coarse grains and industrial crops	10,079	10,016	21,866
Others	22,074	89,320	14,003
Total	124,280	197,538	121,532

In Japan, the Gene Bank has been promoted since 1985 for collecting genetic resources of plants, microorganisms, animals, forest trees, and aquatic organisms both in Japan and overseas. It performs classification, identification, characterization, evaluation, multiplication, preservation, and provides genetic resources and related information for research to national and public research institutions, universities, and public research institutions, universities, and private sector in order to promote national as well as international exchange of resources. The Gene Bank in Japan has maintained a total of about 2,00,000 accessions consisting of wheat, barley, legumes, rice, industrial crops, and coarse grains.

In the Korean Gene Bank, main emphasis was given on collection, conservation, evaluation, characterization, and utilization of genetic resources collected from plants and microorganisms. The RDA Gene Bank held about 120,000 seed samples, three fourth of which were main food crops favored by the Koreans. About 20,000 seed samples were maintained for multiplication, and 14,000 seed samples were preserved at -18°C for base collection.

Improving policy

Agricultural policy goals should be dynamic, consistent and across the national economic priorities. For many countries, important policy objectives are to ensure a prosperous and productive agricultural sector as well as to maintain a healthy and energetic rural population enjoying a high quality of life. Recent changes in new agricultural environments such as emergence of economic blocks and agreement at the Urguay Round are creating unprecedented pressure on Asian agriculture which has poor infrastructure for commodity production and marketing invested as compared with other sectors. The sub-regional countries are underway for an ambitious structural adjustment plan with appropriate government policy to overcome the unfavorable circumstances in the face of market opening.

In China, the average per capita share of various natural resources in China is already small compared with world average, mainly because of the high population pressure. The farmland per capita has decreased from 0.18 ha in 1952 to 0.12 ha in 1970, and to 0.09 ha in 1987 and per capita farmland is likely to shrink to 0.07 ha by the year 2,000. Commercial energy per person is equal to 0.63 ton of standard coal. It's only 5-10 per cent that of average level of U.S. and West Europe. In 1986, the consumption per capita of food, meat, milk, aquatic products, and fruit were only 23 per cent, 18 per cent, 1.1 per cent, 31 per cent, 3.9 per cent and 13.4 per cent, respectively, of that in United States.

Whereas agriculture in China contributes to the development of industry, the latter, on the other hand is not the driving force for the development of agriculture. Quantitative improvement in agricultural products has been significantly achieved in the past to support the large population and the current emphasis has been placed on the improvement in quality of agricultural products. The agricultural

policy in China has been directed to : (i) reform production management siting to China's national conditions, (ii) reform marketing system (iii) adjust and improve rural industrial structure, (iv) reform system of agricultural science and technology and education to accelerate extension, (v) give freedom function to state and agricultural banks and rural credit cooperatives to strengthen agricultural support services, and (vi) support to poverty stricken areas to boost economic development.

The strategies to achieve these objectives in China have been the following (i) to stabilize rural policies and the household system, linking income with output, (ii) to protect the cultivated land conscientiously and organize large scale comprehensive agricultural development, (iii) to increase the input to agriculture, (iv) to strengthen the agricultural research, technology and extension, and (v) to strengthen rural education and improve the standard of mass awareness.

The agricultural policies in Japan have to be oriented towards overcoming the difficulties associated with the decline of self-sufficiency rate in cereals, imbalance between supply and demand in rice as well as other crops, and the decline in number of people succeeding farming activities. In particular, agriculture will have to contribute not only to food production but also to the preservation of land and natural environment and to the enhancement of amenity function of the rural communities.

The recent trends to internalization of the Japanese economy, diversification and sophistication of the consumers' needs need to be furthered so as to solve the problems facing agriculture in Japan. The agriculture policy is directed towards the following: (i) to develop new technologies to meet the needs of the consumers for diversified and high quality agriculture, forestry and fisheries products, (ii) to develop agriculture, forestry, and fisheries by means of development of bio-functions, keeping in view individuality of each zone, particularly enhancement of activities in rural and fishermen communities, (iii) to contribute to the development of agriculture, forestry, and fisheries in solving environmental issues, on a global basis, and (iv) replenish the generic research for enhancing research support to agriculture, forestry and fisheries.

The Korean agriculture, characterized by small-scale family farm system, is still partially commercialized. However, Korea has been taking a series of open market policies since the mid-1980s in order to increase agricultural trade, thereby affecting the total value of agricultural imports by more than two times and also ensuring a diversified import market. Many government and semi-government organizations are involved in the decision making and implementation of Korea's agricultural policy changes in agriculture have to be adjusted to the new world economic order. The agricultural policies and regulation reforms should, therefore, ensure that liberalization. Decentralization public function is envisaged in Korea. As a result agricultural extension function shall be transferred from national to provincial level. A high Investment and financing, of $52.5 billion, is planned for rural areas for the period of 1995-1998 which will be invested for structural adjustment to effectively cope with the agricultural market liberalization. and a further $18.7 billion, collected through special tax plan for rural development to enhance competitiveness by 2004, shall be used for improvement of living environment and welfare. For the protection of agricultural environmental, Korea plans to establish a reduction policy target with a target of 50 per cent reduction in use of pesticides, and 40 per cent for fertilizers, by 2004.

Agricultural policies recently being directed in Korea are as follows: (i) to develop professional labour forces leading to management reforms, (ii) to enhance agricultural production, (iii) to construct industrial complexes in rural areas, (iv) to innovate new technologies for quality production, (v) to improve agricultural marketing systems with increased participation of farmers and fishermen, (vi) to enhance export promotion programme for increasing agricultural export by creating and promoting indigenous and competitive foreign markets for agricultural products, (vii) effective management of agricultural imports, (viii) to improve living conditions in rural areas through improved water supply, reconstructing

of rural villages, and modernizing farm house, improvement of rural education and rural welfare, (ix) to promote social movements and individual farm management consulting programmes in rural areas, deregulation of entry barriers to farmers, new direction of farm support policies, such as, assured need based government loans, (x) to introduce system to protect intellectual property rights, (xi) to promote information networks for agriculture, forestry, and fisheries, (xii) to enhance international cooperation, and (xiii) to conserve the earth's environment and to stimulate public role in agriculture.

Strengthening national agricultural systems

Effective adaptation to global changes in agricultural environment is important to promote the competitiveness in the sub-region. It is, therefore, necessary to strengthen the National Agricultural Research Systems (NARS) through effective training, dissemination and networking of agricultural information, and organizing and managing research projects.

There are about 2000 senior scientists, and about 5,000 technical personnel with engaged in agricultural research in China. Emphasis has also been placed on the training young agricultural scientists on job and their career advancement within the region or in other countries abroad.

In Japan, on-job training of in the fields of bio- and environmental technology, including the basic and specialized application of Radio isotopes and use of satellite data, sericulture, horticulture, agriculture, and other areas is given a high priority.

Similarly, in Korea, RDA, on-job training of researchers and extension workers within the country and abroad, their participation in international conferences, or agricultural technical guidance to various developing countries in the fields of agriculture, vegetable, fruit, agricultural machinery, agricultural economy, rice, and wheat.

In the field of information dissemination, China has established its Agricultural Research Information System (AGRIS) National Center, and contracted with FAO in translation and printing of its publications in Chinese. In Japan, the major national on-line network systems are INS (Information Network System) and DDX-P (Digital Data Exchange Packet) and the national data communication networks are linked with 32 research institutions. Korea has also been setting up computerized databases and information retrieval systems developed on VAX 6,000-420 computer using BASIS software. It has also joined the DIALOG databank in USA since 1986 and provides on-line retrieval services for agricultural researchers on request.

Although the NARS are well organised and strong in the sub region yet, with the new awareness and global developments several non-government organizations (NGOs) have emerged towards the management of non-traditional information networks.

These NGOs, as partners of government organizations, have been established to deliver public services to educate farmers on agricultural technologies and farm management, improve rural life, etc. Agricultural journalism has also contributed to the effective technology transfer to farmers. The role of NGOs in China is not so visible, but with the advent of international trade liberalization, various NGOs are likely to emerge in future.

Collaboration and system-wide initiatives

It is important to enhance the collaboration and cooperation with other advanced countries, and to provide assistance to the developing countries particularly with the increased emphasis being placed on the globalization. At the same time, it is important to give a direction to agricultural research towards 'systems' approach, involving the crop/commodity, agro-eco situations, social settings and further needs.

China developed cooperation with international organizations since later seventees. It has active technical cooperation/interaction with West Germany for the improvement of rural community, with

Canada for agriculture and forestry, with USA for unrelated forestry fields, with Russia for crop physiology and ecology, with Mexico and Brazil for livestock and forestry, with Japan for extensive Science and technology programme, with European Commission for dairy Science and with UNO for food for work project.

In Japan, International Research Center for Agricultural Sciences (JIRCAS) pursues exchange and collaboration with various research centres and other government agencies, including collaboration with IRRI for the development of stabilization technology for rice double cropping in the tropics, with ICRISAT for sustainable cultivation of upland crops in semi-arid tropics, and analysis of environmental changes in agricultural land after forest clearing in the tropics and development of sustainable land use systems, with CIMMYT for improvement of high-yielding wheat varieties using biotechnologies, with IITA for studies on eco-physiology, with CIP for characterization, evaluation and utilization of genetic resources of root and tuber crops, with ILRI for Genetic and physiological studies and biochemical characterization with of livestock, IIMI for improvement of water management, with ICARDA for development of sustainable rangeland management in WANA, with CIAT for eco-physiological studies on upland rice roots, and persistence of tropical pasture plants, and with ICIPE for locust management and development of biological IPM.

In 1994, in Korea contributed to 6 CGIAR centers to aid their researches on global food production. Further, cooperative research programmes undertaken by Korea with the international research centres included with IRRI, Philippines for rice breeding and cultivation, with CIMMYT, Mexico for wheat and maize improvement, with CIP, Peru for potato breeding and production, with IITA, Nigeria for tropical crops research, with CIAT, Colombia for pulse and small grain crops research, with ICRISAT, India for pulse and legumes breeding, with IRGRI, Italy for PGR management, with AVRDC, Taiwan for vegetable crop research, etc.

Besides, Korea is engaged in the cooperative mode research fields of Agricultural chemicals, with UNIDO Philippines, Agricultural mechanization with ESCAP Thailand, Rural development & welfare with AARRO India, Agricultural production & fertilizer utilization with FFTC/ASPAC Taiwan, Utilization of isotopes with IAEA Austria, Rice cropping system with ARFSN/IRRI Philippines, Integrated pest management with UNDP U.S.A., and Animal production with APO Japan, etc.

Overview

The emphasis on general approach to agricultural research in the sub-region has changed from a simple increase in agricultural productivity, that was followed a few decades ago, to the present day emphasis on commercial and socio-economic aspects. Realizing this trend, most Asian countries including China, Japan, and Korea have more recently restructured their national agricultural research systems (NARS) on the basis of individual agricultural research priorities. Through the reorganized NARS, these countries have been able to face the challenges of producing more food and feed for ever-increasing population in a sustainable manner.

The research priorities in the People's Republic of China, Japan, and the Republic of Korea to be effectively pursued by their Research Systems must be framed on the basis of the regional vis-a-vis countries' requirements. These densely populated Northeast Asian countries appear to be able to meet major challenges facing the region, such as, the following :

i. socio-economic changes arising from population growth and urbanization, increasing affluence in the region, and the resulting shift in the rural farm structure.

ii. market openings and international trade agreements which are considered to be essential to the industrial well-being of the region.

iii. increasing emphasis on environmentally sound development, including bio-diversity issues, which will eventually result in an overall social benefit in terms of both economic productivity and quality of life.

iv. decentralization of government responsibilities and budget to regional and local governments with increasing accountability to locally elected authorities.

These challenges also suggest at the framework in which China, Japan, and Korea must provide innovative solutions to ensure national security, and rural prosperity in a globalized economic system.

Accordingly a high priority to food production and security in agriculture, forestry, and fisheries is, therefore, important. Research priorities have some commonalities across countries, particularly for the following :

(i) diversified research and development on new products for consumers,

ii) stable production of quality grain crops,

(iii) biotechnological innovations,

(iv) technical support for production for special local or export markets, and

(v) environmentally sound sustainable production systems in agriculture, forestry, and fisheries.

Besides these common goals to cover up areas specific to their respective needs, research on increasing productivity, protecting the environment and preserving biodiversity is a common concern. Whereas enormous increases in crop productivity that have taken place in the past three decades could be attributed to massive investment in plant breeding, agrochemicals and extension programmes, some new approaches are being advocated to increase the efficiency of inputs, and to extend growing seasons, such as, through the use of polyethylene film tunnels and houses. Increased labour efficiency and productivity is essential in all countries due to declining rural population. China in particular has made advances in hybrid rice development that resulted in significantly higher production. Japan has a strong emphasis on developing new systems of agriculture which take into account energy and environmental efficiencies, while improving the quality of life for farmers. Korea's efforts are more focused on crop breeding using innovative biotechnologies and on increasing the labour efficiency of various production systems. Advances in livestock sector are being made as well in all countries to provide consumers with safe and stable meat supplies. Research on fisheries are promoting fishery technologies for long-distance fishing as well as new methods for aquaculture. These new methods being improved with the input of more basic studies on the ecology and biology of aquatic life.

In the area of environmental protection, all countries are striving to reduce the overall negative environmental impact of agricultural practices. Soil conservation and proper management of watersheds was observed in China, rural environment preservation in Japan, and soil fertility management in Korea. Preserving biodiversity is also an important goal in the sub-region with significant research, survey, and conservation efforts.

Agricultural policy and technology development are developing in parallel. Chinese and Japanese policies are linked to supporting the development of technology and solving agricultural problems. Korean policy has been changing rapidly to adjust for the opening of agricultural trade in the region and to deal with the impact of GATT agreements and WTO rulings. Furthermore, Korea is the first country in the sub-region to develop a policy on reduction in agrochemicals by the year 2004.

China, Japan and Korea have strong extension and information systems for national and international communication and exchange. All these resource systems have the same direction, bring the dissemination of research results to farmers, for the increase in efficiency in production and consumption. It is thus amply clear that the sub-region is active in international collaborative research, in sending

technical experts to other countries and in also providing in-country technical training to foreign agricultural personnel.

The commonalities in the national agriculture situation in each country, such as, of the policy, support for research and extension, and of ecological conditions, clearly suggest that there is much room for collaborative work in the policy research, extension, commercial, and farming sectors. The future challenges can, nevertheless, be better met in a cooperative spirit and with common efforts.

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Pacific Island Countries

PACIFIC ISLAND COUNTRIES

The South Pacific Region covers an estimated area of 5,25,000 km^2 with a population of 6 million and a spread over 30 million km^2 of ocean. Substantial diversity occurs in the ecological typologies within the region and could be categorised into three main groups, i) Large Volcanic Islands : Large, rugged and mainly volcanic land masses which are rich in biological and physical natural resources, some with substantial mineral wealth and include Fiji, Papua New Guinea, Solomon Islands and Vanuatu. There is considerable potential for land development, etc. ii) Intermediate Size Volcanic Islands : These islands have rich soil but little or no mineral wealth except offshore. There is potential to develop land resources but better opportunities lies in marine resources with their exclusive economic zone. This group include the Cook Islands, Federated States of Micronesia, Tonga and Western Samoa, and iii) Atoll Group : These countries have very poor soils with limited resources. The major opportunities lie within marine resources of their exclusive economic zones. These include the Kiribati, Marshall Islands, Tokelau and Tuvalu and parts of Cook Islands, Tonga and Papua New Guinea.

Production systems in the Pacific Island countries ranged from traditional farming to high input production systems. The majority of farmers are involved with moderate production systems. i) Land availability per capita has been found to decrease in some countries, such as, Fiji and Tonga, due to increase in population demanding intensified land use whereas an increase was also recorded in others such as Vanuatu. The ratio of agricultural land to agricultural population ranged from 7.63 ha in Samoa to 0.36 ha in Solomon Islands in 1994. ii) Overuse of available land causing depletion of nutrient, and iii) Customary land tenure traditions and other priorities for urbanisation causing non-availability of land for agricultural purposes are the other limiting factors related to land resources.

Reliance on imported food resources rather than expanding local production is a familiar trend within the PIC which requires significant foreign exchange particularly with the escalating food prices in international markets following trade liberalization. This calls for an enhanced local agricultural production and utilisation with a clear-cut policy to consider several diverse options.

In 1992 imports accounted 90-100 per cent of cereal supplies except Fiji that covered 60 per cent of rice production locally. Potato was the main import for starchy foods although 80 per cent-90 per cent is locally produced, meat and milk production amounted 70 per cent in Tonga and 50 per cent elsewhere. The countries namely in Fiji, Papua New Guinea, Samoa and Vanuatu have specific goal for enhanced agricultural production. In terms of fisheries only 15 per cent requirements are met locally despite the availability of marine resources in abundance. This high dependence on imports is a major threat to economies of PIC from major disruptions in the international markets as well as natural disasters.

The Pacific Island countries are confronted by common problems with basically the same casual-effect. The depletion of natural resources and the problems of development at a sustainable level is a major task. Three general issues that affect any effort towards sustainable development include, i) natural disasters, such as, cyclones due to small size and fragile eco-systems of islands, ii) high population growth rate with increased demands, and iii) exploitation of natural resources under economic pressure.

A continuous clearing of forests for farming and plantation crops has caused considerable loss of biodiversity which is aggregated due to high rate of destructive logging practices, frequent soil erosion, loss of watershed, lack of reforestation and development. The demand for water in terms of both quantity and quality continued to be a major problem and is directly associated with land

use pattern and resource utilisation. This is much critical in the atolls where demand often exceeds availability. Often fresh water supplies are threatened by contamination due to pesticide, poisons, wastes and rising sea levels. Extensive development such as urbanisation, industrialisation, change of life styles continue to threat the balance of water supplies with frequent floods during the wet and droughts in the dry season.

Resource management for both the coastal and offshore fisheries constrained due to overfishing, illegal fishing practices, such as use of dynamite, etc., loss of mangrove areas, damage to coral reefs, exploitation by foreign fleets environmental problems due to continuous and unsustainable mining of sand and gravel, and insufficient economic benefits due to island economies.

Farming systems

Three systems may be clearly distinguished as follows:

Traditional farming systems

Traditional farming is practiced on small holdings with average size of less than 2 ha mostly using few external inputs for local consumption by the household. The major crops in these farming systems are root crops including species of *Alocasia, Colocasia, Xanthosoma, Cassava* and *Ipomea* in high lands and *Cyrtosperma* species in atoll islands. These are grown in an agro-forestry system with other food crops such as bananas, breadfruit, coconut, various fruit trees, medicinal plants, nuts, pulses and spices. This system is excellent for conservation of environmentally sound and sustainable biodiversity. Livestock production under the traditional systems has mixed success. While ruminant production is not as prominent as the monogastric livestock, pigs and poultry appeared to be successful and account for up to 90% of total production in some countries. External inputs are very low with mostly indigenous breeds characterised by low production levels, free ranging, and slow growth rate. Cattle is the main ruminant chiefly for beef production and common in the Cook Islands, Fiji, Solomon Islands, Papua New Guinea, Tonga, Vanuatu and Western Samoa. Goat production is common in the same countries at various levels of production. Sheep has recently been introduced to Fiji where dairy production is also practiced. Most breeds are exotic and are grazed in unimproved pastures or confine to small fenced land. Management is low, poor growth rate, low reproduction efficiency low, poor nutrition and low production.

Moderate production systems

Whereas mixed cropping is practiced at large, yet concentration is on a few selected cash crops in these systems. Root crops featured commonly in most countries but squash in Tonga and ginger, rice and vegetables in Fiji are important components. Family labour is used with additional manpower hired during peak periods. External inputs include mechanisation for land clearing and preparation, agricultural chemicals such as, fertilizer, herbicides and pesticides, which resulted in higher yield per unit area. Food crops or fallow follow the main crop with limited inputs. The system has potential for increased production at a sustainable level with proper management.

Livestock production is semi-intensive with the bulk of breeds and also feed introduced. Chicken production (eggs) is more successful than meat in most countries. The birds are confined to cages or litter and commercially fed. Semi-intensive pig production are common and viable in most PIC. Most operations are small which are usually kept in enclosed areas. The high cost of imported feed for pig production is eliminated. In general, the system has great potential with improved technology and management.

High input production system

The system is, mainly for, (commerce) oriented. It is practice on holdings above 2 ha and features several cash crops, appropriate technology and niche market. High production and returns are ensured

which depend mainly on external inputs. This is often made possible with financial grants and to some extent donor assistance. Examples of such system include ginger and sugarcane in Fiji, squash in Tonga and taro in Western Samoa. The system while being productive has contributed at the same time significantly to soil degradation, deforestation, loss of biodiversity and environment related problems for example, the plantation crops such as coconuts, cocoa, coffee, oil palm have lead to the loss of biodiversity. Further, these crops have suffered due to low international prices, low yield due to several factors, such as, as a result of poor planting material, pests, poor management and inappropriate technology. Successful livestock production for commercial purposes deals mainly with beef cattle grazed under coconuts or open field in Fiji, Vanuatu and to some extent in the Papua New Guinea, Solomon Islands and Western Samoa. A low growth rate, high stock density, low calving rate, poor pastures and management is a common feature. Dairying at the commercial level is not common in PIC due to low milk production, high requirement for external inputs and management. However some success has been achieved in Fiji with great potential for the future.

Forestry

The natural forests, their management and the afforestation projects are more prominent in Melanesian countries which have more forest resources, such as Papua New Guinea (42.1 m ha), Solomon Islands (2.5), Fiji (0.85) and Vanuatu (0.81) as compared with Polynesian countries, such as, Western Samoa (0.16), Tonga (0.01) and Micronesian countries such as the Federated States of Micronesia and Palau. Forest products are economically feasible for PIC earning an average for Papua New Guinea ($460 million), Solomon Islands ($43 million), Fiji ($41 million) per year as an example. Natural forests in the region include lowland tropical rain forest, mountain forests, swamp forests, mangrove forests or coastal strand-forest. Plantation forestry is at the early stages of development except a few countries such as Fiji where large areas have already been developed.

Continuous pressure on an already declining forestry sector is a concern in the region. Deforestation at an alarming rate continued with primary and secondary forestry transformed into industrial, commercial and/or residential areas. Agricultural development often resulted in clearance of forest leaving degraded land no longer suitable for farming. Soil erosion is common and at a detrimental level due to farming practices such as in the Cook Islands and ginger on sloping land in Fiji. Intensive logging have resulted in certain species once abundant to be at the point of extinction for example *Agathis macrophylla* in Vanuatu and Fiji. Monocrop systems have dominated traditional farming systems causing the clearance of forestry and lost of biodiversity such as copra production in Marshall Islands and Kiribati.

Fisheries

Aquatic farming in the region includes subsistence fisheries, commercial artisanal fisheries and industrial fisheries. Aquaculture is becoming important in some large countries.

Subsistence fisheries

Subsistence fisheries is common in the coastal areas, mangroves, inshore waters, in the rural community currently facing problems due to overfishing and pollution. There is a definite potential for subsistence fisheries development but, the remoteness from markets is the main bottleneck.

Commercial artisanal fisheries

It is most common fisheries production system in the region involving unsophisticated techniques such as motorised vessels without processing facilities. Fishing zones include the lagoons, shallow waters and outer reef edges. The main outlet for fish harvest is the local market. Further development depend on improving technology such as better fishing vessels processing facilities, equipment and marketing.

Industrial fisheries

This involves joint ventures between local authorities and foreign companies in deep or off-shore waters. The sector is involved mostly with the production of frozen or canned fish catering for export. Technology is sophisticated with the operation of large vessels, capital, skill management including market systems. Many of the PIC take advantage of their specific economic zone through joint ventures or leasing to foreign companies.

Aquaculture

In some PIC, where land is not a major constraint, some success has been achieved in aquaculture. Seed/spawn production is successful in Fiji and the Solomon Islands. Tilapia production, giant clam hatcheries, mussel production has been introduced with success to several countries of the region notably Fiji, Tuvalu, Solomon Islands, Micronesian Islands and Western Samoa. Poor technology and management, however, constitute the main problems.

Post harvest and processing technologies

The bulk of agricultural commodities in the region are marketed fresh. Information on post-harvest handling is lacking in most countries. In fresh produce not meeting market and quarantine standards in several cases mainly due to inappropriate technology and poor management. Pest problem has been a major constraint to trade in some of the produce. Assistance to PIC by various donor agencies in this area at both the bilateral and/or regional level have been substantial. The Regional Fruit Fly Project is one example of collaborative efforts in the region. Organisations in the region involved with these efforts include Aus-AID, EU, FAO/UNDP, USAID, NZ AID, SPC, GTZ and USP/IRETA/SOA.

Agro-processing industries in PIC has progressed well especially with larger countries. This may be attributed to low prices of commodities, for example, copra into oil or coconut cream, soap in Western Samoa or expansion of the agricultural sector, such as, sugar, industrial alcohol and spirits from sugarcane in Fiji, chips from taro, banana and breadfruit, cocoa in Western Samoa; ginger processing, fruit processing, wood chips, furniture in Fiji; traditional nuts in Solomon Islands, Papua New Guinea and others. Processing of livestock is carried out in some countries but still at a rudimentary level. Butter and powdered milk are processed in Fiji while meat is processed in sausages or canned in countries such as Western Samoa, Fiji, Vanuatu and others. Value-added products are limited but have great potential within the region, for example, production of tuna jerky in Kiribati and sashimi market in Japan are good examples.

Marketing

The marketing system in PIC is not well developed. The bulk of the agricultural produce is marketed fresh except for a few agricultural commodities. Marketing boards, commodity boards and cooperatives handle the marketing in most countries. Independent or privately operated enterprises are much more effective with greater success at large. It is often difficult to develop marketing systems due to poor infrastructure, high transport costs and insufficient resources. Exporters often lack resources and/or market intelligence to organise/supply the right product at the right time failing to exploit market opportunities. Root crops, fruit and vegetable are sold in market centres or road-side stalls. Post-harvest handling and transportation are poor resulting in poor quality produce and short shelf life.

Export of root crops, fruits and vegetables are made to Australia, New Zealand, West Coast of North America, and sometimes Japan. The export commodities include ginger, yams, cassava, root crops (taro, yams, cassava, alocasia), fruits (pawpaw, water-melon, bananas and plantains, coconuts mango) and some tropical vegetables. Major constraints with export of fruits and fresh produce are the irregular supply and lack of quarantine. The recent concern over fruit flies in the region have

made export of fruits and vegetable extremely difficult. It has become necessary for individual governments to have facilities for post-harvest treatment for potential exports so as to improve trading.

Livestock and products are geared for domestic markets in most PIC. As such most countries are importers of meat and other livestock products. The major problems for marketing livestock produce are small sizes, lack of skills, commercialisation, infrastructure and supply. Successful beef export is carried out in Vanuatu. Improved marketing system to include pricing is required to encourage livestock production as the domestic demand in most countries exceeds supplies.

Despite the huge advantage of most PIC in fisheries with their economic zones, the majority imported large quantities of canned fish. However, some export of high valued fish such as tuna is practiced to earn foreign exchange. Development of fisheries infrastructure to include organised catches, marketing and management should be a priority to improve efficiency, stability and output.

Domestic demand for timber is high in PIC with a number of commercial operations being set-up. Significant amount of foreign exchange is earned through timber export by some countries including Fiji, Papua New Guinea and Solomon Islands. At the same time, timber imports to meet local demand is high in many countries which may continue to rise in future.

NATIONAL AGRICULTURAL RESEARCH SYSTEMS IN PACIFIC ISLAND COUNTRIES

Considerable variation exists for NARS among countries of the Pacific sub-region which ranges from well established set-up to non-existent systems. The latter is common in small countries.

Several Research Structure and Organisation systems operated within the PIC with mixed results. Some concrete set-ups developed in the early period of the century less effective often failing to address new situations. In most countries, structural organisation for the linkages operation of agricultural research is lacking. Rather the set ups create problem with other services notably the extension. In such cases the operation of research services at the national level and that of agricultural extension at the provincial level has suffered due to poor linkages and communication.

In some countries changes in structure and organisation are taking place, such as, an independent national institute for research has come up in Papua New Guinea; single division has been set up for research in agriculture, fisheries, forestry and livestock in Western Samoa; private research set-up has been established for specific commodities such as sugar in Fiji.

Concern for information and communication barrier is common in the various systems in operation. There is a definite need to build up effective NARS so as to achieve the following.

i) to improve the flow of communication between levels and among units within the system establishment,

ii) to improve collaboration with other units such as the extension and information and

iii) to improve and/or modify the set ups to fit so as to work in the research division.

Agricultural research policy

Most countries recognise the need for an effective agricultural research policy that would ascertain positive interaction between the system and national development policy. The various systems in operation reflected agricultural research policy as fixed; too general and/or "insignificant" which is positive interaction between the system and national development policy, required to respond to programs and priorities that support the national development policy. A short-term vision and a top-down approach without the inclusion of all relevant stakeholders are among the common weaknesses in the current scenario.

Some PIC have already started with the basic process of setting priorities, and allocation of resources and making long-term plans. However most of the countries neither have an existing agricultural research policy nor trees are in the process of formulating one. Fiji and Papua New Guinea have made considerable progress with their own efforts. The Cook Islands, Solomon Islands, Tonga and Western Samoa have also shown some headway whereas the rest countries still depend on external assistance or project oriented research. In general, the need for setting up research priorities for the sub-region and the countries is strongly felt.

Several regional organisations and institutes collaborate with agricultural research in the PIC but these do not follow target specific research properties. Emergency requirements such as pest outbreaks or other specific requests from countries are met in these collaborative works. IRETA which deals with research in the region via the USP/SOA has no definite policy for regional research but the Regional Advisory Board and aid agencies interact to find priorities that could be aided for.

Agricultural Research Management

Six most critical factors that would influence agricultural research management in the Pacific Sub-Region include:

i) Program Formulation and Budgeting,
ii) Monitoring and Evaluating Research Programs,
iii) Developing and Managing Human Resource,
iv) Utilisation and Development of Physical Resources,
v) Information Management and
vi) Acquiring and Management of Financial Resources.

A common practice particularly in Fiji, Papua New Guinea and Tonga has been the project driven, donor oriented program formulation. Other countries are at early stages of such development. Monitoring and evaluation of research programs has been inadequate and the need for an effective program is emphasized. The lack of qualified personnel at the scientific and technical levels has been one of the major constrains in the sub-region. Well designed on-job training programs in the sub-region or abroad, that addresses the weaknesses of the current practices and suggests their remedies, are highly required.

Unavailability, under utilisation, inappropriateness, low quality and poor and insufficient allocation of resources for agricultural research are common problems with the countries which, in conjunction with other factors, limited the implementation of technology. The situation is much critical with smaller countries in comparison to their larger counterparts.

Access to information and communication both at the national and international levels has been a limitation in most of the countries except a few, such as, Papua New Guinea and Fiji. It is primarily attributed to weak organisation set up and management of the system. Therefore, greater benefits could be achieved from information networks at the national, regional and international levels. In framing a suitable policy and its implementation, managements need to examine the levels that can be sustained by NARS particularly under the national capabilities.

Strengthening national agricultural research systems

Strengthening of NARS is urgently needed for most island countries. Except some of the larger island countries such as Fiji and Papua New Guinea which are already having some organised NARS. Agricultural research for productive and sustainable development is presently pursued in the smaller island countries through regional (eco-region) groupings or mechanism. Therefore, in order to strengthen

the NARS, there is a need to pursue the following, i) Institutional Strengthening and Training, ii) Information Dissemination, iii) Organisation and Management and iv) Networks.

Development and participation of agricultural research networks need encouragement for NARS in the region. This will facilitate technical cooperation, human resource development and exchange of ideas, know-how and material. Most of the NARS in the Pacific Sub-Region do not have the capacity to implement research programmes on their own. However through networks research activities could be implemented at collaborative and mutual agreement.

ISSUES, PROBLEMS AND POSSIBLE ACTIONS

The Pacific Island countries are rich in biodiversity as well as cultural diversity. At the same time this sub-region suffers from such factors like poverty, weak economic sectors, narrow resource base, isolation from markets, low food security and vulnerable to natural disasters. Agriculture in these countries is faced with increased demands and strong competition for scarce resources. Sustainable development requires a holistic approach, changes in attitudes, consumption and production systems. Agricultural research on priority areas in collective and/or collaborative mode shall play a vital role in meeting sustained demands. Enhancing self-reliance in supply of food, raw materials, employment and income for the rural community are the primary goals for the R&D sector.

Sustainable farming systems

Agricultural intensification, deforestation and degradation of natural resources due to demand for increased production have lead to serious problems for most countries in the sub-region. The continuation of these practices have posed threat to existence of many species and there is a need of regeneration of such indigenous tree species near extinction in sufficient numbers in appropriate agroforestry systems should be encouraged. Such systems may be developed using both indigenous and exotic multipurpose tree species lower production costs for food, income, shelter, soil conservation, animal food and implemented for sloping land, flat land and low lands. In areas where agroforestry is not practical for various reasons, short duration crops, such as, food legumes may be included in the farming system to improve soil fertility, and increase food production and soil and water conservation.

Considerable experience and technology, external assistance (through FAO, European Union-PRAP and others) is available to assist in improving the current situation which is limited should be strengthened. However, research on legumes and cover crops needs to be encouraged. Some possible action include as follows: i) sustainable agro-forestry systems should be developed to increase and diversify production under traditional systems, improve and conserve soil fertility and moisture, prevent environmental degradation and reduce external inputs. Rare indigenous plant species or those that are near extinction could be introduced in this system, ii) short duration cover crops should be introduced under the intensive systems to improve production levels, prevent degradation of environment, depletion of resources and biodiversity, iii) farming system research should be linked to socio-economic issues that have impact on adoption of new technology.

Plant production and protection

Plant genetic resources

Biodiversity in the Pacific Island countries includes both indigenous and introduced species, cultivated forms and wild life. That sustained the needs of island people for food, fibre, shelter, medicine as well as cultural traditions. However, the sub-region with its fragile ecosystems is vulnerable to rapid changes in population growth, urbanisation, industrialisation, agricultural intensification, deforestation, environment degradation, pollution and trade pressures that challenge the conservation and sustainable utilisation of resources including biodiversity and requires a collected effort to reduce

their impact. Several initiatives in the sub-region to establish and collaborate efforts for conservation of biodiversity, sustainable use and equitable sharing of benefits such as the recent SPC formed PACINET and PPPO should be encouraged and further strengthened.

At the same time collaboration with other regions for the sustainable conservation and use of plant genetic resources should also be encouraged.

Root crops

i) *Taro* : Several pests of economic significance are threatening the taro industry. The taro leaf blight disease *Phytophthora colocasiae* has almost wiped out taro in Samoa, also a serious pest in Hawaii, Papua New Guinea and Solomons. It is a threat to other islands and its spread could bring in devastation. The two virus diseases present in the Solomon Islands and Papua New Guinea have detrimental effect. The Taro Beetle is another major problem present in Fiji, Solomon Islands, Papua New Guinea and New Caledonia. Drought is a major problem in Fiji and Tonga and increasing in other counties due to unsustainable farming practices.

ii) *Yams* : Few varieties are cultivated and the *Anthracnose colletotrichum* sp. is the major disease. However, yams have attained importance as cash crop due to the economic impact of the TLB disease on taro.

iii) *Sweet Potato* : It is a common root crop for most countries with major problems including the scab and the sweet potato weevil. Screening of cultivars for high yield and resistance is done as a major effort in Papua New Guinea involving PRAP and ACIAR.

iv) *Cassava* : Few problems are encountered with the production of Cassava. However, the introduction of high yielding low cyanide level varieties could be useful. The threat of Cassava Mosaic Virus should be considered with the movement of germplasm between countries.

Root crops are significant as source for food, income and tradition in most PIC. There is a need for improved high yielding and pest resistant varieties. Much experience and technology is available elsewhere and access to these networks will be valuable. Improved cultivars of yams are available from IITA, cassava and potato from CIP and sweet potato from CIP and AVRDC. Improved cultivars are available within the sub-region and include sweet potato in Papua New Guinea, taro in the Solomon and Papua New Guinea. A threat of virus diseases has however, limited the distribution of taro and yams in Tonga. Collaborative research in a network should be given high priority for the sub-region.

Possible actions

i) *Pests* : Breeding for resistance to major diseases and pests should be given high priority. Some work in this direction is being taken up at Solomon Islands, Papua New Guinea and Western Samoa which needs priority and support.

ii) There is need to strengthen research on root crops in the network. Genetic resource collection and maintenance of genotypes of root crops that exist in the sub-region and tissue culture for their *in vitro* conservation and dissemination require priority consideration.

Tropical fruits, nuts, spices and vegetables

Although few fruit tree species are grown, mostly in home gardens, yet the indigenous genetic resources have a potential to meet the needs for fruits and improved nutrition. Market availability of fruit tree species is limited and various countries in the sub-region export limited quantities of pawpaw, banana, mango, pineapple and watermelon mainly to New Zealand and Japan.

Post harvest treatment for fruit flies before export constitutes a major area of priority consideration. Although the potential for development is high yet is confined to a few varieties. *Canarium* nut,

Brazilian nut and Terminaria nut species has commercial value and are being promoted in the Solomon Islands and Papua New Guinea.

Vanilla production is successful in Tonga but has potential for other countries. Black pepper, chilly and other spices are currently in high demand. Ginger is successful in Fiji and could be extended to value-added products. The range of vegetables grown in the sub-region, except Fiji, is very narrow. There is potential for export especially to niche markets as done with squash in Tonga.

Cereals and pulses

i) Most PIC except Fiji do not grow paddy due to unfavourable conditions for cultivation. Corn is grown mainly as a vegetable. There is a need to prioritize research on some food grains such as sorghum, for livestock feed or for diversification of farming systems.

ii) Peanut is the most common food legume grown but it is associated with the major problem of leaf rust. Fiji import pulses in huge quantities which indicates a scope for intra-regional market for this commodity.

Coconut

It remains to be the major crop for PIC despite low world prices. External assistance is available to test genetic material and investigation for virus diseases. However, there is a lack of improved high yielding and pest resistant varieties. Improvement in agro-processing, development of technology to clean improved genetic material for distribution and improved management of coconut based farming/cropping systems comprise some priority actions for R&D.

Bananas and plantain cultivation is constrained due to the occurrence of several diseases and pests, such as, the Black Sigatoka Disease (BLS), Bunchy Top Virus and Nematodes. Resistant cultivars to BLS Disease were identified in Tonga and Western Samoa with the assistance from ACIAR and INIBAP for the screening program. A medium level of priority should be attached to research on this commodity with continued assistance.

Livestock production and animal health

Livestock production has a limited scope in the Pacific Island countries due to several factors, such as, poor genetic stock, poor nutrition, high costs of external inputs, inadequate management and labour shortage. Most countries depend on imports of canned meat and cheap cuts which, nevertheless, calls for the development of a semi-intensive indigenous livestock production system. Intensification in poultry is possible in most countries which, however, requires external inputs. Introduction of alternate livestock for beef production may be possible in countries, such as, Fiji and Vanuatu, where land is available and management is adequate. There is a need to develop livestock feed industry for pigs and poultry, using local materials both directly and in various feed formulations, establish market structure and support small scale operations. Improvement in local breeds and management practices need priority consideration being the best option for most PIC. Pasture improvement is essential for cattle and goat production.

SPC provide Animal Health Services through donor assistance for most countries. The current system needs to be improved with adequate training and HRD of the nationals.

Fishery resources

An over-exploitation and depletion of inshore resources, pollution are some of the constraints in this important sector primarily due to lack of appropriate assessment of small-scale fisheries (artisanal and subsistence). In order to prevent further exploitation of inshore fisheries, there is a need to develop offshore fisheries, lack of expertise, information management and weak resources, law enforcement, and improved technology. The potential for marine resources in PIC is huge yet it

needed proper planning and utilisation. This involves policing of catches and development of sustainable programs.

The current efforts by the South Pacific Commission Fisheries Forum Agency in managing marine resources needs to be strengthened and expanded to the entire sub-region and including all stakeholders. In addition, there is a need to strengthen aquaculture to encourage inland fisheries in countries where feasible, such as, in Fiji, Papua New Guinea, Tonga etc.

Eco-tourism has been successful in some countries and it should be encouraged and promoted for an alternative source of income in the sub-region as a whole.

Forest resources

Indiscriminate deforestation leading to the loss of biodiversity and depletion of wildlife is faced primarily due to agriculture intensification, infrastructure development, uncontrolled logging and natural disasters. Lack of policy, human resource development and management skills also contributed to these problems. Various countries have developed conservation policies for forestry resources including protection of endangered species, development of agroforestry and community forestry, watershed management, reafforestation and conservation, manpower training, etc. There is a further need to develop Policy and Coordination, effective use and conservation, integrated with appropriate rural development plans. Research to develop and/or improve on agroforestry systems requires medium term priority, cooperation and collaboration within and outside the PIC sub-region.

Diversification of agricultural production, post harvest management and marketing

A definite potential exists for the agroprocessing and value added industries in agriculture, forestry and fisheries, access to markets in the region and others.

A range of products from coconuts, such as, coconut oil, soap, detergents, cream, fibre, handicrafts and furniture could be fully exploited in the sub-region. Copra meal could be used for formulation of livestock feed. Other traditional crops especially for handicrafts could be utilised and promoted with better technology and management. Several rootcrops, banana and breadfruit are chipped, cooked and sold locally and as export as a small business venture in Samoa and other PIC. Cassava and sweet potato are peeled, frozen and sold in super markets. Small scale industries for preserved tropical fruits are already in operation in some countries and here they have a good potential for further development.

Export of tuna (sashimi) is lucrative yet it requires a well planned and set-up infrastructure. Smoked fish is popular among atoll groups that often face problems with transport, erratic supply, management, facilities for storage and limitations in terms of available technology. It has also been extended to other PIC. The post-harvest handling of produce and communication network, such as, roads are very poor at large resulting in low quality products. The need to have standards for agricultural produce for the local market and export is obvious.

An integrated approach to the system involving a package from the farm level to export shall guarantee regular supplies and meet importing countries' requirements. Such ventures could be encouraged in both public and private sector and need priority attention.

Research and technology transfer

Agricultural research in most PIC is at the rudimentary level, with most operations under the public sector and very little private sector involvement. Most agricultural research (including forestry, fisheries and livestock) concentrate on specific technology and commodity lines whereas a more holistic approach, often involving an interdisciplinary and collaborative approach, among institutes, is required for the future. A judicious consideration of the ecosystem management, production systems, biological

interactions and sustainability is warranted. Review and assessment of indigenous and traditional systems with development of appropriate technology is required. Agricultural research is likely to face competition persistently with other sectors and national priority areas for essential but scarce resources yet needing higher priority to meet the food and other requirements.

Development of national systems to demonstrate their capability in both the management of resources and impact on agricultural production is vital for ensuring allocation of resources from governments and other donor agencies. The exchange of information and experiences between national agricultural systems shall be highly desirable.

Human resource development in the region and extensive training could be used for capacity-building, policy makers, program and project managers, researchers, extensionist, farmers, NGO, private sector and the public at large. Access to NARS within and outside the region needs improvement. An integrated participatory approach at various levels involving all stakeholders should be encouraged. While institutional strengthening is a priority for most PIC its implementation need careful consideration. Most countries may find it difficult to establish institutions at the national level and require mutual assistance and also assistance from the regional interest groups and fora like APAARI.

There is a need to develop and establish agricultural research systems in sub-regional countries with clear vision and policies in accordance with national development plans. The national governments should willingly commit for the resources required, strengthening the NARS and monitoring the impact of agricultural research to production level. Development of common research facilities with specific mandates to address common interests is envisaged. Collaboration and cooperation of specific networks, such as, root and tuber crops on the lines of ASPRAD, banana and plantains, plantation crops, genetic resources etc. has to be fostered on priority. Research to target specific problems, such as, taro (viruses and leaf blight, banana improvement for the development of resistant varieties to bunchy-top virus and black leaf streak disease, coconut production etc. need to be particularly addressed in a time targeted, collaborative mode. A regional institute could be established to service such purposes and collaboration and cooperation with other regional institutes could be assisted.

Linkages between NARS both within and outside the region should also be encouraged. The information network should be particularly strengthened.

AGRICULTURE RESEARCH PRIORITIES AND DEVELOPMENT NEEDS

The sub-region includes two distinct group of islands, the atolls and non-atolls (volcanic) islands. The former includes the Marshall Islands, Kiribati, Tokelau, Tuvalu and parts of the Cook Islands and Tonga and the latter includes Fiji, Cook Islands, Niue, Solomon Islands, Tonga, Papua New Guinea, Vanuatu, Western Samoa (and American Samoa). Though lacking in technological wealth, the Pacific Island Countries show richness in biodiversity and unique ecosystems. Hence the need for strategic planning for sustainability is a high priority. For technical reasons and cost-effectiveness many research programmes will be best undertaken on a sub-regional basis.

In general, small island countries must develop and adopt strategies that allow optimisation of limited resources to prevent or minimise their vulnerability to both economic and natural hazards. The organisation of NARS and their effective linkage with other NARS/IARCs through the regional forum is essential to pay way for an effective development of agricultural research. Focus should be given on activities that i) allow diversification of the economy to increase resilience and alternative source of income, ii) integration of different sectors at the planning and implementation of programmes levels to prevent and reduce degradation of resources, and iii) promote and utilize traditional systems of production with appropriate technology and commit to its development at various levels.

Collaboration and assistance at the regional and international levels include macro-economic environment in fair trade, funding mechanism, sharing of financial constraints and mutual partnership and the external assistance is generally linked with the stringent conditions. The countries at large, lack the required resources and/or commitment to achieve full benefits hamper target achievement. Assistance for at least the identified high research priorities must be concessional with preferential terms and transparency.

Table 32: Priority levels for agricultural research and development for Atoll Countries of the Pacific sub-region

	Activities	Priority level	
		Current	Needed
I.	Crops		
	i. Farming Systems	H	H
	ii. Plantation crops	H	H
	iii. Cereals	L	L
	iv. Spices	L	M
	v. Oilseeds	L	M
II.	Horticulture		
	i. Fruits	M	H
	ii. Vegetables	H	H
	iii. Flowers	L	M
	iv. Roots and tubers	H	H
III.	Livestock		
	i. Cattle	L	L
	ii. Piggery	H	H
	iii. Poultry	H	H
IV.	Fisheries	H	H
V.	Resource Management and Conservation		
	i. Soil	H	H
	ii. Water	H	H
	iii. Environmental concerns	H	H
VI.	Land Use System		
	i. Range and marginal land	M	M
	ii. Agro-forestry	H	H
	iii. Degraded and wasteland	M	M
VII.	Biodiversity Conservation	H	H
VIII.	Biotechnology	M	H
IX.	Institutional Building and Human Resource Development	H	H
X.	Socio-Economic, Public Policy, Market Research Management Research	H	H
XI.	Germplasm Enhancement and Breeding		
	i. Crops	H	H
	ii. Livestock	H	H
	iii. Forestry	H	H
	iv. Fisheries	H	H
XII.	Processing, Product Development & Value Added	H	H
XIII.	Improving Policies	H	H

Table 33: Priority levels for agricultural research and development for Non-Atoll Countries of the Pacific sub-region

Activities	Priority level	
	Current	Needed
I. Crops		
i. Farming Systems	H	H
ii. Plantation crops	H	H
iii. Cereals	M	M
iv. Spices and pulses	M	H
v. Oilseeds	M	M
II. Horticulture		
i. Fruits	H	H
ii. Vegetables	M	H
iii. Flowers	L	M
iv. Roots and tubers	H	H
III. Livestock		
i. Cattle	H	H
ii. Small ruminant	L	M
iii. Poultry	H	H
iv. Piggery	H	H
IV. Fisheries	H	H
V. Resource Management and Conservation		
i. Soil	H	H
ii. Water	H	H
iii. Environmental concerns	H	H
VI. Land Use System		
i. Range and marginal land	M	M
ii. Agro-forestry	H	H
iii. Degraded and wasteland	M	M
VII. Biodiversity Conservation	H	H
VIII. Biotechnology	H	H
IX. Institutional Building and Human Resource Development	H	H
X. Socio-Economic, Public Policy, Market Research Management Research	H	H
XI. Germplasm Enhancement and Breeding		
i. Crops	H	H
ii. Livestock	H	H
iii. Forestry	H	H
iv. Fisheries	H	H
XII. Processing, Product Development and Value Added	H	H
XIII. Improving Policies	H	H

Needs and level of priorities

The need and priority levels of the sub-region for atolls and non-atoll countries are summarized. Individual countries are further presented in the table.The specific ecosystems involved have been kept in view while fixing priorities for agricultural research in PIC.

Lack of clear and precise agricultural research policy constrains development in most of the PIC. Common elements among countries in the sub-region to address this situation include:

i) agricultural research should target ecological, social, economic and technological considerations for both traditional and modern systems,

ii) national development plans should simultaneously consider food security, environment protection and biodiversity conservation,

iii) macroeconomic and sectoral processes that affect population drift to environmentally fragile areas need careful study alongwith institutional reforms to improve on land tenure rights,

iv) priorities of NARS should also include research on economic costs of production,

v) biodiversity conservation, utilisation and sharing of benefits, environmental protection and documentations of traditional knowledge and heritage rights.

Increased productivity, food security and nutrition

Crops

A high priority should be accorded to the development and management of appropriate farming systems including the traditional systems. Cultivation of indigenous plant species, particularly those near extinction, for agroforestry and the conservation of biodiversity equally need high priority. The traditional systems may be improved by introducing short duration cover crops to improve production and soil fertility. There is a need to quantify yield and nutritional value per unit area under different production systems, response to various pest management practices, IPM, genetic resistance and minimised dependence on pesticides.

Promotion of plantation crops, namely coconuts, cocoa, coffee and pandanus (for atolls), development and promotion of plantation crop based production systems utilising less productive existing plantations, utilisation of genetic resources for alternative uses, safe movement of effective exchange germplasm, PGR conservation also need priority consideration.

The crop commodities that need research priority consideration in the region include cereals with a low priority mainly for crop diversification, food legumes (peanuts) with a high priority to improve nutrition, soil fertility, import substitution and livestock feed, pulses (Pigeonpeas, Chick pea), with a medium high priority promote trade of among the sub-regional countries, chilly, black pepper, cinnamon, with a medium to high priority.

A high priority may be accorded to oilseeds in order to increase self dependence and reduce imports. Fruits, vegetables, roots and tuber crops are identified in the high priority category whereas development of flowers has been considered a medium priority.

Horticulture

Introduction and adaptability testing of improved fruit tree species, alongwith improved technology and management practices, development of their post-harvest technology, agro-processing and pest control particularly for fruit flies may be shortlisted as the high priority research areas on fruit plants whereas in vegetables, improvement in production may be aimed through the introduction of improved varieties, better seed production and management technology, organic and hydroponic farming. Taro, yams, allocasia, xanthosoma, cassava, sweet potato and cyrtosperma should be included for the atoll ecosystems. Development of cultivars resistant to the Taro Leaf Blight disease and viruses; introduction, collection, particularly from Papua New Guinea and Solomon Islands, screening and safe distribution of improved cultivars and conservation maintenance of genotypes in the region need priority attention. Strengthening of tissue culture facilities is equally important for conservation, safe exchange and use of germplasm.

Cut flowers have been at the medium level of priority for most PIC. Introduction of improved varieties and technology for niche markets except for Fiji, Western Samoa should also be given the same priority ranking.

Development of root crops and tubers, that anchor the staples in the sub-region, could be best envisaged through network approach for the sub-region on the pattern of ASPRAD and linkages, both inter-and intra-region, involving technology transfer, institutional strengthening, information and research collaboration should be strengthened on a high priority.

Livestock

Potential for the development of piggery, poultry and fisheries in the sub-region is high whereas cattle continues to be a low priority commodity. Development and strengthening of efforts for animal health epidemiological surveys; contingency planning and quarantine improved LPM and processing technology; information management; human resource development and marketing systems need a high priority consideration.

Piggery

Development of pig feed based on local ingredients and improvement in its production systems, identification of poultry species suitable bots for atoll and non-atoll ecosystem and improvement in their production systems need high priority in most countries in the sub region.

Fisheries

A high research attention on fisheries production and marketing should include utilisation of coastal ecosystems, improved resource management through accurate stock assessment and harvesting level; population dynamics and reef ecology; aquaculture development where feasible. There is a further need to improve and adopt policies and legislation for protection and utilisation of marine resources and also to strengthen existing regional and international efforts such as SPC Fisheries Forum Agency in fisheries development.

Resource management and conservation

Soil erosion and degradation is common in PIC both due to natural causes and poor planning for agricultural practices. Urgent measures need to be taken for the development of land use policies and also the development/improvement of sustainable technology planning management practices. Critical areas that need high research priority include,

i) studies on influence of physical and chemical properties of atoll soils on water and nutrient availability and the effect of inorganic fertilizers, pesticides, etc.,

ii) development of suitable technology soil conservation practices that are compatible with farming practices, such as, mulching for retention of organic matter on soil surface and replenishment of nutrients,

iii) alternatives to 'slash and burn' cultivation,

iv) preservation of ecological balance among vegetation, systems and climate and soil under agroforestry introduction of new system components and management practices in relation to agriculture and environmental changes, and

v) improvement and promotion of traditional production systems in relation to soil conservation and management through information network and training through NARS-NARS collaboration.

Any effort to conserve and manage water resources require an integrated effort from all sectors continuous use of pesticides and inorganic fertilizers affecting water availability and quality particularly in atoll countries.

fish tolerant to environmental stresses such as salt, drought, cyclones pests/diseases. Reafforestation under various integrated production systems, introduction and improvement of multi-purpose tree species including those tolerant to environmental stresses, introduction of improved species of fish for adaptability for restocking marine resources and evaluation aquaculture development need to be given high priority on a sub-regional basis.

Processing product development and value addition

Development of appropriate technology and expertise in agro-processing especially small scale operations to increase value and market potential of products improvement in low-cost processing techniques for small scale fish processing and post-harvest management, development of improved technology for utilisation of coconut wood for diversified products, such as, oil, soap, detergent, cream, fibre, handicrafts, timber and animal feed, and improved processing of packed food from root crops, banana and breadfruits, processed fruit products and spices could together result into additional income generation, including foreign income, and should, therefore, receive high research attention in a collaborative mode.

Conclusions

The need to develop and improve NARS in most PIC through institutional strengthening and human resource development is identified to better highest common priority for the sub-region. Particular attention is required to organise and improve management and generate skilled manpower through on job training under the NARS, in other sub-regions or human resource development through career advancement. The results of new and improved technology, appropriate production systems could be effectively extended to farmers/users for the enhanced performance of the agricultural sector only trained and dedicated with good and skilled manpower.

National governments must develop well defined and clear cut agricultural research policies, infrastructure and commitment of resources and the NARS should emerge strong in terms of decision making. Research attention in the inter-NARS and NARI-IARC collective modes has to be suitably planned and mediated by regional interest groups and fora like APAARI which is ultimately linked to the Global Forum and, thereby, visualizes and protects global interests. The APAARI identified priorities in terms of enhanced productivity and production levels in various farm commodities. Development of improved production systems and technology, utilisation of resources at manageable levels, conservation of biodiversity and environmental protection shall guarantee sustainability at all facets of life and should, therefore, be addressed at high priority both by countries/NARS and also by donors/funding agencies.

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ABBREVIATIONS AND ACRONYMS USED

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AFFRC	Agriculture, Forestry and Fisheries Research Council.
APAARI	Asia Pacific Association of Agricultural Research Institutions
APAARI	Asia-Pacific Association of Agriculture Research Institute
Aus-AID	Australian Agency for International Development
AVRDC	Asian Vegetable Research and Development Centre
BLS	Black Sigatoka Disease
CAAS	Chinese Academy of the Agricultural Sciences (People's Republic of China)
CAF	Chinese Academy of Forestry CAF
CAFS	Chinese Academy of Fishery Science
CAS	Chinese Academy of Science
CGIAR	Consultative Group on International Agricultural Research
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maizy Trigo
CIP	Centro Internacional de La Papa
CIP	Centro International de la Papa (International Potato Center-Peru)
COGENT	Coconut Genetic Resource Network
CTA	Technical Centre for Agricultural and Rural Cooperation
DM	Dry Matter
EU	European Union
FAO	Food Agriculture Organization
FRI	Forestry Research Institute
GATT	General Agreement on Tariffs and Trade
GTZ	German Agency for Technical Cooperation
HYVs	High Yielding Varieties
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Center of Insect Physiology and Ecology
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFARD	International Federation of Agricultural Research Systems for Development
IIMI	International Irrigation Management Institute
IITA	International Institute for Tropical Agriculture
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Center for Africa
ILRAD	International Laboratory for Research on Animal Diseases
INIBAP	International Network for the Improvement of Banana and Plantation
IPNM	Integrated Plant Nutrition Management
IRETA	Institute for Research Extension and Training in Agriculture
IRRI	International Rice Research Institute (Los Banos Philippines)
ISNAR	International Service for National Agricultural Research
JICA	Japan International Cooperation Agency (Japan)
JIRCAS	Japan International Research Center for Agricultural Sciences
KOICA	Korea International Cooperation Agency
MAFF	Ministry of Agriculture, Forestry and Fisheries(Rep. of Korea)
NARS	National Agricultural Research System
NARS	National Agricultural Research Systems
NCES	National Crop Experiment Station
NFA	National Fisheries Administration
NFRDA	National Fisheries Research and Development Agency
NGO	Non Government Organization
NGO	Non-Governmental Organization
NIAI	National Institute of Animal Industry
NZ-AID	New Zealand Assistance
OECD	Organization for Economic Cooperation and Development
ORD	Office of Rural Development (Old name of RDA in Korea)
PACINET	Pacific Biosystematics Network
PECC	Pacific Economic Cooperation Council
PIC	Pacific Island Countries
PPPO	Pacific Plant Protection Organization
PRAP	Pacific Regional Agricultural Programme
PRDA	Provincial Rural Development Administration
R&D	Research and Development
RDA	Rural Development Administration (Rep. of Korea)
SDIC	Scientech Documentation and Information Center
SOA	School of Agriculture
SPC	South Pacific Commission
SPFDP	South Pacific Forestry Development Programme
SPPF	South Pacific Project Facility
TDN	Total Digestible Nutrients
UN	United Nations
UNDP	United Nations Development Programme
UNDP	United Nations Development Programme
US-AID	United States Agency for International Development
USP	University of South Pacific
WFP	World Food Programme
WTO	World Trade Organization