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TAC REVIEW OF THE NON-ASSOCIATED CENTRES

ASIA AND THE PACIFIC:

AGRICULTURAL RESEARCH IN THE CONTEXT OF THE AGRICULTURAL DEVELOPMENT CHALLENGE

(Agenda Item 2)

Explanatory Note

At TAC 48, the Committee agreed that as a background to the discussion on a possible expansion of the CGIAR, analytical essays had to be prepared on constraints to increased sustainable production to meet demands for food. The papers were to be prepared by members of the Standing Committee for Priorities and Strategies and both the TAC and CGIAR Secretariats for each of the major developing world regions (sub-Saharan Africa; Asia and the Pacific; Latin America and the Caribbean; and West Asia Northern Africa (WANA)).

Attached is a draft copy of the paper on Asia and the Pacific. The paper was prepared under heavy time pressure and has not been discussed by the Standing Committee for Priorities and Strategies. Please consider the contents as rough draft material, only intended to provide some background information to the discussion on non-associated centres.

This paper should not be quoted and its contents not used for any other purpose than the discussions at TAC 49.

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION

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ASIA AND THE PACIFIC:

AGRICULTURAL RESEARCH IN THE CONTEXT OF THE AGRICULTURAL DEVELOPMENT CHALLENGE

1. Background

The developing countries of Asia and the Pacific have a total population of 2.5 billion people, which constitutes 69% of the population of the third world, and more than half of the world's global population. By the year 2000, their population is expected to increase to 3.1 billion (1.8% per annum). Although the effects of family planning efforts, particularly in China and India, have led to slower population growth rates than elsewhere in developing regions, Asia's population increases are in absolute terms the largest in the world. The area's GDP during 1984/86 amounted to US$ 550/caput, lower than that of Africa or Latin America, although there are strong intra-regional variations. In Southeast Asia it averaged US$ 190, in India US$ 271, in China US$ 442, and in the Pacific countries US$ 1,397 per caput. During the seventies, GDP per caput grew by 3.5% per annum and between 1980-85 by 5.2% per annum (FAO, 1987).

The main features of agriculture in Asia are the high density of rural population, the prevalence of small-scale farms, the scarcity of additional arable land, and the monsoon rainfall pattern on which most cultivation depends (Vyas and James, 1988).

In spite of dramatic improvements in food production during the last 25 years, Asia continues to have the biggest incidence of poverty and malnutrition. Approximately 50% of the continent's population lives below the poverty line, and in India and Bangladesh alone this amounts to 400 million people. About 350 million people in the region are chronically undernourished.

Although the Asia and Pacific region has the largest proportion of the world's population and of rural poor, it only has 15% of the total land area, and available arable land per caput is the lowest of any region in the world. The latter amounts to only 0.8 ha per caput or a little more than half the average of the developing countries as a whole. Although during the last few decades growth rates of food production have been higher than that of its population, the need to improve nutrition and poverty will put increasing pressure on the natural resources of the region. This paper discusses the major challenges to agricultural research and development in the Asia and Pacific region within the framework of the CGIAR.

2. Resource Base 1/

2.1. Land Availability and Use

The total area of arable land in the Asia and Pacific region amounts to 382 million ha, of which 20 million ha is permanently cropped

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1/ Sections 2.1.-2.5. inclusive are largely summarized from FAO (1986 a.)

(Table 1). Together they constitute 19% of the total land area in the region, while forests and woodlands cover 26% and pastures 22%. There is very little room in the area for an expansion of cultivated land.

Table 1 Land Use in Asia and the Pacific

Region	Land Use				
	Arable	Permanent Crops	Permanent Pasture	Forest & Woodland	Other d/
	(millions of hectares)				
South & South-east Asia a/	259.1	15.2	35.5	326.7	208.0
Central Asia b/	103.0	3.6	409.5	161.5	433.3
Oceanic Asia c/	0.4	0.8	0.5	37.2	15.4
TOTAL	362.5	19.6	445.5	525.4	656.7
% OF ASIA	18.1	1.1	22.1	26.1	32.6
WORLD TOTAL	1,371.6	100.1	3,157.4	4,068.4	4,383.5

Source: FAO, 1986 a.

a/ South and Southeast Asia = Bangladesh, Bhutan, Brunei, Burma, East Timor, Hong Kong, India, Indonesia, Kampuchea, Lao, Macau, Malaysia, Maldives, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam.

b/ Central Asia = China, Korea (DPR), Korea (Rep.), Mongolia.

c/ Oceanic Asia = Fiji, French Polynesia, Guam, Kirabati, New Caledonia, Pacific Islands, Papua New Guinea, Samoa, Tonga, Vanuatu.

d/ Wasteland, built-on land, and unused but potentially productive land.

The harvesting index for Asia (harvested land/arable land), excluding China, amounts to 108%, some of the excess above 100% being irrigated or normally unsuitable land (FAO, 1987). Most of the land reserves that exist are in Indonesia, Kampuchea, Malaysia, Burma and Laos (FAO, 1984).

2.2. Soils

About a quarter of the soils of the Asia and Pacific region have no major fertility limitations but the quality varies widely (Table 2). In Southeast and South Asia, only 14% and 18% respectively of the soils have no serious limitations for agriculture; nearly 85% are constrained by mineral stress, drought, shallow soil depth, or excess water. In high-rainfed areas, heavily leached soils constitute 70 to 90% of the total land area (FAO, 1984).

Table 2 Soil Resources of Asia and the Pacific

Soil Groupings	Area (million ha)	% of Total
Soils with no inherent fertility limitations*	523.9	25.4
Soils with severe fertility limitations	360.7	17.5
Shallow soils	585.1	28.4
Poorly-drained soils	184.1	8.9
Heavy-cracking clay soils	69.7	3.4
Coarse-textured soils	52.9	2.6
Semi-desert and desert soils	172.6	8.4
Salt-affected soils	55.5	2.7
Miscellaneous land units (salt flats, rock debris, snow caps and shifting sand and dune)	58.9	2.7
TOTAL	2,064.2	100.0

* Many of these soils however have slope limitations and are subject to erosion.

Source: FAO, 1986 a.

Soils with no serious inherent fertility limitations are suitable for rainfed crop production, although supplementary irrigation may be needed in the dry season in some areas. Such soils cover nearly two thirds of the Philippines.

In Southeast Asia and China, soils generally have strong fertility limitations. Most are chemically poor, being acid and low in organic matter, phosphorous, cation-exchange capacity and base saturation. Nevertheless they have good physical properties and with regular fertilizer applications, adequate erosion protection and careful water control, crops can be grown successfully. In Central Asia, the Himalaya and Southeast Asia many soils are stony, shallow and subject to erosion. Usually they are on steep slopes. The poorly-drained soils

are usually deficient in nutrients and exist mainly in Burma, Bangladesh, the Central Asian steppe zone, India and Nepal. Fertilizers and irrigation could greatly increase their potential.

On Vertisols, the heavy-cracking clay soils, irrigation is generally necessary to obtain sustained crop yields. Because of the poor internal drainage of these soils, ridging and shallow-surface drains could help to substantially increase the productivity of crops. About 74% of Asia's Vertisols are found in India, where they are mostly cultivated under rainfed conditions. ICRISAT has developed improved cropping systems for such soils.

Coarse-textured soils are sandy soils with low moisture and nutrient-holding capacity. They can be found in India, Pakistan, the Pacific Islands and Sri Lanka and suffer considerably from erosion. Desert soils are fertile but require irrigation and applications of nitrogen and phosphorus for sustained crop yields. More than a third of Mongolia is covered by these soils and they also occur in the arid areas of India and Pakistan. Salt-affected soils are fundamentally poor and often not worth improving. They are found mainly in China, Mongolia, India and Pakistan.

Throughout the Asia and Pacific region, steep slopes pose serious limitations to cultivation. In Central Asia 55% of the land is on slopes of above 30%. In Oceanic Asia, 69% of the land falls under this category. In South and Southeast Asia, 60% of the land has slopes higher than 8%.

2.3. Climate

The climate of humid tropical Asia is determined by its location in the low latitudes, the high insulation and size of the landmass, with a vast ocean to the south and east. The dominant climatic features are the monsoons: the southwest monsoon in summer and the northeast monsoon in winter.

The Indian monsoons are preceded by a period of high temperatures (around 40^{o}), and the southwest monsoon accounts for 80-90% of annual rainfall. Southeast Asia has a one-monsoon system in winter. Most of the Pacific Islands and the lowlands of Papua New Guinea are dominated by a tropical climate with abundant, well-distributed rainfall and moderately high temperatures.

Most of Central Asia has a temperate or subtropical climate, with high mountains and desert plateaux predominating in its northwestern part. In the temperate zone of North China and Mongolia, the climate is influenced by the northern polar front and the area has cold, dry winters. The subtropical zone is influenced by the northwest monsoons in winter. In the summer, most of Central Asia is influenced by the southeast monsoons from the Pacific Ocean, which bring tropical typhoons to the coast of China, and heavy rains elsewhere. The average rainfall in China is 600 mm, but there is a large regional variability ranging from 2000 mm in the east to 150 mm in the northwestern deserts.

2.4. Land Degradation

Land degradation is a serious problem in the region. For example, of the total area of 328 million ha in India, 90 million are affected by water erosion, 50 million by wind erosion, 7 million by salinity, and 20 million by flooding. A total of 167 million ha or 51% of the total area of India is thus affected by land degradation. Soil erosion is a major research area to be addressed. FAO has estimated that if soil erosion remains unchecked that by the year 2000 for example in Southeast Asia, the area of potential rainfed cropland could be reduced by 36% and the sustainable potential of rainfed crop productivity by 39%. Irrigated lands face the threat of degradation through salinization and waterlogging. The total extent of salt-affected soils in the Indian plains alone is approximately 6 million ha and it affects 23% of canal command areas. Waterlogging is a problem on 300,000 ha of non-saline cultivated lands. Despite an increased use of fertilizers in the Asia and Pacific region, substantially more macro-nutrients are being removed annually from the soil than being applied to it, and the nutrient level of soils is decreasing.

2.5. Water Resources and Irrigation Potential

Rivers, large natural lakes, and smaller perennial and intermittent lakes are the major sources of freshwater supply in the Asia and Pacific region. In arid zones and on small islands in the region, groundwater is the most reliable source of freshwater. In humid mainland Asia and the larger islands of the Pacific, surface streams are supplemented to varying degrees by groundwater. Asia has the biggest share (30%) of annual precipitation runoff of any major world region. In many countries there is an annual surplus of rainfall and runoff, but due to the lack of storage facilities water demands are not met when required. Changes in watershed characteristics may be partly responsible for the erratic climate causing periodic floods and droughts. Bangladesh and Northeast Thailand, for example, suffer either from too much or not enough water. Even in monsoon countries where rainfall is more consistent, about 80% falls during a concentrated five-month period.

About 50% of the developing world's irrigated land can be found in the Asia and Pacific region, and there is substantial potential for a major expansion, even doubling, of this area by careful management of water resources. Irrigation accounts for about 70% of total water use in the region, although in some countries this proportion amounts to up to 90%. FAO has estimated that between the years 1985 and 2000, 85% of the expansion in irrigated cropland in developing countries will take place in Asia, especially in India. Irrigated agriculture now constitutes nearly 30% of areas cultivated in Asia and it supplies about half of the region's total food production.

While irrigation development has much potential, rainfed agriculture characterizes about 75% of cropped lands in the region, supporting about three quarters of its rural population. Yearly fluctuations in agricultural production in rainfed farming systems are large, and the main factor limiting production is the lack of control of

water. In South and Southeast Asia particularly, the problem of variability of rain is of prime importance. Land use in Asia by agro-ecological category is illustrated in Table 3.

Table 3 Arable Land Use by Agro-Ecological Category (excluding China)

	1982/84	2000
	(Million ha)	
Low rainfall rainfed land (1-119 growing days)	32	28
Uncertain rainfall rainfed land (120-179 growing days)	36	26
Good rainfall rainfed land (180-269 growing days)	37	31
Problem lands (> 269 growing days, or unsuitable soils)	59	57
Naturally flooded land	42	32
Irrigated land	74	121
TOTAL ARABLE LAND	280	294
TOTAL HARVESTED LAND	303	349

Source: FAO, 1987.

The amount of arable land in Asia, excluding China, is expected to increase by 5%, but by increasing the cropping intensity from 108% to 119% through irrigation, the area of harvested land increases by 15%. Only 13% of cultivated cropland has good rainfall, while 21% is classified as problem land. The effects of rainfall are influenced by the soil's physical and chemical properties, particularly its moisture retention and transmission characteristics.

2.6. Population Supporting Capacity

According to FAO (1984), Southwest Asia is the area where land resources are most inadequate to meet the food needs of populations. This area includes part of the WANA region. Both in climate and in soils, it is the least favoured of all regions: only 7% of the land area of 677 million ha is suitable for rainfed crop production. The region's land resources could support only 107 million of its 1975

population of 136 million using low inputs, with intermediate inputs it could support 172 million, and with high inputs 268 million. During the early 1980s the region was in between the low and intermediate level. Given the rate of population increases the region is unable to feed its year 2000 population with low or intermediate inputs, and given the fact that one third of the land is for non-food uses, even with high inputs the region will be critical.

Southeast Asia is the region where, because of the sheer size of the population, by far the largest absolute numbers of people affected by potentially critical land resources exist. Although its climate and soil resources place it among the most favoured regions, the sustainability of its farming systems is at risk. The region is in a critical situation at low input levels, but is generally able to produce just enough food to feed itself, although several countries may face severe food shortages.

2.7. Forestry Resources

Forests and open woodlands cover some 525 million ha or about 25% of the total land area of the Asia and Pacific region. Deforestation in the region was estimated by FAO in 1980 to be running at about 1.8 million ha a year (Table 4). If this trend continues, by the year 2000 some 36 million ha will have been converted to non-forestry uses, amounting to a further reduction of 12% in the closed forest area.

Table 4 Deforestation in the Region (1976-80)

Category	Mean Annual Area Deforested	
	('000ha)	(%)
Logged-over, productive closed broadleaved forests	1,068	58.9
Undisturbed, productive closed broadleaved forests	483	26.6
Productive, managed closed broadleaved forests	106	5.9
Unproductive, closed broadleaved forests	110	6.0
Coniferous forests	35	1.9
Bamboo forests	13	0.7
TOTAL	1,815	100.0

Source: FAO/UNEP, 1981.

About 40 million ha were deforested in tropical Asia in the last quarter century. In the period 1976-80, mean annual deforestation was highest in insular Southeast Asia (880,000 ha), followed by continental Southeast Asia and the centrally-planned countries (633,000 ha), South Asia (273,000 ha), Papua New Guinea (21,000 ha), and Bangladesh (8,000 ha).

Part of the past deforestation which has taken place in the region constituted a logical shift in land use to more productive agriculture. Where forests were located on relatively flat land overlying fertile soils, it was inevitable that forests gave way to agriculture. However, much of the deforestation now taking place is occurring in forests located in the lowland humid tropics or on steep upland slopes. The soils underlying tropical rainforests are predominantly acid latisols that are unsuitable for sustained annual food cropping unless heavily fertilized and intensively managed. Because of increasing population pressure shifting cultivation has in many situations reduced the fallow period to well below the critical minimum needed to restore soil fertility. The consequences are ecological degradation of the land and replacement of the forest by imperata grassland of little economic value. In Indonesia, for example, unproductive degraded forests, imperata grassland and badly eroded former forest lands now cover 22% of the total land area, or 43 million ha.

Short cycle shifting cultivation in upland watersheds is a contributory cause of soil erosion sedimentation and flash flooding. During 1970-80, some 25 to 30 million ha of forest cover was removed from hills and uplands with steep gradients, or from land unsuitable for permanent agriculture.

Five Southeast Asian region countries (Indonesia, Malaysia, Philippines, Burma, Papua New Guinea) supply some 80% of the world's tropical hardwood trade. Large scale selective but extensive commercial logging of higher value dipterocaps (often removing less than 30 of the 600 or more naturally occurring potential timber species per ha) opens up large areas of forest and encourages spontaneous migration and shifting cultivation.

In the region as a whole, fuelwood supplies one third of total energy consumption. Fuelwood removals account for 86% of all wood harvested. In rural areas of those countries where fuelwood is still abundantly available, it accounts for over 80% of household cooking and heating needs. However over-cutting of readily accessible fuelwood supplies in many countries in the region has led to severe fuelwood shortages.

In relation to lowland agro-forestry farming, tree crops are extensively used for integrated agriculture on small farms throughout the region. Leguminous trees and bushes are cut extensively to feed livestock such as Leucaena. Various legumes are used as cover crops under rubber trees in Malaysia and Sri Lanka where, although the shade prevents good forest yields, it permits the growth of seed material. Forages are also grown successfully under coconuts in a number of countries of Southeast Asia and the South Pacific.

In addition to these contributions to agriculture, the natural forests of the region also provide a direct source of fruit and food and

medicinal products and are an important source of germplasm for many agricultural crops in commercial useage. These include crops such as mango, breadfruit, jackfruit, carambola, teak, nutmeg and clove. Some of these germplasm resources are threatened with virtual extinction because of population encroachment.

2.8. Livestock Resources

About one third of the world's livestock population can be found in the developing countries of the Asia and Pacific region, i.e. 97% of buffaloes, 30% of cattle, 56% of goats, 48% of pigs, 28% of sheep, 36% of chickens and 87% of ducks (Table 5). Livestock are an integral part of the farming systems of the region, and the primary role of cattle and buffaloes is to provide a source of draught power. Livestock manure is of substantial importance as a source of fertilizer and household fuel. Offtake rates for cattle and buffaloes are low because of their use for draught power. Although Asia has 37% of the world's population of cattle and water buffalo, it produces only 10% of the world's cattle and buffalo meat. A similar pattern applies to sheep and goats.

Table 5 Livestock Population in Asia and Pacific (1987)*

Species	Asia and Pacific	World	% of World Population
	.....('000).....		
Cattle	384,414	1,277,729	30.1
Buffaloes	134,208	138,374	96.9
Sheep	328,927	1,157,643	28.4
Goats	283,491	501,762	56.5
Pigs	400,635	839,852	47.7
Chickens	3,419,000	9,445,000	36.2
Ducks	434,000	500,000	86.8

Source: FAO, 1988.

* Developing countries only.

Cattle are distributed fairly evenly across the region, but not the other animals. Most of the buffaloes occur in south and southeast regions, while most of the pigs are raised in the Far East, China and the Pacific Islands. During the last two decades there has been little growth in the livestock population of the region.

Asian livestock production is characterized by low levels of productivity, but the outcome of research and development efforts to increase livestock output has been disappointing. Only where economic transformation has been rapid and sustained over a long period of time

has the contribution of livestock to agricultural GDP increased substantially, e.g. in South Korea and Taiwan (De Boer, 1982). Given the continued low productivity per animal, the slow growth in livestock population and the rapid growth in demand, imports of livestock products have increased sharply. Yet, the development of livestock production on smallholder farms would have a tremendous potential for improving incomes and generating employment of rural poor.

2.9. Aquaculture Resources

Asian and Pacific waters produce an annual fish catch of over 25 million tonnes. This represents nearly 40% of the world's total marine fish catch, and 80% of inland fish and aquaculture production. Fish are a major source of protein in most countries of the Asia and Pacific region. In 13 countries, it contributes more than 40% of animal protein supply, and in a further six countries, between 20 and 40%. In some countries fish are also a vital source of foreign exchange and of income and employment. The economy of most of the Pacific countries is largely dependent on the fishing sector.

Aquaculture has a long history in the region and is expanding rapidly. Most of the output is finfish (4.4 million tonnes), molluscs (2.6 million tonnes), crustaceans (312,000 tonnes) and seaweeds (2.75 million tonnes) (FAO, 1989). The diversity of finfish species growing is the highest in the world.

3. Challenges to Agricultural Research

3.1. Crop Productivity

Production of cereals, pulses and other staple crops is the dominant agricultural activity in Asia. Cereals account for about two thirds of cultivated land in most countries, with rice being the most important crop. More than 90% of the world's rice is produced in Asia. Rice provides about a third of food energy supply in East and South Asia, and almost 60% in Southeast Asia.

Wheat and maize are the two other major cereals. Wheat is grown mainly in the semi-arid South Asian countries, predominantly in India and Pakistan. Maize is grown in all Asian countries. Rice and wheat account for about 85% of food production in Asian developing countries (Vyas and James, 1988).

During the last 25 years, increases in cereal production in the Asia and Pacific region have been largely due to yield increases and double cropping in irrigated areas, rather than area expansion. Spectacular gains were made in the productivity of rice and wheat throughout the region. This was largely due to three important changes in production technology: use of modern varieties, irrigation water, and chemical fertilizers. Recent literature (Byerlee, 1988; Pingali and Moya, 1989) has suggested that the effect of each of these factors is reaching a plateau and that the so-called "yield gap" is diminishing, under certain conditions even disappearing. Recently, CGIAR breeding activities have given greater attention to enhancing yield stability.

Modern varieties of rice and wheat have been widely adopted by farmers and are grown on most of the cropland in irrigated and favourable rainfed environments (Dalrymple 1986 a and b). According to Byerlee (1989), modern varieties have largely been exploited as a source of growth in these environments. Since the 1960s, no additional major breakthroughs raising yield potentials in cereals have been made, and the likelihood for them to occur during the next decade appears small. Fertilizer use has increased rapidly in irrigated areas, and in various Asian countries there appears little scope for further expansion. In countries such as Laos, Kampuchea and Vietnam an increased use of fertilizers would require prior policy reforms.

The increased use of irrigation systems has also played a major role in improving the productivity of both rice and wheat production in the region. In recent years, this expansion has slowed down also and the economic return to irrigation projects has been below expectations (IIMI, 1988). Major problems remain with the organization and management of water control. Although modern varieties, improved supplies of irrigation water, and increased fertilizer use accounted for three quarters of the total yield increases in rice and wheat in Asia during the last two decades, there is evidence that the contributions of these factors have reached a stage of rapidly diminishing returns (Byerlee, 1989).

Pingali (1988) has observed that for the irrigated lands in the Philippines, there is almost no gap between the experiment station and the farmer yields and indicates that the long-term prospects, given current technology, are for a stagnation and/or a decline in average irrigated farm yields. Although research is still making considerable contributions in terms of the development of early maturing, and disease and insect resistant varieties, available data from IRRI indicate that irrigated rice yields are reaching their maximum potential even when grown under scientific management on experiment stations. CIMMYT appears to experience similar trends for wheat in the Indian Punjab, although in the Pakistan Punjab yields remain well below their potential (Byerlee, 1989). Pingali (1988) has also questioned the long-run sustainability of intensive irrigated monoculture rice production, as currently practised throughout tropical Asia. These observations would point to the need for greater research efforts in crop diversification, sustaining further intensification of land use, minimum tillage and integrated pest management, and increased input efficiency. It is to be noted that gains with respect to the efficiency of input use lead to increases in producer incomes at no cost to the consumer.

IRRI has classified rice environments in irrigated, rainfed lowland, tidal wetlands, deep water and upland rice ecosystems. Irrigated systems cover 53% of the rice area and contribute 73% to rice production, while rainfed lowland systems cover 27% of the area and 17% of rice production. The contribution of research to future production increases is expected to occur for 85% in the irrigated and rainfed lowland production environments (IRRI, 1987).

The rapid increases in cereal production in favourable environments have not been followed in less favourable environments where progress has been slow. Yet, impressive results have been obtained with farmer adoption of modern varieties of sorghum and wheat,

particularly in India. CIMMYT has reported increasing adoption of semidwarf wheat varieties in arid areas, while IRRI is starting to have an impact in upland rice ecosystems where many of the poorest of the poor depend on this environment for subsistence.

Throughout the Asia and Pacific region, it appears that during the next two decades research on crop and resource management will have to play an increasingly important role in sustaining productivity gains while preserving the natural resource base. In China, Indonesia and countries of South Asia further gains can be made in yields in irrigated areas. Both Byerlee (1989) and Pingali (1988) have observed that reduced input subsidies, declining profitability of cereal production and more open economies will increase the pressure for greater production efficiency. In many Asian countries, shortage of labour has become a serious constraint to agricultural productivity, particularly for weed control. With regard to the importance of cattle and buffaloes as a source of draught power, and the resulting negative effects on their productivity for meat and milk, greater attention should also be given to the development of minimum power tillage systems.

3.2. Livestock Productivity

Demand for livestock products has been rising faster than supply, particularly in those Asian countries with high economic growth rates. There has been little improvement in livestock yields, other than in pig and poultry production. The primary constraint to improving livestock productivity in the region is shortage of feed. To date, the expectation that the Green Revolution would lead to increased supplies of crop by-products and diversification of marginal lands in fodder and oilseed crops, have not been met (De Boer, 1982). Imports of coarse grains and oilseed products have risen sharply. The impact of research has been small, because in the past research has given inadequate attention to farmer resources and objectives in smallholder production systems. Future research will have to give greater attention to the role of animals in farming systems. At the farm level, the intermediate functions of livestock (draught power, manure, security) are of greater importance than the production of milk and meat, and research should therefore not have a single commodity focus. Particular attention should be given to improving the quality and quantity of crop by-products, introduction of strategic seasonal feed supplementation, breed improvement, disease control, and improved marketing.

3.3. Forestry

Forestry's contribution to agricultural GDP growth has been declining sharply in Asian developing countries during the last decade because of the depletion of forestry resources.

Given declining soil fertility, the shortage of animal feed, and the need to rapidly increase the supplies of fuelwood there appears to be a large role for agroforestry in the region. While considerable work has been done in the last decade in developing a better understanding of farmer and community perceptions of the usefulness of agroforestry farming systems, the main gaps in knowledge in the region

lie in quantification of these relationships and in developing a better understanding of incentives that will induce more rapid adoption of sustainable agroforestry systems.

Most of the past work on germplasm conservation has focused on food crops. Despite the fact that tropical forest ecosystems supply many staple foods and contain wild relatives of modern food crops important for future breeding programmes, current research programmes for collecting forest-based germplasm are totally inadequate.

Despite the fact that the region's rainforests are the richest ecosystems on earth and contain about half of the world animal and plant species, less than 20% have been identified.

With respect to fuelwood conservation and development, experience from the 1980s suggests that future efforts to solve the fuelwood crisis in Asia will require a three-pronged strategy involving:

- encouraged use of substitute fuels particularly in urban areas;
- vigorous attempts to conserve fuelwood, e.g., improved charcoal burning methods and use of improved stoves; and
- increased development of new fuelwood resources.

A key area for research is the investigation of tradeoffs between close and wider espacement biomass planting.

3.4. Aquaculture

Aquaculture production in Asia has expanded rapidly and the region now accounts for at least 84% of global aquaculture production, including some 72% of the total farmed production of finfish. Average per caput production of cultured aquatic animals for the region in 1985 amounted to 2.2 kg/annum, compared with 11.1 kg/caput/annum for capture fisheries (FAO, 1989). In Korea, 9.5 kg/caput of aquatic animals were cultured annually and in the Philippines 5 kg. The growth in aquaculture production mainly relates to freshwater. Crustacean culture is the most rapidly expanding sector of aquaculture production in Asia, due to high profits and the potential for foreign currency earnings. Asia now accounts for 75% of the world total of farmed crustaceans and for 99% of the production of seaweeds (FAO, Ibid).

Many of the constraints to culture-based fisheries and aquaculture are local specific or socioeconomic in nature, although there is a strong need for strategic research on breeding and on nutrition. Some Asian countries also face major disease problems and have difficulty producing seed. Research should also give adequate attention to integrated pest and disease management (TAC Secretariat, 1989).

3.5. Vegetables

Vegetables are of vital importance to nutrition, income and employment generation throughout Asia, but particularly in India, China, and the countries of Southeast Asia. Asia accounts for approximately 70% of the production of vegetables in developing countries. The demand for vegetables is increasing rapidly, fueled by the relatively high degree of urbanization and economic growth. TAC has already recommended that the CGIAR give serious consideration to supporting research on vegetables but that this support be limited initially to tomatoes, peppers and onions, and to leafy green vegetables (TAC/CGIAR, 1988).

3.6. Bananas and Plantains 1/

Bananas are of significant importance to nutrition and income throughout Asia, but particularly in Southeast Asia where it is the premier fruit. Southeast Asia is the centre of origin of edible bananas, and harbours a wealth of germplasm materials. Banana is the most important fruit of the Philippines, Thailand, Indonesia and Sri Lanka, while it rates second or third in India, Malaysia and Taiwan. Its primary use is as dessert fruit and staple starch, but bananas also provide secondary products. For the Philippines and Taiwan banana trade constitutes a major source of foreign exchange. Banana production in Asia and the Pacific can be categorized into three basis systems: traditional or backyard growers, smallholder commercial growers, and agribusiness plantations (Kobayashi, 1985). The backyard-growing system predominates in Asia and its output is primarily for home consumption. Commercial production by smallholders is targeted at the urban market while banana plantations cater for exports. The major constraints to banana production in the Asia and Pacific region are viral diseases, Moke and Panama diseases, Sigatoka diseases, and pests (insects and nematodes).

4. Policy Constraints and Stength of National Programmes

Agricultural development in the Asia and Pacific region since the early 1970s can largely be labelled as a success story, although there are intra-regional variations. In general, however, per caput food production has increased steadily and many countries have reached food self-sufficiency. A major reason for this improved performance has been the active role of governments in promoting agricultural development in providing production incentives, investments in infrastructure, promoting technology development and in initiating institutional reforms in land tenure, credit and labour (Vyas and James, 1988). Yet, in almost all countries throughout the region, policy deficiencies remain, particularly with respect to price policies, input subsidies, and operational and institutional arrangements for equitable distribution and management of water.

1/ Summarized from Valmayor (1987), and Fullerton (1987).

The success of agricultural development has also generated a rapid increase in agricultural research expenditures, which during the 1970s rose by 10% per year in real terms but appear to have stabilized during the 1980s (Byerlee, 1989). Most large countries in Asia appear to have good research programmes for plant breeding in basic food crops. An overview of the activities of national research systems in the Asia and Pacific region is provided by FAO (1986 b) and Asian Development Bank (1987).

Byerlee (1989) has noted that many NARS lack a functional mechanism for priority setting, both in problem identification and in resource allocation. Crop and resource management research is generally weak and fragmented among disciplinary groups. Social science research capacity is also in its infancy. Finally, as in other developing regions, the links between research and extension services are ineffective, and operating funds receive an inadequate share of the research budgets. Byerlee has also pointed to the role of private sector research which is already important for coarse grains and oilseeds, as well as for chemical and machinery technologies. Private research focuses on commercial farmers in the more favourable areas.

5. Conclusions

Food production in Asia and the Pacific will have to continue to grow rapidly in order to keep pace with population increases and to improve nutrition. Agricultural development in the region has also an enormously important role to play in income and employment generation and natural resource conservation.

In the near future, slower growth should be expected from the main sources of agricultural productivity increases during the last two decades, i.e. modern varieties, irrigation and fertilizers. Advances of yield potential in cereal crops occur only slowly. Future research efforts should give high priority to improved crop and resource management to exploit this yield potential at the farm level, promote input efficiency and sustain the resource base (Byerlee, 1989). In addition, attention should be given to increasing the productivity of income-elastic food, such as vegetables and livestock products. Aquaculture and banana production are also imortant subject matters in the Asia and Pacific region. Vegetable, livestock and fish production have the additional advantage of being labour intensive and income generating. Integrated pest management and the development of agroforestry should be an integral part of any research strategy for the region. A recent ACIAR study has also pointed to the substantial potential payoffs of forest products research, particularly on alternative fuelwood sources.

Agricultural research may lead to significant gains in food production in the Asia and Pacific region during the next 25 years, provided adjustments are made to existing research strategies. Given the fact that the welfare of more than 3 billion people is at stake, it is a challenge that must be addressed effectively.

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