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CROP DIVERSIFICATION IN THE ASIA-PACIFIC REGION

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
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This publication brings together edited manuscripts of papers presented at the Expert Consultation on "Crop Diversification in the Asia-Pacific Region", held in Bangkok, Thailand, 4 to 6 July, 2000. The consultation was organized and sponsored by the FAO Regional Office for Asia and the Pacific. The report of the consultation was brought out in October 2000 (RAP publication: 2000/14).

FOR COPIES WRITE TO: Meetings and Publications Officer
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Banglamphu, Bangkok 10200
THAILAND
Tel: (66-2) 2817844
Fax: (66-2) 2800445

CROP DIVERSIFICATION IN THE ASIA-PACIFIC REGION

Edited by

Minas K. Papademetriou
and
Frank J. Dent

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
BANGKOK, THAILAND, APRIL 2001

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FOREWORD

Food and nutrition security, income growth, poverty alleviation, employment generation, judicious use of land, water and other resources, sustainable agricultural development and environmental and ecological management/improvement have assumed high priority in the various countries of the region. Crop diversification could be an effective strategy in this direction. Efforts, therefore, need to be made by governments to explore fully the potential and prospects of crop diversification to forge congruence of enhanced productivity, profitability and sustainability.

Against the above backdrop, FAO organized a Regional Expert Consultation on Crop Diversification in the Asia-Pacific Region at the FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, from 4 to 6 July 2000. Experts from concerned countries participated in the workshop. They were able to identify critical issues needing attention. The report of the consultation was published as RAP publication No. 2000/14, in October 2000, highlighting the major recommendations. This publication collates further useful information in the form of proceedings.

Appreciation is expressed to the participants for their presentation of papers and contribution to the discussions. In particular, sincere thanks must be accorded to Messrs M.K. Papademetriou and F.J. Dent for compiling and editing this valuable document. Also, the unfailing support of Mrs Valai Visuthi, who provided assistance in formatting the manuscript, is greatly appreciated.

R.B. Singh
Assistant Director-General
and FAO Regional Representative
for Asia and the Pacific

INTRODUCTORY REMARKS

Minas K. Papademetriou *

Welcome to the FAO Regional Office and to this Expert Consultation which has been organized and sponsored by the FAO Regional Office for Asia and the Pacific. I am grateful to all of you for coming here to contribute to this meeting.

As you know crop diversification could be a very important instrument for food and nutrition security, income growth, poverty alleviation, employment generation, judicious use of natural resources, sustainable agricultural development, and environmental and ecological management/improvement.

Remarkable progress has been achieved in crop diversification in certain countries of the Region, while in others the progress is very limited. The opportunities for further promotion of crop diversification appear to be good. However, at the same time the problems to be addressed are many and varied. I am sure that aspects relating to crop diversification will be adequately deliberated during this Consultation and some useful conclusions and recommendations will be drawn.

Strengthening cooperation among countries, institutions and individual scientists in this field is very important. A forum like this will allow us to learn from each other. We must explore the possibilities of sharing our experiences for mutual benefit. It is in this context, that this Consultation has been convened. Briefly, its objectives are the following:

a) To review the status of crop diversification in the Asia-Pacific region and discuss the problems faced as well as strategies required for overcoming existing constraints.
b) Elaborate on the potential and opportunities for crop diversification for food and nutrition security, poverty alleviation and ecological security.
c) Discuss ways and means of strengthening collaboration on crop diversification.

This is the second time FAO has held an Expert Consultation on Crop Diversification in this Office. Dr. R.B. Singh, ADG/RR, organized the First Expert Consultation on Crop Diversification in Bangkok in September 1987. FAO continues to attach high priority to this issue and the presence here of the Director of the Plant Production and Protection Division (AGP), FAO, Rome, Dr. Mahmud A. Duwayri, is an indication of the importance which the AGP Division is attaching to Crop Diversification.

I wish you all productive discussions and good contacts among one another for the exchange of information, experience and expertise.

* *Senior Plant Production and Protection Officer, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand*.

WELCOME ADDRESS

Dr. R.B. Singh [*]

It is a great pleasure and privilege for me to welcome you to the Expert Consultation on Crop Diversification in the Asia-Pacific Region. May I take this opportunity to extend to all of you warm greetings on behalf of the Director-General of FAO, my colleagues in the Regional Office and myself. Special thanks are due to you all for gathering here to contribute to this Consultation.

As you know crop production is the most important economic activity of the rural areas of the Region and it makes highest contribution to the domestic product of many countries as compared to other sectors. The crop sector also has strong linkages with other sectors of the economy like livestock, industry, trade and commerce, whose output is significantly influenced by the performance of the crop sector. Due to these factors, the growth rate of the crop sector is a major determinant of the growth rate of the overall economy of many countries.

Notwithstanding the highly satisfactory crop production growth rates during the past 30 years in the Region, in recent years growth rates have slowed and there is an urgent need for reversing the trend. It is recognized that the Asia-Pacific Region accounts for nearly 57 percent of the world's population, but has access to only one-third of the world's agricultural land. Water availability is fast declining, while there is widespread degradation of natural production resources. Therefore, the future strategy must be to produce more and more from not only the shrinking but also degrading resources.

Food and nutrition security, income growth, poverty alleviation, employment generation, judicious use of land, water and other resources, sustainable agricultural development, and environmental and ecological management/improvement have assumed high priority in the various countries of the Region. Crop diversification could be an effective strategy in this direction. Every effort, therefore, needs to be made by governments to explore fully the potential and prospects of crop diversification to forge the congruence of enhanced productivity, sustainability and profitability.

Crop diversification is an important instrument for economic growth. However, the ability of a country to diversify in order to attain various goals, will depend upon the opportunities for diversification and responsiveness of farmers to these opportunities. At the same time new problems, threats and challenges will have to be faced. Several of the commodity agreements, such as the International Natural Rubber Organization, have failed to the disadvantage of the majority of developing countries, even though rubber is an important commodity in the Region.

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[*] *Assistant Director-General and FAO Representative for Asia and the Pacific, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.*

New opportunities that would benefit crop diversification are technological breakthroughs, changes in demand pattern, changes in government policy, development of irrigation and other infrastructure, development of new trade arrangements, and others. Similarly, challenges and threats necessitating crop diversification result from: a) market and price risks; b) risk associated with existing crop management practices; c) adverse changes like degradation of natural resources and the environment; and d) socio-economic needs like employment generation, attaining self-sufficiency in some crops and earning foreign exchange from others.

The case of the green revolution in India presents a good example of the effects (positive and negative) of technology induced crop diversification. This technology created opportunities for raising agricultural productivity through diversification in favour of high yielding period-bound cultivars of wheat and rice in areas endowed with reliable irrigation. In this way, green revolution technology resulted in spectacular growth in farm output, which enabled the country to attain food self-sufficiency. However, the green revolution technology has also led to substantial shifts in area in favour of rice and wheat and a high level of crop intensification which are said to be causing degradation of the ecology and natural resources like soil and water in various ways. For example, high crop intensity and intensive use of chemical fertilizers and irrigation are noted to be causing nitrate pollution, soil salinity and waterlogging; while burning of crop residues is contributing to air pollution. To face these challenges and problems there is an urgent need to diversify the cropping patterns.

Significant changes are taking place in domestic and international demand for crop products due to improvement in income and standard of living, fast urbanization, and changing life styles and preference patterns. Trade liberalization and development of transport infrastructure have opened new avenues of trade and have improved access to new and distant markets. This has created new opportunities for crop diversification, especially for enterprising and progressive farmers in the various countries.

Rice is the most important food crop in Asia and will remain so for many years to come. However, in marginal and upland areas of Asia, rice-based cropping systems have low returns. Shifting marginal areas out of rice into more profitable crops is seen as a solution. However, commodity-specific approaches are risky and, given the weak infrastructure and marketing base, may not achieve much for resource poor farmers in rainfed areas. Alternatively, flexible cropping systems for upland farmers that feature production of more income-elastic goods like horticultural products are a means of diversifying their income sources. Indeed, diversification away from rice to high-value crops such as fruits, vegetables and flowers has been successful in many countries of the Region, although quality and timely production are usually crucial to economic success with such high-value crops.

There is no doubt that significant progress has been made during the past few years in crop diversification in the Region. The level of success varies from country to country, but some success stories exist in every country. The fundamental principal of all successful diversification programmes is that they are driven by market demand. There is no point in diversifying into a crop for which market potential is limited. Governments can take several steps to reduce risks and improve marketing facilities through improved roads and communications, construction of wholesale markets, etc. Access by farmers, private traders and

exporters to credit also needs to be improved. Dynamic policies on balance between food self-sufficiency and food self-reliance will be needed.

However, in spite of the significant progress in crop diversification much more remains to be done in this direction. There is a need and scope to further promote crop diversification on scientific lines and realize its untapped potential. FAO looks forward to the advice and guidance of the participants concerning appropriate strategies leading to the realization of this untapped potential.

CROP DIVERSIFICATION IN BANGLADESH

M. Enamul Hoque [*]

1. INTRODUCTION

Agriculture is the single most important sector of the economy in Bangladesh. It is the major source of livelihood in the rural areas, where some 80 percent of the population live. Approximately two-thirds of the labour force is employed in agriculture. Although its share in the GDP is predictably declining, agriculture (crops, livestock, fisheries and forestry) contributes approximately one-third of the GDP and agricultural production accounts for 32 percent of the value of exports. The performance of this sector affects the overall economic growth. With irrigation covering only around 42 percent of the potentially irrigated area, agriculture is still weather dependent and has grown slower than was earlier expected, particularly because of the predominantly small farmer holdings in Bangladesh.

However, Bangladesh is endowed with a favourable climate and soil conditions for the production of a variety of crops all the year round. The rich genetic estate, the richness in ecosystem diversity, and the vast untapped human resources who can learn and adopt new skills have been the major points of comparative advantage in Bangladesh. Thus, there are ample opportunities for crop diversification balancing the production of major crops with that of minor crops. The crop diversification programme (CDP) was launched in the country during the early 1990's. A systematic arrangement of growing a variety of crops in rotation with rice was undertaken, based on farmers' own choice and performances with respect to soil and climatic conditions, thereby ensuring a variety of diverse dietary standards and nutritional status of the rural households. Due attention was given to the protection of nutrient balances in the soil and of all major basic resource endowments in crop production. Improved crop sequences involving rotation of soil exhausting crops followed by recuperative ones, shallow rooted crops followed by deep-rooted ones, legumes in rotation with non-legumes, etc., are envisaged to enrich and maintain soil fertility and crop productivity. In this way it becomes possible to ensure some degree of constancy in crop production, by destabilizing many of the limiting biotic and abiotic stresses.

The key objectives of agricultural development, involving sustainable intensification of rice production and location-specific attempts on crop diversification in the small farmer holdings of Bangladesh, have been aimed at achieving self-sufficiency in food grains production in a sustainable manner by improving the productivity on a short and medium term basis. Another objective is to attain self-reliance in the long-term. To enhance farmers' income through the production of high-value crops and to help maintain a better soil structure for long-term sustainability, a recent policy statement on crop agriculture has called for a departure from "rice-led" growth to a more diversified production base that includes several non-rice crops. The

[*] *Director-General, Department of Agriculture Extension, Ministry of Agriculture, Khamarbari, Farmgate, Dhaka, Bangladesh.*

production of rice as of now has exceeded 22.5 million tonnes and that of wheat 2 million tonnes. Maize production increased by 138 percent during the period 1995/96 to 1997/98. The government is also implementing programmes to promote crop diversification involving high-value crops, fruits and vegetables, potatoes, oilseeds, pulses and spices through appropriate packages of seed-fertilizer-irrigation technologies, This is expected to increase employment, rural income and improve nutritional standards.

2. CROP PRODUCTION AND ECONOMIC SCENARIO

2.1 Review of Past Performance of the Crops Sector

Bangladesh made steady progress in crop agriculture in the post-Independence period. The cropping intensity increased from 148 to 179 percent and foodgrain production almost doubled during the period from 1969/70 to 1992/93. Contributing about 75 percent of the value-added, crops form the largest sub-sector of agriculture. Rice is the dominant crop and largely determines the rate of progress in the agriculture sector and to a significant extent, that of the non-agricultural sectors. It covers about 75 percent of the cropped area and accounts for about 70 percent of the value of crop output. In fact, the entire growth in crop production is due to the growth in foodgrain production, particularly rice. Yield of other non-cereal crops such as pulses, oilseeds and vegetables almost stagnated, while that of wheat increased only marginally.

In 1993/94 and 1994/95, foodgrain production declined as a result of depressed prices and natural disasters, particularly floods and droughts in the northwest, which is the country's surplus gain production region. The average foodgrain production during these two years dropped to 18.71 million metric tonnes (Mt) from the average of 19.31million Mt during the preceding three years from 1990/91 to 1992/93. While drought conditions prevailed during these years, the decline in the rice production in 1993/94 was also due to both damage by floods and the farmers' response to the fall in the price of rice in the preceding year as evidenced by more that 4 percent decline in fertilizer consumption, more than 2 percent reduction in area sown and similar decline in irrigation command area. In 1994/95 total foodgrain production was only 18.17 million Mt as against the expected production of 20 million Mt. This trend started improving from 1995/96 with a foodgrain production of 19.14 million Mt. The year 1996/97 witnessed an all time high foodgrain production of about 20.43 million Mt and it is touching almost 25 million tonnes during the current year 1999/2000. Food production, though continuing to depend on the vagaries of nature, increased substantially over the years, following the introduction of high yielding varieties (HYV) and application of modern inputs like fertilizers and pesticides. However, its dependence on weather continues to result in fluctuations in production. Wide fluctuations in production leads to large instability in foodgrain prices having serious implications for household food security and also for the welfare of the people.

Production of jute fibre reached as high as 8.66 million bales in 1985/86. The production level declined to 4.92 million bales in 1992/93 and has hovered around this level since then. Sugar cane production has remained more or less 7.50 million Mt since 1987/88. Production of potatoes has shown a steady increase. It increased from 0.89 million Mt in 1975/76 to 1.47 million Mt in 1994/95. Other crops like pulses and oilseeds have shown only marginal improvement nationwide. However, implementation of the crop diversification programme

(CDP) during 1990/95 in 125 Thanas gave promising results in terms of yield per hectare of maize, pulses, oilseeds, potatoes, vegetables, etc.

As regards performance of modern inputs, the irrigated area increased to about 4 million hectares in 1996/97 from the level of 2.65million hectares in 1990/91. Ground water irrigation covered 68.5 percent of the total irrigated area while the surface water irrigation was only 31.5 percent in 1996/97. Ground water irrigation witnessed significant expansion during the last two decades. Use of chemical fertilizers increased from 2 million Mt in 1990/91 to 3.02 million Mt in 1995/96. Public sector seed distribution (mainly rice and wheat) occupies only about 5 percent of the total requirements. The large part of the seed requirement is met by the private sector.

The reforms of the agriculture sector have been quite pronounced and visible. For over a decade a wide range of policy reforms have been implemented in the agricultural sector. A few of these are privatization of input distribution, withdrawal of input and food subsidy, import liberalization and a broadening of the scope of private investment in agriculture. In recent years, the coverage of policy reforms in the agriculture sector has substantially expanded to include minor irrigation equipment, agricultural machinery, seeds and agricultural trade.

2.2 Crop Production during the Fifth Five Year Plan

The projection of crop production during the Plan has been worked out keeping in view the production possibilities, agronomic consideration, availability of production inputs and farmers' accessibility to resources and willingness to increase production within the prevailing agro-economic condition. Emphasis will be put on increasing yield per hectare rather than increasing cropped area and shifting from local varieties to the HYVs. The purpose of foodgrain production, in addition to attaining self-sufficiency, will be to provide nutritious food for the entire population.

Bangladesh is endowed with favourable climate and soils for the production of a variety of crops throughout the year. The winter crops are greater in number than the summer monsoon crops. The production of major and minor crops became unbalanced in recent years due to greater emphasis given on cereals, especially rice and wheat. The situation needs to be improved for balanced diet of the people.

The production of minor crops such as pulses, oilseeds, vegetables, fruits, spices, etc., is currently inadequate to provide for the required nutrition in the daily diet of the people. Such a situation will not be allowed to continue. Accelerated production of minor crops, complementary but not competitive with major food crops production as per the requirement for reducing pressure on cereals, will be pursued during the Fifth Plan period. This will improve the daily diet of the people, generate rural employment by intensive cropping with improved technologies, increase farm income and thereby increase the purchasing power of the rural masses. It will also improve the balance of payments by promoting import substitution and export oriented crops.

Fruits and vegetables are important sources of minerals and vitamins and provide a part of the calorie requirement in the daily diet of the people. They also provide most of the food

roughage, which contributes to the prevention of disorders of the digestive system. Besides, vegetable protein appears to be superior to animal protein. The nutritional status of the Bangladeshi diet is on a declining trend due to low intake of vegetables, fruits and spices. The increased production and intake of vegetables by the people will help compensate for debilitating nutritional deficiencies.

The foodgrain production in the terminal year of the Fifth Plan has been projected to be 25.12 million Mt. Out of this, rice production is expected to be 23.40 million Mt as against the production of 18.88 million Mt in 1996/97. The estimates for wheat and other coarse grain production have been made at 1.60 million Mt and 0.12 million Mt, respectively, in the terminal year of the Plan. The actual and projected production of important crops are shown in Tables 1 and 2 and the details of trade in Tables 3 and 4.

Table 1. Production Projection of Important Crops during the Fifth Plan
(Area in million hectares and production in million metric tonnes unless otherwise noted)

Crops	1996-97 (Benchmark)		2001-2002 (Projection)	
	Area	Production	Area	Production
1	2	3	4	5
Rice	10.40	18.88	10.11	23.40
Wheat	0.71	1.45	0.70	1.60
Sub-Total	**11.11**	**20.33**	**10.81**	**25.00**
Other coarse grain	0.10	0.10	0.12	0.12
Total Foodgrain	**11.21**	**20.43**	**10.93**	**25.12**
Potato	0.15	1.85	0.16	2.43
Sweet Potato	0.05	0.50	0.05	0.66
Oilseeds	0.50	0.37	0.70	0.76
Pulses	0.65	0.53	0.78	0.85
Spices	0.15	0.33	0.22	0.50
Vegetables	0.25	1.45	0.30	1.82
Fruits	0.19	2.14	0.26	3.54
Jute (million bales)	0.51	4.87	0.57	7.24
Cotton (million bales)	0.04	0.10	0.11	0.26
Sugar cane	0.18	8.10	0.18	12.37
Tea (million kg)	0.05	54.00	0.05	60.00
Tobacco	0.03	0.04	0.03	0.04

Table 2. Area, Yield and Production of Crops Commercially Grown in Bangladesh
(Area: In Lac Hectare; Production: In Lac Metric Tonnes)

Sl	Name of Crops	1994-95		1995-96		1996-97		1997-98		1998-99		Average for last 5 years		
		Area	Pro-duction	Area	Pro-duction	Area	Pro-duction	Area	Pro-duction	Area	Pro-duction	Area	Pro-duction	Yield/ hectare in tonnes
1	**Aus:**													
	HYV	4.14	7.02	4.19	7.02	4.76	8.43	4.90	8.72	4.41	7.28	4.48	7.69	1.72
	Local	12.50	10.89	11.23	9.74	11.16	10.28	10.75	10.03	9.83	8.89	11.09	9.97	0.90
	Total Aus	16.64	17.91	15.42	16.76	15.92	18.71	15.65	18.75	14.24	16.17	15.57	17.66	1.13
2	**Aman:**													
	B.Aman	9.55	9.04	8.37	7.89	8.40	8.66	8.14	7.80	6.01	5.38	8.09	7.75	0.96
	T.Aman:													
	HYV	21.47	44.83	22.68	46.81	24.72	53.60	25.47	52.06	24.63	47.41	23.79	48.94	2.06
	Local	24.92	31.17	25.42	33.20	24.91	33.26	24.48	28.64	21.01	24.57	24.15	30.17	1.25
	Total T.Aman	46.39	76.00	48.10	80.01	49.63	86.86	49.95	80.70	45.64	71.89	47.94	79.11	1.65
	Total Aman	55.94	85.04	56.47	87.90	58.03	95.52	58.09	88.50	51.65	77.36	56.04	86.86	1.55
3	**Boro:**													
	HYV	24.10	62.01	25.07	68.52	25.47	71.05	26.71	77.96	32.82	101.53	26.83	76.21	2.84
	Local	2.54	3.37	2.47	3.69	2.36	3.55	2.18	3.41	2.46	3.99	2.40	3.60	1.50
	Total Boro	26.64	65.38	27.54	72.21	27.83	74.60	28.89	81.37	35.28	105.52	29.24	79.82	2.73
	Total HYV Rice	49.71	113.86	51.94	122.35	54.95	133.08	57.08	138.74	61.86	156.22	55.11	132.85	2.41
	Total Local Rice	49.51	54.47	47.49	54.52	46.83	55.75	45.55	49.88	39.31	42.83	45.74	51.49	1.13
	Total Rice	99.22	168.33	99.43	176.87	101.78	188.83	102.63	188.62	101.17	199.05	100.85	184.34	1.83
4	Wheat	6.39	12.45	7.01	13.69	7.08	14.54	8.05	18.03	8.82	19.08	7.47	15.56	2.08
	Total Rice & Wheat	105.61	180.78	106.44	190.56	108.86	203.37	110.68	206.65	109.99	218.13	108.32	199.90	1.85
5	Maize	0.09	0.25	0.10	0.27	0.13	0.46	0.19	0.80	0.24	0.85	0.15	0.53	3.51
	Total Food Crops	105.70	181.03	106.54	190.83	108.99	203.83	110.87	207.45	110.23	218.98	108.47	200.42	1.85
6	Pulses	7.10	5.34	6.98	5.25	6.89	5.25	6.84	5.19	6.25	5.10	6.81	5.23	0.77
7	Oilseeds	4.53	3.35	5.55	4.71	5.53	4.78	5.61	4.83	5.80	5.20	5.40	4.57	0.85
8	Potato	1.32	14.68	1.32	14.92	1.34	15.08	1.36	15.53	1.42	18.50	1.35	15.74	11.64
9	S. Potato	0.46	4.34	0.45	4.35	0.43	4.06	0.42	3.98	0.40	3.81	0.43	4.11	9.51
10	Vegetable	2.32	12.03	1.91	12.44	1.96	13.13	2.00	13.29	2.15	14.75	2.07	13.13	6.35
11	Sugar cane	1.80	74.46	1.74	71.65	1.76	75.21	1.75	73.79	1.67	60.00	1.74	71.02	40.72
12	Jute	5.60	53.11	4.58	40.74	5.07	48.66	5.77	58.24	5.25	47.20	5.25	49.59	9.44

Table 3. Bangladesh Foodgrain Trade, 1980/81 - 1998/99
(000 Mt)

Year	Food Aid			Commercial			Public Import			Private Import			Total Import		
	Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total
1980/81	19	732	751	65	260	325	84	992	1076				84	992	1076
1981/82	30	1111	1141	114	0	114	144	1111	1255				144	1111	1255
1982/83	131	845	976	186	682	868	317	1527	1844				317	1527	1844
1983/84	117	1324	1441	62	553	615	179	1877	2056				179	1877	2056
1984/85	125	1181	1306	570	717	1287	695	1898	2593				695	1898	2593
1985/86	27	1060	1087	10	103	113	37	1163	1200				37	1163	1200
1986/87	108	1317	1425	150	192	342	258	1509	1767				258	1509	1767
1987/88	192	1595	1787	398	732	1130	590	2327	2917				590	2327	2917
1988/89	40	1316	1356	21	759	780	61	2075	2136				61	2075	2136
1989/90	41	908	949	258	326	584	299	1234	1533				299	1234	1533
1990/91	10	1530	1540	0	37	37	10	1567	1577				10	1567	1577
1991/92	39	1375	1414	0	150	150	39	1525	1564				39	1525	1564
1992/93	19	716	735	0	93	93	19	809	828	0	355	355	19	1164	1183
1993/94	0	654	654	0	0	0	0	654	654	74	238	312	74	892	966
1994/95	0	935	935	230	390	620	230	1325	1555	583	430	1013	813	1755	2568
1995/96	1	737	738	487	352	839	488	1089	1577	650	200	850	1138	1289	2427
1996/97	10	608	618	9	103	112	19	711	730	15	222	237	34	933	967
1997/98	0	549	549	0	650	650	0	1199	1199	993	142	1135	992.6	1341	2334
1998/99	59	1174	1233	334	429	763	393	1603	1996	2663	805	3468	3056	2408	5464
Average (1980/81 - 89/90)	83	1139	1222	183	432	616	266	1571	1838	0	0	0	266	1571	1838
Average (1990/91 - 98/99)	15	920	935	118	245	363	133	1165	1298	711	342	1053	686	1430	2117

Source: Directorate of Food and NBR.

Table 4. Trade of Crops/products (Import, Export)

Name of Crops	Import (in Million dollars)				Export (in Million dollars)			
	1996-97	1997-98	1997-98 (Jul-Dec)	1998-99	1996-97	1997-98	1997-98 (Jul-Dec)	1998-99
Rice	28.0	247.0	6.0	309.				
Wheat	156.0	122.0	69.0	146.0				
Oilseed	62.0	93.0	48.0	50.0				
Edible oil	296.0	216.0	122.0	138.0				
Tea					38.14	47.47	40.84	36.36
Vegetables					24.91	32.47	19.72	15.00
Raw Jute					116.31	107.77	85.59	47.77
Frozen Food					320.73	293.84	227.44	202.07
Others					26.33	20.38	16.87	15.96
Leather					195.48	190.26	138.43	124.03
Jute goods					317.86	281.42	207.72	211.66

Source: Bangladesh Economic Survey, 1999, MOF, Govt. of Bangladesh.

2.3 Maize and Other Coarse Grains

Maize is now considered as a substitute for both rice and wheat since it can be grown in all seasons. From maize one may get food, oil, fuel, fodder and feed. The present yield potential is too low. It can be increased to the level of HYV wheat provided hybrid varieties are used, adequate demand is created, and fair prices to the growers can be ensured. The genetic yield potential of maize is very high. Bangladesh Agricultural Research Institute (BARI) has already developed five high yielding medium duration maize varieties with grain yield potential of 5-7 Mt/hectare, suitable for flood prone areas. The maize production is planned to increase by 250 percent to 12,500 Mt in 2001/2002 from the benchmark production of about 5,000 Mt. Besides maize, other coarse grains consisting of barley, sorghum, bajra, and millets have considerable importance from the point of use of water resources and development of agro-industries. Considering the increased importance of these minor crops as supplementary food, cattle feed, and industrial raw materials, an increased production programme for these crops will be taken up during the Fifth Plan period, using hybrids.

2.4 Horticultural Crops, Pulses and Oilseeds

The environment in Bangladesh is quite rich for the production of a large variety of fruits and vegetables. Some fruits such as mango, banana, pineapple, jackfruit, etc., have world demand. The main problem of fruit production is its seasonal nature. Year-round production varieties have yet to be evolved. Special efforts will be made during the Fifth Plan to produce at least major fruits and vegetables on a year-round basis and commercialize their production through appropriate research and development programmes. At the same time, emphasis will be given on the qualitative and quantitative improvement of various fruits and vegetables production, including production of mushrooms, flowers, orchids and shrubs, etc. Production of fruits and vegetables has been projected to be 3.54 million Mt and 1.82 million Mt, respectively, by the end of the Plan period.

Potato: Potato is suitable as a security crop in times of rice shortages due to its high carbohydrate content contributing to improved food security. It is also used as a vegetable by various income groups of the country. Since it is a short duration crop, its increased use can reduce the pressure on rice and wheat. Considering the production potential of the crop, potato production is projected to grow to 2.43 million Mt in 2001/2002. The increased production is expected to come from expansion in cropped area and increase in yield per hectare. To this end, true potato seed technology will be encouraged and adopted.

Sweet potato: Sweet potato is considered as a subsistence as well as a poor people's food. Hence, its production will be encouraged on marginal lands, homestead areas, roadsides and elsewhere as a low input crop to ensure its continued availability to, and affordability by low income consumers. Sweet potato production is projected to be 0.66 million Mt in the terminal year of the Fifth Plan.

Pulses: The pulses of Bangladesh comprise of six major crops, namely, lentil, khesari, blackgram, mungbean, chickpea and pigeon pea. Cowpea occupies an important place in the Chittagong area. The cropped area and production of these pulses have been on the decline over the past few years mainly because of the increased emphasis on HYV rice and wheat. But pulses are very important because of their protein supply to the human diet and nitrogen fixation for soil nutrition. Since improved technology can increase per hectare yield of pulses substantially, pulse production is projected to grow to 0.85 million Mt in the terminal year of the Plan as against the benchmark production of 0.53 million Mt.

Oilseeds: Vegetable oil from oilseeds is the main sources of fats in the average Bangladeshi diet. Its present level of consumption is only 25 percent of the FAO/WHO recommended level. Efforts will be made to increase oilseeds production to 0.76 million Mt by the terminal year of the Fifth Plan. Groundnut, sunflower and soybean have been included in this projected production. New seed varieties are being used in the defined area to avoid cross-pollination. Production of foundation and certified seeds of improved varieties and demonstrations of modern technology are important strategies to increase oilseeds production of the country.

2.5 Cash Crop Production during the Fifth Five Year Plan

Jute: Jute is the major fibre crop of the country. Despite the relative decline in importance of jute in agriculture, potential still exists for the fibre to increase its contribution to the economy through productivity increases and diversification. The share of raw jute and jute goods in the total exports of the country has been declining but still remains significant. In this situation, special measures will be taken during the Plan period to encourage farmers to further intensify jute production in order to satisfy domestic and export demand. To enable jute to compete with synthetics, emphasis will be given to related agricultural and technological research efforts. The raw jute production is projected to go up to 7.24 million bales in 2001/2002 as against 4.87 million bales in 1996/97 through per hectare yield increase, availability of better quality seeds, and improved provision of extension and credit support to growers.

Tea: Tea is one of the most dynamic agro-based, labour intensive, export oriented industries of Bangladesh. It plays a vital role in the national economy in both export earnings as well as in employment generation. Plantation and production of processed tea are the two main activities in the private sector. In the public sector, green leaf production was promoted

through development projects implemented by the Bangladesh Tea Board. With the introduction of high yielding varieties, quality planting materials, timely application of production inputs and installation of modern machinery, tea has undergone further improvement and enabled Bangladesh to compete more effectively with other exporting countries. Increased production is expected to come from higher yields and by reducing tea vacancies now existing in the gardens.

Tobacco: Tobacco is one of the important cash crops of the country. The crop grows well in sandy, well aerated, well drained soils and cool climate. Hence, it is grown as a Rabi crop and most of the area is concentrated in the greater districts of Kushtia and Rangpur. Due efforts to expand tobacco cultivation since 1973/74 through support from big cigarette manufacturing firms self-sufficiency in tobacco production was achieved by 1980/81. However, recognizing tobacco's adverse effects on health, policies will be adopted to limit its production by the gradual reduction of cropped area in favour of cotton and pulses. The production of tobacco has been projected to be 0.04 million Mt by the terminal year of the Fifth Plan.

Cotton: Cotton played a very important role in improving the socio-economic conditions of the farmers during the previous Plan period. The production has gone up from 45,800 bales in 1983/84 to about 1,00,000 bales in 1996/97. The yield of seed cotton per hectare has reached a reasonably high level; yet the yield of cotton in the country is low compared to world standards. The major constraints to increased production are inadequate ginning capacity and seed multiplication programme, insufficient expertise and material resources, inefficient system of management, and ineffective extension and marketing organization. Textile mills should encourage commercial plantation through cooperatives in suitable cotton belts. During the Plan period, efforts will be made to provide loans to farmers to ensure supply of improved seeds, fertilizers, plant protection measures, irrigation and credit facilities to the growers along with the practicing of improved technologies in the cotton fields. Cotton production has been projected to be 0.26 million bales by the terminal year of the Fifth Plan as against 0.10 million bales in 1996/97.

Sugar cane: Sugar is the country's most important agro-industry and sugar cane is one of the important cash crops. Sugar cane is grown as a 12-15 month crop in a two year rotation with Aus rice crop during the monsoon season followed in the dry months by oilseeds, wheat or vegetables. Sugar cane yields in the country are low by world standards and the quality is poor. The average yield of sugar cane is about 6.1 Mt per hectare with a sugar recovery rate of 8.10 percent. Sugar cane is grown on about 0.18 million hectares of land. Of this, about 0.095 million hectares are in the sugar mill zone areas and the rest in the non-mill zone areas which produce sugar cane mostly for making gur consumed by the rural people. Research efforts will be strengthened to raise yield per hectare through varietal improvement, better management of water resources, fertilizers and other inputs, improved cropping systems and development of a sugar cane delivery system from farms to mills. Considering the past consumption trend, milling capacity and possible growth rate of production, sugar cane production is projected to be 12.37 million Mt in the terminal year of the Fifth Plan as against the benchmark production of 8.10 million Mt.

2.6 Special Agricultural Zones

Apart from plain land agriculture, there are special agro-ecological zones, which have quite high growth potentials. Specific development policy, strategy and programmes for

these zones are needed to exploit the existing potentials of the following areas: (a) the upland in the hilly areas of Chittagong, Chittagong Hill Tracts and Sylhet, (b) the wetland in greater Mymensingh, Sylhet, Jessore, Pabna, Rajshahi, etc., and (c) the coastal areas of the southern part of Bangladesh. Each requires a distinct set of policies, strategies and programmes because of differences in agro-ecological environment. Research, extension and input delivery will be so designed as to meet the specific requirements of these special agro-ecological zones.

Rainfed Farming: Crop production in Bangladesh is predominantly monsoon dependent. Of the total rainfed areas, about 3 million ha is estimated to be prone to severe drought. The entire Barind and Modhupur Tracts, constituting about 12 percent of the total arable area are characterized by soils of shallow depth having low moisture holding capacity and heavy sub-surface clay. Crop production in these areas and in the Gangetic flood plains is mainly dependent on rainfall and on the inundation from the Ganges river and its tributaries. However, for the whole of the Ganges belt, including the Barind and Modhupur Tracts, no rainfed farming practice specially suited to the prevailing soil and agro-climatic condition has yet been developed. There is, therefore, an urgent need to develop drought tolerant crop varieties and drought mitigating technologies that will make maximum use of the land resources of the rainfed farming systems. Rainfed farming practices will also include supplementary irrigation which will help increase crop production during the Kharif season.

Wetland Farming: Large areas of wetland commonly known as beels, baors and haors in the greater districts of Sylhet, Mymensingh, Jessore, Rajshahi and Pabna hold quite high potentials for the development of crop agriculture and fisheries. Crop agriculture and fish production can be carried out simultaneously. Besides, preservation of biodiversity of the wetland will be given high priority. Greater attention will be given during the Fifth Five Year Plan to exploit the potentials of crop agriculture and fisheries through the provision of a situation specific package of development programmes for research, extension, input supply, etc.

Coastal Farming: Coastal areas in the southern part of Bangladesh constitute a specific ecological zone having specific problems and possibilities. Cyclones, tidal bores, salinity, etc., affecting agricultural output frequently visit these areas. Therefore, there is need for developing a salinity resistant variety of rice, for example, for these areas. Coconut, betel nut, palm and mangrove are major cash crops in these areas. Location specific research, extension and other programmes will be developed and provided for the purpose of exploiting the potentials.

Hill Farming: The upland in the hilly areas of the greater Chittagong district, Chittagong hill tracts and Sylhet district constitute a special agricultural zone requiring location specific services and programmes. High potentials exist for the production of fruits, spices and vegetables in these areas. Agricultural development potentials in these areas are quite substantial. Resources will be provided to develop appropriate technologies that are suitable for upland agriculture.

Cropping Intensity: Bangladesh has, by 1996/97, achieved an estimated cropping intensity of about 185 percent. Out of the net cropped area of 7.6 million hectares, about 55 percent is double cropped and approximately 15 percent triple cropped. However, about 30 percent is still single cropped. Since all the suitable land is already under cultivation, raising the intensity of land use is needed. It is expected that cropping intensity will reach 192 percent

by the terminal year of the Fifth Plan. Cropping intensity from 1992/93 to 2001/2002 is shown in Table 5.

Table 5. Cropping Intensity from 1992/93 to 2001/2002
(Area in million hectares)

	Net Land Area	Total Cropped Area	Cropping Intensity
1992/93	7.64	13.70	179%
1996/97	7.60	14.08	185%
2001/2002 (Projection)	7.50	14.41	192%

3. PATTERNS OF CROP DIVERSIFICATION IN THE COUNTRY AND SUCCESSFUL CROP SEQUENCES

The rate of population increase was 2.8 percent during the 1960's. To feed the ever increasing population, the Government placed emphasis on the production of cereals crops, mainly rice, with the introduction of HYVs of rice and wheat both from home and abroad by launching 'Green Revolution' and ITAP 'Grow More Food' programmes. As a result, production of major cereal crops i.e., rice and wheat, increased tremendously. But the production of minor cereal crops like pulses, oilseeds, vegetables, fruits and spices declined gradually year after year and finally failed to keep pace with the rapid population growth. This involved the use of a huge amount of valuable foreign exchange in importing those minor cereal crops to improve the nutritional and nutrient status of the people and of the soils.

Minor cereal crops are relatively cheap sources of protein and calorie and they also have a positive impact on the nutrient balance of the soil. The farmers can easily cultivate these crops after harvesting the major ones. With this realization and to reduce the huge drain of foreign exchange in importing those crops, the Government of Bangladesh launched a Crop Diversification Programme in the 1990's. After mass awareness creation through demonstrations and other mass media, the farmers started adopting this programme. The crop diversification patterns that are being followed in the country are given below:-

Land Type	Cropping Pattern
High	1. Boro - T.Aman - Fallow 2. Potato - Boro (HYV) - T.Aman 3. Pulses - Jute - Fallow 4. Wheat - Kaon - T.Aman 5. Tomato - Aus - Vegetables
Medium	1. Potato - Boro - T.Aman 2. Wheat - T.Aman - Pulses 3. Oilseed - Boro - T.Aman 4. Boro - T.Aman - Mustard 5. Tomato - Aus - Vegetable
Low	1. Potato - Boro B.Aman 2. Boro - T.Aman - Fallow 3. Kaon - T.Aman - Fallow 4. Wheat - Boro - T.Aman 5. Jute - T.Aman - Fallow

The forces that led crop diversification are described for each major pattern as follows:

Major Patterns	Forces
i. Potato - Boro (HYV) - T.Aman	a. Irrigation facility b. Maximum return c. Land suitability
ii. Wheat - Kaon - T.Aman	a. Irrigation facility b. Credit facility c. Land suitability
iii. Pulses - Aus - Vegetables	a. Improving soil fertility b. Balanced diet c. Maximum profit
iv. Wheat - Aus - T.Aman	a. Irrigation facilities b. Credit facility c. Land suitability
v. Boro - T.Aman - Fallow	a. Land suitability b. Demand of cereal foods c. Improving sol fertility.

Rice, in Bangladesh, is grown throughout the year in three distinct cropping seasons both in irrigated, lowland and upland conditions as follows:

i) Irrigated conditions	1. Potato - Kaon - T.Aman 2. Boro - T.Aman - Fallow 3. Wheat - Kaon - T.Aman 4. Potato - Boro - T.Aman 5. Tomato - Aus - T.Aman 6. Pulses - Aus - Fallow
ii) Lowland conditions	1. Wheat - T.Aman - Fallow 2. Boro - T.Aman - Fallow 3. Potato - Boro - Aus 4. Aus - T.Aman - Fallow 5. Kaon - T.Aman - Fallow 6. Boro (HYV) - Fallow - Fallow
iii) Upland conditions	1. Mustard - Kaon - T.Aman 2. Potato - Kaon - T.Aman 3. Spices - T.Aman - Fallow 4. Wheat - Vegetable - T.Aman 5. Pulses - Aus - T.Aman 6. Wheat - Jute - T.Aman

Diversification around Upland Crops: The upland crops can only survive for a short period if the root zone remains saturated. Most of the CDP crops cannot sustain growth in saturated soils for more than one or two days. Moreover, high rainfall during critical growth stages badly damages the upland crops. With adequate irrigation, most of the uplands can become highly suitable for diversified crops during the dry season and moderately suitable rice fields during the wet seasons. For this, between two main rice crops some selected upland crops are diversified and are grown throughout the year.

Diversification around Other Crops: In a multiple cropping system, farmers are cultivating two vegetable crops either solely (one short and another long duration crop) or mixed/relay

cropping. This has only been possible due to good soil conditions, available irrigation facilities and adequate farmers' knowledge about the vegetable crops and marketing facility etc., which led the farmers to follow crop diversification around other crops.

There are a lot of success stories in crop diversification in Bangladesh, from the CDP project as well as from the ongoing GOB/UNDP/FAO project "Thana Cereal Technology Transfer and Identification" (TCTTI), which are now being replicated in 80 new Thanas using GOB resources and personnel.

To quote one example Md. Tajul Islam of Saganna village of Jhenaidah district is a literate farmer, he owns 5.5 hectares of cultivated land with a small family of 4 members. Farming is his full time occupation. His father was a farmer and migrated to Jhenaidah from Munshigonj. Munshigonj is a famous place for growing banana, potato and vegetables. Mr. Tajul occasionally visits his ancestral village in Munshigonj. Before adopting crop diversification, he used to grow paddy, jute, mustard, sesamum, kaon, etc. After being motivated to grow CDP crops and ensured of irrigation facilities, he now grows HYV Aman, wheat, Aus, banana, papaya, beans, tomato, brinjal, cauliflower, cabbage, potato, chilies and potol etc., and became the pioneer in his village in the field of crop diversification. This has enhanced his income significantly. Seeing this, other neighbouring farmers started practicing crop diversification in his area.

4. CROP DIVERSIFICATION AS A STRATEGY (INSTRUMENT) FOR FOOD AND NUTRITION SECURITY, INCOME GROWTH, POVERTY ALLEVIATION AND SUSTAINABILITY

Malnutrition, in Bangladesh, is still an issue of national urgency with considerable damage to the health and survival of the most vulnerable group i.e., children and women. Though food production has increased over the last few decades, a downward trend in the intake of calories per person per day has resulted in widespread chronic dietary deficiency. The consumption of food items other than the cereals is much less than the minimum requirements. Further, the composition of the diet is not balanced as 85 percent of the calorie and 60 percent of the protein intake is derived from cereals. The main reasons for such a situation are mainly the low diversification of crops, inadequate nutritional knowledge, inequitable distribution of income, and low purchasing power. To address food and nutritional security, a number of projects including TCTTI and CDP have been undertaken in the agriculture sector for increased production of different food items through developing HYVs of cereal crops as well as of pulses, vegetables, fruits, etc. In doing so, the nutritional aspects are given high priority to minimize the existing nutritional deficiency.

The introduction of CDP in the agriculture sector has had a positive effect on raising the production of potato, oilseeds, pulses, fruits and vegetables in the CDP areas as compared with in non CDP areas. The CDP still continues to play a very important role in the economy of the country. Presently, the agriculture sector contributes about 32 percent to the national GDP, nearly 62 percent to the national employment with 57 percent of the labour force in the crop sector alone. It is still the single largest contributor to additional income and employment generation required to reduce rural poverty and to attain sustainable economic development. The TCTTI project has ensured sustainable intensification of rice production in Bangladesh and raised possibilities for expanding crop diversification in the highlands and medium lands during the Rabi season.

The area suitable for crop production is estimated to be a little over 9 million hectares. With the growth in population and other infrastructure development, the cropped areas have been steadily declining. To ensure food and nutrition for the ever increasing population, suitable cropping patterns were introduced based on the concept of crop diversification depending on soils and other agro-climatic conditions, which raised cropping intensity to 185 percent in 1997 from 100 percent in 1979. As agricultural production is seed-fertilizer-water based, so more than 152 production technologies for crops including varieties and management practices have so far been developed. Private traders/distributors were given permission to have a direct access to the bulk purchase of chemical fertilizers as well as to import TSP and MP fertilizers freely which has led to increased availability and wider adoption of chemical fertilizers at the farm level. Irrigation water was ensured through removing the restriction on the imports of small diesel engines, withdrawal of customs duty, and the abolition of tube-well siting restriction in non-surface irrigation areas, which led to a tangible effect on the demand for irrigation equipment and the rate of increase in area under minor irrigation.

The strategy for sustaining agricultural growth is based on changing the nature of Bangladesh agriculture from a relatively high risk monsoon based to lower risk irrigation based cropping system. Sustaining the growth of rice production and emphasizing and stimulating crop diversification are the key strategies to be pursued in future. This will come from rapid application and expansion of HYV seed-fertilizer-irrigation technology, relying more on competitive markets for inputs delivery, stabilizing soil fertility etc. In order to combat environmental degradation due to pesticide use and ensure effective pest management, the practice of integrated pest management (IPM) will continue to be pursued. A capability is being developed to monitor changes in the environment, particularly of soils and surface and ground water with a view to ensure sustainable agricultural development and environmental protection.

5. CHALLENGES, OPPORTUNITIES AND PROSPECTS OF CROP DIVERSIFICATION IN THE COUNTRY

As Bangladesh is endowed with favourable climate and soils for the production of a variety of crops all the year round, so ample opportunities exist for crop diversification, balancing major crop production with minor crop production. Minor crop production has tremendous potential if seasonal fallow land is brought under irrigation with technology packages given to the farmers. The per acre yield of minor crops can be increased by improving agronomic management practices with the existing crop varieties. The main problems/constraints facing CDP relate to a variety of factors. These are marketing problems, ineffective agriculture credit supply, lack of the right kind of technology and low level of investment, non-availability of quality seed, shortage of draught power, lack of maintenance of soil fertility, lack of irrigation coverage, and ineffective research-extension linkages.

Introduction of the Crop Diversification Programme in agriculture has created a golden opportunity to commercialize the production by small holding farmers of those minor crop varieties which are highly profitable and remunerative and which are import substituting and export-oriented through the establishment of community storage and easy transportation facilities. This commercialization of CDP crops can help promote the establishment of joint-venture enterprises in Bangladesh and around the world that will buy,

process and export those labour intensive crops and increase economic activity and the creation of employment opportunities at home and abroad. With the inauguration of the Bangobandhu Multipurpose Bridge in June 1998, the agricultural hinterland of Northwest Bangladesh has been connected to the rest of the country, thereby enabling a commercial angle to Bangladesh agriculture.

More than 20 crop varieties along with improved cultivation practices were so far developed for crop diversification. Moreover, land use inventory capabilities were developed and transferred to the Soil Resource Development Institute (SRDI) for on-going use and application. A significant numbers of Project Implementation Unit (PIU) and NGO officials were trained through 25 local events to enhance their management skills. Some GOB and PIU officials also received foreign training on the administration and management of bilateral and multilateral development of the projects. The ongoing TCTTI project is complementing these activities relating to skill empowerment training and capacity building of farmers and DAE personnel.

Research on agriculture is given the priority thrust to support the increasing population with food, nutrients, clothing and housing from the decreasing land resources. In order to carry out research on CDP crops, Bangladesh Agricultural Research Institute (BARI) was given the top priority. BARI has so far developed and released 9 varieties of potato, 5 varieties of pulses, a number of varieties of wheat, 5 varieties of oilseeds, and several improved cultivation techniques for vegetables. The Department of Agricultural Extension (DAE), being the lead Government agency in the dissemination of technologies to the farmers, is playing an active and vital role with the help of some concerned NGOs to disseminate those extension messages to the farm families.

In order to succeed and bring positive changes towards the development of minor crops, the CDP has an opportunity to get support from the following organizations:

i. *Research* - Research on CDP crops has been entrusted with BARI, Bangladesh Agricultural University (BAU), Bangladesh Institute of Nuclear Agriculture (BINA), and Chittagong University (CU) also conducts research on those crops. So liaison should be made with these institutions.

ii. *Marketing* - The Department of Agricultural Marketing (DAM) needs to be activated with the request to provide market intelligence to facilitate growers with market information and intelligence in cities and rural areas. DAM will promote, popularize and provide marketing support to growers through farming groups and organization

iii. *NGOs* - The involvement of efficient NGOs in association with DAE is likely to accelerate the promotion of CDP activities.

iv. *BADC* - The role of Bangladesh Agricultural Development Corporation (BADC) is confined to the production of foundation seeds of CDP crops in their own farms and certified seed through contract growers.

Infrastructure development and refurbishing of BARI facilities and equipment will provide an opportunity to contribute greatly to maintaining the productivity of research on CDP crops.

6. GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

6.1 Fifth Five Year Plan Targets

Sustainability of high yield and environmental protection remain the principal concerns in recent years. Loss of soil fertility followed by the unbalanced use of chemical fertilizers, lack of adequate quantity of water in some areas as well as their appropriate conservation and management are the major factors causing divergence between potential and actual output of major agricultural commodities. Various studies indicate that the yield potential of the existing HYVs of rice is more than 4 Mt/ha, whereas the average yield of most of the other varieties of rice is around 2 Mt/ha. Major tasks during the Fifth Five Year Plan will be to address these issues. The specific objectives of the Plan will be to:

a) increase productivity and real income of farming families in rural areas on a sustainable basis through sustainable intensification of rice production and situation-oriented crop diversification;
b) attain self-sufficiency in foodgrain production along with increased production of other nutritional crops;
c) encourage export of agricultural commodities, particularly vegetables and fruits keeping in view domestic production and need;
d) promote adoption of modern agricultural practices in dry land, wetland and coastal areas;
e) ensure sustained agricultural growth through more efficient and balanced utilization of land, water and other resources; and
f) encourage comparatively large farms to graduate into commercial farming.

Policies and Strategies: In order to achieve the objectives, the strategies/policies will be evolved and adopted to bring about necessary technical change. The following will be the specific policies and strategies:

a) improvement of the quality of seeds of desirable growth duration which will fit into suitable crop sequences, particularly HYVs and hybrid seeds, and increasing quantity;
b) development of modern, irrigated and least-risk agriculture with greater reliance on competitive markets through supply of agricultural inputs at low cost, making public investment more effective and keeping it limited to key areas as required to supplement private initiatives;
c) strengthening of the agricultural research and extension systems in order to develop new technologies relating to crop varieties, integrated farming system, organic farming, improved agronomic and agro-processing technologies, and for diffusion of the proven technologies;
d) development and dissemination of ecologically sound and sustainable technologies such as integrated pest management (IPM) techniques, and organic and bio-fertilizer use;
e) increasing profitable production of minor crops and thereby maintaining a balanced crop production and improving the nutritional status of the people;
f) development of suitable technologies in rain-fed, dry land and wetland farming system to enhance their productivity;

g) restoration/improvement of soil fertility through better management of the organic matter of soil to improve yields of crops; towards this end, production and use of bio-manure will be encouraged;
h) assistance to small and marginal farmers in forming groups and associations which can i) enhance production and productivity, ii) sustain agro-business enterprises on their own, iii) absorb more credit fund, and iv) adopt/disseminate technologies;
i) participation of NGOs in the agricultural development process;
j) improvement and conservation of plant genetic resources through collection and conservation of germplasm;
k) facilitation of access to markets and promotion of efficient marketing system;
l) formulation of integrated land use policy conductive to optimum use of agricultural resources;
m) implementation of measures to cushion and minimize the damage to agriculture and rural economy brought about by natural calamities;
n) development of capabilities of rural women and the youth to contribute more to agricultural and rural development;
o) restructuring of the existing institutional setup to cope with the changed need;
p) development of human resources through education, training skill empowerment and motivation;
q) development and dissemination of appropriate location-specific and cost-reducing production and post-harvest technologies for reduction of post-harvest losses and the removal of transport bottlenecks; and
r) adoption of policies and regulations that will ensure sustainable agricultural development.

6.2 Major Areas of Public Sector Promotional Activities

The crop production strategy of Bangladesh will be based on the following central thrusts: a) increased distribution of high quality HYV seeds by the public sector; b) accelerated transformation into irrigated agriculture to increase and stabilize crop yields; c) sustainable intensification of the cropping systems; d) decreased dependence on draught power through mechanization and bridging of the yield gaps in irrigated areas; e) improvement of productivity and minimization of production risks in the rainfed, wetland, high land and coastal farming system; f) diversification of farming systems to take advantage of favourable agro-ecological conditions; g) responding to changing consumer demands and developing a more sustainable agricultural system; h) vertical coordination of the production, harvesting and marketing chain; and i) strengthening of extension, research and other support services.

With the adoption of technologically advantageous HYVs of rice and wheat, food production increased on the one hand, but on the other hand, the decline in minor food crop production resulted in malnutrition causing considerable damage to the health and survival of the most vulnerable group. In order to have a healthy nation for quick and sustained economic growth, the government has taken up the Crop Diversification Programme for balancing major crop production with minor crop production. The increased production and intake of minor crops has a tremendous potential to alleviate nutritional deficiencies. Besides, crop rotation - exhaustive crops followed by recuperative crops, shallow rooted crops by deep-rooted crops, legume followed by non-legume etc., enrich/maintain soil fertility. They are also cheap sources of protein and calories. The poor farmer can cultivate

these crops after harvesting the major crops. Awareness building and enthusiasm have made the farmers believe that crop diversification is an effective means to improve the performance of those crops that have potentials to improve the nutritional status of food and soil fertility. Apart from their impact on CDP, the Government has taken the following strategies to reduce the dependence on rice cultivation and also to realize the full potentials for agricultural growth in the country:

- The unexploited but potential areas for specific crops under CDP will be brought under cultivation, where feasible and possible, with improved technologies in a phased manner.
- The promotion support programmes to commercial production will be encouraged to adopt those crops or crop varieties which are highly profitable and remunerative and which are import substituting and export-oriented.
- Farmers' location-specific, innovative technologies applicable to other similar areas will be transferred and incorporated in specific crop production programmes.
- Research on CDP crops, particularly pulses, oilseeds and vegetables will be strengthened to produce double cropped and double seasoned variety of pulses and oilseeds. This will help reduce importation of oilseeds and pulses and save hard-earned foreign exchange, to a great extent.

7. CONCLUSIONS

The introduction of CDP in the agriculture sector has created an awareness among the farmers to grow and consume a variety of crops like pulses, oilseeds, vegetables, fruits, spices, etc. Certain pulses such as chickpea, field pea, mungbean and lentil produce reasonably good yields with better management including irrigation, fertilization and weed control. The profit gained from these crops is higher than that of HYV rice and wheat. The farmers' awareness about the production of vegetables in recent years is better than in the past because of the provision of promotional support to produce more vegetables. The crops with moderately improved varieties are showing good response provided improved varieties and cultural practices are adopted. The HYVs of crops like potato, tomato, beans, mustard, sunflower, watermelon and banana are giving maximum yield when provided with irrigation, fertilization and better management. The promotion programme is being extended to spices and some country vegetables and fruits that do not have HYV, but do have high comparative profitability and incentives for the farmers. The stable and productive land under Deep Tube Well (DTW) and Shallow Tube Well (STW) command areas are being used for minor crops through creating awareness among the farmers.

As crop diversification is believed to be an effective means for improving the performance of agriculture in Bangladesh, so the future directions are formulated based on the assumptions that: (a) there would be more technological advancement of crop production, (b) more area would be brought under irrigation, (c) farmers would use improved varieties and apply improved agronomic management practices, (d) there would be increased use of fertilizer, (e) the IPM concept would be popularized among the farmers, (f) more crops would be grown to increase cropping intensity, (g) flood control and drainage projects would result in more lands free from risk and facilitate crop production, (h) there would be marketing improvement for internal and export demand, and (i) there would be more selective small farm mechanization, particularly in land preparation and also in harvesting to release land quickly for planting the next crops by reducing the turn-around time.

8. RECOMMENDATIONS

Considering the importance of crop diversification for increasing farmers' income and employment opportunities, reducing production risk and improving soil fertility and human nutrition, the following recommendations are drawn:

- By continuous motivation and encouragement, the farmers would be made financially better off by growing at least one CDP crop, vegetable and fruit crop which is much more labour intensive than rice production directly involves women and can employ many more marginal farmers and landless as labourers. The population could be better off, because its nutrition will be improved and the soil will benefit because crop rotation is a proven management technique. So it is imperative to sustain crop diversification.
- Efficient support services and institutions for credit, marketing, processing and packing should be geared up to open the door for CDP crops.
- To encourage crop diversification, some prospective cropping patterns, improved practices and irrigation management should be demonstrated at different locations.
- Further research should be undertaken for varietal improvement of high-value CDP crops and for assessing the technical and economic feasibility of growing them under both irrigated and non-irrigated conditions. As adjustments in growth duration become an obvious necessity, breeding crop varieties which would fit into changed cropping sequences would become necessary for increasing the overall production of the cropping system.
- In view of the predominantly small farmer holdings that are operating, whatever recommendations are made should be specifically targeted to improve the production system of small farmer holdings, tenant farmers and the marginal and landless category of the population.

CROP DIVERSIFICATION IN CHINA

Zuo Mengxiao [*]

1. INTRODUCTION

1.1 Bio-diversity of Genetic Resources

China ranks third in the world in germplasm resources, second only to Brazil and Colombia, and occupies 12 percent of the world's crop species. The country is one of the three centres of origin of cultivated plants in the world and has a great number of wild relatives of cultivated species such as soybean, rice, barley, tea and, therefore, is very rich in germplasm resources of crops. According to statistics, China has more than 1,000 economic tree species, 50,000 local rice varieties, 20,000 soybean varieties, more than 11,000 species of drug plants, more than 4,200 species of forage plants, and more than 2,200 species of important ornamental and flower plants.

1.2 Crop Diversification in China

China has 7,000 years of history in agricultural development and domestication of crops. This heritage of cultivated plants developed and utilized by the farmers is unique in the world. China's vast territory, diversity of climates, as well as its complicated physiography made great contributions to the formation of a variety of ecosystems. With a long period of natural and artificial selection, the farmers in China have created various types of cropping systems to match varied ecosystems exploiting abundant genetic resources of farm crops.

Diversification of farm crops refers to the complex diversification patterns of agricultural cropping systems found under the conditions of farming environments. In short, diversification of crops firstly refers to the species diversification of cultivated crops and secondly refers to the diversification of varieties and ecotypes of the same variety to maximize outputs of primary products as well as value-added processed products to enable farmers to enhance their incomes. The Chinese farmer pioneered this concept long ago as the pressure of population on land was so great that he was compelled to diversify his cropping systems in order to be self-reliant within the physical resources available to him.

2. CROP PRODUCTION AND ECONOMICS SCENARIO

2.1 Commercial Production of Major Crops

The Chinese government always puts agriculture at the forefront of the national economy, and assists in improving the conditions of agricultural production continuously by stabilizing the basic policies in rural areas. The government thus protected and mobilized the

[*] *Senior Agronomist and Deputy Director, Department of Crop Production, Ministry of Agriculture, Beijing, China.*

enthusiasm of the farmers in their production efforts, and brought about the sustained and stable growth in the production of major crops.

2.2 Economy of Crops and Internal Trade

Increasing cropping intensities in farming systems across China using the concept of horizontal diversification brought about economic emancipation to millions of farmers. As an important sector of China's agriculture and national economy, the production of farm crops occupies a very large portion and an important economic place in the gross domestic product of agricultural production and domestic commodity trade. However, because of the increase of consumption level of the increasing population, the proportion of output value of crops in the gross product of agricultural production and domestic commodity trade shows a declining trend.

2.3 Import and Export of Agricultural Products

In recent years, owing to the impact of Asia's economic crisis and the resultant lessening of the buying power of domestic consumers, China's import and export of agricultural products (Table 1) were also influenced in varying degrees and significant changes have taken place in the infrastructure of import and export policies.

Firstly, among food grains, the volume of export of rice increased (it reached its highest record of 3.745 million tonnes in 1998 since the founding of the People's Republic of China) and that of imports declined. The volume of export of maize and soybean declined and their volume of imports increased by a big margin (the volume of imported soybean reached 3.197 million tonnes for the first time in 1998). The volume of imports of wheat and barley also declined by around 20 percent.

Secondly, the volume of exports of raw cotton increased and its volume of imports declined substantially. The volume of exports of vegetable oil and sugar declined. Both the volume of imports and exports of vegetables and fruits increased by a big margin, but the income from their exports declined sharply.

Table 1. Import and Export of Main Agricultural Products in China in 1998
Unit: million US$

Classification of Agricultural Products	Import	Export	Net Export
Cereal grains	1989.47	2147.98	158.51
1.Wheat	278.57	1.41	-277.16
2.Rough rice, rice	120.04	927.17	807.13
3. maize	31.77	531.68	499.91
4. Sorghum	0.02	2.46	2.44
5. Other cereals	265.54	34.76	-230.78
6. Processed cereal products	70.05	368.10	298.05
Other produce	3219.54	5537.19	2317.65
1. Vegetables	71.29	1473.85	1402.56
2. Fruits	241.78	433.31	191.53
3. Processed vegetable & fruit products	23.58	1022.42	998.84
4. Coffee, tea	19.73	520.10	500.37
5. Sugar and sugared food	2787.83	1310.04	-1477.79
6. Drinks, wine, and vinegar	75.33	450.10	374.77
7. Miscellaneous products	83.32	327.37	244.05

Source: Chen Liangbiao, The prospects of China's food security and selection of policy.

3. PATTERNS OF CROP DIVERSIFICATION

3.1 Research and Utilization of the Diversification Strategy for Crops

Agricultural scientists have developed a large number of new varieties and combinations of various crops with the characters of early maturity, high yield, high quality, and broad adaptability by using different methods. According to the preliminary statistics, there are 5,600 varieties or more of 41 species of field crops, and 516 varieties of 36 species of garden crops, including fruit trees and vegetables, which have been developed from 1949 to 1998 in the whole country. Among these varieties, there are 365 varieties that cover an area of over 67,000 km^2.

It should be pointed out that intensive cultivation has always been a traditional cultivation method of the Chinese farmers and the main purpose of intensive cultivation is improvement of the level of farmland and resources utilization. The process in developing the high yield and high efficient model and system of companion cropping, intercropping, mixed cropping, and multiple cropping is just the developmental process of the diversification strategy among farmers in China.

Most of the early crop improvement work and adaptability studies were originally carried out by farmers themselves. From these early advances made in crop improvement and development, the Chinese scientists built upon the indigenous technologies to achieve the high degree of sophistication in agricultural technology that is currently existing.

3.2 The Formation and Development of the Diversification Methodologies for Rice

Rice is the first grain crop in China and China attaches great importance to selection and breeding of rice varieties. The indica rice (*Oryza sativa*, subsp. hsien) variety “Guanglu’ai” with the characteristics of tolerance to fertilizer, lodging resistance, and high yield was developed in 1959 and accomplished the incorporation of early maturity and dwarfing characteristics into new rice varieties. This was the first breakthrough made in China in the history of rice breeding. In the early 1970’s, the Chinese Academy of Agricultural Sciences and Hunan Academy of Agricultural Sciences jointly organized national cooperation in scientific research on hybrid rice and made an important breakthrough in the "three-line" system of hybrid rice production, thus accomplishing a leap forward in the history of rice development. This achievement in scientific research not only provided a new method for raising rice yields, but also opened up a new way for the utilization of heterosis in self-pollinated crops, and thus greatly enriched the theory of genetic breeding. This achievement won the state the Special Grade Prize for Innovation awarded by the Chinese government in 1981 and won international prizes five times. The work carried out in China on the origin and evolution of rice, the response reaction of rice varieties to conditions of light and temperature, and the discovery, identification and utilization of thermo-sensitive genic male sterile line of rice, not only laid a foundation for the protection of germplasm resources of rice in China, but also made a great contribution to the diversification of rice culture systems in many parts of the world.

3.3 The Formation and Development of the Diversification Patterns for Wheat Production

Wheat is the second most important grain crop in China and the development and utilization of its varietal resources received much attention. Bima No.1 and other varieties were bred in the 1950's. These possess the characters of rust resistance and high yielding ability, so they were well received by the farmers and were popularized over a large area. Jinan No.2 and other varieties with the characteristics of disease resistance and high yielding ability were bred in the 1960's. They were popularized over a large area in the winter wheat growing area of northern China. From the 1970's, the original varieties were gradually replaced by the improved dwarf varieties which possess the characteristics of rust resistance and high yielding ability. Each change of varieties made a great contribution to improvement of per unit yield of wheat. In recent years, cooperation in breeding for resistance to diseases among the scientific research departments has been further strengthened and a number of rust resistant and high yield varieties of wheat have been bred and are under demonstration for extension on a large scale.

In addition, China has also made a great breakthrough in new breeding methods and increased knowledge of the wheat crop, such as the classification of wheat, analysis of wheat varieties and their pedigrees, the allo-octoploid triticale bred by hybridization between wheat and rye through chromosome doubling, and the new wheat varieties of Xiaoyan No. 4, No. 6 and No. 967 bred by hybridization between wheat and quackgrass (*Elytrigia repens*). These have made important contributions to the development of wheat in China.

These new advances in wheat breeding have helped Chinese farmers make significant advances in crop diversification. In view of the planting systems now being adopted in the field, the multiple cropping patterns now make it possible for three crops to be grown every two years or two crops per year with a combination of wheat-maize or cotton-maize which has become popular among farmers in northern China for some time now. Another success story in crop diversification in recent years is the popular planting pattern of autumn vegetables (radish and Chinese cabbage) intercropped with spring wheat in the north part of Northeast China where the per mu income increased by 200-250 yuan RMB, making this cropping pattern well received by the farmers.

3.4 The Formation and Development of the Diversification Strategy using Maize and other Crops

Maize is a major grain crop in China and its diversification changes continuously following breakthroughs in the cross breeding of maize. In the 1950's, inter-specific hybrids were mainly used in maize production in China. Early in the 1960's, in addition to the utilization of inter-specific hybrids, these were combined with double hybrids, three-way cross hybrids, top cross hybrids, and the advantage of heterosis was used comprehensively in maize production. In recent years new progress has been achieved in the selection and breeding of special purpose hybrid maize with high oil content, high protein content, and high lysine content as well as sweet maize and glutinous maize. These hybrids have not only played an important role in increasing the yield of maize, but also contributed to the development of diversification programmes using maize varieties.

Significant social and economic efficiency has been obtained in the selection and popularization of new varieties of other crops, for instance, the new combination of Qinyou

cabbage (*Brassica caulora* Pasq.) bred by using three lines, and the use of new varieties of soybean, peanut, sugar cane, tobacco, tea, bast fibre plants, fruit trees, vegetables etc., in diversifying traditional cropping patterns.

4. CROP DIVERSIFICATION AS A STRATEGY FOR MAXIMIZING FOOD PRODUCTION

4.1 Security of Food and Nutrition

China is a country with the highest population in the world. The Chinese government always attaches importance to grain production and takes grain production as the basis of national food security and social stability. In the past 20 years or more, since the implementation of the policy of reform and opening to the outside world, the total amount of grain required for consumption has been effectively resolved in China. China's grain yield per capita has reached about 400kg. Along with the development of the economy, the urban and rural residents became more sophisticated in their demands based on specific varieties, quality and nutritive value of foods. In recent years, the type of crops grown has been regulated progressively, with a bias towards the reputed, special, high quality, new and rare agricultural products which have been developed rapidly.

4.2 Alleviating Poverty and Increasing Income and Employment

The Chinese government always attaches importance to the development and production of grain, increasing agricultural production, and solving the problem of self-sufficiency in food and clothing. In general, the problem of grain security has been largely resolved. However, owing to the unequal development between areas as well as the harsh natural environment in certain regions, and poor links in the distribution chain with poorly equipped transportation systems, there are still about 42 million people who have not enough to eat and wear even as recently as 1998.

To solve these problems, the government is trying hard to improve the conditions of agricultural production, quicken the economic development in poverty-stricken areas and guarantee grain security for the poor people in rural areas on the basis of the policy of stabilizing the rural areas and increasing agricultural inputs. Meanwhile, attention is also stressed on the protection and development of crop resources, guiding and encouraging farmers to adopt a market-oriented cropping structure, enlarging the scope of employment for farmers and enhancing their income. In 1998, the poverty-alleviating fund invested by the government exceeded 18.3 billion yuan RMB. This investment was used in planting and raising the production of poverty-stricken villages and families through a micro-credit scheme, which indeed promoted the economic development of poverty-stricken areas and helped in solving the problem of providing sufficient food and warm clothing.

4.3 Rational Utilization of Land, Water and other Resources

Protecting arable land, saving water and developing and using natural resources of the environment rationally is the base for ensuring national grain security, and achieving sustainable development of agriculture as well as preserving the national wealth of crops and safeguarding the ecological balance. The Chinese government always provides special protection to arable land. For instance, the basic farmland protecting system, which has been

carried out for years, guarantees the dynamic balance of the total amount of farmland, resulting in a stable grain sown area of over 110 million ha for years. Meantime, water-saving irrigation farming is actively developing and the technologies of drip irrigation, spray irrigation, infiltration-protecting irrigation, pipe-borne water delivery systems etc., are being extended widely. Up to 1998, the area of all water-saving irrigation systems reached 13 million ha, and the irrigation water-utilization efficiency exceeded 40 percent. Besides, the Chinese government also strengthened the work of construction of ecologically friendly agricultural systems and environment protection programmes. For example, the construction of the pilot counties of ecologically safe agriculture, the construction of natural reserves of forest land and grassland, and the plan for implementing by stages and in groups the policies of returning the land on steep slopes over 20 degrees from farming to forestry and grass, returning the land for farming around lakes to lake conservation areas and so on. These policies and measures will be helpful in the development of better crop diversification programmes and ecological protection in China.

4.4 Sustainable Development of Agriculture, Environmental and Ecological Management

In the past, due to the indiscriminate exploration and utilization of grassland, wetland, forest, mountain areas, rivers and lakes for agricultural production, a great deal of wild plants and animals were lost or are close to extinction. Biodiversity was adversely affected, which directly influenced the sustainable development of agricultural production systems. In recent years, the Chinese government has already begun drawing up short-term objectives and a long-term plan to solve these problems. In order to achieve harmonious development between increase of agricultural production and protection of the natural environment, China has brought forth the plan of demonstrating to counties and villages the concept of ecological agriculture, and at the same time, the green project which is to protect the environment has also been started. To date, China has drawn up legislation to cover the “Law of Environmental Protection”, “Law of Forest”, “Law of Grassland”, “Regulations of Wild Plant Protection”, “Regulations for Protection of New Varieties of Crops” and so on. Four series of standards for rational utilization of fertilizers have been issued,` in turn throughout China, which has further strengthened the protection, management, monitoring and proper utilization of agricultural resources and the environment. Meanwhile, in order to protect the resource base of agricultural biology and promote the sustainable development of agriculture, the government and the scientific research departments are also concentrating on sustaining and extending environment-friendly agricultural technologies such as combining traditional technology with highly sophisticated new technologies; selection and breeding of high-yielding, high quality, and highly resistant varieties; carrying out rational rotation cropping (conservation of land fertility, disease, insect pest and grass control); encouraging intercropping, relay inter-planting, and multiple cropping; carrying out biological control and integrated control of diseases, insect pests and grasses; rational application of fertilizers according to formulations; and utilization of water-saving irrigation as new crop diversification strategies.

5. CHALLENGES FACED BY CROP DIVERSIFICATION (PROBLEMS AND LIMITING FACTORS)

At a certain point of time in the future, with the increase of the total population, improvement of people's living conditions and decrease of the area of arable land, enhancing the yield and quality of crops will be the primary task facing China's agriculture. After entering WTO, Chinese agricultural products will encounter stronger international competition and market pressures. These facts, to some degree, will promote intensity, scale and specialization of crop production, and these will also challenge the development of the crop diversification process. Besides, with the increase of agricultural produce trade after joining WTO, more attention should be focused on "biological incursion" or "biological contamination" of adventitious species and genetically engineered material, which will endanger our crops and their living environment as well as people's security. For instance, the black rot of sweet potato originated from America, entered China through Japan in the 1930's, spread over 20 provinces throughout China from the 1940's to 1960's causing great losses, and is still harming the crops up to now. Another case in point is that of fusarium and verticillium wilt of cotton that originated from America, entered China with seeds in the 1930's, and became the most serious diseases in the history of cotton cultivation in China. Therefore, strengthening biological quarantine and scientific prevention of "biological incursion" will become essential topics of crop diversification issues in the future.

6. CONCLUSIONS

The Chinese government attaches importance to and supports the broader concept of diversification of crops in China and significant social effect has been obtained. The administrative and scientific research departments at all levels have accumulated a wealth of data relating to the current status of resources and development and most of the residents have received or participated in the activities of the judicious use of resources and the environment. China is a developing country with a huge population. However, the development of the economy has brought increasing pressure on its natural resources and environment. The solution of the relationship between development and protection and the realization of sustainable development of resources and environment and improvement of the country's economy will be the challenge of the century that faces China in the future. Since China's population is daily on the increase while its farmland is daily on the decrease, more problems and contradictions between the development of agricultural production and the diversification of crops will need to be solved, so the burden is heavy and the road is long in the development of peasant agriculture through the diversification of crops in China.

With the development of a market economy, the role of administrative intervention is on the decline while the costs are on the increase. Therefore, under the present conditions of China, diversification of crops must find a broad living space under the theoretical guidance of coordination for sustainable development.

Policies, rules and regulations and other peremptory protections are necessary. However, as the development of the national economy is still at a relatively low level and the state finance is still insufficient, all social forces should be mobilized to participate in the crop diversification process. In addition, various departments and the people at all levels in the production areas in particular, must be mobilized for active participation and various methods should be adopted to coordinate the problems of resource utilization and

environment protection. Special attention should be paid to encourage testing, adoption and popularization of various developmental models that combine the overall interests of crop diversification. Attention must also be paid to the adoption of suitable agro-technology for improvement of crop diversification, so as to lower the loss of agro-resources, enhance the sound management of agro-ecological systems, and guarantee the sustainable development of an agricultural system based primarily on the concept of crop diversification.

CROP DIVERSIFICATION IN INDIA

C.R. Hazra [*]

1. INTRODUCTION

India is a country of about one billion people. More than 70 percent of India's population lives in rural areas where the main occupation is agriculture. Indian agriculture is characterized by small farm holdings. The average farm size is only 1.57 hectares. Around 93 percent of farmers have land holdings smaller than 4 ha and they cultivate nearly 55 percent of the arable land. On the other hand, only 1.6 of the farmers have operational land holdings above 10 ha and they utilize 17.4 percent of the total cultivated land. Due to diverse agro-climatic conditions in the country, a large number of agricultural items are produced. Broadly, these can be classified into two groups - foodgrains crops and commercial crops. Due to the challenge of feeding our vast population and the experience of food shortages in the pre-independence era, 'self reliance' in foodgrains has been the cornerstone of our policies in the last 50 years. Around 66 percent of the total cultivated area is under foodgrain crops (cereals and pulses). Concurrently, commercial agriculture developed for whatever reasons in the pre-independent phase also kept flourishing during the post independent period. Commercial agriculture not only catered to the domestic market but has also been one of the major earners of foreign exchange for the country.

Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to lessen risk. Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. The crop shift (diversification) also takes place due to governmental policies and thrust on some crops over a given time, for example creation of the Technology Mission on Oilseeds (TMO) to give thrust on oilseeds production as a national need for the country's requirement for less dependency on imports. Market infrastructure development and certain other price related supports also induce crop shift. Often low volume high-value crops like spices also aid in crop diversification. Higher profitability and also the resilience/stability in production also induce crop diversification, for example sugar cane replacing rice and wheat. Crop diversification and also the growing of large number of crops are practiced in rainfed lands to reduce the risk factor of crop failures due to drought or less rains. Crop substitution and shift are also taking place in the areas with distinct soil problems. For example, the growing of rice in high water table areas replacing oilseeds, pulses and cotton; promotion of soybean in place of sorghum in vertisols (medium and deep black soils) etc.

[*] *Agriculture Commissioner, Department of Agriculture and Cooperation, Ministry of Agriculture, Krishi Bhawan, New Delhi, India.*

2. CROP PRODUCTION AND ECONOMICS SCENARIO

The share of the agriculture sector in the total GDP has declined rapidly (24.2 percent) after 1980/81 (34.8 percent) and this trend will continue. By 2020, the share of agriculture in the total GDP of the country is likely to be reduced to 15 percent due to faster development of non-agriculture sectors. The agriculture sector at present employs 60 percent of the country's work force. With the development of alternative sources of employment in the rural areas, viz., agro industries, supportive infrastructure, etc., it is hoped that the share of population dependent on agriculture will come down, though not commensurately, by the year 2020. It is hoped that 45-50 percent of the population will be dependent on agriculture by that time.

India's performance during the post-independence period has been a matter of pride and satisfaction. The agricultural sector has left behind the era of shortages and dependence on imports and arrived at a stage of self-sufficiency and occasional surpluses. The Green, White, Yellow and Blue revolutions have been landmarks that have been claimed and recognized the world over. India is now the largest producer of wheat, fruits, cashew nut, milk and tea in the world and second largest producer of vegetables and fruits. India is the largest producer, consumer and exporter of spices in the world and the largest exporter of cashew. Foodgrains production has increased four-fold since independence, from 51 million tonnes (Mt) during 1950/51 to 203 Mt during 1998/99. The scourge of severe food shortages is now a thing of the past as is the dependence on imports. India's agriculture has passed through four distinct phases of strategy: a) starting with the intensification of efforts in identified areas, using traditional technology and expansion of area during the pre-Green Revolution period; b) through a new strategy of use of modern inputs and high yielding varieties in irrigated areas during the late sixties and the seventies, (Green Revolution); c) further through a period of greater focus on management of linkages and infrastructure, such as, marketing, trade and institution building; and, d) to an era of liberalization and relaxation of controls during the nineties. The journey has been arduous but rewarding. The agriculture sector has been successful over the past five decades in keeping pace with the rising food demand of a growing population (already crossed one billion in May, 2000). This sector provides raw materials to the major industries of the country which are largely agro-based like cotton, sugar, etc. It contributes nearly 16 percent of the country's total export.

India has made tremendous progress in the agricultural sector over the last 50 years. From 'hand to mouth' conditions in the early sixties, we have not only become self reliant in foodgrains but have acquired sufficient resilience to tide over the adverse conditions. Wheat production has increased around 10 times and rice production 4 times during this period. These achievements are the result of a policy framework of improving rural infrastructure including irrigation, research, extension, provision of agricultural inputs at reasonable prices, and marketing support through minimum price mechanism.

In spite of the impressive achievements, the Indian agricultural sector continues to face poor infrastructure conditions. Less than 36 percent of the cultivated land is under any assured irrigation system. Farmers on the remaining two thirds of the land are completely dependent on rainfall, which is also greatly characterized by large variations in terms of precipitation both spatially and in time. For a large majority of farmers in different parts of the country gains from application of science and technology in agriculture have yet to be realized. As a result, the productivity levels of many major crops in India do not compare very favourably with the yields obtained in agriculturally advanced countries (Table 1).

Further, these factors coupled with high illiteracy constrain the farmer's ability to shift to more remunerative cropping patterns in response to market signals. Therefore, their capacity to take advantage of the opportunities presented by liberalization of trade is limited. The country's agriculture has gained in strength and resilience since independence, although growth in agriculture is highly skewed over regions and crops. However, the agriculture sector in India is now faced with intense internal and external pressures arising from the impact of policies of economic liberalization. Efficient and effective management of agriculture will be crucial in the years to come for acquiring enduring self-reliance and ensuring sustainable growth with an emphasis on consideration of equity.

3. PATTERNS OF CROP DIVERSIFICATION

3.1 Crop Diversification in the Indian Perspective

With the advent of modern agricultural technology, especially during the period of the Green Revolution in the late sixties and early seventies, there is a continuous surge for diversified agriculture in terms of crops, primarily on economic considerations. The crop pattern changes, however, are the outcome of the interactive effect of many factors which can be broadly categorized into the following five groups:

a) Resource related factors covering irrigation, rainfall and soil fertility.
b) Technology related factors covering not only seed, fertilizer, and water technologies but also those related to marketing, storage and processing.
c) Household related factors covering food and fodder self-sufficiency requirement as well as investment capacity.
d) Price related factors covering output and input prices as well as trade policies and other economic policies that affect these prices either directly or indirectly.
e) Institutional and infrastructure related factors covering farm size and tenancy arrangements, research, extension and marketing systems and government regulatory policies.

Obviously, these factors are not watertight but inter-related. For instance, the adoption of crop technologies is influenced not only by resource related factors but also by institutional and infrastructure factors. Similarly, government policies - both supportive and regulatory in nature - affect both the input and output prices. Likewise, special government programmes also affect area allocation and crop composition. More importantly, both the economic liberalization policies as well as the globalization process are also exerting strong pressures on the area allocation decision of farmers, essentially through their impact on the relative prices of inputs and outputs. Although the factors that influence the area allocation decision of farmers are all important, they obviously differ in terms of the relative importance both across farm groups and resource regions. While factors such as food and fodder self-sufficiency, farm size, and investment constraints are important in influencing the area allocation pattern among smaller farms, larger farmers with an ability to circumvent resources constraints usually go more by economic considerations based on relative crop prices than by other non-economic considerations. Similarly, economic factors play a relatively stronger role in influencing the crop pattern in areas with a better irrigation and infrastructure potential. In such areas, commercialization and market networks co-evolve to make the farmers more dynamic and highly responsive to economic impulses.

What is most notable is the change in the relative importance of these factors over time. From a very generalized perspective, Indian agriculture is increasingly getting influenced more and more by economic factors. This need not be surprising because irrigation expansion, infrastructure development, penetration of rural markets, development and spread of short duration and drought resistant crop technologies have all contributed to minimizing the role of non-economic factors in crop choice of even small farmers. What is more, the reform initiatives undertaken in the context of the ongoing agricultural liberalization and globalization policies are also going to further strengthen the role of price related economic incentives in determining crop composition both at the micro and macro levels. Obviously, such a changing economic environment will also ensure that government price and trade policies will become still more powerful instruments for directing area allocation decisions of farmers, aligning thereby the crop pattern changes in line with the changing demand-supply conditions. In a condition where agricultural growth results more from productivity improvement than from area expansion, the increasing role that price related economic incentives play in crop choice can also pave the way for the next stage of agricultural evolution where growth originates more and more from value-added production.

3.2 Consequences of Crop Pattern Changes

Turning now to the socio-economic and environmental consequences of crop pattern changes, the Green Revolution technologies have fomented, among other things, an increasing tendency towards crop specialization and commercialization of agriculture. While these developments have positive effects on land/labour productivity and net farm income, they have also endangered a number of undesirable side effects like reduced farm employment and crop imbalances. Although the expansion of commercialized agriculture has fomented new sets of rural non-farm activities and strengthened the rural-urban growth linkages, it has also weakened the traditional inter-sectoral linkages between the crop and livestock sectors. Besides, crop pattern changes also lead to serious environmental consequences that take such forms as groundwater depletion, soil fertility loss and waterlogging and salinity - all of which can reduce the productive capacity and growth potential of agriculture over the long-term. A classical example is the rice-wheat system in Northwestern India replacing traditional crops like pulses, oilseeds and cotton.

3.2.1 Crop Pattern Changes: A Temporal Analysis

The temporal analysis of the changes in crop pattern is observed both at the national and state level. For the purpose of the present study, crop pattern changes at the all India level are evaluated by considering the area share of crops and crop groups at four time points capturing, respectively, the triennium ending (TE) averages of areas in 1966/67, 1976/77, 1986/87 and 1996/97. These time points have been selected so as to capture the major events and stages in the evolution of Indian agriculture which are of direct relevance to the purpose of this study.

The pre-Green Revolution situation is represented by the 1966/67 period. The post-Green Revolution situation is represented, on the other hand, by three sub-periods. These periods have been chosen deliberately to highlight the temporal differences in the factors contributing to agricultural growth. In the first of these three post-Green Revolution periods, i.e., 1966/67 to 1976/77, the impact of the Green Revolution has mainly been on wheat, especially in the irrigation-wise better endowed Northwestern parts of India. But in the second period, i.e., 1976/77 to 1986/87, the new technologies have expanded to other regions

and also covered crops such as rice. During this period, the Southern and Eastern regions showed remarkable improvement in agricultural growth and productivity. More or less during the same period, the benefits of the new crop and irrigation technologies that were confined earlier to large and medium sized farms have also started percolating to the small farms. The third period, i.e. 1986/87 to 1996/97, is characterized by a number of policy changes including the launching of the Technology Mission on Oilseeds (TMO) as well as price support and stabilization policies for oilseed crops. During this period there is also a marked shift in the pattern of agricultural investment in favour of the private sector. This period not only covers such important policy changes as unleashed by agricultural liberalization policies but also represents the consolidation phase of rural infrastructure. Since these four periods can capture well the changes in the set of factors that affect crop pattern, they can provide a better analytical framework for evaluating both the nature and technical context of crop pattern shifts observed not only at the national level but also at the state level.

3.2.2 Crop Pattern Changes: Analysis at the all India Level

The analysis of crop pattern changes to be attempted at the macro level (national) will focus on three main aspects. These aspects are: a) the nature and direction of area shifts across crops and crop groups observed through time, b) the implications of these shifts for crop diversification and balance in the inter-crop allocation of existing and additional areas brought under cultivation, and c) the output and productivity impact of crop pattern changes.

Temporal Changes in the Area Share of Crops

The temporal behaviour of crop pattern changes at the all India level can be seen from Table 2 and Table 3 that show, respectively, the area share of main crop groups and major crops for the four periods. Though obvious, it needs to be stated that the changing area share of crops is due as much to shift in area under other competing or alternative crops as to the relative area allocation of fresh areas brought under cultivation. In any case, the changing area share of crops does capture the ongoing changes in the comparative advantage calculus of farmers. The changes in the comparative advantage of crops reflect, in reality, the ongoing changes in relative prices of inputs and outputs, production conditions (including irrigation expansion), development and spread of new crop and farm technologies, extension and input support policies and trade policies and domestic regulations. As such, the changing area share of crop pattern, though looking deceptively simple, becomes a useful tool for understanding the direction in which crop pattern changes are influenced by the variations in the comparative advantage of crops and crop groups (Tables 4 and 5).

Returning to Tables 2 and 3, both tables provide evidence for a substantial area shift from cereals to non-cereals. Although cereals gained a marginal increase in area share in the first decade of the Green Revolution, their area and share declined gradually thereafter. Between 1966/67 and 1996/97, 3.35 percent of the gross cultivated area (GCA) - representing approximately about 5.7 million hectares (m/ha) - has shifted from cereal crops to non-cereal crops. Since the area share of pulses taken as a group also declined by 1.57 percent during the same period, the area share of foodgrains as a group declined by 4.92 percent during 1966-97. In area terms, the shift from foodgrains to non-foodgrains involves an approximate area of about 8.36 m/ha. While cereals and pulses have lost area, the major gainers of this area shift are the non-foodgrain crops especially oilseeds. The area share of oilseeds as a group that has gone up by 4.08 percent accounts for about 83 percent of the

8.36 m/ha involved in the area shift between 1966/67 and 1996/97. As we consider the share of individual crops within cereals, although the share of cereals as a group has declined, the area share of rice has increased continuously over all the four periods. Wheat, although having a declining area share until 1986/87, also gained in its share when the entire period is considered. Thus, the area loss of cereals can be attributed entirely to the declining area share of coarse cereals, especially sorghum, pearl millet, barely and small millets. It can be noted that even within coarse cereals, the area share of maize shows a marginal improvement over the years. Within oilseeds, the crops showing steady improvement in their area share are: rapeseed and mustard, soybean and sunflower. Among these three oilseeds gaining in area share, rapeseed and mustard are substantially grown as intercrops with wheat. On the other hand, the area shares of other oilseeds including groundnut (that has a dominant area share within oilseeds) but excluding coconut, which is more a plantation crop than field crop, have either fluctuated or declined. The area share of groundnut, though improved during the last period, has declined as compared to its share in the pre-Green Revolution period. But, the declining area share of crops - especially those with only a marginal change in their area share - need not necessarily imply a decline in the actual area under these crops. Since the Gross Cropped Area (GCA) is constantly increasing over time, partly through an expansion of net sown areas as in the initial stages of the Green Revolution and partly through increasing intensity of cropping mainly by irrigation expansion, the declining area share can coincide with an increase in absolute increase in the area under crops. This can be seen from Tables 4 and 5 showing actual area under various crops and their groups. Although the increase in the area share of other commercial crops is not as dramatic as that of oilseeds, it is still notable because of its implications for the direction of Indian agriculture. But, among these other commercial crops that cover fibres, spices, fruits and vegetables, and other field crops such as tobacco and sugar cane and plantation crops, only spices, fruits and vegetables show a steady improvement in their area shares, whereas others show mostly a declining trend. This is particularly true for fibres and other field crops that have over four fifths of the total area under the broad group of other commercial crops. However, sugar cane, included in the category of other field crops, shows an increase in its area share. This is also true for cotton included in the fibre category. While all spice crops show a gradual increase in their area share, only three of the six crops included in the fruits and vegetables category show a gain in their area share over the years. These crops are banana, potato and onion.

3.3 Success Story in Crop Diversification

It is clear that most of the area shifts that occurred during the three decades between 1966/67 and 1996/97 is from coarse cereals to oilseeds. Three notable aspects of this area shift towards oilseeds can be noted. First, most of these area shifts have occurred particularly during the decade ending 1996/97. A protective trade environment, favourable price policy and the connecting of the Technology Mission on Oilseeds (TMO) during this period have all enhanced the comparative advantage of oilseeds. As can be seen from Table 2, the area share of oilseeds that increased just by a percentage each during the two decades before 1986/87 has risen suddenly by 43 percent during the decade ending 1996/97. Second, the area shift during this period comes mainly from barley and pulses other than pigeon pea. Since most of those crops losing their area share are usually grown under rainfed conditions where oilseeds can also be grown, the area shift can be said to involve mostly rainfed areas, although comparative advantage and crop rotation considerations often favour oilseeds even in groundwater irrigated areas. Thirdly, as can be seen from Table 3, there is also a significant area shift within oilseed crops. For instance, while the area shares of rapeseed and mustard, sunflower and soybean are increasing steadily, those of sesamum, linseed and

nigerseed are declining gradually. Thus, the area shift has favoured only a sub-sector within the oilseed sector partly because of constant changes in the comparative advantage of different oilseeds and partly because of the impact of changing consumers' preferences on the relative demand of oilseeds.

3.4 Crop Diversification and Composition

As noted already, area shifts and crop pattern changes can lead either to crop specialization or to crop diversification. The area share of foodgrains increased during 1967-76 due partly to their yield advantages created by irrigation expansion and Green Revolution technologies and partly to government policies pursued to encourage food production and eliminate food imports. As a result, there was a tendency towards cereal centered specialization. But, later when increased productivity of foodgrains, especially cereals, made it possible to allocate more area to other crops such as oilseeds with a severe supply shortage, the specialization tendency witnessed earlier has given room for overall crop diversification. Even within such an overall crop diversification, it is also possible to see specialization tendencies within each crop group. For instance, within cereals, the declining share of coarse cereals and increasing share of wheat and rice indicates a rice and wheat centered specialization. Such a specialization has become possible because within the achievement of self-sufficiency, mainly through an expanding production of wheat and rice, the food implication of coarse cereals has declined almost coinciding with their declining demand prompted by an increasingly incurring income level. On the other hand, within oilseeds, even though groundnut still has a dominant area share, the growth of area under rapeseed and mustard, sunflower and soybean indicates an ongoing structural change leading to diversification within the oilseed sector. The issue of crop diversification, although considered in area terms, assumes significance in view of its effects on the supply-demand balance of main crops and crop groups. The rice and wheat-centered specialization, for instance, indicates an increase in the supply of wheat and rice but a reduced supply of coarse cereals. Since the demand for coarse cereals is declining and that for wheat and rice is increasing due to changes in the income pattern, the changes in their supply are actually necessary to achieve the required demand-supply balance. A similar line of argument can also be extended to other crops where in addition to domestic demand, international demand and supply also assume significance.

Clearly, during the Green Revolution period, the foodgrains category has evinced an increasing tendency towards specialization with an unbalanced area composition, whereas the non-foodgrains category has shown an increasing tendency to diversify with an improved balance in their area composition. But, during 1976-97 the non-foodgrains category has also caught up with the specialization tendency and area imbalance that characterized foodgrains throughout the entire period. The reason for the specialization tendency within foodgrains is rather obvious in view of the declining area share of coarse cereals and the increasing area share of rice and wheat. The changing area share of crops can also explain the specialization tendencies observed among the non-foodgrains. As we have seen in the context of Tables 2 and 3, the area shares of oilseeds and other commercial crops have increased especially during the post Green Revolution period characterized by a prices and market-responsive agriculture inevitable in the aftermath of achieving food self-sufficiency. It is important to note, however, that oilseeds are more diversified with an enhanced balance in their area composition. Within foodgrains, on the other hand, while cereals tend towards specialization with an increasing imbalance in their area composition, pulses evince a tendency to diversify with a declining imbalance in their area composition. The latter result is mainly due to the

fact that the area shares of the dominant pulses such as gram have declined to give room for other pulses such as pigeon pea. But it should be noted that diversification and area balance achieved by pulses have occurred only with a reduced area share. Among the non-foodgrain crops, spices are notable not only for their increasing tendency towards diversification but also for a declining imbalance in their area composition. In contrast, fibres, fruits and vegetables, other field crops and plantation crops have all evinced a specialization tendency especially after 1986/87.

3.5 Production and Productivity Effects

The evaluation of crop pattern changes and their implications for crop diversification and area composition cannot be completed without considering their output and productivity effects. The production and productivity effects of area shifts can be evaluated by considering both the growth rates of output, area, and yield of various crop groups as well as the crop group specific patterns evident in the relative contributions of area and yield to overall output growth. Table 6 shows the growth rates and sources of growth for the major crop groups at the all India level for the three periods, i.e., 1966-76, 1976-86 and 1987-97. The shift of area from cereals (especially coarse cereals) has not led to any decline in their output thanks to an impressive performance of their yield levels. The productivity improvement in cereals has been such that it compensates even for the area loss of cereals occurred during 1986-97. Notably, in the case of coarse cereals that have suffered a heavy area loss ever since 1976, yield improvement has been substantial especially in the last period. As a result their output growth, which was only marginal during 1976-86, has jumped to 1.14 percent during 1986-97. For pulses, on the other hand, even though area growth has increased from 0.21 to 0.32 percent between the last two periods, their output growth turns out to be negative due to a fall in their yield levels. Foodgrains showing a steady rise in their output growth have a story similar to that of cereals as the contributions of their yield growth is increasing; whereas, those of their area growth are declining even to become negative in the recent period. Turning to the growth rates and growth sources of oilseeds, it is useful to distinguish the trend observed for the three oilseeds, i.e., rapeseed and mustard, sunflower and soybean from that observed for the oilseeds as a whole. This is because of the fact that the area shares of these three oilseeds have grown tremendously since 1976. Due to their faster expansion, their combined area share of 6.85 percent observed at present is higher than the combined share of both groundnut and sesamum, which dominated the oilseed sector in the pre-Green Revolution era. While the output growth of nine oilseeds has been impressive as compared to that of other crop groups, it is not as impressive as the combined output growth of the three fast growing oilseeds. However, there is a marked difference in the sources of output growth between the nine oilseeds and its sub-group. Although the contribution of area growth dominates that of yield growth in both cases, the contributions of area growth are far higher in the case of the three oilseeds as compared to that in the case of nine oilseeds. It should be noted that it is the higher area growth observed in the case of the three oilseeds, which has also compensated for the declining area share of some of the traditional oilseeds such as sesamum, linseed and nigerseed. Since the yield growth of the three oilseeds is also higher than that obtained for the nine oilseeds, the productivity improvement in the case of former is also relatively higher than that of the traditional oilseeds. There is also a notable shift in the sources of output growth among the commercial crops (i.e., crops other than cereals, pulses, and oilseeds) as yield growth that dominated over the area growth during 1966-1986 becomes dominated in turn by a area growth during 1986-97.

The implications are clear that area shifts from crops need not be a problem as long as their productivity levels are increasing faster to compensate for their declining area share. This is what has happened especially in the case of coarse cereals that have been a net donor of area to oilseeds and other commercial crops. Despite their negative area growth of -4.36 percent, they managed to maintain a positive output growth of 1.14 percent thanks to an impressive yield growth of 5.51 percent. Since this pattern is more or less repeated in the case of cereals as a whole, it is reasonable to say that the area shift has not affected food security. On the other hand, since the area shifts were from low-value coarse cereals to high-value oilseeds and since such shifts were accompanied by yield improvements within the oilseed sector, the area shifts have not only increased the overall output of edible oils but also contributed to an enhancement of the income level of farmers. In this sense, the area shifts have actually contributed to broaden the foundation of food security.

4. CROP DIVERSIFICATION AS A STRATEGY FOR VARIOUS NATIONAL COMMITMENTS

4.1 Food and Nutritional Security and Poverty Alleviation

The agricultural growth rate of around 2.7 percent per annum in the post-independence period was much higher than the negligible growth rate of 0.3 percent per annum in the first half of this century. It is not only in the areas of foodgrain production but also the production of commercial crops like cotton, oilseeds, sugar cane, fruits and vegetables as well as livestock products and fisheries have recorded significant increases since independence. Poverty eradication is one of the major objectives of plan development. The magnitude of the problem is quite staggering. The incidence of poverty declined from 54.9 percent in 1973/74 to 36 percent in 1993/94. The absolute number of population did not decline much throughout this period of 20 years. There were 321 million poor in 1973/74 and 320 million in 1993/94. In the rural areas, the corresponding numbers were 261 million and 244 million. The land resources are limited and the average size of holding in India is only 1.57 ha for the census year of 1990/91. The main determinants of poverty are: i) lack of income and purchasing power contributable to lack of productive employment; ii) the continuous increase in price of food, specially foodgrains which account for 70-80 percent of the consumption; and iii) inadequacy of social infrastructure, affecting the quality of life of the people and their employability.

The National Agenda for Governance of the present government has given top priority to doubling food production in the next 10 years. The food includes foodgrains (rice, wheat, coarse cereals, pulses), oilseeds, sugar (sugar cane), fruits and vegetables, meat, milk, and fish. The Action Plan envisages a detailed strategy and specific problems of productivity to substantially increase the supply of various food items in such a way that the demand for such items for the entire population is comfortably met and some exportable surplus also becomes available. The development strategy to be perused in the medium term has been consciously interwoven with the country's food security concern.

4.2 Natural Resource Management for Sustainable Agricultural Development

It is known fact that there is little scope for further expansion of the net sown area (142 m/ha) and that land scarcity will become an acute feature of the rural economy. Water is a precious national asset and there are several concerns regarding water resources in the

country. Therefore, a judicious use of land and water resources will have to be the central theme for sustainability of agricultural growth. There has been a growing concern in recent years about the deteriorating conditions of soil health and water resources due to improper management and pollution. The deterioration in land and water resources has been in the form of land degradation, waterlogging and decline in watertable. There is a greater need to have an integrated approach in the management of plant nutrients, chemicals and taking effective measures to deal with the overall pollution problems. There are several possible technologies and alternatives to reduce the use of chemicals in agriculture. These alternatives are not perfect substitutes to chemicals but adoption of these can substantially reduce the adverse impact on environment. Proper land and water management policies would reduce environmental degradation. Community and village institutions should be encouraged to participate in protecting natural resources from degradation. Programmes for regeneration of land and water resources will be strengthened.

4.3 Agricultural Planning: an Area Approach

A new approach to agricultural planning - the Agro Climatic Regional Planning (ACRP) was put into action in 1988. This holistic approach digresses from the sectoral approach of planning practiced so far in the country. It explicitly recognizes the local resource endowments and constraints of the agro-climatically homogeneous regions, quite often cutting across the States. The ACRP can be considered as a bridge between the resource base and decentralized planning, which aims at providing a scientific support to planning for attainment of sustainability and having due consideration of basic resources and the local needs. The project was initiated by regionalizing the country into 15 zones/regions and later into 73 sub-regions and subsequently demarcation of sub-zone/region within a State using district as the lowest unit of analysis. The principles used for this sub-regionalization were those which relate intrinsically with the character of the agricultural economy like soil, climate, rainfall, etc. In a recent study, agro-climatic zones have been delineated into 4 agro-economic zones to address the issues of poverty, productivity and sustainability. These agro-economic zones are: i) High Productivity Zone (103 districts); ii) Low Productivity - High Potential Zone (181 districts); iii) Low Productivity Zone (179 districts); and iv) Ecologically Fragile Zone (Himalayan and Desert areas).

5. CHALLENGES, OPPORTUNITIES AND PROSPECTS OF CROP DIVERSIFICATION

5.1 Constraints in Crop Diversification

Crop diversification in the country is taking the form of increased areas under commercial crops including vegetables and fruits since independence. However, this has gained momentum in the last decade favouring increased area under vegetables and fruits and also to some extent on commercial crops like sugar cane, cotton and oilseeds crops specially soybean. The major problems and constraints in crop diversification are primarily due to the following reasons with varied degrees of influence:

i. Over 117 m/ha (63 percent) of the cropped area in the country is completely dependent on rainfall.

ii. Sub-optimal and over-use of resources like land and water resources, causing a negative impact on the environment and sustainability of agriculture.

iii. Inadequate supply of seeds and plants of improved cultivars.

iv. Fragmentation of land holding less favouring modernization and mechanization of agriculture.

v. Poor basic infrastructure like rural roads, power, transport, communications etc.

vi. Inadequate post-harvest technologies and inadequate infrastructure for post-harvest handling of perishable horticultural produce.

vii. Very weak agro-based industry.

viii. Weak research - extension - farmer linkages.

ix. Inadequately trained human resources together with persistent and large scale illiteracy amongst farmers.

x. Host of diseases and pests affecting most crop plants.

xi. Poor database for horticultural crops.

xii. Decreased investments in the agricultural sector over the years.

5.2 Globalization and Crop Diversification

With the advent of WTO and India being a member and signatory to GATT, the scenario of the agricultural sector will not be the same as that of past. With the liberalization of trade and providing the market access of agricultural produce between the different countries, the country will be required to promote much more diversified agriculture. For crops on which we have substantial area and production, specially foodgrains, the import market has to be insulated through increased productivity which gives us a kind of comparative advantage and also a level playing field so that large scale importation is contained and farmers interests are protected. The crops which are traditionally exported like basmati rice and spices and condiments also need to be supported in terms of area expansion and quality improvement to look towards much more opportunity for export. Crop diversification in the areas of certain tropical fruits and also a few vegetables also need support for both production and post-harvest handling in terms of their export opportunity. Accelerated growth in fruits and vegetables production is also required for improved nutrition of the country's population. In future, with improved living standards along with increased purchasing power, more and more people will look for nutritional and quality foods which will also call for greater crop diversification. There are some production areas such as food crops, plantation crops, poultry, dairy, sugar, cotton and oilseeds in which India has made its mark. There are some in which its emerging strength is already evident - sericulture, marine and inland fisheries for example. There are also others which now attract less attention, but in which the competitive advantages that India possesses can put it on the top of the world. No country grows such a wide range of fruits, vegetables, and flowers and in such abundance as India and yet it has no record worth mentioning in horticultural exports. The rich variety when processed and marketed, can help India take care of the health needs of its population besides being major export commodities

5.3 Emerging Technology and Crop Diversification

It is being increasingly realized that agriculture is no longer a subsistence activity carried out by peasant cultivators, but rather an enterprise and manufacturer of biomass using land, water, genetic material and the latest in technology. The agriculture of the twenty first century will increasingly be a farmers' entrepreneurship harnessing technologies to optimize returns from his land and investments he makes on it. Biotechnology and genetic engineering in crops with focus on primary productivity and also on many quality traits will go a long way to improving the yield and quality of many important crop plants. With the advent of such emerging technologies and consequent scope for increased economic returns, the diversification in favour of such crops will be the future focus. Many other related technologies and their adoption will also inject an added dimension in crop diversification. Decision support systems, governmental policies, geographic information system, application of information technology leading to market information etc., will also lead to crop diversification primarily on economic considerations.

5.4 Research and Developmental Support for Crop Diversification

Future agriculture will be much more knowledge and skill based rather than the traditional subsistence agriculture. In the wake of globalization and opening up of the global market, there will be much more opportunity for entrepreneurship development in agriculture. This also calls for paradigm shifts in research and technology development and also the transfer of technology for successful crop diversification. The research system not only needs to address the issues connected with continuance and indulgence and knowledge in the areas of emerging technologies but also create a cadre of scientists through the continuous upgrade of skills and human resource development. The researchers also need to popularize the technologies, impart knowledge and skills to the extension functionaries for the transfer of technologies to the farmers. This knowledge-based farming will call for much more interaction between the researchers, extension workers and farmers. The fruits of the innovative technologies should reach the farmers at the earliest and also spread in the quickest possible time.

5.5 Institutional and Infrastructure Developments Towards Crop Diversification

To sustain and operationalize crop diversification, institutional support is required to the two thirds of the country's crop area which is rainfed. Crop diversification in terms of reducing the risk of rainfed farmers is also very vital to a country like India two thirds of the farmers are also resource poor. However, crop diversification in well endowed area is more of an economic consideration. The National Agricultural Research System with its Crop and Commodity based Institutions, Natural Research Management Based Institutions and State Agricultural Universities are jointly addressing the issues connected with the crop diversification. The government of India has also developed a counter support mechanism through the establishments of Crop Directorates for each of the major crops and groups of crops like Oilseeds and Pulses for developmental and technology transfer focus on each of these crops and commodities. These Directorates act as a coordinating agency between the research and development activities on the one hand and between the Federal Government at the central and Regional Governments at the State level for technology transfer and other promotional activities.

6. GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

Considering the importance of crop diversification in the overall developmental strategy in Indian agriculture, the government of India has taken several initiatives for agricultural development in general and crop diversification in particular. These initiatives are as follows:

i) **Launching a Technology Mission for the Integrated Development of Horticulture in the Northeastern Region:** The programme will establish effective linkages between research, production, extension, post-harvest management, processing, marketing and exports and bring about a rapid development of agriculture in the region.

ii) **Implementing National Agriculture Insurance Scheme:** The scheme will cover food crops and oilseeds and annual commercial and horticulture crops. Small and marginal farmers are eligible for 50 percent subsidy under the Scheme.

iii) **Operationalizing Technology Mission on Cotton:** The Technology Mission will have separate Mini-Missions on technology generation, product support and extension, market infrastructure and modernization of ginning and pressing units.

iv) **Provision of Capital Subsidy of 25 percent for construction/modernization/ expansion of cold storages and storages for horticultural produce.**

v) **Creation of Watershed Development Fund:** At the National level for the development of Rainfed lands.

vi) **Infrastructure Support for Horticultural Development with emphasis on Post-harvest Management.**

vii) **Strengthening Agricultural Marketing:** Greater attention to be paid for development of a comprehensive, efficient and responsive marketing system for domestic marketing as well as exports by ensuring proper quality control and standardization.

viii) **Seed Crop Insurance:** A pilot scheme on Seed Crop Insurance has been launched which will cover the risk factor involved in production of seeds.

ix) **Seed Bank Scheme**: About 7-8 percent of certified seeds produced in the country will be kept in buffer stock to meet any eventualities arising out of drought, floods or any other form of natural calamities.

x) **Cooperative Sector Reforms:** Amendment to the National Cooperative Development Corporation (NCDC) Act, 1952, and Replacement of the Multi-State Cooperative Societies (MSCS) Act, 1984.

All these measures will lead to crop diversification and increase the production and productivity of crops.

7. CONCLUSIONS

India, being a vast country of continental dimensions, presents wide variations in agroclimatic conditions. Such variations have led to the evolution of regional niches for various crops. Historically, regions were often associated with the crops in which they specialize for various agronomic, climatic, hydro-geological, and even, historical reasons. But, in the aftermath of technological changes encompassing bio-chemical and irrigation technologies, the agronomic niches are undergoing significant changes. With the advent of irrigation and new farm technologies, the yield level of most crops-especially that of cereals-has witnessed an upward shift making it possible to obtain a given level of output with reduced area or more output with a given level of area and creating thereby the condition for inter-crop area shift (diversification) without much disturbance in output level. Besides, as agriculture become drought proof and growth become more regionally balanced, there has been a reduction in the instability of agricultural output.

In the face of these new changes including the achievement of food self-sufficiency, the area shift that tended towards cereals in the immediate aftermath of the Green Revolution, has started moving in the opposite direction, i.e., from cereals to non-cereals.

Although these reverse area shifts actually took place in the mid-1970's as a part of the process of commercialization, they became more pronounced since the mid 1980's as a response partly to emerging supply deficit in edible oils and partly to the changing comparative advantage of crops. Since the recent trend in inter-crop area shifts has it origin in the price and trade policy changes of the 1980's, they indicate the increasing market influence on area allocation. The area under commercial crops has almost doubled in the last three decades. Among the foodgrain crops, the area under superior cereals, i.e., rice and wheat, is increasing; while that of coarse cereals (millets) is on decline. The area share of jute and allied fibres has also gone down substantially. Like any other economy, the share of agriculture in the GDP is also declining in India. Increase in income from the agriculture sector, further growth of non-crop sub-sectors within agriculture; faster growth of non-food grain crops; and faster growth of superior cereals among the food grains are all happening, but the pace of such change is far too slow. An accelerated pace of diversification to create positive import of higher income, higher employment and conservation and efficient use of natural resources emphasizes the need for efficient policies, especially in technological development, selective economic reforms and institutional change. A strategy of crucial importance is growth enhancing non-farm activities. This calls for investment in rural infrastructure and skill upgradation and it also implies a careful examination and adjustment of macro-policies, which influence the relative profitability of different activities and in turn determine the nature and pace of diversification. In order to ensure social equity, policies on structural adjustment and reforms must pay special attention to the band of marginal and small farmers and agricultural labourers. The direct benefits from diversification should reach these sections of the farmers.

Table 1. India's Yield as Percent of World Yield, 1996

Food Crops						
India as % of World's	***Rice***	***Wheat***	***Maize***	***Bajra***	***Jowar***	***Pulses***
Average Yield	49%	98%	38%	72%	57%	73%
Highest Yield	30%	31%	19%	20%	18%	31%
Non-Food Crops						
India as % of World's	***Potatoes***	***Groundnut***	***Sugar cane***	***Sunflower seed***	***Rapeseed***	***Seed Cotton***
Average Yield	98%	76%	109%	51%	65%	59%
Highest Yield	42%	36%	70%	27%	27%	34%

Table 2. All India: Temporal Change (percent) in the Area Share of Main Crops and Crop Groups, 1966/67 to 1996/97

No.	Crops	TE 1966/67	TE 1976/77	TE 1986/87	TE 1996/97
1	***Rice***	23.90	24.13	24.75	25.29
2	***Wheat***	11.99	10.01	9.62	15.03
3	***Coarse Cereals***	26.49	29.20	28.09	18.70
4	***All Cereals***	62.38	63.34	62.47	59.03
5	***Gram & Pigeon Pea***	7.26	6.48	6.25	6.30
6	***Other Pulses***	8.06	7.99	7.85	7.45
7	***All Pulses***	15.32	14.46	14.10	13.75
8	***All Foodgrains***	77.70	77.80	76.56	72.78
9	***Sunflower & Soybean***	0.54	0.79	0.91	0.77
10	***All oilseeds***	11.27	11.24	12.07	15.35
11	***Fibres***	6.28	5.25	5.18	5.72
12	***Spices***	0.64	0.83	1.02	1.12
13	***Fruits & Vegetables***	0.75	0.92	1.15	1.40
14	***Other Field Crops***	3.04	3.54	3.51	3.23
15	***Plantation Crops***	0.33	0.42	0.51	0.41
16	***All Commercial Crops***	11.03	10.96	11.36	11.87
17	***All Non-Cereals***	37.62	36.66	37.53	40.98

Table 3. All India: Temporal Change (percent) in the Area Share of 52 Major Crops, 1966/67 to 1996/97

Sl. No.	Crops	TE 1966/67	TE 1976/77	TE 1986/87	TE 1996/97
1	*Rice*	23.90	24.13	24.75	25.29
2	*Wheat*	11.99	10.01	9.62	15.03
3	*Sorghum*	1.82	1.65	0.77	6.75
4	*Pearl Millet*	8.03	7.00	6.52	5.81
5	*Maize*	3.23	3.73	3.51	3.60
6	*Finger Millets*	1.70	1.58	1.44	1.05
7	*Small Millets*	3.06	2.88	1.87	1.01
8	*Barley*	8.66	12.37	13.97	0.49
9	*Gram*	5.55	4.86	4.35	4.27
10	*Pigeon Pea*	1.71	1.62	1.90	2.04
11	*Blackgram*	0.00	1.33	1.85	0.62
12	*Greengram*	0.00	1.50	1.78	0.60
13	*Horsegram*	0.00	1.26	1.09	0.21
14	*Peas & Beans*	0.00	0.43	0.29	0.14
15	*Lentil*	0.00	0.57	0.63	0.22
16	*Lathyrus*	0.00	0.98	0.71	0.19
17	*Mothbeans*	0.00	1.21	0.86	0.12
18	*Other Pulses*	8.06	7.99	7.85	7.45
19	*Groundnut*	4.99	4.44	4.27	4.55
20	*Castor*	0.28	0.30	0.38	0.45
21	*Sesamum*	1.74	1.39	1.30	1.15
22	*Rape & Mustard*	1.97	2.11	2.34	3.82
23	*Linseed*	1.17	1.27	0.80	0.52
24	*Safflower*	0.21	0.42	0.55	0.43
25	*Nigerseed*	0.33	0.38	0.36	0.34
26	*Sunflower*	0.00	0.19	0.52	1.20
27	*Soybean*	0.00	0.06	0.82	1.83
28	*Coconut*	0.59	0.68	0.73	1.07
29	*Cotton*	5.39	4.54	4.38	5.11
30	*Jute*	0.54	0.41	0.56	0.46
31	*Mesta*	0.23	0.21	0.18	0.11
32	*Sunnhemp*	0.12	0.09	0.06	0.04
33	*Pepper*	0.07	0.07	0.07	0.11
34	*Chillies*	0.46	0.46	0.51	0.52
35	*Ginger*	0.02	0.02	0.03	0.04
36	*Turmeric*	0.04	0.05	0.06	0.08
37	*Coriander*	0.00	0.16	0.23	0.25
38	*Cardamom*	0.04	0.06	0.07	0.06
39	*Garlic*	0.00	0.02	0.04	0.06
40	*Banana*	0.14	0.14	0.18	0.25
41	*Potato*	0.31	0.38	0.51	0.68
42	*Sweet Potato*	0.12	0.15	0.11	0.08
43	*Tapioca*	0.18	0.24	0.17	0.15
44	*Onion*	0.00	0.00	0.16	0.23
45	*Papaya*	0.00	0.01	0.02	0.01
46	*Sugar cane*	1.73	1.77	1.78	2.39
47	*Tobacco*	0.27	0.25	0.25	0.24
48	*Arecanut*	0.09	0.11	0.11	0.15
49	*Guarseed*	0.95	1.41	1.37	0.45
50	*Tea*	0.23	0.23	0.24	0.25
51	*Coffee*	0.02	0.08	0.13	0.05
52	*Rubber*	0.07	0.11	0.13	0.10

Table 4. All India: Temporal Change in Area (thousand hectares) Composition of Crop Groups, 1966/67 to 1996/97

Sl. No.	Crops	TE 1966/67	TE 1976/77	TE 1986/87	TE 1996/97
1	*Rice*	35728	38625	41154	42978
2	*Wheat*	17930	16018	15995	25548
3	*Coarse Cereals*	39610	46741	46711	31788
4	*All Cereals*	93268	101384	103860	100314
5	*Gram & Pigeon pea*	10848	10367	10393	10712
6	*Other Pulses*	12057	12787	13044	12661
7	*All Pulses*	22905	23154	23437	23373
8	*All Foodgrains*	116172	124537	127297	123686
9	*Sunflower & Soybeans*	807	1270	1511	1310
10	*All oilseeds*	16848	17988	20071	27837
11	*Fibres*	9383	8403	8618	9716
12	*Spices*	950	1326	1695	1904
13	*Fruits & Vegetables*	1120	1480	1913	2382
14	*Other Field Crops*	4544	5665	5828	5486
15	*Plantation Crops*	489	677	840	691
16	*All Non-Cereals*	56238	58691	62402	71389
17	*All Crops*	149506	160075	166262	171703

Table 5. All India: Temporal Change (thousand hectares) in Area Composition of 52 Major Crops, 1966/67 to 1996/97

Sl. No.	Crops	TE 1966/67	TE 1976/77	TE 1986/87	TE 1996/97
1	*Rice*	35728	38625	41154	42978
2	*Wheat*	17930	16018	15995	25548
3	*Sorghum*	2716	2643	1282	11471
4	*Pearl Millet*	12010	11202	10846	9868
5	*Maize*	4830	5965	5840	6121
6	*Ragi*	2541	2530	2398	1790
7	*Small Millets*	4569	4606	3114	1713
8	*Barley*	12944	19795	23231	825
9	*Gram*	8296	7778	7231	7253
10	*Pigeon Pea*	2552	2589	3162	3459
11	*Blackgram*	-	2135	3082	1049
12	*Greengram*	-	2405	2967	1014
13	*Horsegram*	-	2012	1809	358
14	*Peas & Beans*	-	693	475	245
15	*Lentil*	-	914	1054	381
16	*Lathyrus*	-	1566	1176	316
17	*Mothbeans*	-	1934	1436	203
18	*Other Pulses*	12057	12787	13044	12661
19	*Groundnut*	7458	7109	7092	7729
20	*Castor*	416	487	629	771
21	*Sesamum*	2596	2228	2166	1952
22	*Rape & Mustard*	2943	3382	3895	6487
23	*Linseed*	1753	2026	1325	879
24	*Safflower*	313	668	907	726
25	*Nigerseed*	494	601	604	584
26	*Sunflower*	0	304	870	2038
27	*Soybean*	0	95	1370	4860
28	*Coconut*	875	1087	1213	1811
29	*Cotton*	8054	7266	7288	8678
30	*Jute*	800	662	927	783
31	*Mesta*	347	334	303	194
32	*Sunnhemp*	181	141	100	60
33	*Pepper*	109	111	122	190
34	*Chillies*	690	736	845	890
35	*Ginger*	23	26	53	67
36	*Turmeric*	65	72	107	140
37	*Coriander*	-	251	388	417
38	*Cardamom*	62	95	116	97
39	*Garlic*	-	35	64	104
40	*Banana*	206	232	302	421
41	*Potato*	460	610	841	1162
42	*Sweet Potato*	180	239	182	136
43	*Tapioca*	267	389	282	247
44	*Onion*	-	-	274	395
45	*Papaya*	7	11	32	20
46	*Sugar cane*	2580	2841	2960	4061
47	*Tobacco*	402	394	408	403
48	*Arecanut*	137	179	189	255
49	*Guarseed*	1425	2252	2271	767
50	*Tea*	342	363	404	428
51	*Coffee*	37	135	213	92
52	*Rubber*	111	178	224	172
	All Crops	149506	160075	166262	169949

Table 6. All India: Temporal Change in the Sources of Growth of Main Crop Groups

Crops	Periods	Percent Growth Rate in			Output Growth from	
		Output	Area	Yield	Area (%)	Yield (%)
Cereals	**1766-76**	2.43	0.47	1.96	19.28	80.72
	1976-86	2.55	0.14	2.41	5.65	94.35
	1986-97	2.78	-0.25	3.03	-9.14	109.14
Coarse Cereals	**1766-76**	0.60	1.05	-0.45	175.87	-75.87
	1976-86	0.05	-0.02	0.07	-50.20	150.20
	1986-97	1.14	-4.36	5.51	-381.16	481.16
Pulses	**1766-76**	0.84	0.43	0.41	51.25	48.75
	1976-86	1.35	0.21	1.15	15.22	84.78
	1986-97	-0.88	0.32	-1.20	36.39	-136.39
Foodgrains	**1766-76**	2.25	0.46	1.79	20.46	79.54
	1976-86	2.44	0.16	2.29	6.40	93.60
	1986-97	2.53	-0.15	2.67	-5.83	105.83
Nine Oilseeds	**1766-76**	2.55	0.55	2.01	21.42	78.58
	1976-86	3.02	1.22	1.80	40.31	59.69
	1986-97	6.28	3.05	3.22	48.68	51.32
***R&M+SF+SB**	**1766-76**	4.69	2.29	2.40	48.79	51.21
	1976-86	8.19	4.93	3.27	60.13	39.87
	1986-97	10.92	7.38	3.53	67.62	32.38
Commercial Crops	**1766-76**	2.95	0.78	2.17	26.49	73.51
	1976-86	1.55	0.37	1.18	23.96	76.04
	1986-97	4.27	2.23	2.04	52.18	47.82
Non-cereals	**1766-76**	1.87	0.59	1.28	31.59	68.41
	1976-86	2.81	0.57	2.24	20.38	79.62
	1986-97	5.00	1.89	3.12	37.67	62.33
All Crops	**1766-76**	2.62	0.51	2.11	19.48	80.52
	1976-86	1.94	0.30	1.64	15.63	84.37
	1986-97	3.78	0.60	3.17	15.98	84.02

**R & M = Rapeseed & Mustard; SF = Sunflower; SB = Soybean. (These three oilseeds are taken as a separate group in view of the faster growth of both their area and output in recent years).*

CROP DIVERSIFICATION IN JAPAN

Masa Iwanaga [*]

1. INTRODUCTION

1.1 Japan's Rapid Evolution to an Industrialized Country

During the post-war era, Japan has experienced a drastic change in its economic status and in the role of agriculture in the society. Its economy has grown to the second largest in the world. This change has been accompanied by social changes in the area of agriculture and food systems in Japan. For example, the grain self-sufficiency ratio on a calorie basis declined to 40 percent in 1998. This is the lowest among the OECD member countries. The relative importance of agriculture as an industry has also declined. The agricultural population represented only 4.5 percent of the total population in 1997, significantly down from 13 percent in 1961. Rice consumption per capita declined to 65 kg per capita per year in 1998. It was 118 kg in 1962. These changes are major driving forces in crop diversification efforts in Japan.

1.2 Characteristics of Agriculture in Japan

Agriculture is an industry producing foods using the natural ecosystem, and specific forms of operation are largely influenced by geographic conditions. Farming styles also vary considerably in different countries and regions depending on the economic conditions there.

The major characteristics of agriculture in Japan are as follows:

- In Japan, located in the Asian monsoon zone, rice farming has been operated nationwide as a key planting system suitable for its hot and rainy summer season. Some regions on the Pacific Coast with a dry winter and low rainfall operate a double cropping system by using winter (secondary) wheat.

- Mountainous areas account for 61 percent of the total national land area and there is only limited flat land available in Japan. Consequently, competition exists in land use. Under these circumstances, the ratio of farm land is about 14 percent of the total national land area, and the cultivated land under management per farm household is small at about 1.6 hectares. This contrasts with other industrialized countries such as the USA, UK, Germany and France which have average farm sizes of 176.1 ha, 70.1 ha, 30.3 ha and 38.5 ha, respectively.

- As a result of the ongoing improvement of irrigation infrastructure for the further development of paddy field farming, the ratio of irrigated area to all agricultural land is 56 percent, one of the highest figures in the world. Paddy fields are effective in preventing damage caused by continuous cropping, thick weeds and soil erosion,

[*] *Director, Biological Resources Division, Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan.*

leading to stable agricultural production. Rice, highly stable in production and rich in nutrition, has supported the large population living in a limited land area, and helped to build the world's most densely populated society in the early 18th century.

- The small size of farming operations and difficulties in controlling water use at the individual farm level required collective control and use of water, facilitating the formation of farming communities. Community rules established to ensure smooth operations had a considerable influence in fostering the spirit of mutual aid and creating and passing on traditional rural cultures.

Agriculture in Japan has developed its own unique characteristics under the considerable influence of natural and socioeconomic conditions. To achieve sustainable development of agriculture and implement a crop diversification strategy, it is necessary to study appropriate measures taking into consideration of the above characteristics.

2. CROP PRODUCTION AND ECONOMICS SCENARIO

The food self-sufficiency ratio in Japan showed sharp decreases during the period from 1965 to 1998, down from 73 to 40 percent on a calorie supply basis and 62 to 27 percent on a grain basis (Figure 1). From a long-term standpoint, one of the major factors behind this declining trend is a fundamental change in Japanese dietary patterns, as reflected in the increasing consumption of animal products and fats and oils, which are largely dependent on imported feed grains and oilseeds, due to the restraints on national land area and ever decreasing rice consumption (Figure 2).

In recent years, both trends as mentioned above have shown a slowdown, while the domestic production of wheat and soybeans has continued to decline. This is a key factor behind the declining self-sufficiency ratio in the short term.

As the world food supply/demand situation could be tight in the mid- and long-term, the Japanese people are now showing great concern over the future food supply in Japan, characterized by very low food self-sufficiency (Figure 1). France, UK and Germany have improved their self-sufficiency ratios over the last 30 years while the Japanese ratio declined. The national government assumes great responsibility in assuring the availability of the food supply to its people. Since there are certain limitations on stockpiling and importing, it is important to increase domestic agricultural production as much as possible in order to secure a stable food supply.

The food self-sufficiency ratio is an effective and easy to see indicator for verifying the extent to which domestic agricultural production could satisfy national dietary requirements. Thus, the aims of the Basic Plan for Food, Agriculture and Rural areas is to identify the issues to be dealt with (by farm operators, consumers and food industries), and then to set up specific targets of food self-sufficiency ratio under the new Basic Law (see later).

In the Basic Plan developed in March 2000, major target food self-sufficiency ratios (2010 as target year) were set up, namely: 45 percent on a calorie supply basis, 30 percent on a grain basis, and 62 percent on a grain for staple foods basis. Although it is essential that more than 50 percent of all calories supplied by food should be covered by domestic

production, these ratios were determined in light of their attainability by 2010 and possible effects on the promotion of efforts and measures by relevant parties.

The top 30 most widely grown crops in 1997 are listed Table 1. Rice still dominates in terms of acreage and production value, but there are many vegetables, fruits and other crops that are significantly contributing to the farm economy.

Japan is the largest importer of foods and agricultural products in the world. In 1998 it spent 7.5 trillion yen, approximately 70 billion US dollars, for food imports. Foods constitute about 21 percent of all imports to Japan. Wheat, maize, soybean, meats, and vegetables constitute the major imports. Agricultural exports from Japan were 0.36 trillion yen, equivalent to only 4.8 percent of the food imports in the same year.

Table 1. Thirty Most Cultivated Crops in Japan in 1997

Crop	Cultivated Area (ha)	Yield (t)	Value (x 100 million Yen)
1. Paddy Rice	1,953,000	10,030,000	27,094
2. Wheat	157,500	573,000	856
3. Potato	103,000	3,394,300	1,322
4. Soybean	83,200	145,000	377
5. Sugar Beet	68,500	3,685,000	665
6. Orange	66,000	1,553,000	1,660
7. Other Cereals	57,450	-	-
8. Tea	51,800	401,000	1,136
9. Radish	49,800	2,020,000	1,208
10. Apple	49,300	993,000	1,192
11. Sweet Potato	46,500	1,130,000	1,053
12. Cabbage	37,900	1,504,000	965
13. Young Corn	31,600	302,000	380
14. Chestnut	30,000	32,900	99
15. Onion	27,200	1,256,000	751
16. Persimmon	27,100	301,200	425
17. Spinach	26,100	330,900	1,111
18. Leek	24,700	549,300	1,146
19. Chinese Cabbage	24,400	1,135,000	508
20. Carrot	23,200	714,800	532
21. Grape	22,800	250,900	1,179
22. Taro	21,400	269,900	418
23. Lettuce	21,400	532,700	725
24. Plum	19,100	136,200	387
25. Pear	18,500	404,200	1,149
26. Water Melon	18,500	613,900	848
27. Pumpkin	17,100	244,700	249
28. Cucumber	16,400	797,700	1,754
29. Melon	15,800	359,300	1,316
30. Egg Plant	14,000	474,900	1,156

3. PATTERNS OF CROP DIVERSIFICATION

The main struggle that Japan has faced within the post-war era is rice production. Rice is the staple food in Japan and having a sufficient rice supply was the main objective at

household and national levels for some years after the Second World War. Improvement of cultivation techniques and adoption of improved cultivars, together with supportive governmental policies, allowed Japan to meet its rice supply needs. Changes in life style and social structure, driven by drastic economic growth, resulted in a reduction in rice consumption in the mid-1960's. Average consumption of rice declined from 115 kg in 1960 to 95 kg in 1970 and to 66.7 kg in 1997. Table 2 shows changes over time in the relative importance of crops and livestock (including milk production). Rice, wheat, pulses, and sericulture have declined, while vegetables, fruits, flowers and livestock have increased in relative importance in the farm economy.

Table 2. Change of Relative Importance (%) of Agricultural Products Based on Farm-Gate Value

Year	Rice	Wheat	Pulses	Roots & Tubers	Vegetables	Fruits	Flowers	Sericulture	Livestock
1960	47.4	5.5	2.5	3.0	9.1	6.0	0.5	3.0	15.2
1970	38.3	0.6	0.8	1.4	16.2	7.1	0.9	1.6	25.9
1980	32.9	1.9	0.9	1.7	18.1	8.1	2.0	0.7	27.2
1990	30.1	1.1	0.8	2.3	21.9	8.5	3.8	0.2	25.2
1997	28.1	1.1	0.8	2.1	22.9	8.6	4.5	0.0	26.2

4. CROP DIVERSIFICATION AS A STRATEGY

4.1 Use and Consumer Demands

Crop diversification takes places not only for production reasons but also, often more importantly, for use and consumption demands. The drastic increase in annual income was accompanied by demand for diversification of diet by consuming more vegetables and fruits, as well as increased demand for ornamental plants and higher quality products. The transition to modern lifestyles influenced the status of nutritional quality. Figure 3 shows the change of nutritional uptake in terms of sources of calories. The increasing consumption of fat is evident and it has already passed the upper limit (25 percent) for a desirable diet for a Japanese. The average Japanese now spends 25 percent of total food expenditures on eating-out and processed foods. The importance of better education of the general public on nutrition concerns is recognized. Development of nutritional products attractive to the young generation is important and crop diversification efforts should be in line with this.

4.2 Multi-Functionality of Agriculture

The traditional role of agriculture is the production of food. The social recognition of the role of agriculture has expanded to the multiple function of agriculture. A crop diversification strategy should be in line with this view of multi-functionality. This means that food production should not be the only concern or objective of crop diversification efforts. For example, paddy fields should be well conserved not only for food production reasons but also for their ecological and social value. Cultivation of crops such as wheat and

soybean using paddy fields should contribute to the conservation of the rice-based farming system.

4.3 Environmental Externalities of Japan's Paddy Fields Farming

Located in the Asian monsoon zone, Japan has an annual precipitation of 1,800 mm, almost twice as high as the world average. The country is confronted with the substantial risks of flood and water shortage mainly because of the relatively steep river gradients caused by the mountain range of 2,000 - 3,000 m elevation running through the centre of the main island, and seasonal torrential rainfalls such as the summer rainy season and typhoons, as well as the strong water demand required to supply the 124 million population living in a small country.

Against such a background, paddy field farming has been built up as a key system that plays a major role not only in food production but also to mitigate the severe geographical and climatic conditions and preserve the environment which has prevailed throughout the country's history of more than 2,000 years.

While there are more than 2,200 years of climatic background in the country's long history, it has been widely recognized by the public, that, without making major demands on natural resources, paddy fields are highly effective in preventing floods and fostering water resources (as effective as dams). In addition, the terraced paddy fields are highly effective against soil erosion on the steep hillsides.

Farm areas which are composed of paddy fields provide landscape, sightseeing and recreational sites. Furthermore, paddy fields also provide a circulating soil system and purify NO_2 and SO_2 in the air.

Moreover, in contrast to uplands, paddy field farming is in line with sustainable agriculture. As proven through centuries of practice, it is free from the damage resulting from repeated cultivation and accumulation of salinity and is less harmful in terms of ground water contamination. According to calculations by the substitutive cost method (Table 3), the total value of environmental externalities provided by paddy fields is estimated to reach 4,600 billion Yen (this is approximately US$45 billion at the exchange rate as per May 31, 2000).

Table 3. Estimated Value of Paddy Fields According to the Substitutive Cost Method (Billion Yen)

Function	Benefits	Estimated Value (Yen)
Function of Preventing Flood	Mitigating the damages caused by floods	1,952.7
Function of Fostering Water Resources	Supporting steady water flow and inexpensive ground water supply	739.8
Function of Preventing Soil Erosion and Landslide	Mitigating the damages caused by soil erosion and/or landslides	47.2
Function of Soil Purification	Reducing the cost of waste treatment such as food leftovers	4.5
Function of Preserving Rural Landscape and Recreational Amenities	Value of visits by urban inhabitants	1,711.6
Function of Air Purification	Absorbing contaminants and purifying the air	171.7
Total Environmental Externalities		**4,627.5**

The values of Table 3 are based upon "*Research on the Environmental Externalities of Paddy Fields*", Mitsubishi Research Institute, March 1991, and estimated again with a consideration to changes of the unit cost and the other data after the publication of the above-mentioned research.

5. CHALLENGES, OPPORTUNITIES AND PROSPECTS OF CROP DIVERSIFICATION

During the last decades, policy makers and agricultural scientists have struggled to develop policies and technologies to meet Japan's transformation in its socio-economic structure. A forward-looking strategy for crop diversification is needed for this evolving society and rapidly integrating world economy.

5.1 Food Industry

An overview of the food supply system from farmers to food industries indicates that the agriculture and fisheries market of 16.2 trillion Yen recorded 80.4 trillion Yen in the final consumption stage after gradually adding to its value over the course of time from the processing stage to the distribution stage. In more specific terms, 20 percent went to perishable foods, 50 percent to processed foods, and 30 percent to eating out meals. While the percentage of perishable foods has been declining, those of processed foods and eating-out have been increasing.

The food industry and agriculture have been closely inter-linked through the supply and demand flow of raw agricultural products. In recent years, however, food imports for the

food industry have sharply increased. Consequently, domestic agriculture should improve the production and supply system to meet the food industry's needs.

The agriculture sector should work closely with the food industry and contribute to a harmonious relationship by proving raw materials that fit well with industry needs and consumer preference and concerns, such as food safety.

5.2 Trends in Farmers and Agricultural Workforce

The total number of farm households was 3,239,000 as of January 1, 1999, 53,000 less (down 1.6 percent) than the previous year. Of this figure, the number of commercial farm households was 2,475,000, down 1.9 percent from the previous year. The number of full-time farmers with male worker(s) at productive age involved showed a 2.4 percent decline, while the number of full-time aged farmers has continuously increased.

The population of those mainly engaged in farming as of January 1, 1999 was 3,845,000 (including both male and female workers), down 1.2 percent from the previous year, but that of those aged 65 years old and over showed a 2.1 percent increase. As a result, the ratio of aged workers of 65 years old and over accounted for 51.3 percent, more than half of the total farming population. Agricultural production systems including choice of crops to be grown will be influenced inevitably by this population structure.

5.3 Production of Wheat, Soybeans and Feed Crops in Paddy Fields

The production of wheat and soybeans in paddy fields has not been extensively implemented, because planted areas change considerably along with the changing size of the production adjustment of rice. Higher profit, however, could be gained because of the higher efficiency enabled by group farming and integrated land use of core farmers, as well as quality improvement. Disseminating the best practices nationwide may be effective in promoting this type of farming.

Wheat and soybeans produced in paddy fields vary considerably in terms of yield and quality, and a system to supply homogenous products in a large quantity, in response to consumers' needs, has not been fully established. To improve this situation, it is necessary to demonstrate basic farming techniques on farms, develop varieties reflecting end-users' evaluations, and improve and stabilize yield and quality by securing the required quantity.

In the area of feed crops, efficient production should be encouraged through field grouping, while promoting close cooperation between cultivated plant farmers and livestock farmers. Further research is needed for the identification of proper feed crops and varieties in meeting with demands.

Land extensive farming based on a paddy field farming system is essential to increase domestic production under the new Basic Law. Expectations are growing that producers nationwide should make efforts to extensively produce wheat, soybeans and feed crops and work for sustainable agricultural development and increased self-sufficiency ratio through the realization of highly profitable paddy field farming.

5.4 Varietal Diversity and Consumer Needs

Crop diversification efforts should not be limited to crop species choice. Genetic differences within the same crop species make an important contribution in meeting different production constraints and consumer needs. There is a strong interest among consumers in new products, especially in relation to novelty and better health.

The emphasis on productivity and profitability tends to reduce the number of varieties grown in farmers' fields. In the case of wheat, rice, soybeans, potatoes, sweet potatoes and apples, the top five varieties dominate more than 50 percent of areas grown to those species. The tendency of over-dominance of a few major varieties is escalating in many crops.

New types of crop variety are needed to meet new markets. For example, the Ministry of Agriculture, Forestry and Fisheries initiated a new project on the development of novelty rice varieties, creating new demands in 1989. The project has developed many interesting and useful findings and varieties, including rice varieties with very high or very low content of amylose. Amylose is the key factor for determining cooking quality and adaptability for processing. Aromatic rice and coloured rice with adaptation to Japanese growing conditions and consumer preferences were also successfully developed. The introduction of a rice variety with low allergen for those allergic to rice and a rice variety with low protein for those with kidney problems were especially welcomed by society. Through similar efforts, glutinous wheat was recently developed, with the major selling point of higher quality for noodles.

6. GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

The Cabinet has adopted The Basic Law on Food, Agriculture and Rural Areas. The objective of this Law is to stabilize and improve people's lifestyle and to develop the national economy through comprehensively and systematically implementing policies on food, agriculture and rural areas. This will be accomplished by establishing basic principles and basic matters for realizing them and clarifying the responsibilities of the state and local governments. It has four basic principles, namely securing stable food supply, fulfillment of multifunctional roles, sustainable agricultural development, and development of rural areas.

The Japanese government gives due importance to assisting developing countries for their socio-economic development. Japan has been the largest supplier of Official Development Assistance (ODA) in the last several years. Japan has contributed 38 percent of foreign aid in the area of agriculture and food in the world (Figure 4) reflecting its view of agriculture as the key engine of socio-economic stability and development.

International cooperation in the food and agricultural fields is very important in dealing with food problems, relieving poverty in developing countries, and realizing sustainable development. Japan, as one of the world's leading contributors to foreign aid, should further promote various forms of cooperation and partnership among government agencies, as well as make effective evaluations of project efficiency, with the view of carrying out more effective and efficient international cooperation. It is important here to engage in such activities in line with the WTO agricultural negotiations.

7. CONCLUSIONS

The Japanese socio-economic system, thus far pursuing material wealth under rapid economic growth, is now at an important turning point as the new century is approaching.

With increasing public awareness of limited global resources, environmental problems and possible food crises, people around the world are now beginning to reassess their values and lifestyles and develop new values and a civilized way of life with greater emphasis on harmony, coexistence, health, and comfortable and peaceful living. Food, necessities for our "daily living and life", and agriculture and rural areas, fundamentals for food production, are also being viewed in a new light, and expectations are growing as to their roles as the basis for our safety and security.

In response to such growing expectations, the Basic Law on Food, Agriculture and Rural Areas, as promulgated and enforced on July 16, 1999, thoroughly reviews the post-war agricultural policies under the Agricultural Basic Law and sets up a new policy making scheme under the new principles. This new Law should be a guideline for policy making on food, agriculture and rural areas in the coming century. Governments at all levels (national, local and municipal), farmers, consumers and any other relevant parties should work together under the proper role sharing to implement specific measures developed under the new Law.

Figure 1. Change of Self-Sufficiency Ratio on a Calorie Supply Basis during 1965 to 1998 in Japan

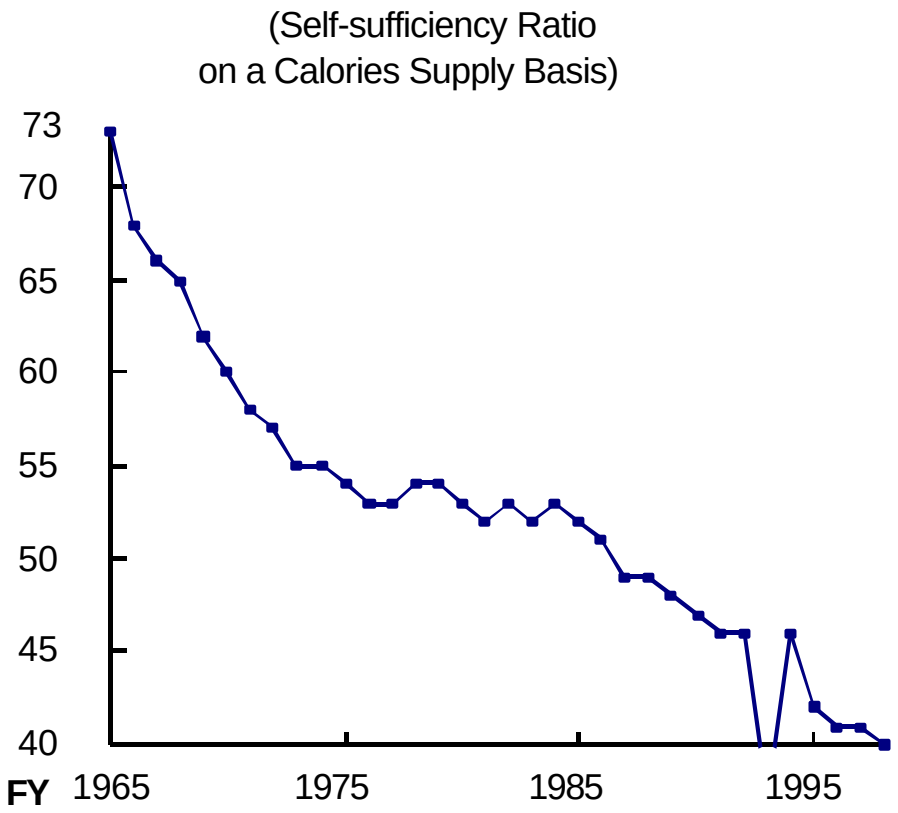


Figure 2. Change of Rice Productivity (kg/0.1 ha , in left scale) and Rice Consumption per Capita per Year (kg, in right scale) during 1960 to 1997 in Japan

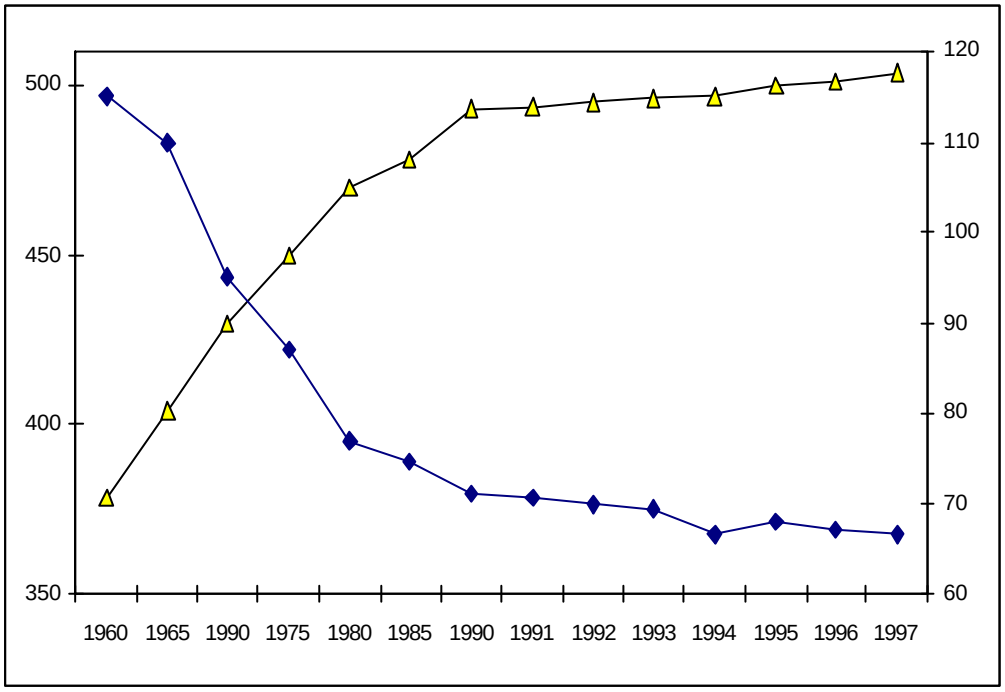


Figure 3. Calorie Consumption and Breakdown by Type of Nutrient

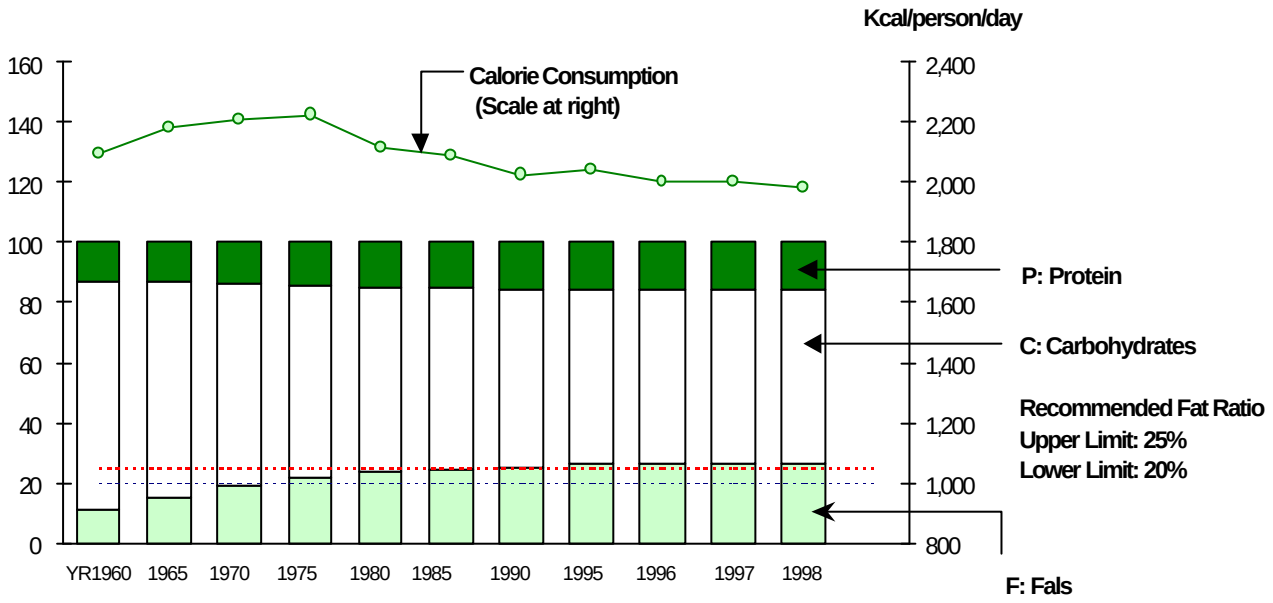
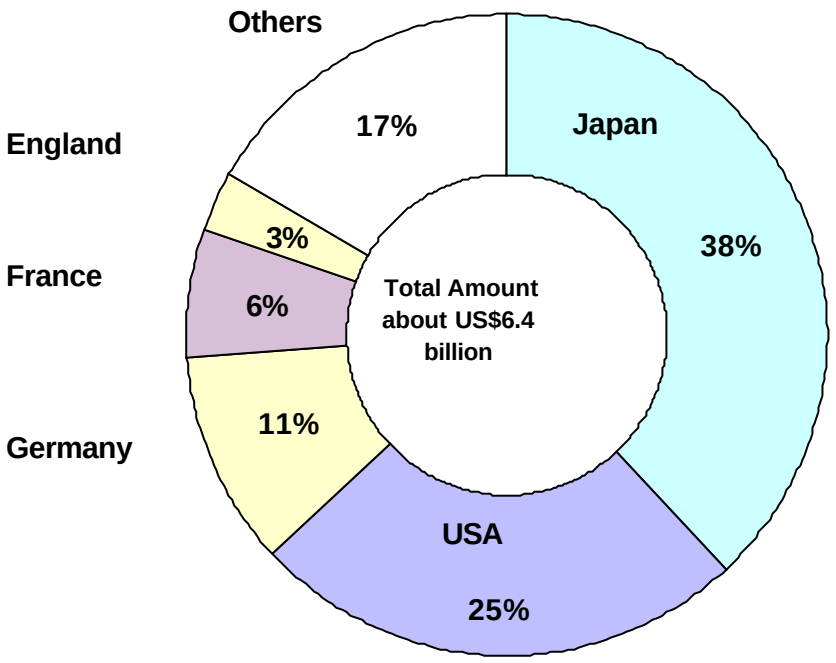


Figure 4. Aid Provided by Major Countries in Foods and Agriculture in 1996



CROP DIVERSIFICATION IN MALAYSIA

Tunku Mahmud Bin Tunku Yahya [*]

1. INTRODUCTION

Agricultural or crop diversification is practiced in Malaysia. Traditionally, horizontal diversification or the cultivation of an increasing number of crops as opposed to one or two major crops is the practice. Oil palm, rubber, cocoa and rice have been and continue to be the major crops grown by the private and public sectors. However, other crops such as coconut, tropical fruits, vegetables, flowers, annual crops etc., are being grown by the smallholders and the private sector.

Vertical diversification that refers to the upstream and downstream activities of a particular crop or crops is also being practiced. It starts from primary production (farm products), goes through primary and secondary processing and finally the finished products. The vertical variant gives increasing emphasis to intra and inter-sector linkages thereby developing the relevant value chain in order to be competitive.

2. CROP PRODUCTION AND ECONOMICS SCENARIO

The area under agriculture in Peninsular Malaysia increased from 33 percent in 1984 to 37 percent in 1995 (Table 1). In Sarawak it increased from 26 percent in 1976 to 32 percent in 1992 (Table 2), while in Sabah the area under agriculture increased from 7 percent in 1985 to 10 percent in 1991 (Table 3).

The bulk of agriculture land in Malaysia is devoted to rubber, oil palm and rice (Table 4). Nevertheless, the acreage under rubber is on the decline since the early eighties. Oil palm has taken its place, showing an increasing trend from 1,482,400 hectares in 1985 to 2,540,000 hectares in 1995 reflecting an average annual growth rate of 5.5 percent. Rice increased from 655,000 hectares in 1985 to 670,000 hectares in 1995, with an average annual growth rate of 0.2 percent. Vegetables increased at an annual growth rate of 2.8 percent from 31,800 hectares in 1985 to 42,000 hectares in 1995. Fruits that include durians, pineapples, banana, papaya, starfruits etc., grew as fast as oil palm at 5.6 percent per annum from 150,100 hectares in 1985 to 260,000 hectares in 1995. Other crops showed decreasing trends. Cocoa that reached a peak of 419,100 hectares in 1990, took a downturn in 1995 to about 190,000 hectares. Coconut acreage reached the highest level of 334,100 hectares in 1985 but started to decline to about 250,000 hectares in 1995. Pepper reached a peak of 11,500 hectares in 1990 but declined to 10,000 hectares in 1995. Tobacco also declined to 11,000 hectares in 1995 from 16,200 hectares in 1985.

The contributions and performances of the selected crops from 1985 to 1995 are highlighted below.

[*] *Senior Research Officer/Assistant Director, Economic and Technology Management Centre, Malaysia Agricultural Research Development Institute (MARDI), Kuala Lumpur, Malaysia.*

The Natural Rubber (NR) industry contributes to national development in terms of export earnings, Gross Domestic Product (GDP) as well as employment and income, involving about 420,000 smallholders and 53,000 estate workers. The NR industry also provides employment opportunities in other ancillary activities such as in trading, processing and manufacturing. In 1995, export earnings from NR and rubber products amounted to RM7.9 billion (USD 2.1 billion), representing 3.9 percent of the total export value. Between 1985 and 1995, production contracted by 27.2 percent from 1.47 million tonnes to 1.07 million tonnes and the decline was experienced by both the smallholder and estate sectors (Table 5). This was due to the weak rubber prices prevailing during the period. The decline in production led to the closure of many processing factories, especially the smaller and less efficient ones, due to the shortage of raw materials. The remaining factories are operating at an average of 55 percent capacity. The import of raw materials from other producing countries will be on the increase to meet the demand of local processors and rubber product manufacturers.

The oil palm industry has evolved from a mere producer and exporter of crude palm oil (CPO) into a more diversified entity, creating new downstream and supporting industries. Over the years, it has remained resilient in the face of many challenges and has continued to contribute significantly to the national economy. Its contribution to GDP amounted to RM6.8 billion in 1995 or 5.7 percent, up from RM3.6 billion in 1985. Among the primary commodities, palm oil is the country's largest export earner, totaling RM13 billion (US$3.4 billion). About 250,000 families in Government land schemes and independent smallholdings as well as 80,000 workers in the private estates of Peninsular Malaysia are dependent on this industry for their livelihood. Concurrent with the rapid expansion in oil palm planted areas, the number of oil palm mills also increased. At the end of 1995, there were 281 oil palm mills with an annual operating capacity of 50.8 million tonnes of fresh fruit bunches (FFB), 41 refineries and 13 oleochemical manufacturers with an annual operating capacity of 10.15 million tonnes and 0.82 million tonnes, respectively. Processed palm oil exports grew from 3.4 million tonnes to 6.5 million tonnes during the period 1985-95 (Table 6).

Over the 1985-95 period, the country recorded an increase in average yield and total rice production (Table 7). National yield recorded an increase from 2.7 tonnes per hectare to 3.2 tonnes per hectare during the period. Peninsular Malaysia recorded an average yield of 3.7 tonnes per hectare in 1995, while Sarawak and Sabah averaged 1.2 and 2.7 tonnes per hectare, respectively. Total rice production increased from 1.7 million tonnes in 1985 to 2.1 million tonnes in 1995. The eight main granary areas, which accounted for more than 70 percent of rice production, recorded an increased yield from 3.3 tonnes per hectare in 1985 to 4 tonnes per hectare in 1995. Over the 1985-95 period, domestic production accounted for about 77 percent of the total domestic consumption. In 1995 importation of rice amounted to 427,570 tonnes valued at RM356.1 million (US$94 million).

Cocoa production increased from 108,000 tonnes in 1985 to 247,000 tonnes in 1990 but subsequently declined to 132,000 tonnes in 1995. Cocoa remains an important agro-based industry for the country. During the 1990-1995 period, exports of these products have increased by about 48 percent, from RM307 million (US$81 million) to about RM453 million (US$119 million) (Table 8). The cocoa industry is a source of livelihood for about 120,000 smallholder families and provides employment for about 36,000 workers in the estate sector. Additionally, a substantial number is employed in supporting industries such as

in processing, grinding and manufacturing. Currently, Malaysia has 10 grinding factories with a production capacity of 125,000 tonnes per year.

The fruit industry is a smallholder-based industry involving 270,000 farmers. In 1995, the area under fruits was 260,600 hectares, and in the year 2010 it is forecasted to increase to 375,000 hectares (Table 9). For the 1985-95 period, the production of fresh fruits increased at the rate of 4.8 percent per annum from 638,100 tonnes to 1,019,900 tonnes. The total value of fresh fruits exported increased from RM72.3 million (US$19 million) in 1985 to RM170.2 million (US$45 million) in 1995 (Table 10). The major fruits exported were melons, durians, papaya, banana and starfruit. The exports of processed fruits increased from RM110 million (US$29 million) in 1985 to RM165 million (US$43 million) in 1995. However, Malaysia is still a net importer of fruits and fruit products.

The production of vegetables has increased from 540,700 tonnes in 1985 to 718,100 tonnes in 1995 at an average annual growth rate of about 2.9 percent (Table 11). In the year 2010, it is forecasted that the planted acreage will increase to 86,000 hectares with a production of 1.6 million tonnes (Table 12). The export of vegetables has increased at the rate of 15.2 percent per annum from RM39 million (US$10 million) in 1985 to RM160 million (US$42 million) in 1995. The value of import has increased from RM276 million (US$73 million) in 1985 to RM683 million (US$180 million) in 1995 (Table 13).

The productivity of coconut smallholdings is very low, the average annual yield being 4,000 nuts per hectare compared to a potential of 20,000 nuts per hectare using recommended varieties. Nevertheless, Malaysia is a net exporter of coconut products. Total exports in 1995 amounted to RM165.2 million (US$43 million) while imports totaled RM77 million (US$20 million) as shown in Table 14. However, currently most coconut processing firms are having problems getting the coconuts domestically and are therefore operating below capacity leading to inefficiencies in the production of coconut-based products.

Overall, the contribution of the agricultural sector to GDP, employment and export earnings is on the decline (Table 15). In 1975, the contribution of agriculture to GDP was 28 percent but in 1995 it has gone down to 13.6 percent. In 1975, the contribution of agriculture to employment was 37 percent but declined to 18 percent in 1995. The contribution of agriculture to export earnings in 1975 was 50 percent and in 1995 it was only 13.1 percent.

The forecasted land use in the year 2010 indicates that rubber, coconut and cocoa holdings, as well as planted areas of rice will be reduced by 505,000, 70,000, 60,000 and 220,000 hectares, respectively (Table 16). In Sabah and Sarawak where there are substantial land areas, new land development will be undertaken.

3. PATTERNS OF CROP DIVERSIFICATION

Rice is mainly grown by smallholders with an average farm size of about 1.06 hectares. Wetland rice constituted 85 percent of the total rice area in the country with the remaining 15 percent made up of upland rice. In Peninsular Malaysia, 76 percent of the area is provided with extensive irrigation and drainage facilities while only 15 percent of the area in Sabah and Sarawak are irrigated. About 72 percent of rice production comes from the eight granary areas that are able to produce two crops in a year.

About 78 percent of the rubber grown in the country is under the smallholder sector and most of them have holdings of less than 3 hectares. The average output per tapped area in the smallholder sector is about 941 kg per hectare while that of the estate sector is about 1,119 kg per hectare. The current shortage and high cost of labour has affected the tapping of rubber and thus rubber output. Although the Rubber Research Institute of Malaysia (RRIM) has developed clones such as RRIM 900 and RRIM 2000 series that are superior in producing both latex and wood, the adoption by smallholders is limited.

In the case of oil palm, private estates account for the largest share of planted areas (49 percent), followed by Federal Land Schemes such as FELDA, FELCRA and RISDA (33 percent), independent smallholders (10 percent) and state schemes (8 percent). The bulk of Malaysia's palm oil exports are confined to basic processed products. Other higher value-added products such as margarine, cooking oil, shortening, beta-carotene, and vitamin E are slowly but surely becoming more important.

The area under cocoa cultivation is mainly in Sabah. However, the grinding factories are mainly located in Peninsular Malaysia. The high freight costs and low shipping frequency between Sabah and Peninsular Malaysia has affected the competitiveness of the industry.

Most of the fruit cultivation is by smallholders. There are many types of fruits grown depending on the suitability of the crop in the area. However, there are a few public agencies such as FELCRA and state agencies that undertake large-scale cultivation of fruits. The popular fruits cultivated are banana, durian and dokong.

Vegetable cultivation is dominated by smallholders. Most of them operate on smallholdings close to urban areas. There are a few that operate larger holdings of 50 or more acres under rainshelters. These are found in the southern state of Johor, which is closer to the Singapore market. In the Cameron Highlands, vegetables are also grown and the produce is transported daily to Kuala Lumpur. Lately, there has been a shift towards floriculture production in the highlands.

4. CROP DIVERSIFICATION AS A STRATEGY FOR VARIOUS NATIONAL COMMITMENTS

A provider of food will continue to be the role of agriculture in Malaysia. The eight major granary areas have been reserved for rice cultivation where new varieties or new technologies from Research and Development (R&D) work can be adopted. The area will be able to meet the changing domestic consumption needs towards high quality rice. The mini granary areas that support only one season of rice are free to choose what alternative crops to plant. It can still be one season of rice and another season of vegetables or other short-term crops such as sweet potato, watermelon, or sweet corn.

The agriculture sector through crop diversification can be the provider of high quality raw materials to the industrial sector for the agro and resource-based industrial development. The industrial sector, which will be the engine of growth until the year 2020, requires the support of other sectors particularly the agriculture sector to get it moving efficiently and

competitively. The linkage generates considerable employment, income, economic growth and reduces poverty.

The cluster-based agro-industrial development as identified in the Second Industrial Master Plan (IMP2), 1996-2005, seeks to strengthen both inter and intra-sectoral linkages including the development and expansion of intermediate and supporting industries. Through this approach, agricultural production will be more specialized to meet the needs of various domestic and global market segments. This will encourage the production of high quality and high value produce, facilitate product differentiation and increase value-added agriculture.

5. CHALLENGES, OPPORTUNITIES AND PROSPECTS OF CROP DIVERSIFICATION

5.1 Challenges

There are many challenges facing the agricultural sector in general and crop diversification in particular. Firstly, there is a need to reduce labour requirements in agriculture. There is an acute shortage of farm labour leading to high employment of immigrant workers in the agricultural sector. This is due partly to the slow adoption of mechanization in certain production processes, especially harvesting.

Secondly, there is a need to maximize land utilization. Land for agricultural activities is becoming more limited due to conversion for other uses such as industrial, residential and urban uses. Despite this, there are still substantial areas of idle agricultural land and abandoned holdings. It is estimated that there are about 400,000 hectares of idle agricultural land all over the country and this has been and continues to be a big problem.

There is a need to strengthen the competitiveness of Malaysian agriculture. The implementation of the agreements under the World Trade Organization (WTO) and the Common Effective Preferential Tariff (CEPT) scheme of the ASEAN Free Trade Area (AFTA) have created greater competition for Malaysian agriculture.

There is a need to enhance private sector investment in food production. Total private investment in agriculture during the 1990-95 period was only RM9.5 billion as compared to RM84 billion in manufacturing.

The smallholders need to be transformed into a more commercial sector. Efficiency gaps are still substantial between the smallholder and estate sector. The smallholder sector continues to experience problems of low productivity and uneconomic holdings size.

The concerns for environment and sustainable development at both the domestic and global levels require more innovative and efficient agricultural practices for economic development of the sector as well as to maintain the ecological and environmental balance of the country.

5.2 Opportunities

There are tremendous opportunities for downstream activities. Where technologies are available, they should be acquired and tried out. The higher prices for the final products

should be attractive to justify the investment in these activities. Take for example the processed fruit industry. The industry that includes juices, puree, concentrates and processed fruit products has become one of the world's major agri-businesses. There are opportunities in this area such as minimally processed fruits, tropical fruit juices, natural food ingredients, functional food, modified food ingredients, health food, convenience food, frozen fruits, beverages and high fibre products.

The changing consumer tastes for environmentally friendly goods or pesticide free goods open the door for organic farming or soil-less culture techniques of production. The popularity of portable hydroponics containers among the hobbyists signals the opportunities for bigger commercial ventures.

As production becomes more competitive, there is a need to be more efficient, with high productivity and minimal costs. Precision farming through the use of advanced technologies such as remote sensing, Geographical Information System (GIS), Global Positioning System (GPS) and Decision Support System (DSS) must be given due consideration. The oil palm plantations are showing keen interest in this venture for the good of the industry.

5.3 Prospects

The demand for rice in both international and domestic markets is expected to increase. In the domestic market, the consumption of rice is projected to increase from 1.8 million tonnes in 1995 to 2.3 million tonnes in 2010 due to population increase. Under a tight supply situation in the international market there exists prospects to expand domestic production of rice to cater for domestic demand. At the same time increasing income and higher standards of living will lead to changing preferences towards higher quality rice. Given the price premium for high quality rice, there is potential for development of the rice industry based on this product group.

The prospects for growth of the fruit industry are bright due to the expected increase in domestic consumption of both fresh and processed fruits and expanding world demand for tropical fresh and processed fruits. Based on production capability and demand, there is potential for the country to enhance production of fruits and be competitive to cater for selected fresh fruits demand in the domestic market and in niche export markets.

Based on cost structure and demand, there are prospects for Malaysia to concentrate on production of high quality fresh vegetables for both domestic and export markets and also on a few selected vegetables for processing. Using high technology for growing vegetables under controlled environment, there is potential for production of high value temperate vegetables such as cauliflower, broccoli, celery, leek and bell pepper in the lowlands for import substitution.

6. GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

In the 1960’s and 1970’s, with abundant land and cheap labour, Malaysia pursued an expansionary policy on rice and export crops such as rubber, oil palm and cocoa. The Government undertook heavy investments in infrastructure, institutional building and new

land development to develop these crops in order to earn foreign exchange, create employment and income earning opportunities, as well as reduce poverty.

The National Agricultural Policy (NAP) was promulgated in 1980. The emphasis then was to continue new land development and consolidation of uneconomic farm size through in-situ development. The policy stressed productivity-driven growth, recognizing the need for the sector to be efficient to sustain agricultural growth in the long run.

The period 1984-1990 marked an important threshold in the transformation and development of the Malaysian economy. This era saw the rapid expansion of the manufacturing sector. Favourable policies towards industrialization created conditions not attractive for agricultural investment and consequently led to the outflow of resources from agriculture. The overall development of the agricultural sector was beset with problems including labour shortages and rising wages, and increasing competition of land for other uses.

Subsequently, the first NAP was reviewed and the second NAP (1992-2010) was introduced. Greater emphasis was given to address productivity, efficiency and competitiveness issues in the context of sustainable development and linkages with other sectors of the economy. The policy also outlined both medium and long-term strategies for expanding food production, a greater role of the private sector, marketing reform and accelerated agro-based industrial development.

In 1997 NAP2 was reviewed and NAP3 was formulated to cover the period 1998-2010. The overriding objective of NAP3 is the maximization of income through optimal utilization of resources in the sector. This includes maximizing agriculture's contribution to national income and export earnings as well as maximizing income of producers. NAP3 will continue to pursue agricultural growth through moderate expansion of land and further intensification of land use. There will be substantial reduction in rubber, rice, coconut and cocoa areas and most of these areas will be replaced by agroforestry, oil palm, fruits and vegetables cultivation. In Sabah and Sarawak where there are substantial land areas, new land development will be undertaken.

7. CONCLUSIONS

Crop diversification will continue to be practiced in Malaysia. Malaysia started with horizontal diversification, and is now moving towards vertical diversification. A balanced development strategy between the various sectors of the economy is important to avoid a wide disparity in income, reduce poverty, and provide good infrastructure development and utilities, better homes and quality of life.

There are many challenges facing the country but there are opportunities and prospects. The Government is providing the direction in the form of NAP3 and IMP2 and the private sector or the entrepreneurs should be able to take calculated risks in order to venture into the relevant businesses. As we approach globalization, competitiveness is the essence and high productivity and efficiency cannot be ignored. New technology or innovative technology is an important vehicle towards competitiveness.

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Table 1. Agriculture Land Use in Peninsular Malaysia

	1984		1995		Annual Growth (84-95)
	% of Area	Total Area (ha)	% of Area	Total Area (ha)	
Total land	**100.00**	**13,237,063**	**100.00**	**13,209,455**	**-0.02**
Agric. land	33.28	4,405,949	37.20	4,909,923	0.90
Rubber	15.14	2,003,456	14.00	1,854,744	-0.64
Oil palm	9.39	1,243,534	14.10	1,858,448	3.35
Paddy	3.38	447,624	3.21	425,080	-0.43
Mixed Hort.	2.09	277,006	2.19	289,080	0.36
Coconut	1.58	209,196	1.43	189,785	-0.81
D/fied crops	0.42	54,970	0.39	51,165	-0.60

Source: Bahagian Pengurusan Tanah, Jabatan Pertanian, Semenanjung, Malaysia

Table 2. Agriculture Land Use in Sarawak

	1976		1992		Annual Growth (76-92)
	% of Area	Total Area (ha)	% of Area	Total Area (ha)	
Total land	**100.00**	**12,325,216**	**100.00**	**12,325,216**	**0**
Agric. land	26.01	3,205,525	31.93	3,935,031	1.21
Shifting cultvn	22.70	2,797,288	27.48	3,387,003	1.13
Rubber	1.57	193,052	1.76	217,381	0.70
Paddy	1.07	131,339	1.02	125,084	-0.29
Oil palm	0.16	19,985	0.54	67,063	7.12

Source: Agriculture Statistics of Sarawak (1993), Department of Agriculture, Kuching

Table 3. Agriculture Land Use in Sabah

	1985		1991		Annual Growth (1985-91)
	% of Area	Total Area (ha)	% of Area	Total Area (ha)	
Total land	**100.00**	**7,371,100**	**100.00**	**7,371,100**	**0**
Agric. land	7.44	548,243	10.16	749,045	4.46
Rubber	1.15	84,746	1.19	87,483	0.45
Oil palm	2.54	187,226	4.65	342,476	8.63
Cocoa	2.34	172,713	2.73	201,327	2.19
Coconut	0.77	57,006	0.79	57,955	0.24
Paddy	0.52	38,440	0.80	58,722	6.05

Source: Agriculture Statistics of Sabah (1993), Department of Agriculture, Kota Kinabalu

Table 4. Agricultural Land Use, 1985-1995 (`000 hectares)

Item	1985	1990	1995	Average Annual Growth Rate (%)		
				1985-1990	1990-1995	1985-1995
Rubber	1,948.7	1,836.7	1,690.0	-1.2	-1.7	-1.4
Oil Palm	1,482.4	2,029.5	2,540.0	6.5	4.6	5.5
Cocoa	303.9	419.1	190.0	6.6	-14.6	-4.6
Paddy[1]	655.0	680.6	670.0	0.8	-0.3	0.2
Coconut	334.1	315.6	250.0	-1.1	-4.6	-2.9
Pepper	5.4	11.5	10.0	16.3	-2.8	6.4
Vegetables[1]	31.8	35.2	42.0	2.1	3.6	2.8
Fruits	150.1	204.6	260.0	6.4	4.9	5.6
Tobacco[1]	16.2	10.2	11.0	-8.8	1.5	-3.8
Others[2]	94.3	94.8	106.0	0.1	2.3	1.2
Total	**5,021.9**	**5,637.8**	**5,769.0**	**2.3**	**0.5**	**1.4**

Sources: Economic Planning Unit, Ministry of Agriculture

Notes:

[1]Paddy, vegetables and tobacco are based on planted area.
[2]Others include sugar cane, coffee, sago, tea and floriculture.

Table 5. Hectarage and Production of Natural Rubber, 1985-1995

Year	Hectarage (`000 hectares)			Production (`000 tonnes)		
	Estates	Smallholdings	Total	Estates	Smallholdings	Total
1985	428.8	1,519.9	1,948.7	504.3	965.2	1,469.5
1990	348.7	1,488.0	1,836.7	399.6	892.4	1,292.0
1995	254.3	1,435.7	1,690.0	242.6	831.4	1,074.0

Source: Ministry of Primary Industries

Table 6. Hectarage, Production and Exports of Palm Oil, 1985-1995

Year	Hectarage (`000 hectares)	Production (`000 tonnes)		Exports (`000 tonnes)	
		CPO[1]	CPO[2]	PPO[3]	Oleachemicals
1985	1,482	4,133	512	3,421	153
1990	2,029	6,095	827	5,634	129
1995	2,540	7,726	1,037	6,495	521

Source: Ministry of Primary Industries

Notes: [1]Crude palm oil
[2]Crude palm kernel oil
[3]Processed palm oil

Table 7. Paddy Production, 1985-1995 (`000 tonnes)

Area	1985	1990	1995
Granary			
Muda (MADA)	701.0	724.9	862.2
Kemubu (KADA)	108.2	163.7	181.2
Kerian Sg. Manik	144.1	128.7	163.3
Barat Laut Selangor	97.4	142.0	146.7
Seberang Prai	31.7	35.9	62.7
Seberang Perak	20.5	70.5	56.9
Ketara (Besut)	19.5	25.5	35.3
Kemasin Semerak	-	6.5	19.7
Total Granary	**1,122.4**	**1,297.7**	**1,527.7**
% of National Production	64.3	68.8	71.8
Non-Granary	**623.0**	**587.3**	**600.0**
% of National Production	35.7	31.2	28.2
Grand Total	**1,745.4**	**1,885.0**	**2,127.0**
Total Planted Area (ha)	**654,974.0**	**680,647.0**	**672,787.0**
Average Yield (kg/ha)	**2,665.0**	**2,769.0**	**3,162.0**

Source: Ministry of Primary Industries

Table 8. Cocoa Grinding and Export Value of Cocoa Products, 1985-1995

Year	Grinding (tonnes)	Domestic Consumption (%)	Export Value (RM `000)				
			Cocoa Paste	Cocoa Butter	Cocoa Powder	Chocolates	Total
1985	27,000	24.3	4,854	117,328	10,975	3,049	136,206
1990	70,000	28.3	16,338	241,307	24,406	25,331	307,382
1995	103,540	48.6	24,228	330,511	42,174	56,678	452,591

Source: Ministry of Primary Industries

Table 9. Forecast of Hectarage and Production of Fruits, 1995-2010

Year	1995	2000	2005	2010	Average Annual Growth Rate (%)			
					1995-2000	2000-2005	2005-2010	1995-2010
Planted hectarage (`000 hectares)	260	290	330	375	2.2	2.6	2.6	2.5
Production (`000 tonnes)	1,019.9	1,234.9	1,660.4	2,232.5	3.9	6.1	6.1	5.4

Source: Ministry of Agriculture

Table 10. Imports and Exports of Fresh and Processed Fruits, 1985-1995 (RM `000)

Year	Fresh	Processed	Total
Imports			
1985	198,721	58,479	257,200
1990	204,784	58,016	262,800
1995	312,709	131,591	444,300
Exports			
1985	72,315	110,085	182,400
1990	142,404	163,696	306,100
1995	170,239	165,361	335,600

Source: Department of Statistics

Table 11. Hectarage and Production of Vegetables, 1985-1995

Year	1985	1990	1995	Average Annual Growth Rate (%)		
				1985-1990	1990-1995	1985-1995
Planted hectarage (`000 hectares)	31.8	35.2	42.0	2.1	3.6	2.8
Production (`000 tonnes)	540.7	609.6	718.1	2.4	3.3	2.9

Source: Ministry of Agriculture

Table 12. Forecast of Hectarage and Production of Vegetables, 1995-2010

Year	1995	2000	2005	2010	Average Annual Growth Rate (%)			
					1995-2000	2000-2005	2005-2010	1995-2010
Planted hectarage (`000 hectares)	42.0	48.0	64.0	86.0	2.7	5.9	6.1	4.9
Production (`000 tonnes)	718.1	907.4	1,179.8	1,616.5	4.8	5.4	6.5	5.6

Source: Ministry of Agriculture

Table 13. Imports and Exports of Fresh and Processed Vegetables, 1985-1995 (RM `000)

Year	Fresh	Processed	Total
Imports			
1985	211,028	65,019	276,047
1990	305,809	61,019	366,828
1995	559,627	123,821	683,448
Exports			
1985	29,147	9,945	39,092
1990	74,649	50,744	125,393
1995	100,414	60,039	160,453

Source: Department of Statistics

Table 14. Exports and Imports of Products from OECP Group, 1995

Crop	Exports		Imports		Trade Balance (RM million)
	Value (RM million)	%	Value (RM million)	%	
Coconut	165.2	50.5	77.0	3.5	88.2
Pepper	103.6	31.6	9.6	0.4	94.0
Tobacco	0.7	0.2	129.0	5.9	-128.3
Sugar	4.1	1.3	771.8	35.5	-767.7
Cassava	3.3	1.0	46.7	2.1	-43.4
Maize	5.7	1.7	990.7	45.6	-985.0
Tea	2.9	0.9	27.3	1.3	-24.4
Coffee	41.9	12.8	123.7	5.7	-81.8
Total	**327.4**	**100.0**	**2,175.8**	**100.0**	**-1,848.4**

Source: Department of Statistics

Table 15. Agricultural Contribution to GDP, Employment and Export Earning, 1975-1995 (%)

	1975	1985	1990	1995
GDP	28	20	18.7	13.6
Employment	37	31	26.0	18.0
Export earnings	50	30	22.0	13.1

Table 16. Forecast of Agricultural Land Use, 1995-2010 (`000 hectares)

Item	1995	2000	2005	2010	Average Annual Growth Rate (%)			
					1995-2000	2000-2005	2005-2010	1995-2010
Rubber	1,690.0	1,490.0	1,395.0	1,185.0	-2.5	-1.3	-3.2	-2.3
Oil Palm	2,540	3,125.0	3,461.0	3,637.0	4.2	2.1	1.0	2.4
Cocoa	190.0	130.0	130.0	130.0	-7.3	0.0	0.0	-2.5
Paddy[1]	670.0	660.0	475.0	450.0	-0.3	-6.4	-1.1	-2.6
Coconut	250.0	180.0	180.0	180.0	-6.4	0.0	0.0	-2.2
Pepper	10.0	11.0	11.0	11.0	1.9	0.0	0.0	0.6
Vegetables[1]	42.0	48.0	64.0	86.0	2.7	5.9	6.1	4.9
Fruits	260.0	290.0	330.0	375.0	2.2	2.6	2.6	2.5
Tobacco[1]	11.0	11.0	11.0	11.0	0.0	0.0	0.0	0.0
Others[2]	106.0	130.0	150.0	180.0	4.2	2.9	3.7	3.6
Total	**5,769.0**	**6,075.0**	**6,207.0**	**6,245.0**	**1.0**	**0.4**	**0.1**	**0.5**

Sources: Economic Planning Unit, Ministry of Agriculture

Notes:
[1] Paddy, vegetables and tobacco are based on planted area
[2] Others include sugar cane, coffee, sago, tea and floriculture

CROP DIVERSIFICATION IN NEPAL

K. C. Sharma [*]

1. INTRODUCTION

1.1 Agriculture as a Complex Profession

Actually agriculture is a complex profession in the sense that it is an outcome of the efforts from different types of institutions including farmers. Technology developed by research institutions is transferred to the farm community though extension. Before an appropriate technology is evolved, a lot of efforts from different institutions need to be made. After the technology reaches the field, the farmer requires integrated services from different technical units. How to grow a new variety in the field is a challenge for the farmer. Agronomic knowledge, pathological knowledge, soil related knowledge, irrigation knowledge, post-harvest knowledge and marketing knowledge should exist as preconditions for the farmers; then they can go along with a new variety of crop in the field. Credit and necessary inputs are also preconditions.

1.2 Agriculture is Basically Traditional

The main actor in any agricultural development system is the farmer. The farmer is basically a traditional person. It is easier to go along with what he is doing rather than having to change. When we say change in technology, the farmer has to adopt a lot of new practices for the change to occur. He requires more money to buy more inputs needed by new technology. In many cases, he needs to employ more skilled labour for which training is required. For high production technologies, irrigation should be ensured, fertilizers should be available, seeds should be of good quality and management should be skilled. Having received all these the production, which is the main focus of high technologies, may still remain low or may not meet expectations. Agriculture in Nepal is always risky and therefore if you try to change something it becomes more risky. Because of this the farmer tries to stick with traditional agriculture.

1.3 The Farmer

The farmer is the key player in farming. Whatever the scientists may do, if the farmer does not adopt it, no progress takes place. The farmer is surrounded by different circumstances in which there may be a lot of problems, constraints and opportunities. The farmer therefore needs motivation first and then facilitation on the way to adopt new practices.

The farmer or any person undergoes different stages before he adopts new things. For example, one should require the information first followed by rising interest. Then he starts evaluating the new information or technology. Positive evaluation leads to trial and then

[*] *Project Coordinator, Crop Diversification Project, Ministry of Agriculture, Kathmandu, Nepal.*

adoption if perceived good and rejection if bad. If the farmer is forced to adopt a new practice without his own evaluation or willingness, there is a likelihood that it might not continue, but if he is motivated and convinced, the practice will be well taken.

1.4 Technology

Technology is another important aspect on which the adoption by the farmer depends. There are certain attributes of technology such as the cost, simplicity, profitability, divisibility, immediate return and so forth. If the technology is difficult or complicated and it is of high cost, the farmer will be reluctant to accept while on the other hand if the technology is highly profitable and cost effective, it is likely to be adopted.

On the other side the technology should be suitable to the locality in terms of climate, topography and local need. A technology which is not feasible in the area should be avoided.

People these days have become result oriented. Anything you adopt should give positive impact. It should be an environmentally friendly, economically viable, socially justifiable and locally satisfying type, otherwise people will reject it. In this view, researchers should take note that the technologies generated should be suit the farm community as well as the local climate of course, with the qualities mentioned.

1.5 Ecology

Nepal can be divided into three ecological zones, namely: Terai (plain), Mid-hills and High hills. Terai is the main area where cereal crops can be extensively grown. Because of the tropical and sub-tropical climate in the region, food crops, vegetables and fruits of tropical and sub-tropical nature are the main agricultural produce. As we go higher we have mid-hills where different types of crops can be grown. This is the region where different climates are available. For example, at the foot of the hills the climate is sub-tropical whereas at the top of the hills it is temperate. Food crops at the foot and fruits as well as potato at the top of the hills are the main crops in this region. High hills is a region where a snowy (alpine) climate is prevailing. Potatoes, temperate fruits, livestock (sheep and goat) are the main commodities of this area. So it is the ecology that creates a lot of differences in temperature and commodity and these create a possibility for crop diversification.

Crop diversification represents the growing of a variety of agricultural commodities that are commercially viable and locally acceptable. The farmer has limited land where he wants to grow everything possible for home consumption. Whatever may be the crop intensity, this type of approach is not commercially viable. These days the farmer has to be commercialized for sustained livelihood. Commodities having higher comparative advantage and higher marketability should be grown on a commercial basis. In order to encourage commercialization, the production pocket concept and farmers group approach as encouraged by the Agriculture Prospective Plan (APP) should be fully implemented.

Selecting the crops or commodities with higher comparative advantage and higher marketability and growing them on a commercial basis is defined as crop diversification. Commodities grown on hills can be off-season for Terai. If this is the case, why not encourage hill farmers to grow these types, such as off-season vegetables?

We know hill farmers face many problems and constraints. They are simply on a subsistence level and hence they cannot talk of commercialization as such. They have to have a group attitude, production pocket approach, commercial outlook, and innovative ideas. Similarly, Terai farmers have also several constraints of different nature. They have to change the existing agricultural system drastically. Before they change the system they should be changed mentally, meaning that they should develop the mentality of entrepreneurship and learn a trading mechanism, so that their agricultural system is guided by commercialization.

In this context, it seems we have a lot of choices or options in selecting agricultural commodities. Because of different climatic conditions, we can grow a lot of crop species in the country. At the same time we have different commodities at our disposal. The only thing we need is to develop innovative ideas towards commercialization.

Considering this, crop diversification is defined as an instrument by which the farmers can grow the best profitable commodities on their land and earn money from it. For this, they should know which commodities are suited to their locality and earn more profit. They should also know how these commodities can efficiently be produced for the market and how these commodities can be efficiently sold on the market- both internal and external.

2. CROP PRODUCTION AND ECONOMICS SCENARIO

The productivity of cereal crops is very low. Rice is the most important cereal crop and its productivity in the mountains averages 1.7 to 2.0 t/ha while in the hills it ranges from 1.6 to 2.3 t/ha. The yields are higher in the Terai, being 2.6-2.9 t/ha, but are still lower than those of other countries in South and Southeast Asia.

Maize being the second most important staple food commodity in Nepalese agriculture and economy, covers nearly 80 percent of the hill area. It is totally grown under rainfed conditions and mostly on marginal land with very little use of commercial fertilizers. Maize is commonly grown with millet, mostly in a relay system. Other important cropping systems are maize associated with soybeans, legumes, radish, potatoes and upland rice. The Terai region, which has high potential for winter and spring maize, accounts for 20 percent of the maize area and this is increasing, particularly in the winter due to accessible markets. Under rainfed conditions, pulses can play an important role in crop diversification. Lentil is the most important pulse crop in the western part of the country. Soybean accounted for about 7 percent of the area and 7 percent of the production of legumes in Nepal, with the hills accounting for 80 percent of area and production. The average yield is about 0.7 t/ha. Intercropping with maize gives good yields. Oilseed crops such as rapeseed, mustard, toria, groundnut, sesame and sunflower have potential in the country particularly in western regions. They are both oil producing and income generating crops. Millet is predominantly planted with minimal inputs other than household labour, and is often grown under stressful conditions and on marginal lands where other crops do not succeed. Despite these constraints the average yield is surprisingly high at around 1.1-1.2 t/ha.

The area, production and yield of maize has improved marginally over the last 25 years in the Terai, whereas in mid and high hills the area has increased by 200 percent, but yields have declined by 17 percent. In the case of grain legumes, there is a big yield gap between research stations and farmers' fields. This may indicate that the generated

technology still needs to be refined and/or verified in farmers' fields and conditions. The major constraints identified for other potential crops such as oilseed, sugar cane and millets, include lack of irrigation, fertilizer, and improved varieties as well as pest and disease infestation. The area, production and productivity of major crops during 1998/99 are shown in Table 1.

Table 1. Area, Production and Yield 1998/99 (Nepal)

	Crops	Area (ha)	Production (MT)	Yield (kg/ha)
1.	Paddy	1514210	3709770	2450
2.	Maize	802290	1345910	1678
3.	Millet	263950	291370	1104
4.	Wheat	640802	1086470	1695
5.	Barley	31843	31798	999
6.	Oilseeds	190429	119731	629
7.	Potato	118043	1091218	9244
8.	Sugar cane	53894	1971646	36584
9.	Pulses	308008	228840	743

Source : Statistical Information on Nepalese Agriculture 1998/99, Agriculture-Statistics Division, Nepal.

The share of agriculture, forestry and fisheries of the GDP has declined from 51 percent (at factor cost) in the Five Year Plan (FYP) of 1985 to 49.5 percent in the FYP of 1990 and to 40 percent in the FYP of 1998. Overall annual GDP growth has been erratic, ranging from 2.7 to 2.9 percent over the past six years. Growth in agriculture during the first two years of the Ninth Five Year Plan (FYP 1995/96 - 97 /98) has been well below expectations and does not auger well for the overall achievement of plan targets. It is indicated that an overall economic growth rate in the FYP of 1999 is 3.4 percent (2.4 percent for the agricultural sector and 4.1 percent for the non- agricultural sector).

Within the agriculture, forestry and fisheries sector, the long-term growth rate of 2.8 percent per annum masks considerable fluctuations between groups of commodities. Growth in food grains has averaged only 1.9 percent, while that of cash crops has been 4.3 percent, and other crops (including pulses, fruits and vegetables) 3.5 percent. Within these categories individual commodities vary even more, with paddy recording an average growth of only 1.9 percent per year compared to wheat at 4.0 percent. Production of oilseeds remained fairly static, increasing by only 1.3 percent per year compared to 5.7 percent for potatoes and 4.0 percent for pulses. The growth of individual commodities is indicated in Table 2.

Table 2. Growth of Agricultural Commodities 1998/99 (Nepal)

	Agricultural Commodities	Annual/Growth (%)
1.	Paddy	1.9
2.	Maize	2.3
3.	Wheat	4.0
4.	Millet	3.5
5.	Barley	1.7
6.	Sugar cane	11.6
7.	Oilseed	1.3
8.	Potato	5.7
9.	Pulses	3.5

Source: Economic Survey FYP of 1998/99, Ministry of Finance, 1999 HMGN/Nepal

So far as trade is concerned, India is and will continue to be the largest export market for Nepal's agricultural products, including secondary crops such as lentils, ginger, oilseeds and vegetables. There is scope for import substitution of agricultural products such as sugar, pulses, vegetables, dried chillies and vegetable oils. On the basis of the market investigation there are a number of crops that will have the potential in any future project including vegetables and vegetable seeds, sugar cane, soybean, pulses, oilseeds, ginger, potato, chillies (dried), maize and fruits (banana and citrus). All have sufficient annual demand increment to warrant promotion.

National mustard oil demand is in deficit by an estimated 27,000 tonnes. Sales are reputed to be increasing by 25 percent per year. The local crop has higher oil recovery rates than the imported one.

The lentil's export markets are India, Bangladesh, Pakistan and Sri Lanka. Nepalese demand is 122,000 tonnes, which exceeds the supply of 113,520 tonnes per annum.

Potato production has increased by 8 percent over the last three years to 972,000 tonnes per annum, which amounts to 80 percent of the country's requirement. Similarly, Nepal's sugar production was estimated at 95,000 tonnes in 1998/99. Domestic production has increased by 250 percent over the last four years. Fifty percent of the domestic requirement is being met by imports from India.

In the Terai, maize is emerging as a commercial crop for processing into glucose, breakfast cereal, animal food and corn oil. The demand for maize is expected to grow by 4 percent per year over the next 20 years as a result of increased demand for food in the hills and in the Terai.

The demand for fresh ginger can be termed as optimistic. Export earnings from ginger have doubled over the last three years and domestic household consumption is rising. However dried ginger exports are declining. With regards to dried chillies, imports from India amount to 7,933 tonnes. The study shows that 67 percent of the vegetables consumed in the country originates from India. Off-season vegetable production is considered the solution for increasing farmers' income.

Apart from bananas, the demand for fruit is not optimistic. Bananas are exported to India in considerable quantities.

The quantities of marketed vegetable seed vary from 350 to 400 tonnes, of which 30 percent is exported mainly to Bangladesh. The export and import status of the various commodities is indicated in Table 3.

Table 3. Export-Import Situation of Agricultural Commodities 1998/99 (Nepal)

	Commodities	Production (Mt)	Import (Mt)	Export (Mt)
1.	Paddy	3640860	8489	–
	P. Rice	2076122	4499	20197
	P.Bran	256035	–	10500
2.	Wheat	1030320	7858	1112
	Wheat flour	836731	970	22000
	Loaf and others	59105	255	1392
3.	Maize (corn)	1367340	10334	–
4.	Millet	285120	872	398
5.	Barley	37150	66	38
6.	Other cereals	–	890	60
7.	Potato	971680	105649	1368
	Processed potato	–	40	40
8.	Sugar cane	1762580	40	46
	Sugar	64541	20197	648
9.	Lentil	113520	–	2292
	Black gram	17674	308	–
	Chick peas	13512	–	150
10.	Vegetable	1449472	98589	1712
11.	Fresh fruits	415167	28736	24258
	Proceed fruits	1800	2807	1320
	Dried fruits	–	–	–

Source: Agricultural Marketing Information Bulletin (Special Issue, 1999)
DOA, Marketing Division, Nepal

3. PATTERN OF CROP DIVERSIFICATION

Nepal is a land locked country bordered by India in the east, south and west, and China in the north, with a total of area of 147181 km^2. The average length (east to west) is 885 km, while the breadth (north to south) is 193 km. The country is broadly divided from east to west into three agro-ecological zones of approximately equal area. The Southwest zone is the Terai or plains, which are the northern extension of the Gangetic Plains of alluvial soils and have an elevation of 100-300 meters above mean sea level (mmsl). The middle zone comprises the less densely populated hills, which are cut by a series of valleys. Attitude ranges from 250-4,000 mmsl, and the zone is characterized by steep valleys that are often terraced for extensive agriculture. The topography of the hill zone results in different microclimates that can be suited to specific crops. To the north is the mountain zone which extends to over 8,000 mmsl. The mountain zone is the least populated and has the lowest intensity of agricultural activity.

Accordingly, if we try to see the country from the climatic point of view, in the plains or Terai there is hot and humid or subtropical to tropical climate, while in the hills both subtropical climate in the foothills and temperate climate on the top of the hills prevail. The mountains have very cold climate. Based on the prevailing climatic conditions, different types of crops can be grown. Primarily, rice, wheat, legumes and oilseeds are the major commodities of the Terai, rice, maize, wheat, pulses and oilseed are major commodities in the hills and potato, barley, buckwheat and amaranthus are the commodities suitable for the mountains. Potato and vegetables can be grown in every ecological zone. Among the fruits, mango, litchi, banana, pineapple and guava are major commodities, while in the hills citrus is the main fruit. Banana, guava, pears, and peaches can also be grown in this belt. In the high hills or mountains temperate fruits such as apple, apricot, walnut etc., are appropriately cultivated. Based on the above conditions the cropping patterns are as follows:

a) Terai (Plains)

Irrigated Lowland

Rice - Wheat - Maize
Rice - Potato - Vegetables
Rice - Peas - Rice
Rice - Lentil - Vegetables
Rice - Mustard/Peas - Vegetables

Unirrigated Lowland

Rice - Wheat - Fallow
Rice - Mustard/Peas- Fallow
Rice - Lentils - Fallow
Sugar cane

Upland

Maize - Mustard

b) Hills

Irrigated Lowland

Rice - Wheat - Maize
Rice - Potato - Maize
Rice - Wheat - Vegetable
Rice - Lentils - Vegetables
Rice - Vegetables - Rice

Upland

Maize + Millet - Black gram - Fallow
Maize - Millet - Vegetables
Maize + Legumes - Potato - Fallow
Maize + Ghaiya - Vegetables - Fallow
Ghaiya - Legumes - Fallow

c) Mountains

Maize - Vegetable - Fallow
Potato - Potato - Fallow
Maize - Wheat - Fallow
Niger - Potato - Fallow
Maize - Fallow - Fallow

Whether irrigated or rainfed, rice is the staple crop of the lowland. This is because rice is the staple food commodity of the Nepalese people. It is considered a prestigious crop in the society. In the lowlands wheat is another important food commodity. Both these crops are consumed by every family.

Similarly, maize is the second most important food crop in the hills. This is mainly grown for family consumption. Farmers also sell it if they have surplus production. In many hill areas, millet is another important food item. Hill farmers feel that millet is highly nutritious for them.

In high hills or mountains, potato is the main crop taken as food followed by maize, buckwheat, barley etc. Because of the cold climate, farmers of this area harvest mostly one crop in a year.

In every agro-ecological zone, priority is given to food crops first and then to cash crops. People need food crops for meeting household needs and cash crops for income generation. Traditionally, farmers grow every sort of possible crop needed for home consumption. This is the reason why there are mainly two types of cropping patterns, namely rice based in the lowlands and maize based in the uplands.

With regard to success stories of crop diversification, many farmers have successfully adopted cultivation of different off-season vegetables like cabbage, peas, cucumber, tomato etc., using modern technologies. Bananas are becoming very popular in the Terai region, where they are grown on a commercial basis. Other important commodities that are being adopted by farmers are cauliflower, sunflower, lentils, mushroom and soybean. These commodities have high demand locally and farmers therefore can sell these items easily.

4. CROP DIVERSIFICATION AS A STRATEGY FOR ACHIEVING VARIOUS GOALS

The Agriculture Prospective Plan (APP) is a 20-year plan on which the whole agricultural strategy of the country lies. The main objectives of APP are to reduce poverty by 35 percent over a 20-year period; and to increase the rate of growth of agricultural GDP from the current low level of 3 percent per annum to about 5 percent, thereby using agriculture as the growth engine for the rest of the economy. The government has established a strategy for implementation of the APP, such as the pocket package strategy, and GO-NGO-Private sector partnership etc. Pockets of commercially feasible commodities will be developed and a suitable package of technologies will be provided.

Considering the climatic conditions, the following commodities for diversification have been identified:

a) *Vegetables*:
   - Summer vegetables - lady's finger, squash, beans, tomato, etc.
   - Winter vegetables - cauliflower, cabbage, radish, carrot, peas, etc.

b) *Fruits*:
   - Summer fruits - mango, litchi, guava, pineapple.
   - Winter fruits - apple, walnut, apricot, peach etc.
   - Citrus fruits - mandarin, orange, lime etc.

c) *Spices* - ginger, turmeric, cardamom, garlic, etc.

d) *Vegetable seeds*

e) *Sugar cane*

f) *Soybean*

g) *Pulses* - lentil, gram, pigeon pea, etc.

h) *Potato*

i) *Chilli*

j) *Maize*

k) *Oilseeds* - mustard, sunflower, etc.

Working Strategy

- Pocket areas as defined by the APP is the strategy for implementation.

- Within the pocket areas farmers groups will be formed, comprising mixed groups of men and women farmers, and specific women farmers groups particularly in areas and for crops where women are the key decision makers.

- To make the farmers groups sustainable, appropriate measures will be adapted.

- In order to make the groups independent, the formation of cooperatives and higher level organization are being encouraged.

- The approach will be demand driven with the demand coming from the farmer groups. The research and extension services are provided on the basis of farmers' needs.

- The needs and requirements of the farmers are identified through group meetings in the pocket area itself.

- The farmers are being encouraged to undertake marketing through demonstrations, training and workshops.

- The private sector involvement is encouraged in appropriate areas, such as processing, marketing etc.

- In every potential district, a joint forum for traders and producers is being encouraged.

- Besides technical and input services, credit services are being made available to farmers.

The whole agricultural system has been divided into two areas i.e., food security and commercialization.

Crop diversification does not only addresses food security and commercialization, but also makes judicious use of land, water and other resources. Any commodity which is locally feasible commercially and has higher comparative advantage can be taken into consideration so that there will be income growth which contributes to poverty alleviation. Even small and marginal farmers come into groups and can have a commercial type of farming. In this way the system can be made economically sustainable, environmentally friendly and ecologically sound.

As regards the implementation, besides the concerned agencies, there are different committees at different levels i.e., District level, Regional level, Central and National level. These committees have representations from line agencies, NGOs, private sector, and farmers etc. Problems encountered are taken to these committees and discussed thoroughly to bring out solutions. They also provide guidelines to implementers and suggestions to policy makers. Crop diversification programmes if implemented properly help improve the whole agricultural system.

5. CHALLENGES, OPPORTUNITIES AND PROSPECTS OF CROP DIVERSIFICATION

Crop diversification is a popular strategy to maximize the use of land, water and other resources. It can meet different requirements of people's food supply and can generate earnings for farmers. However, there are several constraints to crop diversification, which can be summarized as follows:

Policy Constraints

- Due to ineffective linkage mechanisms between extension and research no joint planning is practiced. As a result no prior commitment is made for the supply of seeds and other planting materials.

- There is no policy to test, verify and multiply seeds introduced by farmers in the border area of India.

- Seeds distributed by Aggrovate centres are reported to be not always of good quality or not recommended by the districts.

- The regional seed, soil and plant protection laboratories have limited authority and support to test and verify the quality of seeds, fertilizers and pesticides.

Institutional Constraints

- Research centres recommend cereal varieties without sufficient foundation seed. As a result recommended varieties cannot be made available in all districts.

- Seed potatoes are not available for production due to lack of storage facilities.

- Quality is not monitored during distribution.

- In the case of fruit tree plant distribution, the fruit development division of the Department of Agriculture (DOA) allocates the number of nursery plants to be purchased by the District Agricultural Development Office (DADO) from the recommended resource centres, farms and registered nurseries. DADO reports that nursery plants are either not available or not of proper quality standards predetermined by the fruit development division.

Regulatory Constraints

- The price of Agricultural Inputs Corporation (AIC) seeds increases due to handling and management charges, even though subsidized.

- There are no special arrangements for seed multiplication, local collection and distribution.

- In the case of plants to be produced by private farms and nurseries, there is no certification system.

- There is an open distribution of plants from India in the border districts. However, there are doubts about the quality of this planting material.

Miscellaneous Constraints

- Transportation: The transportation network is very weak, particularly in the hill areas. Thus, transportation of planting materials to production sites and of produce to the markets is usually difficult and expensive.

- Budgetary: In APP, there is a provision that the production pockets will be connected with agricultural roads, so that the produce can be transported to nearby markets and the planting materials can be sent to production sites easily. But for this, the allocated budget is not enough.

Opportunities and Prospects of Crop Diversification

- Existence of climatic diversity, as a result of which many high value crops can be successfully grown.

- The farmers group approach, in which the farmers can be united to produce as well as to sell and tackle the problems.

- Initiation of a bottom-up planning process.

- Small and marginal formers can be included in the groups for farming. This means even small and marginal farmers can practice farming on a commercial basis to generate income from their small piece of land.

- The Ministry of Agriculture and Cooperatives has a good network of extension services and motivation measures for farmers.

- Women farmers' proactive involvement in mainstreaming.

- GOs + NGOs + Private sector are encouraged to work hand in hand on the same platform.

- Representation of farmers in agricultural committees at different levels.

- Expanded market centres and marketing technologies. Also, development of entrepreneurship thinking of farmers.

6. GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

Policies and strategies for crop diversification go along with the policies and strategies of the whole agricultural system. The following are some of the major policies and strategies of the Government, which are indicated clearly in the Agriculture Prospective Plan (APP) and the Ninth Agriculture Plan. The APP provides the central focus for agriculture and rural development.

It recognizes the need for a different strategy for the Terai region and a different strategy for the hills and mountains. The Terai strategy is technology driven with the objective of providing year round irrigation for most of the cultivated area and thus enables rapid growth in the basic food staples. The strategy for hills and mountains is demand driven with the objective of increasing production of high value crops.

The Ninth Agriculture Plan is giving due attention to crop diversification and commercialization. Fifteen to twenty years ago farmers were not aware of the advantages of crop diversification and the government paid little or no attention to it. Consequently, farming was mostly traditional. In the lowlands the farmers used to grow rice followed by wheat and in the uplands maize followed by millet. At the most they used to grow 2 crops in a year whether lowland or upland. Cropping intensity was very low. Gradually, diversification started and farmers could judge which crops to grow in their field for optimum benefit. Many farmers changed their cropping system from traditional to modern. An income generating type of agriculture was initiated among small and marginal farmers. Big farmers started commercialization. Due to the enhancement of technological development, farmers had several options for the commodities. In the meantime, the farmers' group concept was initiated and pocket strategy came into implementation. The group and pocket approach in agriculture accommodated all farmers (small, marginal and big), and because of group spirit they were oriented towards commercialization. Crop diversification contributes:

- To increased cropping intensity.
- To generation of employment opportunities.
- To commercialization of farming.
- To growing high-value crops in order to derive higher profits.
- To reduction of migration of male household members for work because of on-farm income earning opportunities.
- To engagement of women farmers in income generating activities.

7. CONCLUSIONS AND RECOMMENDATIONS

Crop diversification is an important strategy for overall agriculture development in the country. It provides the farmers with viable choices of commodities to grow on their land. Nepal has different agro-ecological zones with a variety of climates ranging from tropical in the Terai to alpine in the high mountains. Besides the climatic factors, the farmers need options on high value exportable commodities. Crop diversification can meet this type of need of the farmers.

Previously, the farmers used to concentrate on a few major crops such as rice, maize and wheat. A considerable area in the hills and high hills was left fallow because of the fact that there was no diversification in practice. With the increase of population traditional agriculture could not meet the food requirements and therefore diversification was introduced. Crop intensity was thereby increased and annual per unit production was raised.

Crop diversification should continue with due emphasis on the following:

- Technological packages should be provided to the production pockets based on their level of development i.e., whether the pocket is a basic pocket, or a commercializing pocket or a commercial pocket etc.

- Exportable high value commodities should be identified for each of the districts and production cost should be reduced so that Nepalese produce can compete with Indian produce (which has very low price).

- The focus should be on priority commodities such as off-season vegetables, vegetable seeds, citrus, apple, mushroom etc., which can have good markets (both domestic and external).

- The production pocket area and farmers group approach which has been initiated in the country should be strengthened and, in order to make it sustainable, the following activities should be conducted regularly:

    - Workshops to support the development of pocket area activities.
    - Orientation towards cooperative groups.
    - Promotion of mass communications.
    - Conduct of regional technical working groups (RTWG) meetings regularly.
    - NGOs to be active in facilitating the group formation process.

- Women must be identified as full members of community groups. This will enhance their self-confidence and social status and can be effective in introducing a large number of women to decision making processes.

- Efforts of line agencies and resource centres should concentrate on the production pockets, so that the pockets become stronger and more effective.

- A forum among traders, producers and extension agents should be established. This approach will help farmers to have direct exposure in marketing aspects.

- Regular training to production pocket area farmers on production technologies particularly on selected commodities and on marketing aspects including processing, packaging, grading, etc., should be provided.

- Nepal is expected to become a member of the World Trade Organization (WTO) by the year 2001 and this would require more focus on crop diversification.

CROP DIVERSIFICATION IN THE PHILIPPINES

Rene Rafael C. Espino and Cenon S. Atienza [*]

1. INTRODUCTION

The Philippine economy is largely dependent on agriculture. Of the approximately 73 million population in 1998, the agriculture sector employs more than 11 million people and about 26 percent of these are women. There are about 29 million people dependent on agriculture.

In 1998, the total area planted to crops was 11.6 million hectares. Of these, 5.5 million hectares are devoted to rice and corn, 4.8 million hectares for major crops and 1.3 million hectares for other crops. Major crop products exported include coconut, sugar, pineapple, banana, coffee and mango. On the other hand, rice and corn continue to be imported to meet the demand of the growing population.

The Department of Agriculture (DA) is the government agency responsible for all agricultural activities in the country. The DA has a number of staff bureaus and attached agencies that conduct activities on crop production, regulation and R&D. The attached agencies look at a specific crop, e.g., the Philippine Rice Research Institute (Philrice) for rice, the Sugar Regulatory Administration (SRA) for sugar cane, the Philippine Coconut Authority (PCA) for coconut, the Fibre Development Authority (FIDA) for abaca and other fibre crops, the National Tobacco Administration (NTA) for tobacco, and the Cotton Development Authority (CODA) for cotton. On the other hand, the staff bureaus like the Bureau of Plant Industry (BPI), the Bureau of Post-Harvest Research and Extension (BPRE), the Bureau of Soils and Water Management (BSWM), the Bureau of Agricultural and Fishery Product Standards (BAFPS), and the Bureau of Agricultural Statistics (BAS) have multi-crop responsibilities.

A crop diversification scheme is largely dependent on climatic conditions. There are four climate types in the Philippines, namely, Type I with two pronounced seasons, dry from November to April and wet during the rest of the year; Type II with no dry season and with very pronounced maximum rainfall from November to January; Type III where seasons are not very pronounced and relatively dry from November to January; and Type IV where rainfall is more or less evenly distributed throughout the year.

The DA has adopted crop diversification as a strategy to promote and hasten agricultural development. As such, this paper presents crop diversification in two perspectives. One aspect is planting a cash crop after the main crop and the other is planting intercrops (permanent or cash crops) in-between the main crop, usually a permanent crop. This strategy helps attain the goal of the Department in increasing productivity and farm income notwithstanding the benefit of environmental conservation.

[*] *Programme Director and Consultant, High Value Commercial Crop Programme, Department of Horticulture, College of Agriculture, University of the Philippines, Los Baños, Laguna, Philippines.*

The objectives of this paper are threefold, namely: a) to review the existing crop diversification schemes in the country; b) to present the opportunities and constraints in the adoption of crop diversification; and c) to review government policies related to crop diversification.

2. CROP PRODUCTION AND ECONOMICS SCENARIO

2.1 Crop Production Area

In the 1991 Census of Agriculture and Fisheries, there were 9.97 million hectares of agricultural land (BAS, 1997). Of these, 55.3 percent of the farmlands were used for growing temporary crops and 41.8 percent were planted to permanent crops. There were 4.61 million farms and the average national farm size was 2.16 hectares; 37 percent of the farms were less than a hectare in size.

The total area devoted to agriculture has been declining. It can be noted in Table 1 that in 1989, the area for agriculture was 13,147,100 hectares; in 1998, this was reduced to 11,664,600 hectares, a decrease of 1.48 million hectares. Cereal crops dominate the production area for the period under review considering rice and corn to be the staple foods of the Filipinos. From 1989 to 1993, more area was planted to corn than rice; however, from 1994 to 1998, more area was used for rice production.

Coconut, banana, sugar cane, cassava, and pineapple are considered major crops in terms of area planted and export potential. Among the commercial crops, it is interesting to note that there was a tremendous increase in area planted to mango, that is, from 56,400 hectares in 1989 to 93,900 hectares in 1998. This can be attributed to the export potential of this fruit.

2.2 Volume of Crop Production

Table 2 presents the annual production of both major and minor crops in the Philippines. Lowest production for both rice and corn was observed in 1998 at 8,554.8 metric tonnes and 3,823.2 metric tonnes, respectively. However, in 1999 (report of the Bureau of Agricultural Statistics), rice production increased to 11,700 metric tonnes (27.4 percent increase) while corn production increased by 761.4 metric tonnes (16.6 percent increase).

There is a declining trend in coconut production. Lowest production was observed during the last two years. This has been attributed to felling of trees for lumber production and the relatively old coconut trees. On the other hand, mango production increased due to the increase in area planted. Highest production was observed in 1997 (987.1 metric tonnes). In general, the production of major and other crops did not change dramatically during the period under review.

The low production of agricultural crops in 1998 was due to the occurrence of typhoons "Loleng" and "Gading".

2.3 Yield Per Hectare of Agricultural Crops

Table 3 shows the average yield per hectare of agricultural crops. The average yield per hectare of rice and corn is low at 2.6-2.9 metric tonnes per hectare and 1.2-1.6 metric tonnes per hectare, respectively. There is a continuous decline in the yield of sugar cane. From a high of 81.8 metric tonnes per hectare in 1989 this decreased to only 52.5 metric tonnes per hectare in 1998, a decrease of about 35 percent.

The average yield of mango and rubber is increasing. In mango, the average yield increased from a mere 5 metric tonnes per hectare in 1989-1992 to 10 metric tonnes per hectare in 1997-1998. Rubber yield increased from a low of 1.99 metric tonnes in 1989 to 2.44 metric tonnes in 1998.

2.4 Share of Crops in National Agricultural GDP and Trade

From 1992 to 1996, agriculture contributed 20.93-22.28 percent of the GDP. Latest statistics show that in 1994-1998 (BAS, 1999) the Philippine economy grew by an average of 4.55 percent in terms of GNP or 3.92 percent in terms of GDP. The country's economic performance before 1998 had real growth in GDP from 4.39-5.85 percent. The regional currency crisis and adverse weather conditions in 1997-1998 greatly affected the economy.

From Table 4, it is evident that the percent share of agriculture to GNP is decreasing both at current and constant prices. The Gross Value Added in agriculture has been increasing (Table 5). However, the crops sector posted negative growth in 1990 and 1998, that is, -0.78 and -12.86, respectively.

2.5 Trade of Crop Products

Table 6 presents the agricultural foreign trade statistics from 1989 to 1998. The value of agricultural imports was lower than the value of exports from 1989 to 1993. From 1994 to 1998, however, the reverse can be noted.

The volume of sugar exported is on the decline. This can be attributed to decreasing area devoted to sugar production, lower production per unit area and high production cost. Likewise, decreasing export volumes of desiccated coconut, coffee and copra are evident. However, increasing export volumes can be noted in coconut oil, copra oil and banana.

3. PATTERNS OF CROP DIVERSIFICATION

With growing population, urbanization and industrialization, the area devoted to crop production has been declining. As a result, new strategies were formulated and crop diversification is one of these. As a strategy, crop diversification maximizes the use of land and optimizes farm productivity and incomes.

There are several factors associated with crop diversification. According to Gonzales (1989), the adoption of crop diversification schemes is dictated by both physical and economic factors. Physical factors include land capability, rainfall patterns, water quality, crop suitability and technology. Economic factors, on the other hand, include costs, prices,

markets, and economic viability of alternative cropping schemes (Adriano and Cabezon, 1989).

Farmers have shifted to rice-based farming systems due to constraints like inadequate water, land suitability and climatic conditions (Obcemea et al., 1996). Furthermore, they attributed adoption of this scheme to income stability, increasing demand for non-rice crops, and high profitability per unit area.

Francisco (1995) reported that three factors determine the farmer's choice of rice cropping system. These are farmers' technical knowledge in growing the crop, adaptability of the crop to the local conditions, and amount of resources available to finance the production expenses. Aside from these are market forces that affect prices of both the output and inputs and level of government support extended to the cultivation of both major and other crops.

3.1 Diversification in Rice Lands

Diversification in rice lands started in the 1970's when researchers began developing technologies and strategies for optimizing farm productivity (Galvez, 1990). According to Adriano and Cabezon (1989), diversification of specific non-rice crops in irrigated lands began only during the mid-1980s. This government policy was adopted to raise farm incomes and intensify employment opportunities in the rural areas.

The International Rice Research Institute (based in the Philippines) initiated rice-based cropping studies in the mid-1970's (Miranda and Panabokke, 1989). This led to the introduction of crops other than rice during the dry season following the wet season rice crop.

In the rainfed and upland areas of the Philippines, there are 25 rice-based patterns with rice as the main crop followed by another crop (Adriano, 1989). According to the National Agricultural Research and Extension Agenda (BAR, 1989), cropping patterns differ by geographical location (Table 7).

A wide range of crops can be grown after rice depending on rainfall and availability of water, elevation and land features of the environment. Corn, tobacco, garlic, and legumes are the major crops after rice in these four regions. In 1991-1995, rainfed lowland rice-based cropping systems, namely, rice-corn, rice-garlic, rice-mungbean, rice-sweet pepper, and rice-tomato were evaluated in Ilocos Norte as part of the Rainfed Lowland Rice Research Consortium implemented by Mariano Marcos State University, the Philippine Rice Research Institute (PhilRice) and IRRI (Obcemea et al., 1996; Yokohama et al., 1998).

In a nationwide survey done by PhilRice in the last two years (unpublished), six major cropping patters, namely, rice-rice, rice-vegetables, rice-fish, rice-corn, rice-legumes, and others, were studied. The percentage of each cropping pattern was determined aside from information such as area devoted to rice farming, number of rice farmers, average landholding, tenurial status, seed production area, and local problems in rice production.

3.2 Diversification in Coconut Lands

In coconut, diversification means the simultaneous growing of one or more crops in a coconut area. Cash crops or permanent crops can be grown depending on a number of factors. These are the environment (soil, topography, and climate), socio-economic (tenure and capital) and technical (available technology and management requirements) factors that could either be within or beyond the control of the farmers (PCARRD, 1993). Furthermore, eight important considerations have been identified in intercropping coconut. These are: amenability of coconut farms to intercropping, available market, favourable climate, suitable soil conditions, favourable slope of the land, farmers' resources and attitudes, technical and working arrangements, and availability of good planting materials.

A wide range of crops can be grown under coconut. Permanent crops like coffee, cacao, abaca, lanzones and other fruit trees can be established. Cash crops, on the other hand, include corn, peanut, sweet potato, pineapple, banana, mungbean, arrowroot, ramie and vegetables, among others.

As stated earlier, one or more permanent and cash crops can be grown under coconut. When a combination of crops of varying heights, rooting system, and canopy patterns to maximize utilization of sunlight, soil nutrients, and moisture is grown, this is referred to as a multi-storey cropping pattern. This pattern consists of three levels, namely, coconut as the top floor, perennials as the mid-storey crops and low-growing annuals as the ground floor crops. Aside from the multi-storey cropping system, Felizardo (1988) reported that livestock and poultry are grown under coconut in a number of provinces in the country.

The suitability of the above-mentioned crops as intercrops has been extensively studied. The climatic and soil requirements of most intercrops have been determined. There are a number of technoguides, brochures, manuals and pamphlets that detail crop varieties to be used, cultural management practices and post-harvest and storage operations. In most cases, the profitability of intercropping with coconut is included in these publications.

3.3 Successful Crop Diversification Patterns

Table 8 presents the documented successful crop diversification practices in the Philippines. According to Adriano (1989), garlic production exceeded that of irrigated rice in the Ilocos region. Likewise, onion production was very profitable in the Central Luzon Region. Similar results were reported by Gonzales in 1989; in Ilocos and Central Luzon regions, the highest profit was obtained from onion, peanut and garlic.

As intercrops of coconut, passion fruit, banana, pineapple, and cacao have been documented to give high net returns. Research using black pepper + papaya/cacao + pineapple under 17-year old coconut conducted in Davao Research Centre produced a net profit of PHP 8,234 per hectare per cropping as against PHP 2,494 from coconut alone.

4. CHALLENGES, OPPORTUNITIES AND PROSPECTS OF CROP DIVERSIFICATION

Moya and Miranda (1989) discussed the technical, social and institutional issues in diversifying rice areas. Technical issues include the intricate and differential relationships among edaphic, climatic, hydrologic, biotic and agronomic properties of the flooded rice environment and dryland non-rice production systems. Socio-economic issues are hinged on

profitability of cultivating non-rice crops compared to rice, availability of markets and unstable prices of non-rice crops. On the other hand, institutional issues include irrigation service fee payment, level of government support and farmer participation.

In the rice-onion cropping system, farmers encountered more economic than technical problems. Production-related problems include lack of capital and high cost of inputs (Marzan, 1989).

In a preliminary study conducted by Cablayan and Valera (1989), four constraints to crop diversification were identified. These were dry season rainfall, availability of irrigation water for rice, limited irrigation management and inappropriate on-farm irrigation and drainage facilities. Furthermore, they noted that farmers in some areas were unfamiliar with growing non-rice crops under irrigation. Unstable farm gate prices deter many farmers from practicing diversification.

Adriano and Cabezon (1989) discussed in detail the emerging economic issues and constraints to crop diversification. Vital economic issues include matching supply and demand, reallocation of investments, and strengthening of institutional linkages.

In a review on rainfed lowland rice-based cropping systems done by Obcemea et. al. (1996), a list of factors that influence farmers to diversify to non-rice crops was presented. These were income stability, increasing demand for vegetables and non-rice crops, and higher profitability per unit area. Market supply and demand, stability of prices, cost of inputs and quality of non-rice products were identified as economic factors affecting crop diversification. Other equally important factors include availability of irrigation water, land suitability, climatic conditions, availability of management technology, time constraints caused by the presence of the rice crop, farmers' preference, resource base, influence of neighbouring farmers or extension agents, and land tenure.

In a study involving 266 farmers cultivating tobacco, cotton, tomato, onion, mungbean, garlic, corn, and peanut, Gonzales-Intal and Valera (1989) identified conditions conducive to crop diversification. These were low income from other sources, profitability as seen from other farmers, sufficient rice supply for one's own consumption, availability of seeds, insufficient water supply, experience, perception of high market prices for the crop, and presence of technical and institutional support.

5. GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

In order to strengthen the agriculture sector, crop diversification was identified as a strategy in the Medium-Term Philippine development Plan, 1987-1992. This strategy was pursued to support food security, greater employment opportunities, increased farm incomes, and reduced dependence on traditional export commodities which are facing declining demand in the world market (Adriano and Cabezon, 1989).

At the Department of Agriculture, a National Committee on Crop Diversification (NCCD) was created in 1992. This committee is inter-agency in nature and its main function was planning and implementation of a crop diversification programme. Four commodity-based plans were prepared which include rice, corn, coconut and sugar cane. These plans

were used in the preparation of the DA's Medium Term Development Plan in the early Pecson, 1993).

A number of economic policies to promote crop diversification were formulated by the Philippine government (Adriano and Cabezon, 1989). In pricing policy, the government reduced the price support for rice with the view that some farmers will shift to alternative cash crops. Likewise, the government wants to reduce its direct intervention function in the marketing of rice by relying more on the private sector both to trade (domestic and international) and to hold stocks.

Tax and tariff policies were adopted to eliminate import quotas and minimize the number of permits required for importation and lower the average tariff level. Likewise, there was abolition of all export taxes. Gradual elimination of all subsidies is a national policy. In the agriculture sector, subsidies were gradually eliminated since pricing of inputs and outputs has already been deregulated.

Increased public expenditures on R&D and other rural infrastructure facilities are stipulated in the Agriculture and Fisheries Modernization Act of 1997. From a low 0.2 percent of the GVA allocated for research, there has been a substantial increase in government allocation for R&D. By the year 2002, R&D investment will be 1 percent of the GVA. A number of development programmes include investment in rural roads, transport and communications. As a result of these, an efficient price system is created which is a potent promotion for crop diversification.

Crop diversification in rice and corn areas will proceed favourably due to the implementation of the Agrarian Reform Programme. This is on the premise that as leaseholders or owner-cultivators, these farmers can decide what is best for their lands.

Current and Future Government Programmes on Crop Diversification

On agricultural R&D, crop diversification is a component of the Philippine National Agenda for Research and Development. In crops associated with cropping systems, the following are the concerns:

Coconut

- Piloting of Coconut-based Farming Systems and Technology.

Cacao and Coffee

- Assessment of existing crop mix patterns adopted by cacao and coffee farmers.
- Cacao-based and coffee-based vegetables and legumes intercropping system in flat and hilly lands.
- Occurrence and severity of insect pests and diseases as affected by different cropping patterns.
- Nutritional requirements of cacao and coffee as influenced by different cropping systems.
- Economics of intercropping cacao and coffee with other crops in flat and hilly lands.

Rubber

- Alternative legume covers in rubber farms.

- Economics of cover cropping in smallholder rubber farms.
- Rubber cropping system model demonstration farms.

The Philippine Coconut Authority has three major on-going programmes as part of a nationwide programme entitled "Maunlad na Niyugan Tugon sa Kahirapan". These are:

- Model Coconut Farms - the major objective is to improve farm productivity and quality of life of coconut farmers by increasing their incomes. This programme has a crop diversification component.
- Replanting and Fertilization Programme - involves planting and replanting efforts with balanced fertilization, cover crops and intercrops
- General Farm Assistance/Extension Services - concerned with the strengthening of linkages among coconut farmers, R&D and extension.

The Philippine Rice Research Institute is currently engaged in database development on rice-based farming systems which includes cropping patterns and number of adopters on a nationwide scale.

The Department of Agriculture is currently negotiating for World Bank Assistance on the project entitled "Smallholder Tree Crops Development and Diversification Project". The project aims to alleviate poverty, accelerate private investment in agro-industries, conserve and rehabilitate the environment, and contribute towards agricultural and overall economic growth by increasing long-term output, value added and exports for which the Philippines has a comparative advantage.

In order to enhance production and productivity the government continuously provides irrigation services to the farms. In 1997, about 1.34 M hectares were covered by irrigation and drainage facilities. This was approximately 43 percent of the total potential irrigated areas.

6. SUMMARY AND CONCLUSIONS

The agriculture sector has been a major player in the Philippine economy. With changing national and global trends, the sector has identified a number of strategies to be competitive. A strategy that has helped alleviate poverty and increase productivity is crop diversification. The passage by the Philippine Congress of the Agriculture and Fisheries Modernization Act in 1997 is a giant leap towards reaping the previous efforts of both government and private sectors on crop diversification.

Two perspectives on diversification are presented herein. One is planting alternate crops after the main crop and the other is planting one or more crops in-between a perennial crop. The emphasis of the former is on rice while that of the latter is coconut. This is so because crop production areas in the country are mainly devoted to these two important crops. Furthermore, government resources, over the years, have been largely allocated to these crops, and such cropping strategies have been documented. There are other cropping patterns practiced in some areas, e.g., corn-legume and corn-root crops. However, these are not fully documented; hence, these are not discussed in this paper.

There are a variety of factors that affect the adoption of crop diversification. These are the biotic (soil and kind of crop), environmental (climate), socio-economic and institutional factors. For emphasis, the socio-economic and institutional factors were discussed more than the other two.

Four important government policies that directly or indirectly affect crop diversification were presented. These are, pricing policy, tax and tariff policies, policy on public expenditure, and agrarian reform.

Past, present and future programmes and projects on crop diversification are, likewise, presented. Present and future programmes largely depend on the active participation of the private sector with the government providing technical and infrastructure support.

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Table 1. Production Area of Commercial Crops in the Philippines, 1989-1998 (BAS)

Item	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Harvest area ('000 ha)	13147.1	13096.3	12983.7	12520.4	12549.0	12786.9	12574.8	13015.6	13024.7	11664.6
A. Cereals	7186.5	7138.3	7014.5	6529.5	6431.7	6657.3	6451.0	6686.8	6568.1	5524.2
Rice	3497.3	3318.7	3425.0	3198.1	3282.4	3651.5	3758.7	3951.1	3842.3	3170.0
Corn	3689.2	3819.6	3589.5	3331.4	3149.3	3005.8	2692.3	2735.7	2725.8	2354.2
B. Major Crops	4725.0	4698.2	4716.2	4730.6	4873.9	4876.8	4790.4	4956.1	5110.4	4822.6
Coconut	3110.0	3112.0	3093.3	3076.7	3075.2	3082.7	3064.5	3149.0	3314.4	3115.8
Sugar cane	261.7	235.3	271.5	267.0	384	401.6	302.0	395.6	375.2	330.5
Banana	295.5	300.2	311.3	321.4	325.8	326.5	322.0	326.9	338.3	337.1
Pineapple	61.0	59.7	57.7	60.6	66.8	68.4	68.6	45.0	40.4	40.2
Coffee	143.2	143.2	143.1	142.0	146.5	146.4	144.4	151.2	150.1	148.4
Mango	56.4	56.7	56.9	57.2	60.5	65.0	80.4	87.7	92.9	93.9
Tobacco	63.3	63.2	67.9	95.0	90.9	51.7	56.3	54.2	51.1	47.6
Abaca	107.7	106.7	107.4	107.0	102.2	102.2	103.1	116.8	112.5	106.3
Rubber	86.1	86.3	88.0	84.2	85.4	86.0	86.7	90.0	92.9	93.2
Cacao	18.2	18.4	17.3	16.8	16.8	16.1	16.2	15.9	15.1	15.0
Cassava	213.1	213.8	211	204.3	211.4	213.1	225.9	228.3	230.5	216.5
Sweet potato	138.3	136.7	136.5	140.8	147.1	147.4	145.9	141.0	141.7	128.0
Peanut	50.4	44.5	39.1	44.6	44.9	47.1	47.6	28.7	26.6	24.7
Mungbean	35.7	36.7	34.3	32.7	33.1	34.0	34.9	35.5	36.4	34.6
Onion	6.5	6.4	6.4	5.8	6.5	7.6	8.7	9.8	11.9	12.8
Garlic	6.1	6.4	4.5	4.2	4.3	5.8	6.3	6.3	7.9	7.7
Tomato	19.7	20.0	19.5	18.2	15.6	17.5	17.9	16.9	17.1	14.9
Eggplant	15.4	16.4	14.5	15.5	17.4	17.8	17.6	18.1	19.0	18.1
Cabbage	6.9	6.4	6.9	7.5	10.4	10.7	8.5	8.0	7.9	7.3
Citrus	29.4	29.2	29.1	29.1	29.1	29.2	32.9	31.2	28.5	30.0
C. Other Crops	1235.6	1259.8	1253.0	1260.3	1243.4	1252.8	1333.4	1372.7	1346.2	1317.8
Other fibre crops	37.0	33.4	31.5	37.7	55.1	41.9	46.4	35.8	32.6	29.2
Other root crops	108.0	109.6	107.6	109.2	108.7	109.0	124.0	126.5	123.1	119.2
Tubers	125.7	135.7	134.9	132.8	132.1	133.0	143	145.6	141.8	139.7
Spices	35.9	38.6	36.1	36.9	36.8	37.0	42.1	43.6	47.3	45.5
Fruit bearing vegetable	313.2	328.0	314.5	313.9	312.3	315.0	331.5	336.3	332.9	327.0
Leafy/Stem vegetable	166.7	171.2	172.8	174.5	171.6	171.8	179.8	181.4	177.7	172.4
Other legumes	30.2	30.5	31.1	31.3	31.0	36.0	41.8	40.5	39.4	38.5
Other fruit nuts	331.7	327.7	338.1	339.2	330.6	331.6	338.4	371	362.8	360.8
Others	87.2	85.1	86.4	84.9	65.2	77.5	86.4	92	88.6	85.5

Table 2. Production of Agricultural Crops in the Philippines, 1989-1998 (BAS)

Item	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Crops ('000 Mt)	64207.1	61566.5	64109.3	63837.4	65766.5	68525.6	62164.8	69128.5	68301.4	57931.5
A. Cereals	13981	14173.3	14328.3	13747.8	14232.1	15057.3	14669.1	15434.9	15601.4	12378
Rice	9458.8	9319.4	9673.3	9128.9	9434.2	10538.1	10540.6	11283.6	11269.0	8554.8
Corn	4522.2	4853.9	4655.0	4618.9	4797.7	4519.2	4128.5	4151.3	4332.4	3823.2
B. Major Crops	41648.1	38684.6	41091.1	41329.5	42776.4	44689.2	39242.2	44003.4	44631.2	37789.3
Coconut	11810.4	11940.4	11290.9	11404.9	11328.4	11207.0	12183.1	11368.1	12118.5	10905.3
Sugar cane	21424.8	18666.9	21824.5	21801.9	22915.1	24695.2	17774.4	23142.2	22273.1	17347.9
Banana	3190.3	2913.3	2951.1	3059.2	3144	3192.6	3489.5	3311.8	3773.8	3560.8
Pineapple	1178.8	1156.8	1117.1	1135.2	1287.4	1331.5	1442.8	1542.2	1638.0	1495.1
Coffee	155.9	134.1	133.4	127.6	134.2	132.6	134.0	119.0	130.0	121.3
Mango	370.1	337.6	307.0	330.0	440.1	541.7	595.1	896.0	987.1	931.5
Tobacco	79.9	81.7	85.2	117.9	104.8	56.9	63.7	64.9	65.3	71.1
Abaca	88.4	80.5	85.2	84.3	59.5	66.4	64.8	70.4	67.1	71.3
Rubber	171.9	185.4	180.7	172.5	174.3	178.5	181.2	192.7	221.3	227.6
Cacao	9.4	9.9	9.6	7.5	7.7	7.9	7.9	7.9	7.8	7.4
Cassava	1846.9	1854	1815.7	1784.9	1843.0	1890.5	1905.9	1910.8	1958.0	1786.7
Sweet potato	60.3	668.9	662.3	677.2	659.1	667.8	667.9	654.2	631.4	568.1
Peanut	37.6	34.8	31.4	34.06	34.0	36.6	36.2	33.5	25.8	25.0
Mungbean	25.1	26.7	25.1	23.2	23.4	24.2	26.7	26.8	27.5	27.7
Onion	65.3	61.5	60.3	56.7	61.5	73.6	88.4	83.3	85.4	87.7
Garlic	17.2	17.9	12.4	11.8	12.3	15.7	17.2	18.6	20.2	19.3
Tomato	178.7	184.0	177.2	165.4	138.5	150.6	155.8	162.6	166.4	138.3
Eggplant	111.6	112.7	104.0	110.4	111.7	123.5	130.7	157.6	195.0	180.1
Cabbage	75.9	68.3	75.8	83.2	155.1	151.3	130.0	98.1	95.9	85.5
Citrus	149.6	150.2	142.2	141.7	142.4	145.1	146.8	142.7	143.6	131.6
C. Other Crops	8578.0	8708.6	8689.9	8760.1	8757.9	8779.1	8253.5	9690.2	8068.8	7764.2
Other fibre crops	64.6	58.4	77.6	92.9	65.6	65.1	68.3	61.4	51.7	43.2
Other root crops	121.3	132.3	128.7	128.5	132.0	132.3	133.0	151.0	137.3	132.5
Tubers	214.0	201.4	198.4	206.4	212.1	213.0	215.0	216.7	188.2	181.6
Spices	26.3	27.0	26.5	26.8	27.6	28.0	30.0	32.4	28.1	27.1
Fruit bearing vegetables	2887.6	2910.2	2812.7	2895.4	2973.5	3005.3	2812.2	3134.1	2748.3	2648.9
Leafy/Stem vegetables	1097.2	1080.2	1124.6	1110.4	1086.1	1072.6	1104.4	1308.5	1143.8	1103.6
Other legumes	34.0	34.3	35.0	34.7	35.7	35.9	37.0	35.2	30.5	29.5
Other fruits	3639.3	3764.9	3784.4	3762.2	3681.0	3680.8	3307.0	4101.3	3233.2	3108.0
Others	493.7	499.9	502.0	502.8	544.4	546.1	546.6	649.6	507.7	489.8

Table 3. Yield (tonnes) Per Hectare of Commercial Crops in the Philippines, 1989-1998

Item	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
A. Cereals										
Rice	2.70	2.81	2.82	2.85	2.87	2.88	2.80	2.86	2.93	2.69
Corn	1.22	1.27	1.29	1.38	1.52	1.50	1.53	1.52	1.58	1.62
B. Major Crops										
Coconut	3.79	3.84	3.65	3.71	3.68	6.34	3.98	3.61	3.65	3.50
Sugar cane	81.86	79.33	80.38	81.66	59.67	61.49	58.85	58.49	59.36	52.49
Banana	10.79	9.70	9.48	9.52	9.65	9.78	10.84	10.13	11.15	10.56
Pineapple	19.32	19.38	19.36	18.73	19.27	19.46	21.03	34.27	40.54	37.19
Coffee	1.08	0.94	0.93	0.89	0.91	0.90	0.92	0.78	0.86	0.81
Mango	6.56	5.95	4.39	5.77	7.27	8.33	7.40	10.21	10.62	9.92
Tobacco	1.26	1.29	1.25	1.24	1.15	1.10	1.13	1.19	1.27	1.49
Abaca	0.82	0.75	0.79	0.78	0.58	0.65	0.63	0.60	0.59	0.67
Rubber	1.99	2.15	2.05	2.05	2.04	2.07	2.09	2.14	2.38	2.44
Cacao	0.51	0.54	0.55	0.45	0.45	0.49	0.48	0.49	0.51	0.49
Cassava	8.66	8.67	8.60	8.74	8.71	8.87	8.43	8.37	8.49	8.25
Sweet potato	4.77	4.89	4.85	4.81	4.48	4.53	4.58	4.63	4.45	4.43
Peanut	0.75	0.78	0.80	0.76	0.75	0.77	0.76	1.17	0.96	1.01
Mungbean	0.70	0.73	0.73	0.71	0.71	0.71	0.76	0.75	0.75	0.80
Onion	10.46	9.61	9.42	9.77	9.46	9.68	10.16	8.50	7.17	6.85
Garlic	2.81	2.79	2.75	2.81	2.86	2.71	2.73	2.95	2.55	2.51
Tomato	9.07	9.20	9.08	9.08	8.87	8.60	8.70	9.62	9.73	9.28
Eggplant	7.24	6.87	7.17	7.12	6.42	6.93	7.43	8.71	10.26	9.95
Cabbage	11.00	10.67	10.98	11.09	14.91	14.14	15.29	12.26	12.14	11.71
Citrus	5.08	5.14	4.88	4.87	4.89	4.97	4.46	4.57	5.03	4.38
C. Other Crops										
Other fibre crops	1.74	1.75	2.46	2.46	1.19	1.74	1.47	1.71	1.58	1.48
Other root crops	1.12	1.21	1.19	1.18	1.21	1.12	1.07	1.19	1.11	1.11
Tubers	1.70	1.48	1.47	1.55	1.60	1.70	1.50	1.48	1.32	1.29
Spices	0.73	0.69	0.73	0.72	0.75	0.73	0.71	0.74	0.59	0.59
Fruit bearing vegetables	9.21	8.87	8.94	9.22	9.52	9.21	8.48	9.31	8.25	8.10
Leafy/Stem vegetables	6.58	6.31	6.51	6.36	6.33	6.58	6.14	7.21	6.43	6.40
Other legumes	1.12	1.12	1.12	1.11	1.15	1.12	0.88	0.87	0.77	0.76
Other fruits	10.97	11.48	11.19	11.09	11.13	10.97	9.77	11.05	8.91	8.61
Others	5.66	5.87	5.81	5.92	8.35	5.66	6.32	7.06	5.73	5.72

Table 4. Gross Value Added in Agriculture and Share to Gross Domestic Product, 1989-1999 (BAS)

Year	Levels (PhP)*	% Change	% Share		Year	Levels	% Change	% Share	
			GNP	GDP				GNP	GDP
AT CURRENT PRICES					**AT CONSTANT PRICES**				
1989	117640		12.87	12.71	1989	86541		12.55	12.37
1990	130290	10.75	12.11	12.09	1990	85870	-0.78	11.91	11.91
1991	141880	8.9	11.24	11.37	1991	88714	3.31	12.24	12.38
1992	158258	11.54	11.42	11.71	1992	87662	-1.19	11.89	12.19
1993	192767	21.81	12.85	13.07	1993	89660	2.28	12.00	12.21
1994	209198	8.52	12.05	12.36	1994	92775	3.47	11.80	12.11
1995	244600	16.92	12.49	12.83	1995	93269	0.53	11.31	11.63
1996	268134	9.62	11.86	12.35	1996	96418	3.38	10.90	11.36
1997	263560	-1.71	10.45	10.89	1997	99973	3.69	10.75	11.20
1998	251240	-4.67	8.99	9.42	1998	87118	-12.86	9.36	9.81
1999	309915	23.35	9.88	10.37	1999	78267	-10.16	8.12	8.54
GROWTH RATE 1989-1998			**10.5**		**GROWTH RATE 1989-1998**			**-0.83**	

*in Philippine Peso

Table 5. Selected Macroeconomic and Agriculture Sector Statistics, 1989-1998 (BAS)

Item	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
GNP (Million Pesos)	689693	720955	724754	737139	746921	786136	825164	884226	931118	931763
Growth Rate (%)	5.73	4.53	0.52	1.71	1.33	5.25	4.96	7.16	5.30	0.07
GVA IN AGRICULTURE (Million Pesos)	150128	153414	158225	159385-	163556	168419	171069	177553	183661	171548
AGRICULTURE SECTOR GROWTH RATE (%)	4.24	2.19	3.1	0.73	2.62	2.97	1.57	3.79	3.41	-6.56
Crops	2.64	-0.78	3.31	1.19	2.28	3.47	0.53	3.38	3.69	-12.86
Livestock	10.34	3.18	1.23	0.79	4.66	4.78	5.18	6.6	5.34	4.14
Poultry	10.81	10.22	3.36	10.87	6.19	2.62	5.25	11.27	6.84	-0.34
Fishery	3.56	3.9	3.96	1.17	1.37	1.14	3.79	0.48	-0.04	1.21
Agricultural Activities and Services	3.66	8.2	1.7	4.23	0.74	1.49	-10.54	5.11	1.96	-5.89
POPULATION (Million Persons)										
PHILIPPINES	60.10	61.48	62.87	65.34	66.98	68.62	68.35	69.95	71.54	73.14
Urban	25.32	26.25	27.19	28.14	33.65	34.47	34.45	35.25	36.05	36.85
Rural	34.78	35.23	35.68	36.11	33.33	34.15	33.90	34.70	35.49	36.29
AGRICULTURAL LABOUR AND WAGES										
EMPLOYMENT IN AGRICULTURE (Million Persons)	9.90	10.09	10.29	10.73	11.14	11.29	11.15	11.64	11.32	10.93

Table 6. Agricultural Foreign Trade Statistics, 1989-1998 (BAS)

Item	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Value (in million US$) of agricultural exports	1707.96	1701.13	1844.67	1866.49	1918.25	2072.02	2499.06	2306.64	2337.57	2224.67
Value (in million US$) of agricultural imports	1315.33	1555.23	1259.17	1559.71	1626.20	2114.26	2648.65	3095.85	3101.80	2894.57
VOLUME OF AGRICULTURAL EXPORTS ('000 Mt)										
Ten Principal Exports										
Sugar	210.26	246.98	274.14	208.06	324.19	182.11	153.21	317.70	197.82	184.80
Coconut oil	763.49	773.63	839.89	882.22	859.20	848.76	1340.41	792.65	1107.65	1177.03
Banana	851.05	839.78	955.41	820.77	1153.47	1155.18	1213.41	1253.07	1153.69	1147.11
Pineapple in syrup	191.49	179.13	194.28	197.54	237.13	459.55	191.65	203.48	185.30	84.23
Copra oil-Cake or meal	477.12	643.90	612.45	539.69	488.49	574.22	756.34	474.55	571.00	543.77
Desiccated coconut	94.52	75.34	80.74	85.22	93.34	75.11	73.06	69.58	76.79	71.89
Tuna, frozen except pellets	57.06	55.07	51.23	50.29	71.97	78.37	68.30	74.35	78.20	78.92
Coffee, raw or green, not roasted	24.97	9.10	4.63	1.39	0.72	4.10	2.42	0.49	0.54	0.71
Copra	79.47	97.30	80.69	34.20	26.77	23.80	33.75	3.09	6.92	3.60
Abaca (in '000 bales)	179.64	177.29	156.32	141.11	123.23	145.15	159.83	138.04	156.30	192.30
Cereals	16.08	0.09	11.86	35.14	17.93	45.00	0.07	0.23	0.37	0.21
Rice	16.00	0.00	10.01	35.10	0.54	0.00	0.00	0.00	0.00	0.04
Corn	0.08	0.09	1.85	0.04	17.39	45.00	0.07	0.23	0.37	0.17
VOLUME OF AGRICULTURAL IMPORTS										
Cereals ('000 Mt)	392.03	936.94	0.36	1.24	202.25	1.05	471.27	1264.72	1025.36	2632.95
Rice	219.77	592.73.	0.06	0.64	201.61	0.16	263.25	862.38	722.40	2170.83
Corn	172.26	344.21	0.30	0.60	0.64	0.89	208.02	402.34	302.96	462.12
VALUE OF AGRICULTURAL IMPORTS (million FOB US$)										
Cereals and cereal preparations	337.01	470.87	226.24	301.04	352.15	394.65	533.23	843.08	771.12	980.80
Fertilizers, manufactured	103.69	104.07	131.06	144.89	124.94	169.61	194.53	194.62	213.96	161.77
Dairy products and bird eggs	216.56	252.84	210.73	252.80	260.50	316.36	409.53	388.46	406.01	300.30
Feeding stuff for animals excluding unmilled cereals	176.97	173.91	152.95	185.66	234.31	194.94	263.05	197.26	310.69	282.84
Tobacco and tobacco manufactures	65.50	65.36	81.80	102.80	96.50	177.92	118.81	71.52	141.48	107.35
Coffee, tea, cocoa, spices and manufactures	13.68	21.70	23.65	26.45	32.18	44.89	52.24	49.66	78.94	66.09
Fish, crustaceans, mollusks and preparations	36.50	47.93	62.19	61.13	48.78	52.78	58.76	68.88	70.18	57.02
Meat and meat preparations	17.76	20.51	16.81	23.42	29.50	57.32	68.97	96.71	129.86	92.10
Vegetables and fruits	51.00	50.25	37.08	54.42	65.68	99.36	96.78	122.78	137.31	108.08
Fixed vegetable oil and fats	18.39	18.43	16.25	23.99	13.05	24.27	18.17	32.31	32.80	30.70
Cereals	70103.57	166539.93	132.07	428.32	36057.66	495.37	109105.34	379743.26	265443.27	664182.73
Rice	57963.00	116889.70	36.69	248.89	35760.49	75.39	75665.27	294042.40	211324.02	585867.36
Corn	12140.57	49650.23	95.38	179.43	297.17	419.98	33440.07	85700.96	54119.25	78315.37

Table 7. Dominant Rice Cropping Patterns in Four Regions in Luzon, Philippines (adopted from Adriano, 1989)

Region	Cropping Pattern
CAR	Rice-rice, rice garlic, rice-tobacco, rice-legume
I	Rice-rice, rice-legumes, rice-fallow, rice-tomato, rice-corn
II	Rice-rice, rice-fallow
III	Rice-rice, rice-fallow

Table 8. Successful Crop Diversification Patterns in the Philippines

Cropping System	Location	Yield/ha	Profit/ha	Reference
1. Rice-onion	Talavera, Nueva Ecija	3.43	6,116.00	Agulto, 1989
2. Rice Garlic	Laoag, Ilocos Norte	1.7-2.4	14,006.00-17,249.00	Adriano, 1989
3. Rice-Peanut	Ilocos Region	1.80	25,990.00	Gonzales, 1989
4. Rice-Mungbean	Ilocos Region	0.88	6,147.00	Gonzales, 1989
5. Rice-Onion	Central Luzon	10.66	64,380.00	Gonzales, 1989
6. Coconut+Cacao	Murcia, Negros	-	30,202.50	PCARRD, 1993
7, Coconut + Passion fruit	Lucban, Quezon	-	30,000.00	PCARRD, 1993
8. Coconut + banana	Southern Mindanao	-	ROI=163-631%	PCARRD, 1993
9. Coconut + Pineapple	Southern Mindanao	-	ROI=68%	PCARRD, 1993
10. Coconut + Pineapple + Cacao + Banana	Jaro, Leyte	-	18,892.00	PCARRD, 1993

CROP DIVERSIFICATION IN SRI LANKA

S.S.B.D.G. Jayawardane [*] and L. A. Weerasena [**]

1. INTRODUCTION

Sri Lanka is an island in the Indian ocean located between 79° 50' and 82° longitude and 6° and 9° 50' latitude. The total land area of the island is 6.5 million hectares and the population is 19 million.

The extent of irrigable land in the country has been increased to 483,000 ha including 80,000 ha of well drained upland with the commissioning of lands under the Mahaweli river system and other major irrigation schemes in the post independence era resulting in a breakthrough in rice production. Sri Lanka has become nearly self-sufficient in rice production. However, cultivation of rice in well drained soils in major irrigation schemes is considered to be a waste of irrigation water due to high percolation rates observed. Cultivation of non-paddy crops in the well drained soils could save water and thus pave the way for crop diversification in major irrigation schemes.

The cost of rice production has increased tremendously during the past few decades and consequently rice production has become uneconomical in marginal rice lands, especially in the wet part of the island. Therefore, more lands have become available for crop diversification. The potential areas of crop diversification in the island are found in different ecological settings. Cultivated crops and cropping patterns adopted vary with the agro-ecological conditions. Hence, the definition of crop diversification contains an extensive meaning for Sri Lanka. Thus it could be defined as the *cultivation of alternative crops or adoption of alternate cropping patterns instead of traditional crops and cropping patterns.*

1.1 Climate

Sri Lanka is located in the tropical belt of the world climatic map. The central hills of the country divide Sri Lanka into three major climatic zones by acting as a barrier to the monsoon winds. The three major climatic zones are named as wet, intermediate and dry zones which receive an average annual rainfall of >5000-2500 mm, 2500-1750 and 1750-900 mm, respectively. Further, three main regions in the island have also been identified, based on elevation, namely, the low country (0 – 300 m), mid country (300 – 900 m) and up country (>900 m). These climatic zones are further sub-divided into 24 agro-ecological regions, each one being more or less uniform in climatic conditions and in soils. Major irrigation schemes are predominantly found in the dry zone and a few are found in the other two zones. Rainfed wetland rice cultivation is mainly practiced in the wet zone.

[*] *Director General of Agriculture, Department of Agriculture, Peradeniya, Sri Lanka.*
[**] *Deputy Director (Research), Regional Agriculture Research Centre, Angunakolapellessa, Sri Lanka.*

1.2 Soils in the Crop Diversification Areas

Characteristics of soils have a key impact on crop selection. The major soil groups in the regions where the diversification has taken place are briefly described as follows:

Reddish Brown Earth Soils (Haplustalfs and Rhodustalfs)

These soils are reddish to reddish brown in colour and found in the upper and mid slopes of the landscape in the dry zone. The normal depth is about 1.0-1.2 m. and the water holding capacity ranges from 100-140 mm/meter depth of soil. The steady infiltration rate ranges from 1-5 cm/hr. The percolation rates of the wet puddled soils for the first time exceeds 100 mm/d and remains at a higher value of 10-20 mm/d even after 6 years of continuous puddling.

Low Humic Gley Soils (Tropaqualfs)

These are greyish soils found in the valley bottoms of the undulating topography. Soils are deep and moderately fine textured. Water percolation rate remains at 2-4 mm/d after 6-10 years of continuous paddy cultivation with puddling. Due to the low percolation rates suitability for crop diversification is very low in this soil group.

Non Calcic Brown Soils (Haplustalfs)

These soils are found in the upper and mid slopes of the landscape and well to imperfectly drained areas. Percolation rate may vary from 1-20 mm/hr. There is a high potential for crop diversification in these soils during the dry season. However, coarse textured members of this group are low in productivity.

Old Alluvial Soils(Tropaquents)

These soils occur in old river terraces. They are generally imperfectly to poorly drained with high infiltration rates of 5-40 cm/hr. The water holding capacity is low as 40-80 mm for a meter depth of soil. These soils are low in productivity.

Alluvial Soils (Tropaquents and Tropofluvents)

These soils are reddish to brownish in colour, moderately fine textured and imperfectly to poorly drained. The majority of these soils occur in flood plains and these soils are generally deep. These soils are more suitable for rice cultivation.

Red Yellow Podzolic Soils (Rhodudults and Tropudults)

These are the most widely spread great soil groups found in the wet zone of Sri Lanka. They occur in diverse landforms and are normally deep. Predominant textural classes of surface soils are sandy loam, sandy clay loam or loam and the structure is usually weak or moderate with crumb or granular structure. Soil reaction is acidic and the cation exchange capacity may vary from 2-10 c mol kg^{-1} in surface soils.

Reddish Brown Latosolic Soils (Rhodudults and Tropudults)

Reddish brown latosolic soils are the next prominent soil group found in the wet zone of Sri Lanka. Most of these soils occur on terrains that have been incised by ecological erosion. These soils are relatively young. The texture is mostly sandy clay loam and the structure is strong crumb to granular under natural vegetation. These soils are normally deep, soil reaction is slightly acidic and the cation exchange capacity may vary from 4-15 c mol kg^{-1} in surface soils.

Immature Brown Loams (Eutropepts and Dystropepts)

These are young soils occurring in close association with Reddish brown latosolic soils and are mostly found in the wet and semi-wet intermediate zones of the country. Soil texture is predominantly sandy loam or loam. Structure is often weak crumb or subangular blocky. Soil reaction is acidic in the wet zone and the cation exchange capacity can vary from 1-20 c mol kg^{-1} in surface soil.

Alluvial Soils (Troporthents and Ustifluvents)

These soils occur mostly in the flood plains and also in valley bottoms in the mid-country wet zone. They are usually deep and variable in drainage and texture. Structure is variable, ranging from well developed to weak. Soil reaction is acidic and the cation exchange capacities may vary from 5-20 c mol kg^{-1}.

Bog and Half-bog Soils (Tropohemists and Troposaprists)

These are mainly confined to the low-lying lands of the west and southwest of the island. These are poor in drainage and rich in organic matter. Strongly acidic, this soil group is low in productivity.

2. CROP PRODUCTION AND ECONOMIC SCENARIO

The contribution of the agriculture to GNP increased by 4.4 percent in 1999. However, the share of the agriculture sector in the GDP gradually reduced during the last three decades from 30.3 to 21.1 percent. In 1999, the share of the agriculture sector in the GDP was 20.7 percent. The reduction of the share of the agriculture sector was primarily due to the fast growth in the industry and services sectors during the past two decades.

Table 1 shows the extent, production and trade of the plantation crops and rice in Sri Lanka. It is clear that the country is producing less than 50 percent of its sugar requirements.

Table 1. Major Crops, Their Extents, Production and Trade

Crop	Area 1,000 Ha	Production 1,000 Mt	Export 1,000 Mt	Imports 1,000 Mt
Tea	195	284	268	-
Rubber	159	97	43	-
Coconut	439	2808 mil nuts	916.48 mil. nuts	-
Rice	781	2868	1.53	214
Sugar cane	7,976	399	-	479

Table 2. Extent, Production, and Imports of Major Field Crops in 1999

Item	Extent (ha)	Production (Mt)	Imports (Mt)
Chilli	21,751	60,031	20,260
Big-onion	4,597	62,729	83,960
Red-onion	6,151	42,648	2,060
Potato	2,171	27,175	128,862
Maize	28,904	31,471	58,956
Finger millet	6,797	5,137	277
Sesame	8,654	4,775	1,091
Green gram	15,362	13,805	7,258
Black gram	8,658	6,730	4,928
Groundnut	10,276	6,540	4,348
Soybean	822	797	1,830
Sweet potato	8,383	51,582	-

Source: Department of Census and Statistics.

Table 2 shows the extent, production and imports of the major field crops in Sri Lanka. These figures further explain that Sri Lanka is largely dependent on the important of field crops, irrespective of their feasibility for cultivation in the island.

Table 3. Production Area and Imports of Major Fruit Crops in Sri Lanka, 1999

Crop	Area (ha)	Production (1,000 Fruits)	Exports (Mt)	Imports in 1998 (Mt)
Banana	48,075	3310,600 bunches	1.250	9,000
Cashew	21,218	1898,326	149.803	-
Lime	6,955	117,663	-	-
Mango	25,800	431,214	3.658	-
Orange	3,464	23,998	0.081	5,602.199
Papaya	3,476	26,874	2.184	21.925
Passion fruit	425	6,202	-	-
Pineapple	4,774	32,626	2,102.069	-
Grapes			-	1,486.46

Source: Department of Census and Statistics.
Imports: Department of Customs.

Total export of fruits was around 7,000 Mt in 1999 and the total production of vegetables has been estimated to be 554,641 Mt in 1999. Table 3 shows that Sri Lanka imports mainly grapes and oranges.

Table 4. Production of Export Crops in 1999

Crop	Production (Mt)
Coffee	2422
Cocoa	1538
Cinnamon Bark	11503
Leaf oil	139
Pepper	4557
Cloves	1902
Cardamom	70
Citronella oil	108
Nutmeg	1335

Source: Central Bank Reports 1999

The total land area under export crops was 91,106 ha and the total earnings reached Rs. 11,598 Million in 1999.

3. PATTERNS OF CROP DIVERSIFICATION

Crop diversification in the country has taken place in different agro-ecological settings. The governing factors behind this diversification in each setting were different and furthermore, the diversification occurs independently in different agro-ecological regions in different time periods. The major agro-ecological settings where crop diversification has been achieved can be identified as follows:

a) Low country Dry zone - Major Irrigation schemes.
b) Low country Dry zone - Minor irrigation schemes.
c) Up, mid and low country Intermediate zones - Anicut schemes and rainfed rice fields.
d) Low country wet zone - Wetland rice fields.
e) Mid country - Marginal tea and rubber lands.

3.1 Crop Diversification in Major Irrigation Schemes

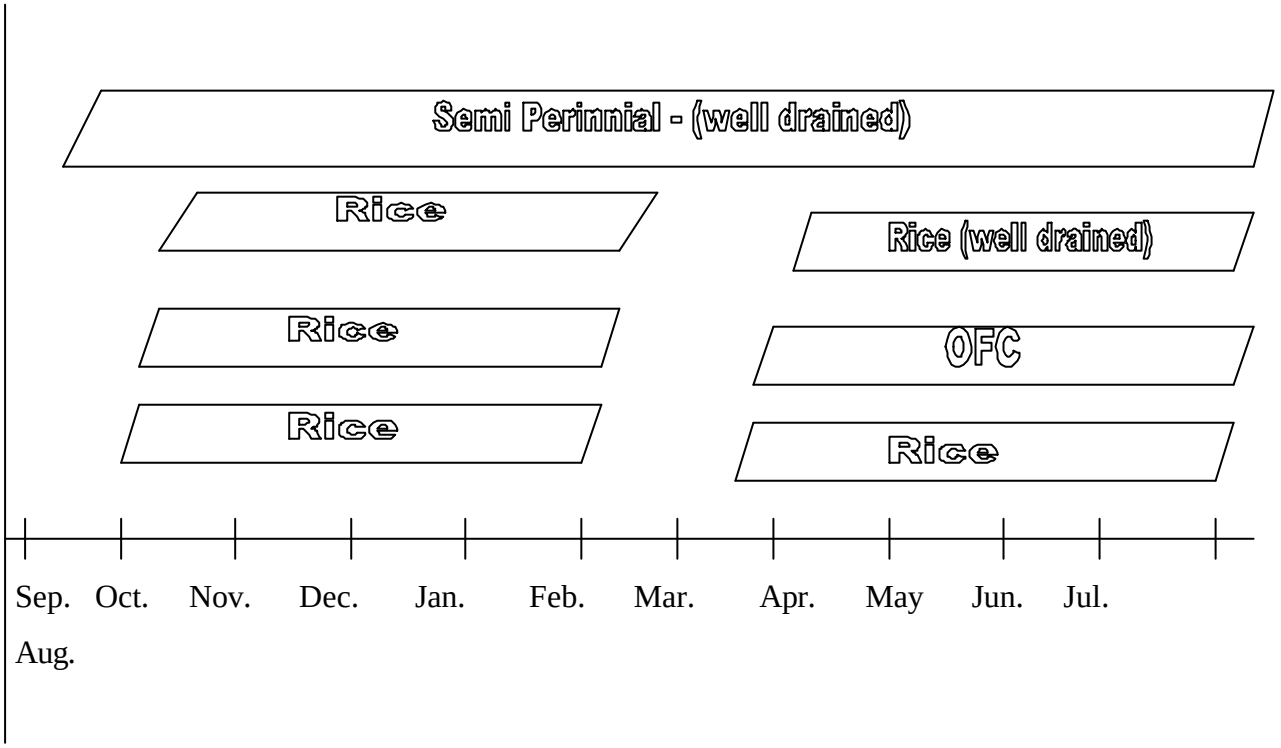
Most of the planning for irrigation schemes took place in the latter part of the 1950's and in the 1960's. A large extent of land was opened for irrigated cropping with the implementation of these plans. Rice varieties with high yielding ability and better agronomic practices for rice cultivation were also developed in the same period and as a result, rice production was expected to surpass the level of self-sufficiency. In order to overcome a possible saturation of rice production, the government planned to introduce crop diversification to the major irrigation schemes. In addition, they realized the importance of cultivating non-rice crops to obtain the best returns from the resources such as land and water. The new irrigation systems were designed with facilities for irrigation management for crop diversification. Land terrain was developed to cultivate non-rice crops in well

drained and rice on poorly drained land classes. Although farmers preferred to cultivate rice in all land classes irrespective of the hydrological regimes, government policies and the attractive prices for non-rice crops, which expanded the margin of profit encouraging them to grow non-paddy crops in well drained land classes.

There are nearly 80,000 ha of well drained lands in the major irrigation schemes available for upland crop cultivation and from this 12,000 ha of lands are at present under sugar cane and a sizeable portion has been cropped with banana. Rice and other annual field crops could be cultivated alternatively in the wet and dry seasons in the rest of the land available. Cultivation of annuals in the dry season saves water for the wet season rice crop. Growing field crops in the wet season is often hampered by heavy rains experienced due to the build up of excess moisture in the root zone forcing the farmers to cultivate rice in the wet season.

There are a few other sub-patterns that could also be identified within the diversification in major irrigation schemes (Figure 1).

Figure 1. Schematic Representation of the Different Diversification Patterns in Major Irrigation Schemes



i. Semi-perennial irrigated crops in well drained and rice in poorly drained land classes.
ii. Wet season rice in all land classes and dry season non-rice annuals in well drained and rice in poorly drained land classes.
iii. Rice in both wet and dry seasons and a short duration grain legume in-between the two seasons.

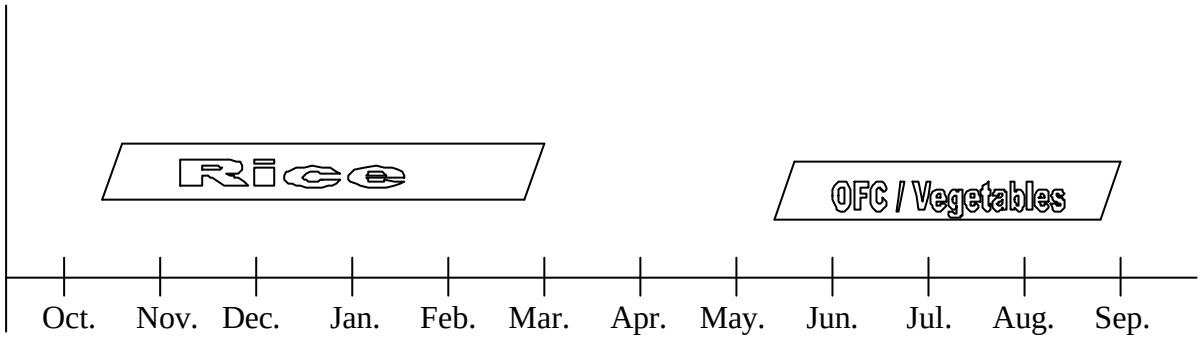
The dominant crops in the first sub-pattern are sugar cane, banana and papaw while chillies, onion, groundnut, vegetables and grain legumes are the dominant crops in the

second pattern. Mungbean *(Vigna radiata)* is the crop that could commonly be observed in the third sub-pattern.

3.2. Crop Diversification in Minor Irrigation Schemes

Minor reservoirs with less than 40 ha command area come under this category. These are predominantly rainfed reservoirs, which contain the water derived from the immediate catchments. Usually, these tanks are filled during the rainy season but the water storage during the dry season is not sufficient for rice cultivation. There are nearly 185,000 ha of irrigated lands in the command area of minor tanks. The majority of the soils in these systems are either imperfectly drained or poorly drained and not suitable for non-rice crops. However, farmers grow them in minor irrigation schemes by avoiding the short rainy period (April, May) in the dry season (Figure 2).

Figure 2. Schematic Representation of the Different Diversification Patterns in Minor Irrigation Schemes

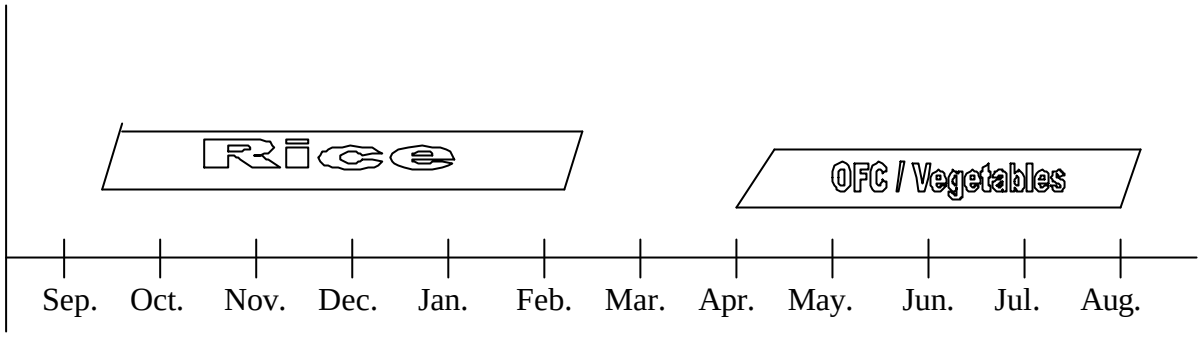


In minor irrigation schemes, wells are often dug to tap the shallow ground water table boosting the availability of irrigation water during dry periods. This has become very popular today and there are several thousand such wells that could be found in the island. The extent of cultivation by each well ranges from 0.25 ha to 0.5 ha depending on the availability of water. A variety of crops could be found in association with such wells, which range from semi-perennial fruit crops such as banana, papaw and lime to vegetables. In certain cases these farmers tend to cultivate non-rice crops even during rainy seasons by improving the drainage conditions of the soils.

3.3 Crop Diversification in Paddy Lands in the Intermediate Zone

The source of irrigation water in upcountry, mid and low country intermediate zones are mainly derived from anicut schemes and minor reservoirs. The landscape is rolling to hilly in the upcountry and mid country and undulating in the low country. Rice is cultivated in the wet season in terraced land in well to imperfectly drained soils. The attractive prices of vegetables and onion have encouraged the farmers to grow them in the dry season and they are cultivated in raised beds prepared within the basins. Occasionally, this vegetable production is affected due to high soil moisture condition occurring with heavy rains.

Figure 3. Schematic Representation of the Different Diversification Patterns in Paddy Lands in the Intermediate Zone



In the upcountry intermediate zone, potato is the major crop that covers a large extent of cultivated lands. Other dominant vegetables are tomato, beans, carrot, cabbage, beetroot and leeks. Presently, part of the extent under potato has been diversified into vegetables.

Potato is not cultivated in the mid country intermediate zone and onion, tomato, cabbage, tobacco, beans, shallots and capsicum are the principal crops found in this pattern. Cucumber, gourds, long beans, okra and capsicum are the leading vegetables grown in the low country. Melon is the only fruit crop cultivated in this part of the diversification pattern (Figure 3).

3.4 Wetland Rice Fields in the Low Country Wet Zone (LCWZ)

In the low country wet zone there are 8,681 ha under major irrigation schemes, 18,016 ha under minor schemes and 68,118 ha under rainfed conditions. The average yield of rice in the region is about 3,000 kg/ha and it has become uneconomical to cultivate rice due to the high cost of production. Also, this area represents the densely populated region where about 40 percent of the total population of the country are found.

A major portion of the paddy lands in the wet zone is very poorly drained and hence unsuitable for upland crop cultivation. The upper order valleys of coarse textured soils are fairly well drained and these soils are presently used for crop diversification. Apart from the prevailing soil physical status, crop selection seems to be dependent on the availability of marketing facilities. In close proximity to urban centres, leafy vegetables are predominantly cultivated, as these fetch a high price and the crops can be grown throughout the year. Other crops cultivated in the low country wet zone are the root and tuber crops (coleus and sweet potato), and vegetables such as long bean, bitter gourd and okra (Figure 4). Banana is the major fruit crop grown in this area.

Figure 4. Schematic Representation of the Different Diversification Patterns in the Low Country Wet Zone

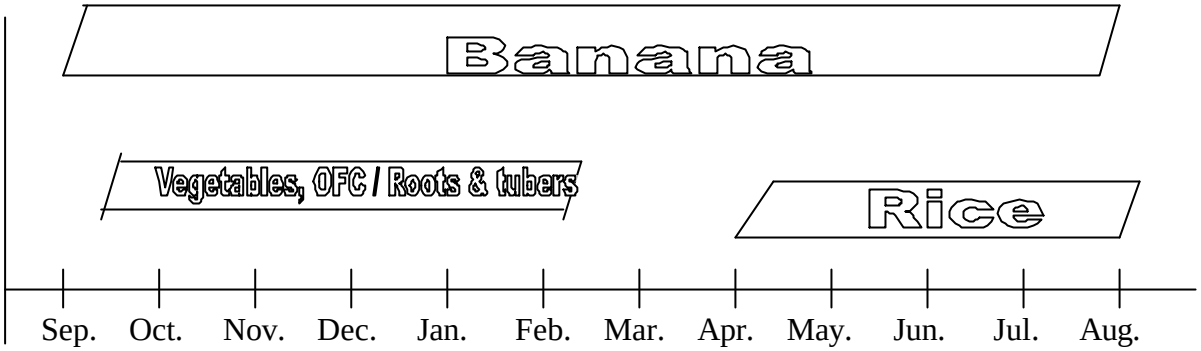


Table 5 shows the costs and returns of this diversified system.

Table 5. Cost and Returns of Diversified Cropping in the Low Country Wet Zone

Indicator	Paddy	Vegetables	Coleus	Leafy Vegetables
Total cost Rs/ha	334,625.00	76,175.00	97,530.00	275,298.00
Gross returns Rs/ha	32,856.00	303,500.00	144,738	397,943.00
Returns to land Rs/ha	6,055.00	226,883.00	47,208.00	122,645.00
Returns to capital unit	1.51	4.72	2.51	1.59
Returns to labour Rs/manday	213	954.00	318.00	250.00

The table clearly shows that returns to the land are negative in rice whereas all the other alternative crops give higher returns. Returns to capital and labour are more favourable in vegetable and Innala (coleus) cultivation.

3.5 Diversification in Mid Country Marginal Tea and Rubber Lands

The seedling tea plantations became marginally productive in the mid country wet zone due to the decline in tea prices, rise of input costs and also due to the soil degradation aggravated by soil erosion. Some of these lands were replanted with vegetatively propagated tea and a part of these lands was shifted to export crops, mainly pepper, cloves and cocoa.

Similarly, poorly managed rubber plantations also became marginal with the reduction in prices as the demand for natural rubber was reduced. The cost of production also increased due to the high wage rates and these conditions led the rubber smallholder to withdraw from rubber and shift towards vegetatively propagated tea cultivation.

3.6 Diversification Around Upland Crops

A diversification trend was observed in some upland crops such as cowpea, onion, gherkin, potato and chillies during the past few years. This was mainly due to the decline in prices owing to over-production of crops, cheap importation and shrinking of export markets.

The potato production in the up country intermediate zone dropped drastically due to the reduction in prices as a result of the import of potato. Similarly, the extent under cultivation of onion and chillies also dropped due to importation of the two commodities. As a result, the lands under these crops reverted to paddy cultivation or to the traditional systems.

Gherkin, on the other hand, was produced in the dry and intermediate zones only for export purposes. However, due to the loss in export markets, gherkin farmers have switched back to their traditional crops.

Banana (Mysore variety) was traditionally grown under rainfed conditions in the wet zone. However, in the past few years it has been cultivated under irrigated conditions and due to the attractive income, the land extent under banana in irrigation schemes increased sharply. At present, prices have dropped mainly due to many socio-economic reasons. Papaw has become the succeeding crop in most of the banana plantations which became uneconomical in production.

3.7 Success Stories of Crop Diversification

There are several success stories in crop diversification in Sri Lanka. The most illustrative examples of crop diversification are:

- Chilli cultivation in the Mahaweli river project H area.
- Onion production in Dambulla (dry zone).
- Potato production in upcountry intermediate zone.
- Vegetable production in mid country intermediate zone.
- Sweet potato production in low country intermediate zone.
- Banana production in Udawalawe river irrigation scheme.

3.7.1 Chilli Cultivation in Mahaweli River Valley H Area

Two decades ago when the import restrictions were imposed, chillies were extensively cultivated in Mahaweli system H (a major irrigation scheme) mainly for dry chillies, under a crop diversification programme. This programme successfully met the chilli requirements of the country until import restrictions were relaxed. The attractive prices obtained for dry chillies resulted due to government policy on import restrictions, availability of proper varieties, quality seeds and the other support services which contributed to the high degree of success in chilli production. At present this situation has partly changed mainly due to the relaxation of import restrictions.

3.7.2 Onion Production in Dambulla (dry zone) Area

Onion cultivation in rice fields during the dry season was initiated in the mid country intermediate zone nearly two decades ago. Owing to the initial success, onion production spread towards Dambulla (Low country dry zone) producing a fair percentage of the national requirements.

However, this production was restricted only to the cultivating season and could meet only part of the demand mainly due to the poor storage characteristic of the produce. With

the relaxation of import restrictions the onion extents in this area declined resulting in a fall in production.

3.7.3 Sweet Potato Production in Low Country Wet and Intermediate Zones

Sweet potato was mainly cultivated only in well drained soils in the wet zone of Sri Lanka. In 1980, the crop was introduced to the minor irrigation projects in the Godakawela area of the low country wet and intermediate zones. Sweet potato was cultivated only during dry seasons in rice fields where rice was always the leading crop in the wet season. Owing to the success of the production effort, the cultivation extent increased rapidly and today this area accounts for about 20 percent of the national production of sweet potato.

3.7.4 Banana Production in 'Udawalawe' Irrigation Scheme

Banana is a water-loving crop that can be grown successfully in the dry zone with irrigation facilities. This crop was initially cultivated in the lands where the water supply was inadequate for rice cultivation. In 1986 there were only 251 ha of banana in the project area and today the extent has increased to nearly 4,000 ha with an average productivity of 25 t/ha/yr. Several reasons can be attributed for the success of this diversification programme. These are:

- Attractive income from the crop (SL Rs. 200,000 – 250,000/ per ha/year).
- Strong agriculture extension programme.
- Presence of an efficient marketing network.
- Suitability of the land.

4. CROP DIVERSIFICATION AS A STRATEGY

4.1.Food and Nutritional Security

Currently, most of the key food crops are grown in the island. However, in order to meet the national demand a larger quantity has to be imported annually (Table 6).

Table 6. The National requirement of some of the essential food commodities in 2000

Crop	Requirement (Mt.)	Extent to be Cultivated (ha)		Present Production (Mt)
		Maha	Yala	
Rice	2,035,000	667,835	381,905	1,781,048
Dry chilli	34,100	17,040	11,780	15,000
Chilli green	285,00	5,440	11,780	15,000
Red onion	35,900	17,040	5,280	42,600
Big onion	126,000	165	4,640	62,700
Potato	101,300	3,000	2,560	11,759
Maize	166,000	34,005	4,175	31,400
Green gram	40,000	14,190	5,760	13,800

Table 6 clearly shows that there is a production deficit in the necessary food commodities. Hence, in order to meet the demand in the future, certainly the land extent under these crops needs to be increased. From the expected production of non-rice annuals, a major portion of green gram and maize can be produced under rainfed conditions. However, for crops such as onions, potato and chillies, the majority of the production is expected from irrigated fields under crop diversification.

Similarly, the per capita fruit consumption in Sri Lanka (5.0 kg/person/year) is far below that of developed countries (45 kg/person/year). There is no doubt that the production has to go up in order to increase the fruit consumption in the country. As a result, fruit crops that could be effectively produced in the island have been identified and it is already planned to increase the land extent under these crops, especially with supplementary irrigation.

In Sri Lanka, nearly 34 percent of the population is still living below the poverty level and in an under- nourished status. Their present level of protein intake is inadequate for optimal growth and development. The expansion of the production of pulses such as green gram, cowpea, soybean and groundnut has to take place to at least supplement part of their protein requirements.

4.2 Income Growth, Poverty Alleviation and Employment

As an outcome of the socio–economic changes that occurred during the last few decades some production systems became uneconomical to operate. Rice cultivation in the wet zone and the marginal tea and rubber lands in the mid country are two examples in this regard. The wetland rice cultivation extent of nearly 94,815 ha and the marginal tea and rubber extent of about 50,000 ha were affected by these changes. This development certainly affected the income level of those dependent on these production systems. As described earlier, crop diversification would generate better income from these lands and transform the marginal operations into profitable enterprises.

There are about 195,000 ha of land available for crop diversification in the dry season. On the other hand, the production of non-rice crops requires more labour throughout the year compared to rice which has only a seasonal demand. Therefore, cultivation of non-rice crops would generate more employment opportunities. In addition, diversification may lead to an increase in production of non-rice crops and may create more opportunities for agro-based industries to be developed. Such a change would undoubtedly generate more income, employment and help to alleviate poverty.

4.3 Judicious Use of Land, Water and other Resources

The well drained soils in the major irrigation schemes have high percolation rates exceeding 100 mm/d. Cultivation of rice in these soils provides low returns for each unit of water used for cultivation. On the contrary, cultivation of non-rice crops need less water and provides relatively higher returns to each unit of water used. Since the cost of irrigation water is fairly high, it is a pre-requisite to use this resource in the most effective manner. Meanwhile, the selection of crops based on the land classes can be practiced effectively. The appropriate crop selection would assure the productivity of the crop, improve the soil conditions and also favour the environment. Crop diversification provides an opportunity for the farmers to shift from one crop to another, depending on market prices and productivity.

5. CHALLENGES AND OPPORTUNITIES

5.1 Constraints in Crop Diversification

Constraints to crop diversification in the island can be grouped into five categories. They can be named as physical, agronomic, economic, social and management constraints.

5.1.1 Physical Constraints

Crop diversification has to be practiced with non-rice crops in the island. Non-rice crops cannot tolerate excess soil moisture and prefer well drained conditions. There are only 80,000 ha of such lands available in major irrigation schemes. In minor irrigation schemes almost all the soils are imperfectly to poorly drained. The situation is even worse in the wet zone where high rainfall and frequent floods often make excess soil moisture conditions unsuitable for growing highland crops.

Land configurations of most of the irrigated rice fields do not favour the use of machinery, especially in well drained parts of paddy tracts. This situation prevents the farmer from using even medium scale machinery for land preparation and increases the cost of land preparation. In addition, due to the requirement of two different ways of land preparation, more energy needs to be utilized. This discourages the farmer from practicing such land preparation as it also increases the cost of production.

5.1.2 Agronomic Constraints

The majority of the upland crops cultivated in Sri Lanka do not tolerate excess soil moisture and water saturated soil conditions and hence the farmers are left with only a few crops such as sugar cane, soybean and leafy vegetables that tolerate excess moisture to some extent.

In rice and non-rice cropping patterns, non-rice crops of the 12-16 weeks age class are preferred and most of the cash crops exceed this age limit. On the other hand, crops in a preferred age group, for example pulses and maize, do not generate sufficient income to be attractive alternative crops. Certain crops such as okra and groundnut, which tolerate excess soil moisture, get affected by viral diseases such as mosaic virus when cultivated in the dry season.

5.1.3 Economic Constraints

Diversified cropping demands high input conditions and this leads to increase in the cost of production. As most of the diversifiable crops are seasonal, production comes to the market within a short interval. In addition, most of this produce is perishable in nature and cannot be stored at farmer-level for a long period. Consequently, market prices fall during the harvesting period. In certain situations traders deliberately lower the prices to obtain high profits for them. The open economic policy that became effective during the past two decades relaxed the import restrictions. The lower world market prices of these food commodities encouraged the import of these items, reducing the market price in local markets. The effect of the combination of all these conditions lowers the overall profit margin for the farmer and they are compelled to shift towards easy crops, and in most cases, this is rice.

In addition to the above scenario, unavailability of good quality seed in time (e.g.: onion) also discourages some farmers from the cultivation of non-rice crops.

5.1.4 Social Constraints

Traditionally, Sri Lankan farmers prefer rice cultivation for cultural reasons and they are also highly knowledgeable in rice cultivation but have little knowledge of upland crop cultivation. Hence, most of the farmers are reluctant to shift from rice to other alternative crops. Paddy on the other hand is an easy crop to cultivate for them and hence they find sufficient time to go for off-farm employment. However, with non-rice crops farmers cannot look for off-farm income though the returns are comparatively high. The absence of knowledge and the need for constant attention in non-rice crops restrict the old generation of farmers to move away from rice and it is the knowledge seeking youth who are mostly interested in cultivating non-rice crops. The majority of the youth are, however, leaving the farm to seek employment in other sectors. Land ownership is another obstacle in promoting non-rice crop cultivation in Sri Lanka. Land ownership is not always with the farmer and therefore farmers have no choice for crops as the decisions lie with the land owner. This situation was created as there was no way of assuring a guaranteed income from the non-rice crops. In addition, the tenancy for rice lands is legally protected in Sri Lanka.

5.1.5 Management Constraints

Irrigation schemes designed after the 1960's have facilities for irrigation management in crop diversification. However, irrigation schemes that have been implemented prior to this period were designed only for continuous water supply. Hence, rotational irrigation, that is a must in non-rice cultivation, is difficult to practice in old irrigation projects.

Heavy rains that occur soon after irrigation or coincide with irrigation create excess water conditions which are detrimental to upland crops. Present irrigation systems do not enjoy the ease of immediate water regulatory facilities between head works and the peripheral distributaries. Therefore, enhancement of water regulatory facilities is also needed for better crop diversification in the irrigation schemes.

5.2 Globalization and New Technologies in Crop Diversification

Generally, the cost of cultivation of all the crops is relatively high in Sri Lanka and in addition, the yields are comparatively low in relation to the subtropical and temperate countries. This could mainly be attributed to the climatic differences among the tropics, subtropics and temperate countries. Due to low yield and high cost of cultivation the prices of agricultural commodities are relatively high. Therefore, options are very much limited for exporting vegetables, pulses or grains. In contrast, importation is continuously taking place as the import restrictions have been relaxed. This situation adversely affects local agricultural production and hampers the crop diversification effort.

The production of condiments such as pepper, cinnamon, cloves and cardamoms has comparative advantages. But expansion of those crops to non-traditional areas, where such cultivation is not being practiced, is very much limited as these require special climatic conditions. Introduction of varieties of condiments that perform well within a large range of climatic conditions is a challenge for the researchers in their respective fields. In this situation, biotechnology can be used for developing new varieties and propagation

techniques such as tissue culture can be used more effectively for the expansion of new crop varieties.

With the open market system, the involvement of government in planning is limited and furthermore, the decisions are now being made by agricultural entrepreneurs. Hence, before entering into any agricultural enterprise, farmers are required to decide on the crops, type of technology etc., and they also need to forecast and anticipate the fluctuations in prices, marketability of the produce, extent of cultivation and the expected total production to avoid future gluts and major price slumps. Similarly, information on the land, soil type, crop suitability etc., should also be useful for the future agriculture entrepreneur. There is a need to have an institution to provide such information to support the decision making of the agriculture producer as well as the traders. In this system both farmer and traders should be able to collect information conveniently.

5.3 Institutional and Infra-structural Development Towards Crop Diversification

5.3.1 Institutional Development

Farmer organizations at different levels of the irrigation schemes are required for effective crop diversification programmes. Such organizations facilitate effective irrigation management, supply of inputs and organizing marketing facilities. This requirement is effectively met in almost all irrigation schemes in the island and the Irrigation Management Division attached to the Irrigation Department is responsible for the activity.

There is a fairly effective agriculture extension network present in the country. It is presently handled by the Department of Agriculture at both provincial and inter-provincial level and by the Mahaweli Economic Agency in the major irrigation schemes. In addition, there are several non-governmental organizations that take certain extension messages to a limited section of the farmers. However, the extension service suffers from lack of sufficient staff at village level to take the extension messages across to the farming community. Therefore, an increase in strength of extension agents at village level is needed to improve the efficiency of the extension service.

The Department of Agrarian Services mainly handles the minor irrigation schemes and is also responsible for supplying inputs and purchasing certain farm produce to a limited extent.

5.3.2 Infra-structural Development

Modern irrigation schemes designed after the 1960's were completed with the following basic facilities:

- Canal system with high canal capacity.
- Gates and regulators for efficient irrigation control.
- Access roads to each and every allotment.

However, the experiences in the last decade show that food and fruit processing factories at regional level are necessary to deal with the problem of seasonal excess production of crops to ensure good market prices for agriculture produce, thus facilitating the diversification process.

6. GOVERNMENT POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

Government policy was to reach self-sufficiency in most of the essential food crops after independence. Hence, government set strategies to fulfill the above policy were:

a. To increase the extent under cultivation during the last four decades, the government planned and commissioned several major irrigation schemes and increased the irrigable land extent to 483,000 ha.

b. Seed and planting material production was handled mainly by the government institutions and seed farms were operated to meet the national demand of seed and other planting materials. Importation of seed potato was mainly handled by the government.

c. Subsidy schemes were formulated to encourage high input usage, especially fertilizer which was provided under the subsidy.

d. Crop insurance was introduced to minimize risks.

e. Guaranteed prices or minimum prices were set and marketing was sufficiently intervened to activate the pricing policy. Government institutions such as the Paddy Marketing Board and the Marketing Department were established to purchase the agriculture produce.

However, with the introduction of an open market system in the early 1980's some of those policies were relaxed. Subsidy for fertilizer was reduced and the private sector was primarily responsible for marketing the agriculture produce. The government institutions for marketing were not functioning effectively. Although there was a minimum price for most of the commodities, the government could not maintain it as the state institutions responsible for marketing were ineffective. Government involvement in seeds and other planting material production was reduced to a substantial degree and the private sector participation was encouraged and promoted. The cost of production of crops increased as the fertilizer subsidy and most of the direct and indirect subsidies were reduced.

Although the import restrictions were relaxed, a certain level of protection was maintained. However, these measures were not sufficient to avoid the decline in local production of chillies, onion, pulses and potato to a significant extent.

Currently, the government adopts the trade liberalization policy where GATT, SAFTA and other regional trade agreements promote free trade. This makes most of the crop production at the existing level of technology under the present wage rate comparatively disadvantageous. Hence, the imported produce competes with the local commodities and deprives the local farmer of his self-employment. For example, the extent of potato cultivation, which was 4,430 ha in 1996 dropped to 1,119 ha during the last three years. However, the production area of condiments such as pepper and cinnamon has increased as Sri Lanka has a significant comparative advantage in condiment production.

7. CONCLUSIONS

- There is good potential for crop diversification in Sri Lanka and this potential is well realized in major and minor irrigation schemes except in the wet zone of Sri Lanka.

- The diversification patterns in rice lands in the intermediate zone of the up country and mid country have been successfully established. Diversification in major irrigation schemes in rice lands of the low country wet zone is also operated with limited success. However, the stability of the system largely depends on the market prices of agricultural produce.

- Susceptibility of crops to excess moisture is the major physical constraint in all rice-based crop diversification systems. Insufficient number of available candidate crops is a major constraint in all diversification patterns.

- Since market forces are the driving force for diversification, efficient operational systems encompassing a decision support system have to be developed. The diversification enterprises must also suit the international and regional trade policies.

- Infrastructure development of agriculture enterprises and agro-based industries is necessary for further promotion of the diversification programmes.

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CROP DIVERSIFICATION IN THAILAND

Chavalvut Chainuvati [*] and Withaya Athipanan [**]

1. INTRODUCTION

Thailand is located in the Indochina Peninsula with a total area of about 51.36 million hectares. Her territorial boundaries connect with Malaysia in the south, Cambodia in the northeast to east, Laos in the northeast, and Myanmar in the northwest to west.

Geographically, the country may be divided into four regions. In the central, northern, northeastern and southern regions, altitude modifies the temperature considerably. It is cool enough in the northern region to produce temperate fruits and vegetables (also vegetable seeds); cool and dry in northeast region, and modestly humid in the central region. These three regions have three seasons: rainy during late April to October, winter from November to February, and summer from March until April. In the southern region, there is no cool season and the climate is wet, but with less solar radiation than is needed for maximum crop yields. Thailand's climate is tropical and monsoonal, influenced by the southwest monsoon except for the south. Average annual rainfall and temperature vary, ranging from 998-4,603 mm of precipitation and a temperature regime of 24.4-29.3 ^{o} C (76-85 ^{o} F).

Administratively, Thailand is divided into 76 provinces, each headed by a governor. There are 787 districts and district branches, 7,404 sub-districts, and nearly 66,604 villages in the 76 provinces. The population in 1996 was over 60 million people, and of this population 64 percent reside in the rural areas. Approximately 90 percent of the rural people, or 5.2 million farm families, earn their income through subsistence farming, particularly rice cultivation and other field crop production.

In Thailand, 64 percent of the population are engaged in agriculture. Most of them grow single crops such as rice, cassava, corn, sugar cane etc. The proportion of income per capita of those engaged in agriculture to other sectors was 1:13 in 1997. Several development programmes have failed because there were no realistic assessments of the limited resource base of small farming systems.

The survival and social-economic pattern of the householders was not taken into full account. The basic assumption is that small-scale farmers in Thailand will be responsive to development efforts if the technology fits their needs, aspirations and environments.

The Department of Agricultural Extension (DOAE) has realized such drawbacks and put more efforts to solve these kinds of problems. The strategy is in line with the government's policy during the 7th and 8th National Economic and Social Development Plan (1992-1996 and 1997-2001) which attempted to restructure agricultural production systems

[*] *Deputy Director-General, Department of Agricultural Extension, Ministry of Agriculture and Cooperatives, Bangkok, Thailand.*
[**] *Senior Subject Matter Specialist, Farm Management Group, Agri-business Promotion Division, Department of Agricultural Extension, Ministry of Agriculture and Cooperatives, Bangkok, Thailand.*

by promoting diversified crops instead of a single crop; which took into account income distribution of farmers and natural resources conservation, including environmental issues.

Therefore, the main concept implied in farm diversification (crops, livestock and fisheries) and crop diversification programmes should be placed in a proper perspective in order to

- respond to the objectives and goals of the farmers such as consumption, household utilities, income etc;
- increase farm income and provide a continuous income for farm families;
- reduce farmers' risk and encourage them to make their own farm plans;
- promote various farm enterprises to avoid any risk and uncertainties from natural disasters and marketing setbacks;
- encourage the farmers to recycle farm wastes and integrate farm activities such as crops, livestock and fisheries;
- minimize the use of external inputs; and
- conserve the natural resources and balance the agro-ecosystems at the farm level.

2. AGRICULTURE SITUATION IN THAILAND

About 41.5 percent (21.28 million hectares) of the total area are farm holdings, with some 17.5 percent of this presently under irrigation. This land, both irrigated and non-irrigated, is used by some 5.2 million farm families to produce agricultural goods for domestic consumption and export.

Among the large number of crops of economic significance, rice is the most important which is widely grown in all regions and covers about half of the country's cultivated area. Other major field crops are cassava, corn, sugar cane, oil crops and perennial trees such as para rubber, fruit trees cover the rest of the area. The utilization of farm land is as follows: 51 percent for paddy, 24 percent under field crops, 17 percent under fruit trees and other tree crops and others occupy 8 percent. The major planted areas of selected crops are rice, maize, cassava and rubber. The planted area, yield, production and value of economic crops in 1997/1998 are shown in Table 1.

Table 1. Planted Area, Yield, Production and Value of Economic Crops

Crops	Area (1,000 ha.)	Yield (ton/ha.)	Production (1,000 tonnes)	Value (Million of US$)
Major rice	9,113.28	2.14	18,789	3,275.39
Second rice	1,156.96	4.23	4,791	825.37
Maize	1,396.64	3.20	3,832	421.52
Cassava	1,071.04	14.93	15,591	491.12
Sugar cane	943.52	49.68	46,873	594.12
Para Rubber	1,831.04	1.42	2,169	1,262.90

The National Economic and Social Development Plan also places emphasis on the commercialization of agriculture, moving away from subsistence farming towards intensive monocrop production for export. However, the proportion of the agricultural gross domestic product (GDP) declined to 25 percent in the 3rd plan and less than 15 percent in the 7th plan,

respectively as shown in Table 2. The Table 3 indicates the GDP in agricultural sector from the 3rd - 7th plan which includes crops, livestock and fisheries, sharing about 60 percent, 8-10 percent and 9-11 percent of GDP in the agriculture sector, respectively.

Table 2. Gross Domestic Product Value during the 3rd - 7th National Development Plan

Unit : percentage

Sector	3rd Plan 1972-1976	4th Plan 1977-1981	5th Plan 1982-1986	6th Plan 1987-1991	7th Plan 1992-1996
1. Agriculture	25.08	21.39	19.01	14.88	10.30
2. Non-Agriculture	74.92	78.61	80.99	85.12	89.70

Source: National Economic and Social Development Board (NESDB), 1997

Table 3. Gross Domestic Product Value in Agricultural Sector

Unit : percentage

Sector	3rd Plan 1972-1976	4th Plan 1977-1981	5th Plan 1982-1986	6th Plan 1987-1991	7th Plan 1992-1996
Agriculture	100	100	100	100	100
- Crop	60.8	60.7	63.2	61.9	61.3
- Livestock	8.8	9.9	9.5	10.6	10.7
- Fishery	9.8	9.7	9.7	10.7	11.7
- Forestry	10.4	7.7	5.3	3.2	0.6
- Simple Agriculture Processing Product and Agriculture Services	10.2	12	12.3	13.6	15.7

Source: National Economic and Social Development Board (NESDB), 1997

The situation of import and export of crop products in 1997 showed that the principal agricultural products exported included rice, para rubber, cassava products, fruits and vegetables (fresh, frozen, processed and canned), non-glutinous and glutinous rice flour, canned pineapple, refined sugar etc. Principal agricultural products imported were paper and paper products, soybean products, raw cotton and lint, wheat, palm oil, vegetable seeds etc.

3. NEED FOR AGRICULTURAL DEVELOPMENT

During the past three decades, national development grew increasingly in various aspects, in particular, industries, services and agriculture. Natural resources were much utilized, both directly and indirectly, for production in each of the sectors. Agricultural inputs were brought into use, i.e., fertilizers and chemical pesticides. Impact of such development resulted in deforestation, soil fertility loss, drought, flooding and serious outbreaks of plant pests as well as pollution of soil, water and the atmosphere. Thai farmers, particularly rural poor and even average growers, could not produce as much as expected. They suffered accordingly from low production, low prices, but high cost of production.

Over the past few years, agricultural development policy placed emphasis on increasing production which mainly relied upon natural resources, the transfer of technology and the support of certain production inputs. Although such development can achieve the goal to increase farm production sufficient for domestic consumption, import substitution, exports, and raw materials for local processing industry, it was found that the producing farmers are the ones who have been burdened with the economic imbalances. An income gap between farmers and those engaged in other occupations is wider to the extent that farmers are considered as the poorest group.

The problems of farmers' income and the downward trend of the agricultural sector growth stems from major factors such as: shortage of water for agriculture, less and inconsistent rainfall distribution, deterioration of farm land, as well as competition in the world trading of agricultural commodities being dominated by protectionism on the part of several groups of nations. Taking this into account, the government and the Ministry of Agriculture and Cooperatives have set up the policy on restructuring of agricultural production systems with a view to maintain the growth rate of the agricultural sector and to raise farmers' incomes. The policy will be diverted from the promotion to increase production to place more emphasis on the increase of farmers' incomes and the alleviation of prevailing poverty problems. This can be done by providing the farmers with alternatives suitable for their area potential, their readiness and market opportunities so they will be able to make decisions on restructuring their own production systems while balancing the utilization of natural resources.

4. TYPICAL FARMING SYSTEMS

The typical cropping systems practiced in each region can be divided as follows:

a. North: Mountainous upland area where the cropping patterns are upland rice, field crops (cropping systems such as soybean- mungbean, corn- mungbean, mungbean-cotton, corn-sorghum etc.) and fruits such as lychee, longan, mango etc. The fruit tree-based cropping systems are mostly intercropped with field crops, vegetable crops and flowers. With only 10 percent of the lowland under irrigation, the cropping systems are wet season rice followed by dry season rice or soybean, mungbean, peanut, tobacco, sweet corn, baby corn, onion, garlic, tomato, water melon etc. The typical cropping systems in this region, therefore, are rice-based cropping systems and fruit tree-based cropping systems.

b. Northeast: Rainfed rice is mainly grown once a year in the semi-arid plateau with sandy infertile soil. Dryland cash crops planted are cassava, jute and mulberry for sericulture. For the lowland under irrigation, wet season rice is grown followed by dry season rice or soybean, mungbean, peanut, jute, sesame and some vegetable crops. In addition, diversification has also been carried out in this region, especially with such fruit trees as mango, sweet tamarind, banana, papaya etc., as well as livestock and rice-fish culture in rainy season as alternative agriculture production enterprises. The typical cropping systems, therefore, are rice-based cropping systems and field crop-based cropping systems.

c. Central Plain: Two or three crops of rice area are grown annually in the most fertile region of the country with the largest irrigated area. Other major crops are fruit trees, vegetable crops, field crops and also livestock. The cropping systems under irrigation are wet season rice followed by dry season rice or soybean, mungbean, peanut, sweet potato,

water melon, sesame, and some vegetable crops such as sweet corn, baby corn, yard long bean, pumpkin, cucumber etc. For uplands the cropping systems are corn-sorghum, sesame-mungbean, mungbean-corn etc. During the last few years, fruit-tree based cropping systems have been practiced in this region. Livestock and fisheries have also been integrated with crop enterprises. The typical cropping systems in this area, therefore, are rice-based cropping systems and field crop-based cropping systems.

d. South: The major crop is rubber. Rice, fruit trees, vegetables, other cash crops, marine fisheries and prawn farms are also important. For the lowland, the cropping systems are wet season rice followed by dry season rice or water melon, peanut, mungbean, sweet corn, taro etc. Rubber-based cropping systems, can be widely seen in upland area in the rainy season. Most of rubber plantations are intercropped with upland rice, sweet corn, peanut, pineapple, banana and other field crops. Fruit and other perennial trees such as coconut, rambutan, mangosteen, durian, longan, oil palm, coffee, cocao etc., are mixed and intercropped with the same crops as in rubber-based cropping systems.

Farmer's Decision Making towards Diversification

Whether alternative proposals by a government agency will be accepted or not is a question of the incentives provided and understood by the target farmers. In viewing the alternative proposals in economic terms, the farmers will consider whether the income generated by the alternatives is higher than the traditional one. As to the social aspects, an alternative plan may or may not be suitable for their farm resources in terms of land, labour and capital availability. That means market and farm resources are the main factors influencing the decision making (and risk taking) which are the farmers' own choice, and not the government's choice. The farmers will not accept the alternatives if they cannot see a market opportunity. The farmers will also consider whether the land, labour and capital they have are suitable for a diversification programme.

5. PROBLEMS/CONSTRAINTS IN AGRICULTURE

Problems in agriculture stem from technical, economic and social factors. Major problems can be summarized as follows:

Poverty of Farmers and Income Distribution

In general, farmers are poor because of their main engagement in agricultural production, which has to face difficult conditions such as natural disasters, uncertainties of markets and farm prices, as well as good quality produce to meet market demand. Farmers are regarded as the poorest group in the country.

Production Efficiency

Agricultural production efficiency in Thailand is relatively low because the production depends mainly on rainfall; farmers are therefore unable to integrate the adoption of technology for the increase of their crop productivity. Furthermore, most farmers are less educated, which is a constraint in laying down production plans in line with changing situations. Besides, there are problems with farming in unsuitable land. These factors result in the low production of various crops.

Land Tenure

More than half of the Thai farmers have farm holding sizes of less than 3.2 hectares per household. In the future, the farm land tenure is expected to gradually decrease because of limited land resources as well as the inability to compete with other production and services sectors to secure additional land. The small plots of land occupied by farmers are usually situated in non-irrigated areas; their income is therefore low which is insufficient for their subsistence.

Marketing and Farm Prices

In general, the quantity of supplies of farm products is unstable and low because most farmers are small producers. The quantity of their production is in small amounts. Farmers still lack the facilities to store their produce after harvesting for even short periods. The farm prices are determined by the marketing mechanism at different periods and farmers have no bargaining power for their produce.

Technology Transfer and Dissemination of Information for Decision Making

Another problem and constraint of farmers is their education, which is normally at the compulsory level only. However, the development of technology to increase the production efficiency and value of products is deemed necessary because the dependence on natural factors only does not enhance the competition in the world market. With the decrease of soil fertility, the major production inputs, technology and proper management has become essential. So, it is necessary that technology from elsewhere be modified and improved to suit local conditions before transferring to the farmers. However, the farmers' adoption of such technology requires updated and reliable information together with the readiness of capital for procurement of production inputs.

Environment differences and non-transferable technology becomes one of the major constraints. This is because research on crops, in the form of basic research, is carried out at the research station. Consequently, technology transfer is not appropriate or fitted to the farmers' circumstances because of different locality and environment variables.

Socio-economic constraints include cost and return for enterprise investment, supporting inputs attitudes and traditions. Besides that, information flows hardly ever reach the farmers.

Funds for rural credit are limited with the result that farmers have to borrow from money lenders, traders and middlemen in order to buy farm inputs and produce from the market. Borrowing money usually means paying interest rates as high as 10 percent per month.

6. POTENTIAL FACTORS

Land: The cultivated land is approximate 21.28 million hectares of which rice alone covers 10.88 million hectares or more than 50 percent of land used. During the past decade, rice cultivation has decreased therefore increased productivity from existing land and crop

intensification by managing proper cropping systems and crop diversification are deemed necessary.

Labour Distribution: Farm labour is one of the limited farm resources. At present, labour mobilization is a very important problem for farm development since skilled labour in rural areas has migrated to the industrial areas. However, farm machinery is available, as is mechanization technology for use for substitution of farm family labour.

Capital: The Bank for Agriculture and Agricultural Cooperatives (BAAC) provides credit to the farmers as short term, intermediate term and long-term loans. Moreover, the commercial banks have a similar policy to support the farmers' loan scheme as BAAC. When farmers acquire money from money lenders, they have to pay interest higher than loans from the BAAC or the commercial banks. However, the farmers can accumulate their own capital by themselves or through union saving or revolving funds in the villages etc.

7. SUSTAINABLE AGRICULTURAL MANAGEMENT FOR SMALL FARMERS IN THAILAND

From past to present, a shortage of water supply for agricultural activities has been a major problem facing Thai farmers. The impact is severe for the agricultural areas, which rely heavily on rainwater. Unfortunately, such areas where there is little precipitation constitute a predominant part of the country with mostly rice and field crop farming being implemented. Such a condition limits farmers from carrying out their cultivation to only once a year during the rainy season. Moreover, farmers are exposed to high risks and damage due to adverse environmental conditions of soil, climate, and inconsistent rainfall patterns. Although efforts have been made to tackle water shortage problems, for example, by digging ponds to store water, appropriate sizes or systems have never been determined. There are still other factors which magnify the shortage of water such as unsystematically planned crop cultivation or mono-cropping farming systems.

Being aware of this situation, His Majesty King Bhumibol Adulyadej graciously set up an initiative to relieve the farmers from suffering and guide them through the plight of water scarcity, with minimal impacts and pain.

His Majesty' s ingenious solution was named the "New Theory". It serves as a set of principles or guidelines on the proper management of land and water resources to create optimum benefits for farmers who own a small piece of land.

In the "New Theory: a Novelty in Agriculture", His Majesty King Bhumibol Adulyadej gave guidelines to the people who live in rural areas (farmers) by Royal Proclamation:

"…New theory… a new way to help people make a living on subsistence level. They might not be that rich but they would not starve either.

"…An integral part of this programme is the division of land into 3 parts, one for rice farming, another for gardening and the last portion for water storage…"

The New theory is a novel approach and concept aimed at assisting individual farmers possessing a small piece of land in being able to manage the utilization of land and water for agricultural activities properly in order to create optimum benefits. The implementation plan is divided into three phases as follows:

7.1 Phase 1: The allocation of Land for Farming Activities and Housing Area

The small piece of land is divided into four parts. Part 1, or about 30 percent is set aside for digging a pond to store water for cultivation as well as for raising aquatic animals and plants. Part 2, or about 30 percent will be used for rice farming which will provide the family with sufficient rice for consumption all year round. Part 3, or another 30 percent of the land is allocated for planting of fruit trees, vegetables, field crops, etc., from which farmers can sell the surplus to the market. The last 10 percent is reserved as a place for housing, animal raising, and other purposes. The ultimate goals of the theory are to ensure that during the dry season, a sufficient amount of water will be available for cultivation; farmers will have enough rice to eat all year round and become self-reliant at an economic level; and hopefully, unity will prevail within the community.

From “New Theory” phase 1, There are main principles and important guidelines, which can be described as follows:

a. The main idea of the "New Theory" is to serve as a production system that allows farmers to become self-sufficient, self-reliant, and frugal. To be viable, this concept requires unity and willingness of the community to work with and assist one another in order to reduce expenses, similar to the traditional practice of Long Khaek (traditional mutual help gathering for an activity such as rice harvests).

b. With rice being the staple food for every Thai household, the theory estimates that, if each family carries out rice cultivation over an area of 0.8 hectares they will be guaranteed a whole year’s supply of rice for consumption. This means that farmers will not have to buy rice at an unreasonably high price and can lead their lives freely because they have become self-reliant.

c. Another important point is that the storage of water must be sufficient to supply farming during the dry season or dry spells. Therefore, the concept ensures that a part of the land is set aside for the construction of a pond to store sufficient water for all year round cultivation. According to His Majesty’s guideline for cultivation of 0.16 hectare, a farmer will need about 1,000 cubic metres of water. Thus, under the "New Theory", if an area of 0.8 hectares is used for rice farming and another 0.8 hectares for field or fruit crop farming (a total of 1.6 hectares), approximately 10,000 cubic meters of water will be needed annually.

Therefore, under the assumption that each piece of land has a total area of 2.4 hectares, a formula has been derived for farmers to apply on their plots as follows:

- an area of 0.8 ha for rice cultivation.
- an area of 0.8 ha for field and garden crops cultivation.
- an area of 0.48 ha for a pond with a depth of 4 metres and a storage capacity of 19,000 cubic metres which is a sufficient amount to supply farming and other daily needs during the dry season.
- an area of 0.32 ha for housing and other activities.

In any case, a decision about the size of the pond should be made based on the local geographical and environmental conditions as follows:

- If the implementation plot is located in an area which depends on rainfall, then the pond should be dug quite deep in order to prevent evaporation, thus allowing all year round water supply.

- If the implementation plot is located in an area which depends on an irrigation system, then features of the pond can be flexible, in terms of the depth, or width. Only the local suitability needs to be considered because with an irrigation system, a water replenishment source is secured.

The purpose of having a pond is simply to allow farmers an all year round water supply for their occupation and consumption usage. His Majesty referred to it as a 'regulator', implying that a well-defined water replenishing cycle system has been established to support farming all year round, particularly during the drought and dry spell periods. However, this does not mean that farmers can cultivate Na Prang rice (off-season rice farming). If the water in the pond is insufficient, it is then necessary to pump water from an existing nearby dam, thus depleting the amount of water that has been stored in the dam. It is recommended for farmers to cultivate rice during its regular season, which is in the rainy period. Meanwhile, during the dry season, farmers must consider other suitable types of crops to cultivate in order to use the stored water both efficiently and optimally.

- In the rainy season, water will be plentiful for rice and cultivation of other crops.

- During drought or dry spell periods, it is most suitable to cultivate crops that do not require large amounts of water, such as beans.

d. For this scheme to divide the land in order to produce optimum benefits, His Majesty based his calculations on the fact that each farmer owns an average land area of 2.4 hectares. However, the following plan is not a fixed formula but simply a guideline in which farmers who own more or less of this amount of land can adjust the 30 : 30 : 30 : 10 ratio.

In any case, the described ratio only serves as a recommended formula or as a guideline. Adjustments of the ratio can and should be made to suit each area's location characteristics such as the soil type, the amount of rainfall, and the environment. For instance, in the southern region where rainfall is more plentiful or in areas where sources of water are available to continuously replenish the pond, it will be possible to reduce the size of the pond and allocate the surplus land.

Recommended Types of Crops and Animals for Farming

Crops

Fruit trees and Other Perennial Plants: mango, coconut, tamarind, jackfruit, sapodilla, orange, banana, custard apple, papaya, santol, sesbania, horseradish, neem tree, cassod tree, lead tree, etc.

Short-lived Vegetables and Flowers: sweet potato, taro, yard long bean, eggplant, jasmine, aztec, globe amaranth, rose, Calotropis, tuberose, etc.

Mushrooms: nang-fah mushroom (*Pleurotus sajor-caju*), straw mushroom, abalone mushroom (*Pleurotus cystidiosus*), etc.

Herbs and Spices: areca palm, betel pepper, pepper, elephant yam, Centella asiatica, ebony tree, ringworm bush, vetiver grass, as well as certain types of crops such as holy basil, common basil, mint, basilicum, lemongrass, etc.

Wood and Firewood: bamboo, coconut, palm, camachile, combretum, coral tree, siris, lead tree, eucalyptus, neem tree, cassod tree, Pterocarpus, Dalbergia, Dipterocarpus alatus, etc.

Field Crops: maize, soybean, groundnut, cowpea, pigeon pea, sugar cane, cassava, castor, kapok, etc. Some types of field crops could be harvested when they are still young and sold in the market because they can get better prices than when they are ripe. Such types of crop are maize, soybean, groundnut, cowpea, pigeon pea, sugar cane, cassava, etc.

Soil nourishing and ground cover crops: pigeon pea, Caribbean stylo, African sesbania, sesbania, sunhemp, sword bean, cassod tree, lead tree, green pea, etc. After they have been harvested, the soil can be ploughed and turned over to further nurture the soil.

It must be noted that many plants provide more than one benefit. Emphasis in plant selection should be placed on perennial plants because they do not need intensive care once they are fully grown; while their products are obtained all year round if different types of plants have been selected. These perennial trees will provide shade and moisture to the living area and the environment. Not only that, it is necessary to consider the area's natural characteristics. For instance, eucalyptus should not be planted around the edges of the pond, instead, trees that yield fruits would be more suitable.

Animals

Aquatic animals such as common carp, nile tillapia, common silver barb, and catfish will provide protein supplements and can also be sold to earn additional income. In some areas, frogs can also be bred.

Pigs or chickens are raised along the edges of the pond. In this case, pig and chicken dung may be used for fish and duck feed.

Once farmers understand the principles and apply the preliminary steps described in Phase 1 successfully, they can then proceed to improve their living status in becoming self-sufficient; to cut down most of the expenses; and to be free from the external constraints. In order to accomplish greater productivity, it is necessary to follow the steps in Phase 2 and 3, respectively.

7.2 Phase 2: United Force of the Community

Once farmers have grasped the overall concept and successfully implemented Phase 1, which produced satisfactory outcome, it is time to begin Phase 2. The second phase suggests that farmers pool their efforts, resources, and form themselves into groups or cooperatives to execute the following activities:

a. Production (crop selection, soil preparation, irrigation system, etc.)

In this aspect, farmers have to work together in the production activities, which include water for storage, pond preparation, crop varieties selection, fertilizers, and other required inputs.

b. Marketing (sun-dry area, silo, rice mill, product distribution, etc.)

Once they have produced the product, the next step is for farmers to make the necessary preparations in order to optimize marketing prices of their produce. These activities include provision of a central rice-drying area, a silo to gather the rice crop, and a rice mill as well as grouping to sell their produce at a satisfactory price, which, in the process, also reduces their expenses.

c. Well-being (food, clothing, etc.)

Farmers also need to have a decent living standard, which equips them with the basic needs of life such as food and clothing.

d. Welfare (public health services, loans, etc.)

Each community should offer security and needed services such as a public health station or funds established to provide loans to carry out the community's activities.

e. Education (school, scholarships, etc.)

The community should play a dominant role in promoting the pursuit of education, for example by establishing a fund to support the education for youth.

f. Society and Religion

The community will serve as a tool for social and moral development with religion as a welding component.

All the above-mentioned activities require complete cooperation from everyone concerned, be it the government agencies or the private sector, and equally important, members of that community.

7.3 Phase 3: Joint Efforts between Groups or Cooperatives and Organizations or the Private Sector

After Phase 2, individual farmers or groups of farmers would then proceed to Phase 3, which involves making the necessary contacts and coordination to establish a fund or ensure funding from credit sources such as banks or companies, in order to assist them in the investment for activities that improve the quality of their life.

Under such arrangements, both farmers and the credit sources will receive mutual benefits as follows:

- Farmers can sell their rice at a higher price (without being suppressed in terms of the price they want in exchange for the products).

- Credit sources can buy rice at a lower price (since they buy directly from farmers and mill the paddy by themselves).

- Farmers can obtain consumer goods at a low price because they can buy in bulk (by operating like a cooperative store and having the privilege of buying commodities at a wholesale price).

- Credit sources can dispatch their personnel to various locations to implement different activities, which guarantee better results.

8. GOVERNMENT'S POLICIES AND STRATEGIES FOR CROP DIVERSIFICATION

The achievement of agricultural development over the past resulted from the country's existing natural factors which made it more advantageous than other nations, i.e. favourable climatic conditions, vast and fertile planted areas, oversupply and cheap agricultural labour costs. All these factors contribute to low production costs although the yields per unit area are not particularly high. However, as far as the world market is concerned, Thailand faces stiff competition from the agricultural sector of many countries of the world.

In the past, plans and directions for agricultural development were laid down in line with the economic changes and the national development guidelines as follows:

During the period of the First and Second National Economic and Social Development Plans, emphasis was placed on the improvement of the country's basic infrastructure. This included the construction of large-scale dams for irrigation and electricity, roads, the support for research, agricultural promotion and experimentation. Although these plans helped to develop infrastructure in farming communities, they did not trigger any dramatic improvement in the farmers' production levels.

The Third and Fourth Plans gave emphasis on speeding up agricultural production, quality improvement of export products, and production diversification. The latter was aimed at widening the range of commodities, that is rather than dwelling only on the major traditional crops like rice, maize, cassava, and para rubber. During this period, there was a great number of forest encroachments and expanding farm land. Hence, the importance of providing land ownership was taken into account by the promotion of land reform programmes. Still, this development did little to change the income distribution structure. It was envisaged that income derived from the agricultural sector was much lower than that of other sectors.

During the Fifth Plan period, importance was given to the increase in production efficiency rather than expansion of planted areas. Attention was also paid to income distribution, expansion of prosperity to rural areas, and alleviation of rural poverty problems. But the national development during this plan caused a remarkable disparity of income between agricultural and non-agricultural sectors. With regard to the Sixth Plan, its

development guidelines had been continued from the previous plan, focusing on restructuring of agricultural production, increasing production efficiency, promoting the application and transfer of technologies appropriated to each area, encouraging the private sector's involvement in agricultural development, improving the utilization and conservation of natural resources, as well as improving the administrative system of agricultural development.

The last three development plans of the Department of Agricultural Extension (DOAE) in 1982-1996 have focused on high output agriculture, resulting in a degradation and misuse of natural resources and causing serious pest, disease, soil and water problems, as well as problems to farmers' health. This has led to production problems, especially for the rural poor who have little or no access to credit and land rights.

The main objectives of agricultural extension development plan of DOAE during the 7th National and Economic Social Development Plan (1992-1996), were to:

- maintain and stabilize the agricultural sector growth rate and commodity prices.
- generate even income distribution and raise farmers' income.

The objectives are to be met through the following policies:

- restructuring agricultural production systems.
- stabilize farm prices and farmers' incomes.
- development of farmers' institutions, improving the quality of life of farmers and maintenance of the environment.
- development of the agricultural extension administrative system.

The promotion of crop diversification is a main component of these policies, aiming at improving small farmers' incomes and their standard of living through producing a low risk farming system, with a low capital input, which at the same time conserves natural resources and causes no harm to the farmers' health.

9. AGRICULTURAL EXTENSION POLICY AND MEASURES (FISCAL YEAR 2000)

The country's economic and financial crisis has had a detrimental effect on the reduction of annual budget expenditures, resulting in critical unemployment in industrial, commercial and services sectors. Meanwhile, the crisis also affected the increase in agricultural production costs since farm inputs such as chemical fertilizers, pesticides and other agricultural chemicals, pharmaceutical products and fuel have to be imported from foreign countries.

The agricultural sector has played a dominant role in food production; provision of raw materials for downstream industries; creation of job opportunities in rural areas to absorb the labour force; and foreign exchange earnings derived from the export of agricultural products. As a result, in this current crisis state, it is anticipated that the agricultural sector can help alleviate and rapidly revive the national economic situation to normal levels.

In order to maintain the growth rate in the agricultural sector, to increase the capability in export competitiveness of agricultural products to foreign markets, to accelerate domestic production for import substitution, to create jobs in rural areas to absorb unemployed workers and to prepare for global climate change, the Ministry of Agriculture and Cooperatives (MOAC) has adjusted its action plan for implementation in the last period of the 8th National Economic and Social Development Plan to include the following: 1) restructuring of the agricultural sector; 2) increasing in production efficiency and reduction of production costs; 3) improvement of products quality and processing; 4) restructuring of the MOAC; 5) promotion of rural savings; 6) management of chemical fertilizers and other agricultural chemicals; 7) management of forest, soil, water, coastal areas, and biological resources; 8) preparation for global climate change; and 9) preparation for the 21st Century.

With regard to the adjustment of the MOAC's roles and functions, the Department of Agricultural Extension (DOAE) has therefore been tasked to be a core agency to transfer agricultural technology (crop, animal raising, and fisheries) and to provide agricultural information services to farmers on a basis of one-stop service. By this means, farmers can bring the gained knowledge, experiences and skills to engage in their farming occupation to the extent that they can be self-reliant and can increase production efficiency at community level. This results in farmers' income generating, the improvement of the quality of life, the development of capability of local communities in making their own decisions, analyzing problems, participating in production, processing and marketing processes as well as managing national resources and environment which will lead to sustainable agricultural development.

Measures to Support Farmers to be Self-reliant

- Encourage local organizations and farmers to be able to analyze and draw up their own farm production plan at community level with the technical and information support from the extension agents.

- Assist small farmers and those who stay in the state's allocated land to produce food for household consumption by adopting integrated farming, the "New Theory" of agricultural development and other alternative agriculture so as to reduce marketing risks and high cost of production arising from imported production inputs.

- Encourage farmers' institutions or local communities to lessen the dependence upon external funds and promote rural savings as internal funds, instead. This fund will be used for improvement of production efficiency, support of processing and agro-industries or downstream agro-industries towards the production of value-added products. In addition, another fund will be set up to assist farmers and farmers' institutions in marketing aspects.

- Support farmers' institutions and local organizations to provide services in acquiring planting materials, breeding animals, and production inputs which are of good quality and of fair prices to farmers.

- Promote agricultural processing at household level to increase value of the products and develop a wide variety of product types to meet market demand.

- Support the establishment of local markets as places for purchasing and selling agricultural products in each locality.

- Enhance the setting-up of agricultural product storage at local level and accelerate the utilization of the existing ones so that the products can be gradually supplied to the markets according to the periodic demand.

- Promote backyard vegetable and native vegetable production sufficient for household and local consumption.

10. CONCLUSIONS AND RECOMMENDATIONS

It is envisaged that the production structure in the agricultural sector as well as in farm households has changed in line with the changing economic situation. Moreover, during the past few years problems such as water shortage for agriculture and low price for rice were prevailing. Therefore, the government's policy emphasized restructuring the agriculture production system in line with availability of natural resources, market demand and readiness of farmers by a) introducing other promising crops in substitution for the second rice crop and b) replacing rice with more remunerative commodities in areas unsuitable for rice cultivation.

The following are some general recommendations:

- The Ministry of Agriculture and Cooperatives (MOAC) must support and strengthen coordination among government officers in terms of budgetary and technical matters, as well as work benefits. Further, they should coordinate their work in adjusting land models for production systems within diversified cropping systems.

- The Government and/or financial institutions must set up available funds, so that long-term agricultural credit can be provided to build up diversified cropping systems with low interest rates for farmers, in line with their production plan. This will help generate quick returns from their activities.

- The Government must assist landless farmers in acquiring land in special areas in order for these farmers to make a living in agriculture. Furthermore, assistance must be given regarding models of production and related production inputs. The production models should be geared towards crop diversification.

- Local communities and farmer organizations should be assisted in production techniques, management, buying and selling of agricultural inputs and produce as well as in contract farming, so these organizations can function as centres for production and marketing services.

However, crop diversification programmes need a lot of investment. The major policies are: to have available credit systems, manage land reform and infrastructure development, and disseminate agricultural technologies and marketing information to farmers.

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CROP DIVERSIFICATION IN VIET NAM

Nguyen Van Luat*

1. INTRODUCTION

Crop diversification as understood in Viet Nam is defined as the strategy of shifting from less profitable to more profitable crops, changing of variety and cropping system, increasing exports and competitiveness in both domestic and international markets, protecting the environment, and making conditions favourable for combining Agriculture-Fishery-Forestry-Livestock.

Before 1989, when Viet Nam was a net food importer, crop diversification was studied under the National Cropping Systems Project based on rice and under the International Farming Systems Network, coordinated by the International Rice Research Institute (IRRI). The Project aimed mainly to increase food production.

2. CROP PRODUCTION AND ECONOMIC SCENARIO

2.1 Crop Production

There are 18 major food crops, in addition to the main fruit species, cultivated in Viet Nam. The cultivated area, yield and production of these crops are presented in Table 1. Rice occupies around 85 percent of the total area under rice, corn, sweet potato and cassava.

Data from Statistical Publishing House (Hanoi, 1999) show that the total area under crops was increased by 2,665,000 ha from 1990 to 1998. The increase of food crop area was the lowest (20.1 percent). The perennial industrial crop area was the highest (83.4 percent). Vegetables, annual industrial crops and fruit crops, increased by 50 percent as compared to the extents of 1990. Diversification on rice land has decreased, especially in the Mekong Delta, because of the fluctuation of prices of upland crop products grown in rotation with rice or through diversification of rice land. Farmers have frequently met with risks and uncertainty in prices. In the Mekong Delta non-rice food crops only contributed 10 percent to food production.

2.2 Economic Scenario of the Agricultural Sector

Crops, fishery and forestry contributed to the national GDP in 1990 to the tune of 40.7 percent, which decreased to 23.5 percent in 1998, although the net value increased by a big margin.

In terms of value structure, agriculture shared above 80 percent of the total value from agriculture, fisheries and forestry (1995-1998). In the rural economy, agricultural

* *Professor and Senior Scientist, Cuulong Delta Rice Research Institute, Omon, Cantho, Vietnam.*

production accounted for around 80 percent with animal husbandry (17 percent) and services (3 percent) making up the remainder. The country is trying to increase the proportion of the value structure from animal husbandry and services through industrialization and modernization.

With regard to trade of agricultural products, rice, rubber, coffee, tea, cashew nut, peanut, black pepper and other horticultural commodities are exported. Agricultural products imported are cotton, edible oil, milk and tobacco. Major crops for export are shown in Table 2. In 1999, 4.5 million tonnes of milled rice were exported from Viet Nam, which became the second largest rice exporter, after Thailand.

Table 1. Cultivated Area, Yield and Production of the Major Crops

Crop	Area (1000 ha)	Production (1000 tonnes)	Yield (quintal/ha)
Paddy rice	7,362.4	29,141.7	39.6
Corn	649.7	1,612.0	24.8
Sweet potato	254.9	1,517.3	59.5
Cassava	231.6	1,783.4	77.0
Vegetables	401.4	5,150.0	128.3
Beans	221.5	144.1	6.5
Cotton	20.2	20.7	10.2
Jute, kanef	8.7	18.6	21.3
Rush	11.0	67.0	60.9
Sugar cane	283.0	13,843.5	489.2
Peanut	269.4	386.0	14.3
Soybean	127.8	141.3	11.1
Tobacco	31.2	31.7	10.2
Coffee	370,602	409.3	-
Tea	79,180	229,540	-
Rubber	389,778	199,733	-
Coconut	142,504	105,450	-
Cash crops	196,003	53,251	-
Fruit crops	438.4	-	-

Source: Statistical Publishing House, Hanoi, 1999.

Table 2. Main Crops for Export (thousand tonnes)

Crop	1990	1995	1996	1997	1998
Milled Rice	1.624	1.998	3.003	3.553	3.800
Tea	16.1	18.8	20.8	32.2	34.0
Coffee	89.6	248.1	283.7	389.3	379.0
Rubber	75.9	138.1	194.5	194.5	185.0
Peanut	70.7	111.0	127.0	83.0	87.0
Cashew nut	24.7	99.0	16.5	33.3	30.0
Black pepper	9.0	17.9	25.3	23.0	23.0

Source: Statistical Publishing House, Hanoi, 1999.

3. PATTERNS OF CROP DIVERSIFICATION

3.1 Crop Diversification in Rice Land

Rice is cultivated mainly in the Red River and Mekong River deltas. It is difficult to practice crop diversification in the rainy season in both river basins. From November to May or June, upland crop(s) can be grown in rotation with rice if farmers have the capacity to invest on inputs and can get net returns from such cropping patterns. Upland crops in rotation with 2 rice crops are considered as "sub-crop(s)", for which farmers need not pay taxes.

In the Red River Delta, farmers have experience in growing an upland crop between two rice crops. Spring rice is harvested in June and early 'Mua' rice crop is harvested at the beginning of November. The possible upland crops to follow in this cropping pattern are potato, vegetables, beans etc., or at the end of October it could be corn, sweet potato or soybean. They are sown immediately after harvesting rice to avoid low temperature in winter. Short duration and non-photosensitive rice varieties are chosen for the early Mua rice crop. When necessary, crop seedlings for each hill are prepared by sowing seed in separate boxed seedbeds made of leaves or plastic. Sometimes farmers put seedlings of the upland crop in rice fields about 10 days before harvesting the rice crop. Such cropping systems (rice-rice-upland crop) are practiced on hundreds of thousands of hectares in the North, including the Red River Delta. Farmers can get more cash from the upland crops, especially by growing temperate vegetables such as cabbage, cauliflower and potato which can yield 15-20 tonnes/hectare. There is a residual effect from the upland crop for the subsequent spring rice crop which includes minimizing land preparation and weed control costs, and spending less on fertilizer.

In the Mekong delta, there is no problem of low temperatures. Farmers have grown many upland crops in rotation with rice, except crops of temperate origin such as cauliflower. Farmers grow winter-spring rice from November to February, then follow up with an upland crop before summer-autumn rice. It is interesting to note that in Longxuyen quadrangle, peanut has been grown on heavy soils (60 percent clay) on thousands of hectares, which can yield 3-4 tonnes/hectare. The soils in this region are perhaps high in organic matter (5-6 percent) and the difference of diurnal day/night temperature is high (6-10^{o}C). In terms of residues for the next rice crop, groundnut and vegetable soybean (65 days) are considered the best. Generally, no tillage is applied for upland crops. After burning rice straw, farmers make planting holes and place the seed. One of the problems of crop intensification for crop diversification on rice land is damage from floods in the rainy season. Floods occur from the middle of August and recede in November. Farmers are attempting to experiment with new technologies to overcome such constraints, for example, by using rice varieties with a duration below 90 days, or to apply a method of water seeding for the winter-spring rice crop in order to shorten the duration of the crop in the field.

In the 1960's and 1970's, *Azolla* was cultivated on a large scale in about 0.5 million hectares in the north, especially in the Red River Delta. *Azolla* could replace 30-50 percent of N fertilizer for winter-spring or spring rice crop, but this practice has since been abandoned. The reason is that *Azolla* cultivation requires a lot of labour with very precise conditions in the winter season and farmers had to spray insecticides and apply phosphorous fertilizer every 5 days. They also had to manage water and remove dew to dry *Azolla* every day when temperature was low (below 15^{o} C), if not, *Azolla* would die. Leguminous crops

such as groundnut, soybean, mungbean for either cash crop or green manure are feasible cultivation alternatives under these conditions. These leguminous crops can be grown in rotation with rice or intercropped with corn as well. Data from production experiments show that vegetable soybean (65 days for green soybean, 90 days for soybean seed) and peanut are the best for the above purpose, grown either as a cash crop or for green manure. Yield of the following rice crop can be increased by 20-30 percent, or it can decrease N requirement by 30-40 kg/ha. When grown as an intercrop with corn, spacing of 80 cm x 25 cm should be replaced by spacing of 120 cm x (25x40 double lines), as by these configurations the corn population will have the same plant density of 50,000 plants/hectare, which gives the same yield. Three lines with 40x20 cm of leguminous crop can be grown between two lines of corn with a spacing of 120 cm.

3.2 Crop Diversification on Sloping Land

The movement of soil, water and nutrients is the major problem on sloping land. For example, the Red River Basin is located on a split topography with steep slopes measuring 19-37 percent on the average and the Red River, therefore, annually loads 137 billion cusecs of water with a substantial amount of soil and nutrients, leading dramatically to erosion and rapid degradation of soils. Serious deforestation in the past for agriculture development reduced forest cover to 28 percent, but in recent years (1999) it has increased to 33 percent by using different measures.

According to the results of surveys of the National Institute for Soils and Fertilizer (1998), in the North the crop yields have decreased from year to year after clearing forest for crop cultivation. Some of the results are given below:

Crop Yields after the Third Year of Shifting Cultivation (kg/ha)

Crop	First Year	Second Year	Third Year
Upland Rice	1,300	700	400
Corn	2,500	1,500	600
Cassava	12,000	8,000	5,000

Depletion of the Organic Matter (0-30 cm depth) after Forest Cleaning

Cultivation Cycle	Organic Matter (%)
First year after forest cleaning	3.5
After 5 years of tea cultivation	2.5
After 5 years of cassava cultivation	0.9

Human activities under severe population pressure and poverty conditions often neglect erosion control measures on cultivated sloping land, although the best control measures are to keep a forest cover or re-forest, or to plant perennial industrial or fruit crops. In this situation, methods of farming activities are recommended such as planting crops on the contour, in combination with agro-forestry and intercropping.

Leguminous plants such as *Sesbania cannabina, Crotalaria strata, Cassia tora, Vigna indica, Tephrosia candida, Leucaena glauca* and *Medicago hispida*, are used on sloping land either for soil loss reduction or green manure. Cropping patterns of cassava with intercropped peanut and *Tephrosia candida* as hedgerows, or hedgerow tea culture on

the contour with mulching using rice straw can reduce soil loss by 60 percent or 80 percent, respectively, as compared to traditional cassava monoculture.

4. EFFECT OF CROP DIVERSIFICATION

4.1 Food and Nutrition Security

Products from crop diversification can be used for food and nutrition security. According to surveyed data in recent years milled rice use per capita decreased by about 1-2 kg/month; whereas there is an increased consumption of other products from agriculture (vegetable, fruits, sesame, peanut, mungbean, chicken, egg, pork, etc.) and from fisheries (fish, shrimp, crab) as a result of diversification of agricultural systems.

Data from surveys in Ho Chi Minh City in 1993 and 1996 showed that per capita/month consumption of milled rice decreased from 10.3 kg to 7.8 kg; whereas meat, fish, and egg consumption increased from 1.44 kg to 1.7 kg, 1.8 kg to 2.2 kg and 7 to 8.7, respectively. There is evidence of an increased consumption of fruits and vegetables. It is also evident that the volume of milled rice exported from Viet Nam is increasing from year to year. This is not only because of rice production increases, but also the improved eating pattern has contributed to this, since rice per capita consumption has decreased.

4.2 Judicious Use of Land, Water and Other Resources for Income Growth, Poverty Alleviation and Employment

Farming systems (popularly known as 'VAC') have become a popular movement throughout the country, led by the National and Provincial Horticulturist Associations, and supported strongly by the government. VAC can be considered as an economical and ecologically stable system within the framework of small farming households amounting to 13 million. Farmers are able to diversify not only crops, but also fisheries and forestry as well. From the original idea of 'VAC', there are several variations to the concept according to different situations and conditions, such as biogas production, field crops husbandry, agriculture, cropping hilly areas, agro-forestry, etc. There are many farmers growing traditional pesticide-free vegetables such as *Moringa oleifera lamk., Basella rubra L., Telosma cordata Merr.* and traditional medicinal plants for the “green medicine box”, such as *barleria lupulina* for healing toothache, and *Paederia lanuginose Wall* for healing abdominal pains, as well as organically grown vegetables. Hence, these are clean vegetables and clean herbal medicines, devoid of any fertilizer or pesticides in their culture.

Farmers in the Mekong Delta exploit the favourable conditions for practicing crop diversification. Because of the experience of flooding in the rainy season every year and drought condition in the dry season, farmers dig small canals around their fields, and make dikes to prevent submergence of farms. Ditches and dikes also help to keep water when flood waters recede. There are drainage pipes through these dikes to take water with silt and aquatic fauna and to wash away acid from decomposing organic matter when necessary. Framers call such a system ‘Vuong’. On the dike they plant many crops, feed fish and/or shrimp in canals, and grow rice crops in the fields. Before the arrival of floods, they harvest the rice and fish, and when floods recede, fish colonize the canals once again as the next rice crop is planted. Farmers can, and have to minimize chemical usage to protect the fish/shrimp in canals and the poultry and pigs living on the dikes.

There are some advanced techniques used for increasing rice production, decreasing water use and other material inputs, and making appropriate conditions for diversifying crops in rotation with rice, or feeding fish or ducks with insects that inhabit the rice fields. Some of these techniques are described as follows:

An Improved Sowing Method for Rice in the Mekong Delta

Out of the 4 million hectares of rice grown, there are more than 3.5 million hectares where they apply the broadcasting method (the rest is transplanted) with a very high seed rate of 200-250 kg or even higher. These farmers are now using the row-seeding method with the improved IRRI Seeder to replace manual broadcasting. The results from tens of thousands of hectares in all 12 provinces of the region show that application of the row-seeding method can save at least 100-150 kg rice seed/hectare, making better conditions for feeding fish or ducks in rice fields, decreasing damage by rats and other pests, and with a concomitant paddy yield increase of up to 20 percent.

Use of Very Short Duration Rice Varieties to Reduce Rice Crop Duration in the Field

From 1985, the Cuulong Delta Rice Research Institute (CLRRI) has conducted a breeding programme for rice varieties named 'OMCS', which developed short duration types of less than 90 days. Many such OMCS varieties have been released on a million hectares, not only in the Mekong Delta, but also in the South Central region, while some of them used in the North are OMCS7 and OMCS96. The results from research and production on a large scale demonstrate that the very short duration rice varieties (80-90 days) can grow and yield normally. Many of them can yield nearly 7-8 t/ha with high grain quality and resistance to several pests and diseases. Although agro-techniques for these varieties are new to farmers, they prefer to use them to escape from floods in the wet season, from drought and saline intrusion in the dry season, and have the advantage of saving more cropping days for other crops, or for crop intensification. Attempts are also being made to adopt the seedling broadcasting method from China (preparing seedlings for each hill in plastic plates with small holes). Adopting this method and using OMCS varieties, it is possible to shorten the duration of the rice crop in the field by 20-25 days.

5. PROBLEMS, CONSTRAINTS AND FUTURE OUTLOOK

In each agro-climatic zone, there are certain physical constraints. Generally, the main constraints in mountainous, hilly, and middle elevation terraces are erosion, drought, temperature, and soil degradation. Typhoons, floods, low temperatures and pests; and floods, drought and pest infestation are the main physical constraints in the North and South delta, respectively. However, socio-economic constraints are considered as the challenges for the whole country. High inputs for crop production and low quality of crop products are the main problems because of low technology levels applied by many farmers. Credit, post-harvest technology and lack of proper infrastructure facilities are also constraints for crop diversification for the development of sustainable agriculture.

Viet Nam is trying to overcome the above mentioned constraints for agricultural development as well as for crop diversification, in order to meet the requirements of domestic consumption and trade. There are long-term as well as short-term programmes in applying new technologies to improve crop production. National programmes for the

development of new crop varieties and animal races, as well as biotechnology in agriculture, are being funded by the national government.

Out of 22 agriculture research institutes, there are 15 institutes working directly on crops, 5 institutes serving crop production, irrigation and water management, planning and projecting, and policy formulation. They have responsibilities in studying and applying biotechnology, geographic information systems, informatics for planning crop production, breeding new crop varieties, post-harvest and processing, formulating policies for the government, and suggesting development strategies under varying conditions. The mandate of agricultural research institutes is to experiment and explore ways of improving technology for better effectiveness.

Agricultural extension systems are organized for villages, districts and provinces by the central government and are coordinated by the Department of Agricultural Extension. There are provincial extension centres for each province, and extension agencies or extension group at district or village level. Besides extension agencies, there are other extension organizations or activities of people's associations, companies, institutes and universities. All of them pay more attention to crop production.

Crop diversification will be given due attention, because of the requirement of improving consumption patterns, as well as for the benefit of all farmers who comprise approximately 80 percent of the population. Total calories from food of farmers and the poor are based on rice by 80 percent. This dependence should be gradually decreased to 60 percent, replaced by edible oil, vitamins, food rich in protein such as soybean, sesame, fruits, vegetables, peanuts, meat and fish. In terms of trade, total income from different kinds of crop products will be higher and more stable in local as well as in international markets. Finally, strategies for crop diversification have been developed and are available for implementation.

6. COUNTRY STRATEGY FOR CROP DIVERSIFICATION

In the past, when Viet Nam had to import food to meet the need for food security, food production had to be developed at any price, including clearing forest to plant cassava, upland rice, corn etc., on sloping land, resulting in severe erosion. Nowadays, the direction for agricultural development following the current strategy is to develop all aspects of agriculture based on national food security within the limits of resource availability. The strategy is also geared to increase within the short-term all sources of food and vegetables, in order to improve quality of consumption patterns and to decrease malnutrition. It is also planned to effectively change the structure of agriculture and the rural economy based on a stable food supply with emphasis on rice production (National Political Publishing House, Hanoi, 1996). Some of the salient policies of this proclamation are given below.

- The State has declared a policy on marketing economics from the end of the 1980's, which enables food and agro-products to be freely circulated between regions in the whole country, and even in the international markets. Farmers and companies are free to choose markets and consumers to derive the best benefits. Such an approach has promoted agricultural development, including a boost for crop diversification, which has helped to provide many commodities to consumers.

- The State promulgated the Law on agricultural tax with collection level ceiling at 7 percent of the output as against the previously levied 10 percent. Such tax benefits have encouraged agricultural land use efficiency and ensured equity between organizations, individuals and family householders who are offered land use rights when paying taxes to the government.

- Apart from the agricultural banking system, there are credit cooperatives and a credit fund for farmers. These institutions are promoting direct investment for various agricultural development enterprises. The State has formulated many programmes for financial support to the people in rural areas; special priorities were given to poor farmers and upland inhabitants at low interest. This policy has strongly promoted the development of the perennial industrial crop area and fruit tree culture, especially greening the barren land upstream of the Red River Basin and others.

7. CONCLUSIONS

- Crop diversification has been practiced in the country since 1989, when Viet Nam became a rice exporter. From 1990 to 1998, the growing area under rice increased by 20 percent; whereas the area under industrial crops increased by 83.4 percent; and annual industrial crops, fruit crops, vegetables and legumes recorded an increase of 50 percent.

- There have been a lot of State interventions and policies which support crop diversification and agricultural development in general, such as policy on marketing, on agricultural tax and credit; as well as programmes on poverty alleviation, creating job opportunities, greening the barren land, establishing facilities for transportation of inputs, irrigation and other infrastructure. The State also helped to re-organize and increase investment for agricultural research institutes as well as improving systems of agricultural extension organizations.

- There have been a number of technologies transferred to farmers in order to increase both quantity and quality of crops and improve cropping patterns in the delta regions or in the highlands. The results of production strategies show that almost all crops have yielded better, especially rice. Crop commodities exported from Viet Nam included not only rice, but also other crops. For instance, Viet Nam has become a cashew nut exporter and is ranked third in world commerce; it has also been ranked fifth in world coffee exports, and gained recognition for the export of many other commodities such as tea, rubber, peanut, black pepper, fruits and vegetables.

- The biggest constraints limiting crop diversification in the country are high cost of inputs and low quality of produce because of the use of archaic technologies, often resulting in low benefits. It is necessary to invest in research for developing not only improved varieties, but also better agro-techniques that can enhance the potential of varieties. Much attention should be paid on techniques that do not require inputs of expensive chemicals. Farmers should be encouraged to adopt measures to reduce crop duration, such as growing very short duration rice varieties (80-90 days), and application of the seedling broadcasting method in the Delta regions which can reduce crop duration in rice fields by about 20-25 days.

- Cultivated and growing area under rice amounts to 4.2 and 7.6 million hectares, which occupies 54 percent and 68 percent of the national crop area, respectively. It is necessary to reduce the area under rice for crop diversification in order to enable farmers to get higher incomes and practice sustainable agriculture. Two main directions should be applied to enhance crop diversification: a) to increase the trade value of crop products by growing more profitable crops and adding value through processing; and b) to educate farmers of the 13 million households in Viet Nam in improving their dietary habits by consuming non-rice food crops rich in protein, oil, vitamins and minerals.

INTENSIFICATION OF CROP DIVERSIFICATION IN THE ASIA-PACIFIC REGION

H.P.M. Gunasena [*]

1. INTRODUCTION

Most of the developing countries are dependent on agriculture for their economic as well as industrial development. In some of the Asia-Pacific countries, agriculture is the backbone of the economy and they are sensitive to changes in agricultural production, prices and other related policy options in the Region as well as in the global markets. Agriculture development will remain as the mainstay of the developing countries, in spite of the fact that most of them are moving towards industrialization. Therefore, the role of the agricultural sector in any developing country is focussed on food production, gainful employment, foreign exchange earnings, capital accumulation and labour replacement.

2. AGRICULTURAL LAND VS AGRICULTURAL POPULATION IN THE REGION

The total land area of countries in the Asia-Pacific Region vary widely, being highest in China (932.64 million ha) followed by Australia (768.2 million ha), India (297.3 million ha), Indonesia (181.1 million ha). Many small countries such as Bhutan, Fiji, Republic of Korea, and Sri Lanka have land areas below 10 million ha. Agricultural land as a percentage of total land has shown insignificant variation in the last decade. The average was 20.5 percent in 1988 and 21.0 in 1997; except in developed countries namely Australia, Japan and New Zealand, where some decline has been recorded. However, an interesting feature is the decline in the agricultural population to total population, which is common in the developing countries (66-62 percent) and also in the developed countries (7.6-4.9 percent) from 1988 - 1997. The agricultural population has shifted to the industrial sector not only in the Asia-Pacific Region but also in the whole world. The shift in the population from the agricultural to industrial sector focuses on two major issues on crop intensification in the Region. These are the high cost and the non-availability of labour even at any price during the cropping season. The high cost of labour has burdened agricultural production, particularly in the least developed nations, where labour cost alone account for over 50 percent of the total cost of crop production. The labour shortage is likely to continue, and its repercussion can be adverse unless crop production techniques are rapidly changed. The need for less labour intensive production technologies is emphasized.

The growth of population in the world has been rapid, intensifying the pressure on land. The total population in the Region has increased from 2.6 billion to 2.9 billion from 1988 to 1997. The largest populations are seen in this Region with China exceeding 1.2 billion and India (0.98 billion) which is on the verge of reaching the one billion mark. Of the 5.8 billion people in the world, about 50 percent of the people live in the Asia-Pacific Region. The growth of population is rapid, exceeding 3.5 percent in some countries. On the

[*] *Professor and Director, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka.*

other hand, the size of an average holding is smallest in the Region, and the land to man ratio has declined rapidly over the years. The per capita agricultural land available in the Asia-Pacific Region in 1961 was 0.35 ha, which declined to 0.27 in 1988 and further reduced to 0.25 ha in 1997. A further decline in land availability is inevitable due to urban development and industrialization in many of those countries, leading to unprofitable units for crop production.

Crop production can be increased by increasing the extents of agricultural land, which as evident from the above becomes an impossible task. The other alternative is to bring additional land under cultivation by expanding into marginal lands in different countries, but these have been almost exhausted and even with heavy investment may remain marginal. Hence, of the available options, increase in intensity of cultivation and in yields per unit area are the only available options to meet future food needs to feed an ever increasing population.

Technologies continue to be developed in various countries that will have an impact on future crop production. Most of these technologies are directed towards increase in yield due to less land availability. In the future, therefore, increases in food production to enhance food and nutrition security have to be achieved through intensive cultivation and high yield and to a minor extent through increase in land areas. Over 75 percent of the high yield increases will arise from improvement of the yield of crops, with the balance from expansion of land area and cropping intensities.

In the future the potential for yield improvement will be through technological innovations. The potential yield increases are likely to be greater in the developing countries than in the developed countries. It could be argued that the yields in the developed countries have reached optimum levels due to the full exploitation of the available technologies, a "technology fatigue", whereas the yields in the developing countries are always lower than the potential yield under experimental conditions. The yield gaps, which exist in most crops and the actual volumes at varying levels in different countries, point to the need for technologies which are less expensive. Estimates indicate that the yields, obtained in the less developed countries are about half to one third of those of the developed countries and even within the Region wide variations are observed. Therefore, there is much scope to increase the yield of crops.

There is a school of thought that the majority of small-scale farmers could be lifted out of poverty without the use of modern technologies such as improved seed, fertilizer and crop protection chemicals. They believe that soil fertility could be increased by organic manures, farmer bred and maintained indigenous varieties, biological or mechanical control of pests, diseases and weeds and human power to carry out farm operations. Although the low input sustainable agriculture (LISA) is getting popular in some industrialized countries its direct transfer to developing countries will have some resistance. With the present changes in the labour market and global trade, it cannot be applied and may not be relevant to the Asia-Pacific Region.

3. CONCEPT OF CROP DIVERSIFICATION

Crop diversification can be a useful means to increase crop output under different situations. Crop diversification can be approached in two ways. The main form and the

commonly understood concept is the addition of more crops to the existing cropping system, which could be referred to as horizontal diversification. For instance, cultivation of field crops in rice fields or growing various types of other crops in uplands have been defined as crop diversification. However, this type of crop diversification means the broadening of the base of the system, simply by adding more crops to the existing cropping system utilizing techniques such as multiple cropping techniques coupled with other efficient management practices. The systems of multiple cropping have been able to increase food production potential to over 30 t/ha, with an increase of the cropping intensity by 400-500 percent. The other type of crop diversification is vertical crop diversification, in which various other downstream activities are undertaken. This could be illustrated by using any crop species, which could be refined to manufactured products, such as fruits, which are canned or manufactured into juices or syrups as the case may be. Vertical crop diversification will reflect the extent and stage of industrialization of the crop. It has to be noted that crop diversification takes into account the economic returns from different crops. This is very different to the concept of multiple cropping in which the cropping in a given piece of land in a given period is taken into account. Besides the above, some other terminologies are also used to define crop diversification. There are terms such as "crop substitution" and "crop adjustment". It is necessary to indicate here that crop substitution and adjustment are linked to the main concept of crop diversification and are strategies often used to maximize profit of growing varieties of crops. The level of diversification will also be different in various countries. Diversification at farm level will involve growing of several crops for achieving self-sufficiency, but it may be a totally different approach at the national level. Crop diversification at national level will demand more resources and require selection and management of a specific crop or a group of crops sold freshly or value added to achieve higher profits.

There are several advantages of crop diversification, which could be listed as follows;

- Comparatively high net return from crops.
- Higher net returns per unit of labour.
- Optimization of resource use.
- Higher land utilization efficiency.
- Increased job opportunities.

In order to achieve the above benefits the process of diversification should be changed from very simple forms of crop rotations, to intensive systems such as relay cropping and intercropping or specialization by diversifying into various crops, where the output and processing etc., could be different. This process could be similar at farm level and national level.

4. CROP INTENSIFICATION

As stated earlier, primary constraints to achieving food security are the low yield per unit area, high population pressure, and negligible scope for expansion of the area of land for cultivation. Under these circumstances available options will be crop intensification and diversification through the use of modern technologies, especially seeds, fertilizer, irrigation, mechanization of agricultural production, post-harvest processing, storage, marketing and development of new technologies by research.

4.1 Crop Nutrition

A major contribution towards increased yield and sustained production could be achieved by using fertilizers and manures. The actual usage of fertilizers is generally lower in the developing countries than in developed countries and dangers of overuse, as observed mostly in the highly industrialized countries, has not been a problem. Organic matter usage has been less in most countries, but its incorporation into the agricultural systems will make the soils fertile and less degradable. Several problems exist in the use of organic manures such as the volume required, time, labour and opportunity costs. Another recent development is in the development of crop rotations, a strategy towards diversification of agricultural systems to increase productivity and crop yields. This involves the insertion of green manure cover crops or other legumes in the cropping systems as seen in several countries. The popular crop mixes are legumes in maize and other cereals.

The consumption of fertilizers in terms of plant nutrients is a reliable indicator of nutrient usage by different countries in the Region. During 1973-1983 nutrient consumption increased from 17 to 35 million metric tonnes. During 1988-1997 further increases have been recorded from 47 to 63 million metric tonnes in developing countries of the Region, with an average annual growth rate of 3.7 percent. The countries using the highest rates of fertilizer nutrients were China (36 m Mt) and India (16 m Mt). The developed countries of the Region (Australia, Japan and New Zealand) also recorded average annual growth rates of 9.3 percent.

Although the rate of fertilizer used has increased, per hectare usage has been less impressive. Many of the developing countries use less than 20 kg nutrients per hectare and this is regarded as a major reason for low yields. In 1997, the highest rates of fertilizer/ha have been used by the Republic of Korea (471 kg/ha) followed by China (266 kg/ha), Vietnam (218 kg/ha) and Malaysia (158 kg/ha). Among the developed countries of the Region Japan has used the highest amount of nutrients (366 kg/ha) followed by New Zealand (211 kg/ha).

Further analysis of nutrient usage indicates that a large proportion of the fertilizer is used in rice cultivation and insignificant amounts for other field crops. It is necessary to increase the use of fertilizers and manures to ensure high crop responses to the applied nutrients. It is also necessary to encourage the use of organic fertilizers to renovate soils and improve their physical and chemical properties and biological activity. Slow release organic fertilizers are also used in some countries where about 80 percent of total nitrogen is present as organic nitrogen. At normal soil temperatures of around 27^{o} C, about 60 percent of this nitrogen is released over the first four months. The losses due to leaching and volatilization will be less, hence the efficiency may exceed that of mineral fertilizers in the locations where these processes are likely to occur.

4.2 Agricultural Mechanization

Farm power includes human, animal and mechanical sources. In developing countries 80 percent of the farm power comes from humans. There is a trend for the shift of labour from agriculture to industry in most of the developing countries. This has already taken place in the developed countries. This would mean that the few remaining people in agriculture would be required to produce food for more and more people living in urban areas, showing 7 percent growth per year. Besides, labour costs are escalating, accounting

for a high proportion of the cost of production. For instance in Sri Lanka, approximately 50 percent of the total cost in rice production is accounted for by labour. Sometimes, labour is not even available at any price during cropping seasons and lands are left fallow due to shortage of labour. On an average a farmer using his own labour could feed himself and three others, using draft power he can feed 6 persons and use of tractor could increase the number to over 50. Hence, it will be futile to believe that the regional food demand could be met by traditional farming systems. Therefore, mechanization will be an urgent need for all developing countries in the Asia-Pacific Region and benefits of machinery use are generally apparent.

The use of appropriate farm machinery in the production chain will make farming more efficient and enable farmers to diversify cropping by growing more crops. In many countries mechanization at various levels has lead to improved yields and high labourer productivity. It is reported that in China use of mechanization has led to 10 percent yield enhancement and 15 percent if irrigation is included. Use of machinery for harvesting and processing increases yield by simply reducing crop losses. The post-harvest losses in developing countries are reported as 20-40 percent. Saving this amount is equal to increasing the yield without any added costs. Use of agricultural machinery shows an upward trend in the Region. Agricultural tractors in use have increased from 2.2-3.3 million over the period 1977-1987 showing a growth rate of 4.2 percent. Some countries of the Region have developed local agricultural machinery manufacturing industries. Sri Lanka has made remarkable advancements in the commercial manufacture of water pumps, paddy, threshers, dryers, ploughs, puddle wheels, pruning shears, sprayers, milling machines etc., at prices affordable by the farming communities.

It is, therefore, necessary to make realistic assessment of the use of machinery in the agriculture sector with adequate government support to develop an agricultural machinery industry in the Region, to counteract the labour shortages during the growing seasons.

4.3 Irrigation

Water, which was considered a free resource in many countries, has suddenly become a scarce commodity and major threat to food production and food security. According to the International Water Management Institutes nearly 1.4 billion people, a quarter of the world population or a third of those living in developing countries, will face severe water scarcities in the first quarter of the century (Seckler, 1999). While the regional water consumption is increasing rapidly, the water supply is decreasing. The increasing demand for water has several components, while agriculture uses a large proportion of water, non-agricultural water uses are also increasing. Urbanization and higher per capita availability are the main reasons for increased water use. Per capita water availability is already declining rapidly. In Asia, water availability has decreased from 99,600 m^3 in 1952 to 3,300 m^3 in 1999. It is predicted that water availability for domestic and industrial use will increase in developing countries from 13 percent to 27 percent in 2020. When water is rationed industry and domestic supply are protected and agriculture will have to make the best out of what is left.

In the Asia-Pacific Region about 35 percent of the agricultural land is irrigated showing an increase of 6 percent from 1988 - 1997. The irrigated area as percentage of agricultural land in Pakistan is over 81 percent, DPR Korea 73 percent, Japan 63 percent, and the Republic of Korea 60 percent, while in the other countries the figures vary from 1.1 percent in Fiji to 1.4 percent in Bangladesh. The total agricultural land under irrigation has

increased from 130 million ha to 158 million ha from 1988-1997. Large extents are in China (52 million ha), India (57 million ha) and Pakistan (17.6 million ha). In the other countries land under irrigation varies widely. There appears to be potential for further increases in irrigated land in most countries of the Region.

However due to the impending water scarcities in various countries some strategies and action plans may be required to alleviate any adverse situations. The following strategies could be used to overcome these problems:

- Ensure productive use of water in surplus areas for food production without being under-utilized owing to adequate food supplies.
- Develop markets or international mechanisms for reallocation of food from surplus to deficit areas.
- Reduce pollution of surface and ground water due to unscientific irrigation practices.
- Construct reservoirs for harvesting excess water especially in monsoonal regions.
- Conserve water by better irrigation management practices such as drip irrigation.
- Re-use and recycle waste water.
- Transfer water from surplus locations as already practiced in some countries of the Region.

The principle of micro-irrigation to deliver water to the root zone as the crop needs it, is no less valid for fertilizer. The combination of irrigation water with fertilizer, known as "fertigation" will be an obvious solution to get maximum benefits from their inputs while conserving the environment. Micro-irrigation will be an efficient tool to increase water use efficiency and its adoption is increasing. In Israel where these technologies have been perfected, the micro-irrigated area has increased from 10,000 ha in 1975 to 104,000 ha in 1999. FAO estimates that about 30,000 ha in the Near East Region or around 1.4 percent of the total area is under irrigation. In the Asia-Pacific Region also micro-irrigation is catching up. In Sri Lanka many crops such as banana, vegetables and other floriculture crops, coconut etc., are micro-irrigated. This method has many advantages: all nutrients are applied in soluble form and are readily available to the roots; absorption and precipitation processes in the soil are minimized, which is particularly important in the case of P and K; nutrients are placed in the active root zone increasing fertilizer use efficiency and reducing labour cost; and nutrient formula and ratio can be changed according to the crop. These changes can be made at different growth stages, and small doses at frequent intervals minimize osmotic stress in crops grown under saline conditions. Therefore, fertigation could economize on both water and nutrient use, and hence it can conserve natural resources and protect the environment.

There is significant scope for increasing food production through integration of water-based production and services. These include integrating aquaculture and fisheries, a concept referred to as the farming of aquatic organisms into agricultural development efforts.

4.4 Use of Improved Seed

Improved seed is one of the major contributors to crop diversification through development of appropriate cropping systems. The quality seed development at national level will be essential for yield improvement. The increase in annual yield of rice from 1.9 percent in the 1970’s to 28 percent during the 1990’s was attributed to use of improved seed

coupled with better management practices. In most of the countries, estimated area planted to HYVs has increased as shown in Table 1.

Table 1. Estimated Areas planted to HYVs and Hybrid Rice (percentage of total rice areas) in Major Rice-Producing Countries of Asia

Country	1989		1997	
	HYVs[1]	Hybrid Rice[2]	HYVs	Hybrid Rice[3]
Bangladesh	40.7	--	65.0	--
India	62.0	--	70.0	Neg
Indonesia	73.0	--	85.0	--
Myanmar	51.9	--	51.9	--
Philippines	88.5	--	93.0	--
Sri Lanka	90.0	--	95.0	--
Vietnam	--	--	85.0	Neg
China	--	50.0	45.0	50.0

[1]IRRI, 1995
[2]Yuan, 1996
[3]FAO estimate (Neg = hybrid rice was planted to about 120,000 ha in India and about 180,000 ha in Vietnam)

Among other cereals, the highest coverage under modern varieties is for wheat. It is estimated that more than 70 percent of the wheat acreage in major wheat producing countries (Bangladesh, China, India and Pakistan) is under improved varieties. In other crops, use of improved varieties is not extensive, but there is plenty of scope as farmers are quite responsive to the new varieties and have increasingly adopted them as and when they are released for cultivation.

4.5 Protected Agriculture

The most recent addition to crop diversification is the introduction of crop production under controlled environments. This concept known as protected agriculture has made rapid headway, becoming popular among middle income agriculturists. Protected agriculture or controlled environment agriculture is the modification of the natural environment to achieve optimum plant growth. In these systems various factors of the environment such as air, temperature, humidity, atmospheric gas composition, nutrient factors etc., are controlled. These technological developments coupled with use of high quality crop varieties are integrated into a system of agricultural production, which is referred to as protected agriculture.

The main forms of protected agriculture include the use of mulches, row covers and poly-tunnels. It has been a common practice to use organic mulches such as straw, dead leaves, coir dust etc., to modify the environment to make soil more favourable (weed and moisture control) for plant growth. However, in the recent past these low cost agronomic practices have received less attention from the farmers. Plastic mulches are also used for the production of high-value crops and pineapple plantations in Hawaii. Plastic mulches with drip irrigation are widely used as irrigation water and fertilizers (fertigation) could be applied together with the added advantage of reducing cost of production. Row covers have also been used since the 1950's. These are polyester sheets stretched over rows of plants as seen

in tobacco nurseries. These also help to prevent crop damage by insects, sunlight and sometimes frost in cooler areas. These technologies are used with other related technologies, such as hydroponics and drip irrigation and these are the major areas of protected agriculture practiced in different countries. In Sri Lanka, poly-tunnels, drip irrigation and hydroponics are commonly practised and demonstrations have been established by the Department of Agriculture.

In most countries soil is the medium used to grow vegetables and other crops. When plants are grown in the soil several problems are encountered due to many soil borne diseases and pests. These problems increase the cost of production due to the use of pesticides and soil fumigants. This has lead to the use of hydroponics. Hydroponics culture/soil-less-culture is a means of growing plants in a nutrient medium without soil to support them. This method began around the 1930's on a commercial scale with research conducted on many aspects by the University of California, USA. Hydroponics culture will facilitate growing of plants in areas with marginal conditions for crop production, such as adverse climate, soil, disease and pest occurrences. The controlled system with soil-less-culture could be used to obtain high yields but requires good management skills for successful crop production.

Many benefits could be obtained by practicing controlled environment agriculture. Some of the major benefits could be summarized as follows:

The land available for agricultural production is continuously decreasing due to the development of industries, urbanization, housing projects etc. The per capita agricultural land in the Region at present is only 0.25 ha. Therefore, future food production will have to come through intensive cropping on small extents of land and crop production strategies may have to be changed. It is here that the protected agriculture has to be considered due its specific advantages in food production.

Labour is a major limitation in open field agriculture. As protected agriculture requires less labour, it could offset the initial high investment.

Excessive uses of inputs such as fertilizers and pesticides, frequent cultivation, and lack of proper erosion control systems are constant threats to the environment. As input use, particularly fertilizers and pesticides, is controlled in protected agriculture, not only will it be economical in terms of input use but also environmentally friendly and provide products of high quality free of pesticide residues for human consumption.

In drought prone areas, scarcity of water during periods of droughts, and irregular rainfall has been responsible for crop losses. Under controlled agriculture water use is controlled and is minimal. This will be a major advantage in introducing protected agriculture to dry regions.

The major advantage of protected agriculture is high crop yield compared with open field agriculture. These high yields are achieved through the provisions of optimum conditions such as balanced plant nutrition for plant growth, which the open field agricultural operations can never provide.

It is very essential to develop low cost poly-tunnels so that the system could be adopted by many entrepreneurs. The development of structures with locally fabricated

material having sufficient durability should be undertaken to make the systems affordable to as many groups of the farming community as possible.

Another major issue is regarding the type of crops having a competitive advantage that could be grown. The diversification into selection of high-value crops that have markets both locally and overseas and those with high genetic potential for yield and quality will be essential for success. Today, some of the crops grown under controlled environments include: tomato, sweet corn, red, green and yellow bell peppers, strawberry, cauliflower, cucumbers, cantaloupe, lettuce, green peas and ornamentals/cut flowers. To achieve maximum benefit these systems will require easy access to good seed, preferably hybrid seeds, which are commonly used in advanced countries. There is a need to study the feasibility of developing hybrid seeds as imports will be costly and non-affordable by the farmers as they will have to be replenished every season.

Standard methodologies should be developed for crop selection, raising seedlings, production methods, irrigation/fertilizer application, pest control (particularly IPM), which could be used in these high-tech systems. Research and development will be required to refine existing technologies as appropriate to different ecological regions of different countries.

The main markets for protected agricultural products are the super markets, airline caterers, hotel industry and exports to a limited extent. There should be market intelligence, which should be provided to the growers, processors and exporters to encourage and maximize profits.

4.6 Organic Farming

Organic farming includes all types of agricultural production systems, which are environmentally, socially, and economically sound. It has been defined differently by several workers, but all of them lay much emphasis on soil and environment conservation. It is also different to traditional farming in that it involves a holistic approach to sustainable agriculture. This form of crop diversification has spread on the continent, particularly in Germany, Switzerland, Austria, Denmark, Sweden and Finland and is spreading into the Asian and African continents. The demand for organically grown food is gaining momentum all over the world. The USA market volume for organic produce is in the region of 5 billion US Dollars. It is also increasing in developing countries. The question often asked is whether organic farming could feed the rapidly growing world population? This is debatable; but even with the “Green Revolution” with plentiful use of chemical fertilizers, over 800 million people of the world are starving and many may die of hunger.

4.7 Role of the Farming Community

In crop diversification towards sustainability, far greater emphasis should be given to farmer participation in adopting and implementing new technologies. It is also necessary to combine farmers’ traditional knowledge with the contribution of sciences, solicited in a way that addresses their needs, values and objectives. Crop diversification strategies have failed in most cases due to ignorance of farmer involvement and external and internal factors that effect the system. One of the major issues is also crop selection. In rice-based crop diversification, crop selection does not pose a severe problem as it depends on the soil type. In upland crop diversification, crop selection and management depends on market values and

past experience. A sustainable programme of diversification could be achieved only through farmer participation in the planning process. According to Marambe *et. al.* (1999) for crop diversification in minor irrigation schemes in Sri Lanka, the major factors are the decisions made on selection of crops and efficiency of resource allocation and utilization.

4.8 New Technology Development

Asian Agriculture has benefited from innovative front line research during the past two decades. Rapid progress has been made in cereal production due to the development of high yielding varieties of rice, wheat and maize. Cereal breeding, including the production of hybrids, is continuing which will enhance crop production in the Region.

Modern biotechnology in which characteristics based on single genes can be transferred from any organism to plants has resulted in transgenic plants combining disease or insect or herbicide tolerance. Therefore, the emerging genetic technologies could be beneficial to farmers due to their cost effectiveness. On a global level, transgenic crops increased from 2.8 to 12.8 million ha from 1996 to 1997. The industrialized countries grow large extents (75 percent) while developing countries (especially China in the Region) grow only 25 percent. The use of transgenic crops has come under severe scrutiny in recent times and some countries have completely banned their import until the actual situation is clarified.

The development and utilization of new technologies have to be supported at the national level, both in terms of capacity building with appropriate training, and policies programmes, and mechanisms for their implementation. Increased resources for agricultural research and development are essential so that conventional and biotechnological applications can be accelerated and integrated to produce high yielding crops and safer foods. It is now widely acknowledged that conventional technologies will be less than adequate to double food production, and biotechnology will be an essential strategy to achieve food security in the Region.

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UNCTAD'S PROJECT ON CAPACITY BUILDING FOR DIVERSIFICATION AND COMMODITY-BASED DEVELOPMENT

Alexei N. Mojarov [*]

The international community has recognized that horizontal and vertical diversification by commodity dependent developing countries is a priority for their development and invited the United Nations Conference on Trade and Development (UNCTAD) to provide assistance to developing countries in this respect. Starting from 2000, UNCTAD is embarking upon a two-year Project on Capacity Building for Diversification and Commodity-Based Development. In charge of the Project is UNCTAD's Commodities Branch of the Division on International Trade in Goods and Services and Commodities (DITC).

The Project's objectives are: i) to promote the horizontal, vertical and geographical diversification of production and trade structures; ii) to improve governments' capacities to formulate focused, effective and sequenced policies in this respect; iii) to increase the competence of enterprises in adapting their business strategies and supplies to the Post-Uruguay Round trading framework; and iv) to strengthen positive linkages between the commodity sector and the rest of the economy.

Within the framework of the Project the following activities will be carried out:

a) Preparation of policy oriented studies on export diversification strategies of governments and enterprises, and on development implications of diversification for the exchange of experiences and capacity building.

b) Regional workshops for enterprises and government officials, focusing on export diversification strategies of governments and enterprises, and on development implications of diversification.

The workshops will be organized in the four developing regions, namely Africa, Asia, Latin America and the Pacific. These workshops, where not only regional experiences but also those from other regions will be discussed, will provide the framework for national as well as regional or sub-regional capacity building programmes. The regional workshops then will be followed by national workshops expected to be held in 10 countries covering developing regions. The national workshops will bring together the government, the enterprise sector, civil society and relevant international organizations to make proposals on enterprise strategies as well as the most efficient and cost-effective government policies and measures, including those aimed at improving physical and human capacities to promote diversification and to ensure that the disadvantaged segments of the society benefit from

[*] *Economic Affairs Officer, Commodities Branch, Division on International Trade in Goods and Services, and Commodities (DITC), United Nations Conference on Trade and Development (UNCTAD), Palais Des Nations, Geneva, Switzerland.*

diversification, taking into account administrative requirements, sustainability concerns and the social and human context.

The regional workshops for Asia and the Pacific will be organized by UNCTAD in close cooperation with the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The workshop for Asia is tentatively scheduled for the first half of 2001 to be held in Bangkok.

ALTERNATIVE CROPS AND CULTIVARS FOR NEW OPPORTUNITIES

Mahmud A. Duwayri *

"Alternative Crops and Cultivars for New Opportunities" is one of the Programme Entities/Projects of the Crop and Grassland Service of the Plant Production and Protection Division of FAO. There are about 150 crop species which have already received attention from breeders and commerce and have evolved through human intervention into widely cultivated species. Of these, 10-15 produce half of the world's food and materials. This evolution is, understandably, led by the nations with the most resources and is basically for their own and more stable high input and often subsidized systems. Novel technologies in emerging crops, cultivars, protected agriculture and cropping systems need to be made available to and tested in developing countries, where farmers have a need for stabilization of their specific agro-environments, particularly through establishment of suitable species and high-value cultivars with food, feed, fuel, fibre and pharmacological potential. The identification of alternative crops and improved technologies would aim at providing a comparative advantage within a given agro-ecological and socio-economic context. Sustainable intensification of agriculture without further degradation of natural resources remains a challenge.

Risk reduction through diversification (related to climatic and biotic vagaries, particularly in fragile ecosystems and commodity fluctuations) by expanding locally adapted or introducing novel varieties and related production systems, will contribute to improved food security and income generation for resource poor farmers and protect the environment. Small family farms will not be able to increase their total income to acceptable levels with the production of staple food crops as these are invariably of low value for the farmer/producer. To increase income the farmer needs a higher value product that can be obtained by adding value to primary or secondary products. Fruits, vegetables, herbs and spices, flavourings, natural colourants, medicinal plants and others all offer an opportunity for farmers to produce higher value products. Nevertheless, introducing new crops on their own is unlikely to be successful as the whole technological and commercial package needs to be introduced at the same time. Hence, this technical project is based on the introduction of alternative crops with production, processing, marketing technology and nutritional information. The project is closely related to the Special Programme on Food Security as 80 percent of the world's poor live in fragile ecosystems. FAO's multidisciplinary approach and global networking capacity can identify and match new crops and novel cultivars and their production systems to targeted isozones and their peoples for both extensive and intensive applications. A continuing review of technology advance in existing and "new" crops is a pre-requisite and has to be based both on indigenous and international knowledge.

The objective of the Project is the broadening of the crop and cultivar knowledge base for better use of the plant density in support of crop diversification options into targeted eco-zones in relation to food and income security targets and market opportunities.

* *Director, Plant Production and Protection Division (AGP), Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, Rome, Italy.*

The major outputs are:

- Integration of fragmented knowledge on lesser-known plants with localized and/or international potential as crops.

- Assessment and promotion of high-value crops for distinct agro-ecological environments.

- Introduction to and expansion of palms to Africa.

- Technology transfer for integrated greenhouse crop production and protection management.

Integration of Fragmented Knowledge on Lesser-Known Plants with Localized and/or International Potential as Crops

FAO receives many requests for multidisciplinary information on plant species or novel cultivars for which data exists but is scarce and globally fragmented amongst ethnobotanical observations, publications, institutions, private enterprise and networks in general, including the Internet. This global plant resource is under threat from population pressure and other poverty-related interventions causing habitat destruction and excessive wild harvesting. A narrow major crop base exists in environments often unsuitable to the approximately 150 widely cultivated species developed for 'commercial' environments. This major output will harness knowledge on lesser-known species and their environmental requirements, which will help local institutions to decide on diversification for income stability, food security and environmental stabilization.

FAO's multidisciplinary approach and global networking capacity can identify species contacts and integrate scattered information into an ecologically-related knowledge processing system to better respond to member's and other's requests. Information including illustrations, references, contacts, specific methodologies and glossary terms will be gathered from publications, institutions and individuals and collated into species monographs to be delivered through the Internet, via CD-ROMs and hard-copy downloads. Specifically the output will consist of:

- EcoPort and other knowledge and training management systems developed to target plant species adapted to fragile environments; publications on novel crops and novel varieties of established crops.
- Description of Good Agricultural Practices for introduction of new species.
- Species-related training tool on crop production, sustainable utilization and benefits.
- Networks umbrellaed and participation in network meetings.

The Effects of Major Outputs will be:

- Easier access to species-specific and structured information presently not covered by other organizations or institutes resulting in better crop management.
- Potential for crop base broadening for food security and income generation in fragile ecologies identified.

- Broader knowledge on use of the species and its products increase in networking partners and knowledge gathering.

The Indicators of Achieving Major Output Effects will be:

- Amount of fragmented information and training material on ecozone adapted species or varieties collected, structured, requested and delivered through the Internet, CD ROMs, FAOR download and hard copy publication and distribution.
- Number of species described.
- Number of partners working on specific species.

Assessment and Promotion of High-value Crops for Distinct Agro-Ecological Environments

Within new opportunities, which derive from trade liberalization (GATT Agreement) assistance will be provided to member countries to explore the comparative advantage for developing emerging and high-value horticulture and industrial and specialty crops in accordance to their agro-ecological potential and socio-economic interest. The aim is to achieve the full agronomic and economic potential to meet the changing needs of producers and consumers. Information will be collated and disseminated on the origin and propagation of high quality planting materials and their agronomic performance under distinct agro-ecologies and cropping systems. The advantage of selective high quality produce including "bio-labeled" products will be explored to address specific market niches. Special attention will be given to fostering inter-country cooperation and networking amongst scientific institutions with the aim of facilitating coordinated research and development initiatives and to eventually complement the requirements for those crops, which are presently not dealt with by the CGIAR. In this context, priority will be given to principal emerging crops or new cultivars as diversification options for small-scale farmers and commercial-scale initiatives based on out-growers schemes eventually through technology transfer.

The Effects of the Major Output will be:

- Strengthening of on-going sub-regional, regional and global networking among scientific institutions and other partners.
- Improved knowledge and better use of plant bio-diversity towards diversification and use of lesser known crops and cultivars with required agronomic and quality traits for local markets and export opportunities.
- Governments and private sector awareness of the potential for high-value and promising horticultural and industrial crops as a contribution to the global food security strategy.
- Information on high-value crops and cultivars accessible through information materials and database.

The Indicators of Achieving Major Output Effects are:

- Expansion of new crops and cultivars in selective agro-ecological areas.
- On-going cooperative research and development initiatives.
- Commercial and small-scale farmers have adopted new crops species and cultivars as a diversification option.

- Database and information material accessed/consulted.

Introduction to and Expansion of Palms in Africa

Semi-arid (including long dry season) regions are often subject to total loss of annual crops through drought or concentrated rains. These crops demand constant soil disturbance in their cultivation, leading to environmental degradation. The establishment of palm species adapted to specific agro-ecological conditions would help to alleviate such fluctuations and help to protect annual crops and to maintain ecological stability. This, in turn, would help in the establishment of a more balanced generic floric and faunic system; vital in sustainable Integrated Crop Management. Palms are prime candidates for income generation, food security and biodiversity enhancement through environmental stabilization, particularly in semi-arid and sub-humid areas. The major and long-term results will fix rural populations in their environment. Medium-term benefits will establish pilot projects upon which institutions can extrapolate to similar ecologies and procure additional funding for expansion.

Through globally integrated networks, including CG centers, FAO can readily identify opportunities for transfer of technology on palm species potentially adapted to the target environments. AGPC has a proven record of success in technology transfer related to this major output (dates and oil palm) which can be expanded to similar edaphoclimatic conditions and with new introductions to these and other environments. Regular Programme pilot establishment projects will lead to funding from TCP and/or donor and commercial participation. Specifically the major output will consist of:

- Descriptions of the species, products and agro-ecological requirements.
- Exchange of information on cultivation techniques.
- An umbrella of related palm networks.
- Pilot introduction or expansion tests.

The Effects of the Major Output will be the following:

Results of pilot projects and provision of technical information will demonstrate the potential for perennial crop base broadening for food security and income generation in fragile ecologies. It will catalyze the use of palms in perennial/annual crop systems and, in the long-term, enhance environmental protection.

The Indicators of Achieving Major Output Effects are:

- Community uptake of transferred technology, requests for expansion.
- Degree of government, donor or private industry involvement.

Technology Transfer for Integrated Greenhouse Crop Production and Protection Management

In the context of liberalized market exchanges, greenhouse crop production technology offers the possibility to engage and compete with high-value horticultural crops and to sustain the production throughout the year for continued market supply with fresh

produce. This is of particular interest in meeting the demand for new market niches with vegetable and floriculture products. The real potential for increased productivity, control over quality and timing of the production are the real assets.

In addition, protected cultivation techniques will allow a more efficient use of natural resources and a reduction in the application of pesticides. It should be realized that in the race for increased productivity, farmers have often resorted to the excessive use of inputs and specifically mineral fertilizers, pesticides and also irrigation water. These practices are a threat to soil and ground water pollution leading to health hazards for both the producers and consumers. By growing plants in a controlled environment, the conditions are created for reducing the reliance on pesticides applications and for allowing considerable savings on water and fertilizer requirements while catering for high quality and safe produce with higher market value. Assistance will be provided to member countries through technical advise and training for the adoption of Integrated Greenhouse Production and Protection Management (IGPP) by the farmers. The IGPP strategy is proposed as an integrated package combining crop management, climate control and technology, including substrate and hydroponic cultivation aiming at the reduction in use of water, fertilizers and pesticides.

Capacity building will be provided for the design, construction and assembling of greenhouses within the country in order to create job opportunities and to lower the price. Priority attention will be given to the adoption of agronomic and technological solutions aiming at the avoidance of environmental pollution and meeting the requirements of international standards in regard to LMR (Limit of Maximum Residues) as established i.a. by the EU. Through inter-country cooperation and networking IGPP packages will be experimented and validated. Information will be compiled and circulated through modern communication aids including web-site. Greenhouse crop technology is particularly suited to vulnerable and difficult environments including arid and semi-arid regions of North Africa and the Near East as well as high rainfall areas in the humid tropics of tropical Africa, Latin and Central America, Caribbean, Asia, Pacific and Indian Ocean. Greenhouse crop production is expected to be particularly attractive to the young graduates and other private farmers who look for a more "technified" and business oriented agriculture. This output will strengthen the SPFS and specifically it's "intensification" and "water management" components. It will allow to convert areas with less natural potential into highly productive and income generating agriculture areas. Further more the greenhouse creates an attractive working environment to facilitate the work of women irrespective of the outside weather conditions and time of the year. The final success will depend on the availability of market outlets. Therefore, continuous monitoring of market opportunities need to be made and special attention will also be given to the socio-economic constraints, including access to small credits for the establishment of small-scale, family type greenhouse units.

The Effects of the Major Output will be:

- Awareness about the advantages of Greenhouse Crop Technology.
- Increased income and productivity; reduced pesticides applications, improved WUE.
- Countries have formulated a strategy for Greenhouse development within the overall agriculture development policy.
- Knowledge base available about Integrated Greenhouse Production and Protection Management.
- Better crop management practices are applied resulting in better labour comfort and efficiency.

- Business plans have been formulated to promote investment in the Greenhouse crop sector for small-scale farmers.

The Indicators of Achieving Major Output Effects are:

- Greenhouse sector has expanded in different climatic zones (Mediterranean-arid and semi-arid, humid topics).
- More young and women entrepreneurs have become greenhouse crop producers.
- Greenhouse policies adopted including MRL standards.
- Increased availability of high quality and safe horticultural produce originating from the greenhouse crop sector meeting the MRL standards.
- Reduction in the use of agro-chemicals (mineral fertilizers and pesticides).
- Improved water use efficiency (WUE).
- Local private workshops established for greenhouse construction and assembling.

CONCLUSIONS AND RECOMMENDATIONS

- The consultation recognized that crop diversification is one of the best options to increase farm income leading to food, nutrition and ecological security as well as poverty alleviation in the region. Therefore, greater attention should be paid to crop diversification by the governments of the region. Crop diversification could be approached in two complementary and interactive ways; a) horizontal diversification through expanding the crop base by substituting or adding more crops into the cropping systems as commonly practiced by many countries of the region; and b) through vertical diversification in which downstream activities are undertaken to add value, indicating the stage of industrialization of the crops and their economic returns. Vertical diversification is complementary to horizontal diversification, and the opportunities should be exploited for product diversification and value addition to achieve highest economic returns.

- Efforts have been made by different countries to identify high specialty crops, new crops, off-season varieties and production systems, and novel varieties of crops with comparative advantage, mainly fruits, vegetables and ornamentals, to open up new opportunities for farmers. It was noted that the promotion of multipurpose species would also be useful for diversification of agro-processing on small scale at local/national level for productivity enhancement and expanded employment opportunities.

- Rice is the most important crop in Asia. However, in marginal areas, rice-based cropping systems have relatively low returns. Improving the current cropping systems to enhance their sustainability to the extent possible, and shifting marginal areas out of rice into other more profitable crops is seen as a solution. Alternatively, flexible cropping systems for upland farmers that feature production of more income elastic goods like horticultural products are a means of diversifying their income sources.

- Concerns have been expressed regarding the policies of some countries to reduce the extent of land under major perennial crops and rice; and subsequent repercussions of these will have a long-term bearing. It was noted that such crop replacements unless carefully analyzed might have adverse effects on the food and industrial product supply in the region.

- The need for improved seed and other planting materials for effective crop diversification was recognized. The production of quality seed through national seed programmes and efforts of many countries towards hybrid seed development was noted. The consultation recommended the strengthening of national seed enterprises and promotion of private seed industries to supply quality seed and other planting materials which is so vital for crop diversification. Steps should be taken to maintain effective national and sub-regional seed security in the region through regional collaboration.

- The high post-harvest losses of crop produce particularly in horticultural crops which annually account for 20-40 percent in most countries, if prevented, could increase yield by similar amounts. It was recommended that efforts should be made to

minimize such losses. The development of links with the food industry for product diversification and value addition to meet the demands of the changing society was recommended.

- Serious concern was expressed of the soil fertility depletion, due to continued intensive cropping over long periods of time, which needs to be corrected. The use of organic manures as replenishments through direct application or crop rotations and insertion of green manure crops and other food legumes in the cropping systems was recommended.

- Due to the impending labour shortages for agriculture, the need for mechanization of field and post-harvest operations was noted. Need for mechanization of agricultural operations and assessment of the machinery use by the agricultural sector of countries of the region was emphasized. In view of limited land, water and labour supply, the need for adoption of emerging agricultural technologies such as protected agriculture, organic farming, Integrated Plant Nutrient System (IPNS) and Integrated Pest Management (IPM) was emphasized. Efficient input supply systems through micro-irrigation and fertigation should be encouraged.

- The role of the private sector in the development of modern agro-enterprises to infuse capital and technology into diversified cropping systems for effective commercialization for long term sustainability was advocated.

- The importance of diversification to value-added export oriented crops was emphasized. In that context, the need to study marketing opportunities and product standards required by importing countries, as well as price fluctuations, competitiveness etc., prior to embarking on diversification, was highlighted. Furthermore, the availability of market information was considered essential for identifying promising external markets. In general, there is no point in diversifying into a crop for which market potential is limited.

- Individual countries have developed policies, strategies and implementing mechanisms for crop diversification. These include infrastructure development (transport, communication and markets), pricing policies, subsidies, insurance schemes, tax, tariff etc., in order to minimize risks and safeguard the interests of agricultural entrepreneurs. As the strategies adopted by different countries are innovative and diverse, sharing of such information will benefit the other countries to stabilize and sustain their crop diversification initiatives.

- The governments role in recognizing farmers participation in the total process of crop diversification, provision of information on new crop varieties, technologies to be used, potential yields, marketing avenues and incomes to be realized was essential for the development of successful crop diversification programmes. The need for skill development and capacity building and documentation of required information through the production of field manuals, extension leaflets etc., for use by the entrepreneurs was also considered essential.

- Significant changes are taking place in domestic and international demand for crop products due to improvement in income, better standard of living, and changing life styles and preference patterns such as improved horticultural and livestock products.

Trade liberalization and development of transport and communication infrastructure have opened more avenues for trade and have improved access to new and distant markets. This has created new opportunities for crop diversification in various countries.

- The role of FAO as facilitator in the development efforts of crop diversification undertaken by different countries, through holding of seminars and workshops, skills development programmes, information sharing, facilitating germplasm exchanges etc., was recognized. The need for the development of an information database on crop diversification for use by policy makers, farmers, consumers, and other stakeholders was an essential requisite for crop diversification. It was recommended that efforts should be made to compile this database.

  To facilitate all the above-mentioned activities the establishment of a Network on Crop Diversification for the Region was recommended.

- Recognizing crop diversification as an element of poverty alleviation, income generation, equity and natural resource conservation, and to enhance this, a well designed mechanism has to be developed through the participation of international organizations and local governments to strengthen the initiative undertaken by this region.

LIST OF PARTICIPANTS

BANGLADESH

M. Enamul Hoque
Director-General
Department of Agricultural Extension
Ministry of Agriculture
Khamarbari, Farmgate
Dhaka 1215
Tel: (88-02) 8115267, 8111884 (Office), (88-02) 9115724 (Res.)
Fax: (88-02) 8111884
E-mail: dgdaedhk@citechco.net

CHINA

Zuo Mengxiao
Senior Agronomist and Deputy Director
Department of Crop Production
Ministry of Agriculture
No. 11 Nong Zhan Nanli
Beijing 100026
Tel: (86-10) 64192855
Fax: (86-10) 65018272
E-mail: NYSNQC@agri.gov.cn

INDIA

C.R. Hazra
Agriculture Commissioner
Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India
Krishi Bhawan
New Delhi 110021
Tel: (91-11) 3383549
Fax: (91-11) 3383549
E-mail: hazra@krishi.delhi.nic.in

JAPAN

Masa Iwanaga
Director
Biological Resources Division
Japan International Research Center for Agricultural Sciences (JIRCAS)
Ohwashi 1-2
Tsukuba 305-8686
Tel: (81-298) 386305
Fax: (81-298) 386650
E-mail: miwanaga@jircas.affrc.go.jp

MALAYSIA

Tunku Mahmud Bin Tunku Yahya
Assistant Director
Economic and Technology Management Centre
Malaysia Agricultural Research Development Institute (MARDI)
G.P.O. Box 12301
50774 Kuala Lumpur
Tel: (60-3) 89437194, 89437186 (Office); (60-3) 77270921 (Res.)
Fax: (60-3) 89486799
E-mail: tmty@mardi.my

NEPAL

K.C. Sharma
Project Coordinator
Crop Diversification Project
Ministry of Agriculture
Harihar Bhawan, Lalitpur
Tel: (977-1) 523269
Fax: (977-1) 523269

PHILIPPINES

Rene Rafael C. Espino
Programme Director
High-value Commercial Crops Programme
Department of Horticulture
College of Agriculture
University of the Philippines
Los Banos, Laguna
Tel: (63-2) 5240963, 5254004
Fax: (63-2) 5254004
E-mail: hvcc@info.com.ph

SRI LANKA

H.P.M. Gunasena
Director
Postgraduate Institute of Agriculture
University of Peradeniya
Old Galaha Road, P.O. Box 55
Peradeniya
Tel: (94-8) 388318, 389205 (Office), (94-8) 25167, 23914 (Res.)
Fax: (94-8) 388318
E-mail: gunasena@sltnet.lk

L.A. Weerasena
Deputy Director (Research)
Regional Research Centre
Angunakolapalessa
Tel: (94-47) 28204, 28336 (Office), (94-47) 23639 (Res.)
Fax: (94-47) 28204
E-mail: ddrap@sltnet.lk

THAILAND

Chavalvut Chainuvati
Deputy Director-General
Department of Agricultural Extension (DOAE)
2143/1 Phaholyothin Road
Chatuchak, Bangkok 10900
Tel: (66-2) 5793021, 5790121-7 Ext. 204
Fax: (66-2) 5799539
E-mail: chavalv@doae.go.th
chaiboo@hotmail.com

Withaya Athipanan
Subject Matter Specialist
Farm Management Sub-Division
Agricultural Business Promotion Division
Department of Agricultural Extension (DOAE)
Phaholyothin Road, Chatuchak
Bangkok 10900
Tel: (66-2) 5793910, 5790922, 5614877 Ext. 379, 381
Fax: (66-2) 5614885-6
E-mail: Awithaya@hotmail.com

VIETNAM

Nguyen Van Luat
Senior Scientist
Cuulong Delta Rice Research Institute
Omon, Cantho
Tel: (84-71) 861954
Fax: (84-71) 861457
E-mail: clrri@hcm.vnn.vn
clrri@bdvn.vnd.net

ADB

Masahiro Otsuka
Senior Project Economist
Agriculture and Social Sectors Department (West)
Asian Development Bank (ADB)
6 ADB Avenue, Mandaluyong City
0401 Metro Manila, **Philippines**
Tel: (63-2) 6326732, 6324444
Fax: (63-2) 6362295, 6362444
E-mail: motsuka@adb.org

APSA

Noel G. Mamicpic
Director
Asia-Pacific Seed Association
c/o Department of Agricultural Extension
2143/1 Phaholyothin Road
Chatuchak, Bangkok 10900, **Thailand**
Tel: (66-2) 5797545
Fax: (66-2) 9405467
E-mail: apsa@apsaseed.com

UNCTAD

Alexei N. Mojarov
Economic Affairs Officer
Commodities Branch
Division on International Trade in Goods and Services, and Commodities (DITC)
United Nations Conference on Trade and Development (UNCTAD)
Palais Des Nations, 1211 Geneva 10, **Switzerland**
Tel: (41-22) 9175782
Fax: (41-22) 9170509
E-mail: alexei.mojarov@unctad.org

FAO

R.B. Singh
Assistant Director-General
and FAO Regional Representative
for Asia and the Pacific
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, **Thailand**
Tel: (66-2) 2817844
Fax: (66-2) 2800445
E-mail: FAO-THA@fao.org

Dong Qingsong
Deputy Regional Representative
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, **Thailand**
Tel: (66-2) 2817844
Fax: (66-2) 2800445
E-mail: FAO-THA@fao.org

Mahmud A. Duwayri
Director
Plant Production and Protection Division (AGP)
Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla
00100 Rome, **Italy**
Tel: (06) 55004
Fax: (06) 57053152
E-mail: Mahmud.Duwayri@fao.org

Minas K. Papademetriou
Senior Plant Production and Protection Officer
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, **Thailand**
Tel: (66-2) 2817844
Fax: (66-2) 2800445
E-mail: minas.papademetriou@fao.org

Shen Chong-Yao
Plant Protection Officer
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, **Thailand**
Tel: (66-2) 2817844
Fax: (66-2) 2800445
E-mail: Shen.ChongYao@fao.org

Keith R. Chapman
Plant Production Officer (Industrial Crops)
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, **Thailand**
Tel: (66-2) 2817844
Fax: (66-2) 2800445
E-mail: Keith.Chapman@fao.org

Saha Pijush Kanti
Technical Officer (Plant Protection)
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, **Thailand**
Tel: (66-2) 2817844
Fax: (66-2) 2800445
E-mail: Saha.Pijush@fao.org

Valai Visuthi (Mrs)
Secretary
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, **Thailand**
Tel: (66-2) 2817844
Fax: (66-2) 2800445
E-mail: Valai.Visuthi@fao.org