Promoting Implementation of Crop Diversification in Rice-Based Irrigation Systems in Nepal

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INTRODUCTION

FARMING WILL REMAIN as the main economic activity in the foreseeable future in Nepal. At present 93 percent of the population is engaged in agriculture, producing 67 percent of the Gross Domestic Product (GDP) and 80 percent of export earnings. The agricultural resource base is severely limited by the physiographic features of the country, especially in the hills, where, despite the population pressure, only 14 percent of the physical area is under cultivation. The man-land ratio is very high and the agricultural practices are greatly influenced by the diversified agro-ecology and complex farming systems (Figure 1).

The bulk of the agricultural production is made up of food grains, which contribute 60 percent of the agricultural GDP. Rice, maize, and wheat together contribute 96 percent of the cereal production in the country. The contribution of livestock to the agricultural GDP and the overall GDP are 25 percent and 15 percent, respectively.

IRRIGATION AND IRRIGATION MANAGEMENT

Nepal is endowed with enormous potential for water resources development including irrigation. There are three major river systems (Koshi, Gandaki and Karnali) and numerous tributaries from

the Himalaya, the Mahabharat and the Siwalik foothills (Figure 2). Nepal could be considered as one of the richest countries in "hydro-dollars" if its vast potential of water resources could be harnessed to the fullest extent. There could be several multipurpose hydro projects in the country to provide power and irrigation. However, there is no such project at present. Discharge of major rivers is computed to be 150 billion m^3 per year which is enough to irrigate about 8-10 million hectares.

Out of Nepal's total cultivated area of 2.653 million ha, 1.375 million ha is in the Terai and 1.278 million ha in the hills. Of this total cultivated area, 1.766 million ha is estimated to be potentially irrigable, although the total irrigated area at present is less than 1 million ha. An inventory of some potential irrigation projects with command areas of more than 3,000 ha is shown in Table 1.

The irrigation systems are managed either by the irrigation agency, by agency-assisted farmers or by the farmers themselves.

The Department of Irrigation with five Regional Irrigation Directorates and seventy-five District irrigation Offices and semi-government and nongovernment organizations are presently involved in irrigation management. The farmers themselves have likewise been very deeply involved in the construction, operation, maintenance and management of irrigation systems. Farmer-managed irrigation systems (FMIS) cover about 70 percent of the total irrigated area in Nepal (Table 2).

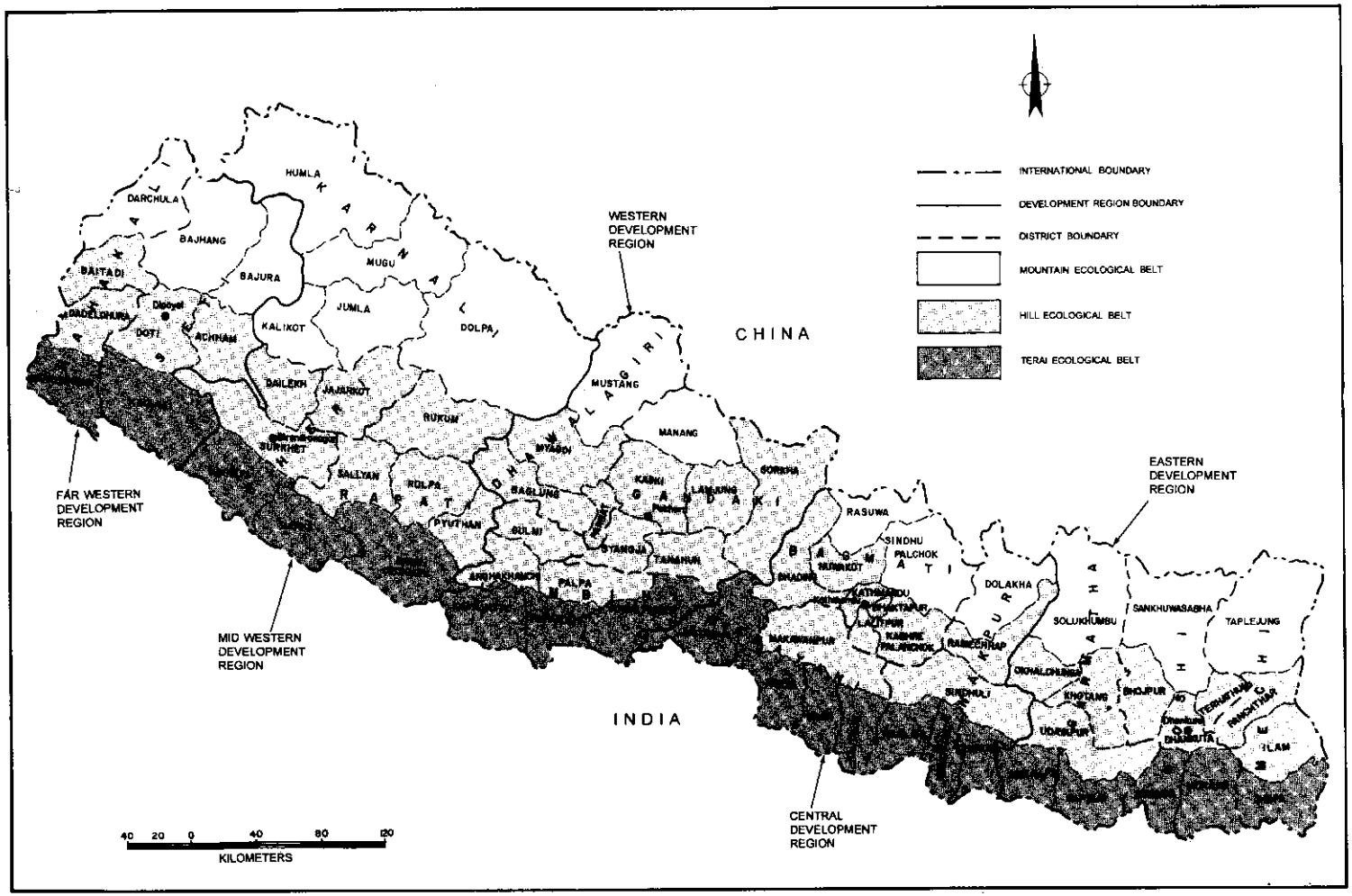
About 50 percent of the irrigated area could be provided with year-round irrigation. This area has complete control over the water supply, and the winter and spring crops are grown with a full (on-demand) supply of irrigation water. The other 50 percent has an adequate water supply only during the monsoon season and the winter crops are grown under partial irrigation or rain-fed conditions.

Problems encountered in the development and management of irrigation systems in Nepal are related to economic, technical and social (institutional) aspects. In all these aspects, Nepal's position is not very strong. As regards economic problems, internal resources are not enough to develop and maintain larger systems and the management, allocation and mobilization of these resources are difficult. Inadequate manpower, weak water user groups (WUGs), ineffective water allocation and water right fixation, and lack of coordination and cooperation among the different agencies for a unified approach to develop and manage a system are some of the main technical and institutional problems.

IRRIGATED RICE-BASED FARMING SYSTEMS AND CROP DIVERSIFICATION

In Nepal, all the areas that have been irrigated are basically rice-based. Many of the irrigation projects (large and medium) so far constructed are usually meant to supplement irrigation for the main season rice crop during the monsoon. Thus, farming, although varying from one agro-ecological zone to another, is mainly rice-based.

Figure 1. Physiographic and agri-ecological divisions of Nepal.



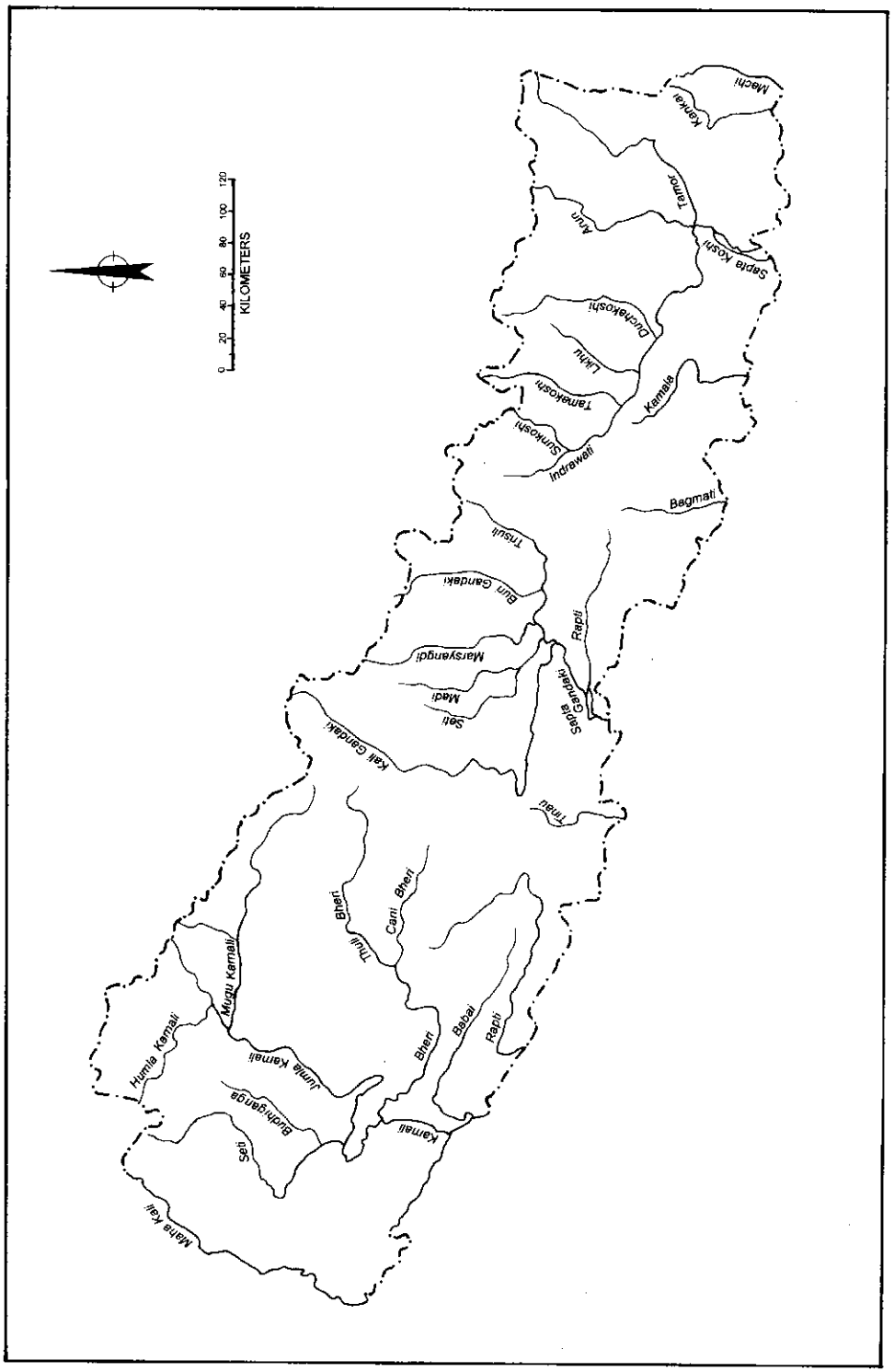


Figure 2. Major rivers of Nepal and their main tributaries.

Table 1. Inventory of some of the potential irrigation projects with a net command area greater than 3,000 ha.

Project (River)	Type	Command area (ha)	Development responsibility	Water source
Bhery-Babai I.P.	New	35,000	DOI	Bhery and Karnali
Geruwa Island I.P.	Impr.	15,000	DOI	Karnali
Jamuar Nala I.P.	Impr.	13,600	DOI	Karnali
Bagmati M.P.	New	122,000	DOI/NEA	Bagmati
Kankai M.P.	Extension to current 8,000 ha	57,500	DOI/NEA	Kankai
Sunkoshi-Kamala Diversion M.P.	Expansion of existing 25,000 ha Kamala I.P.	150,100	DOI/NEA	Sunkoshi and Kamala
East Rapti I.P. (Phase II)	New	6,800	DOI	Mahakali/ GW
Babai I.P.	New	13,500 (with 3 FMIS of 7,000 ha)	DOI	Babai
Marchwar Lift I.P (Phase I)	CAD	4,400	DOI	Tinau
Khutia I.P. (Phase II)	New	3,500	DOI	Khutia
Rato I.P.	New	3,200	DOI/WUG	Rato Nadi
Groundwater Development Project	New	76,910	DOI	Ground water

Notes: I.P. = Irrigation Project. M.P. = Multipurpose Project.
CAD = Command Area Development. Impr. = Improvement.
DOI = Department of Irrigation. NEA = Nepal Electricity Authority.
WUG = Water User Groups.

Table 2. Estimated net command area of irrigation schemes in Nepal.

Irrigation			Terai		Hills		Mountains		Total	
Intensity	Capability	Management	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
Extensive	Monsoon/	DOI	33	84,830	59	8,968	4	333	96	94,131
	year-round	DOI	0	0	2	794	0	0	2	794
Intensive	Monsoon	DOI	4	38,823	15	2,155	0	0	19	40,978
		FMIS	-	234,607	-	86,514	-	16,582	-	337,803
Intensive	Year-round	DOI	16	70,261	6	2,808	0	0	22	73,069
		FMIS	-	234,606	-	86,514	0	16,582	0	337,702
Command	Monsoon/	DOI	1	6,000	0	0	0	0	1	6,000
Area	year-round	DOI	10	52,339	0	0	0	0	10	52,339
Total			-	721,466	-	187,753	-	33,447	-	942,716
		DOI	-	252,253	82	14,725	4	333	141	267,311
		FMIS	-	469,213	-	173,028	-	33,164	-	675,405

A land resources mapping project has categorically defined and described four principal farming systems in the cultivated area of the country. These are as follows:

1. The Main Terai farming system (45 percent of the total cultivated area).
2. The Dun Valley farming system (8 percent of the total cultivated area).
3. The Middle Mountain farming system (39 percent of the total cultivated area).
4. The High Mountain farming system (8 percent of the total cultivated area).

The Main Terai farming system is mostly rice-based with about 50 percent of the area irrigated and 50 percent rain-fed. The Dun Valley is relatively newly cultivated and mainly rain-fed and maize-based. In the Middle Mountain, 80 percent of the area is rain-fed and maize-based and the remaining 20 percent is irrigated and rice-based. In this ecological zone, sometimes, triple cropping is practiced in irrigated areas. The High Mountain farming system is more livestock-based.

A recent study revealed that rain-fed farming occupies almost two thirds (64%) of the total cultivated land area including areas with both rice-based and maize-based cropping patterns depending upon the agro-ecological conditions. Irrigated farming accounts for about one third (36%) of the cultivated area.

However, its share in the total grain production is estimated to be more than 50 percent. The following are some successful crop rotations in Nepal:

1. Crop rotation in hill terraces

Summer *(kharif)*	Winter *(rabi)*	Spring *(zaid)*
1. Maize	Soybean	Mustard
2. Maize	Millet	Oats or barley (fodder)

2. Crop rotation in irrigated land in the jute area (lowland + upland hills)

Jute	Wheat	Barley (for fodder)
Green manure/	Barley for fodder-	
Jute	Potato or mustard	
Jute	Wheat	
Rice/potato	Jute	
Rice	Wheat-mung	
Jute	Rice-berseem	
"Baishaki" mung	Jute-rice/potato	

3. Crop rotation in irrigated land Terai

Jute	Rice	Wheat
Jute	Mung	Wheat
Jute	Rice	Peas
Jute	Rice	Potato
Jute	Mung	Mustard

4. Crop rotation with tobacco in irrigated areas of Siraha, Dhanusha Mehotari and Sariahi

1st year		2nd year		3rd year		4th year		5th year	
Kharif(K)	Rabi(R)	K	R	K	R	K	R	K	R
Maize	Tobacco	Linseed	Tobacco	Wheat	Rice	Wheat	Maize	Tobacco	Rice,
Legume crop									

5. Crop rotation with sugarcane in Morang District, under irrigation

Jute - rice - sugarcane - tuber crop, oilseed crop

Green manure - rice - sugarcane

6. Crop rotation with oil crops, under irrigation, in Nawalparasi, Rupandehi and Kapilwastu districts in the Western Region

Sugarcane + corriander - mustard + sugarcane (mixed) (ratoon) two-year crop rotation.

Two-year rotation	1st year	maize + soybean - mustard
	2nd year	maize + soybean - wheat
	3rd year	rice - chili

7. Crop rotation with rice and vegetables under irrigated conditions in the Kathmandu Valley

Summer	Winter	Spring
Rice	-	Onion or garlic
Rice	Cauliflower	Onion or garlic
Rice	Cabbage	-
Rice	Green onion or green garlic	Cauliflower
Rice	Cauliflower	Potato

8. Crop rotation with cotton in irrigated areas in Bardia, Banke, and the Mid-Western Region of Nepal

	Summer	Winter
1st year	Cotton	Black gram (moong)
2nd year	Cotton	Black gram (moong)
3rd year	Green manure - mustard and gram	Cotton planted later
-	Maize + soybean, Mustard + gram	

PROGRAMS RELATED TO PROMOTING CROP DIVERSIFICATION

Under His Majesty's Government's (HMG's) Ministry of Agriculture, the two main units at the national level that directly or indirectly share the responsibility of crop diversification are the Agriculture Department and the National Agriculture Research Council (NARC). NARC addresses the research aspects of crop diversification and provides information on suitable varieties of cereals, cash crops, legumes, potato and vegetable crops that fit various macroclimates, and crop rotation and diversification, so that the farmers get the maximum profits from the commodities. The Agriculture Department, with its five Regional Directorates and 75 District Agriculture Development Offices, extends such information and technologies to the farmers.

Research and Development

From 1952 to 1976, the Agronomy Division of the Agriculture Department was indirectly responsible for crop diversification. This period was devoted to the development of improved varieties of cereal, cash crops, oil-seed and leguminous pulse crops to meet the needs of the nation. Rice is the main crop during the rainy or kharif season followed by wheat in the winter. Where water is limited, upland rice or maize is grown in the rainy season. In winter, the farmers grow

either mustard or wheat depending on the market demand in the district. Farmers whose land is near the main township of the Terai area prefer winter maize which gives higher yields and has a ready market (for fresh green cobs).

In 1977, the Department of Agriculture started the Cropping System Program (CSP) to carry out extensive testing of technologies for crop development programs. The integrated Cereal Development Project of Winrock International, IADS and USAID/N had helped the national programs of rice, wheat and maize for a period of four years, beginning in 1972, by putting together technological packages that were economically and socially acceptable.

The Cropping System Program (CSP) initially established two sites in the summer of 1977, in Parsa (Parsa District) and Pumdi Bhumdi (Kaski District). Later, in the winter season of 1977-78, three more sites, Chaurjahari (Rukum District), Lele (Lalitpur District), and Khanduari (Sankhuwasabha District) were added. Ratna Nagar (Chitwan District) was established in the winter season of 1980-81.

Socioeconomic surveys were carried out to better understand farmers' practices. Experiments were conducted in farmers' fields to develop cropping system technologies. The technologies were then introduced to farmers in all six sites through pilot production programs. These packages were also tested in other areas of Nepal by the agriculture extension agents of the Department of Agriculture in the District Agricultural Development Offices, through the Pre-Production Verification Trials (PPVT). Simple manuals were also published giving both the methods and the recommended technology, in detail. In 1983-84, based on the results of these verification trials and pilot production programs, the Block Production Program (BPP) was started in an area of 17,000 ha in the Terai by the Department of Agriculture. The program now covers 100,000 ha (1986-87) in 20 Terai districts and 8 hill districts. The CSP was expanded to form the Farming System Research and Development Division (FSRDD) so that farm research can be conducted for other components as well.

In recent years, it was felt that various research activities and agriculture extension activities could not be effectively done. Researches were either duplicated or were academic in nature and did not benefit the farmers. So, a National Agriculture Research and Service Center was established by HMG with the help of USAID/N and Winrock International.

In 1991, the National Agricultural Research Service Center was organized as the National Agriculture Research Council (NARC), with the mandate of helping achieve the national goal of increasing agricultural production and productivity by implementing coordinated components of Nepalese agriculture. To fulfill this mandate, the Farming Systems Research and Development Division was transferred from the Department of Agriculture to NARC. This division takes care of the crop diversification activities. The commodity programs and disciplinary divisions of NARC are as follows:

Commodity Programs

1. National Citrus Development Program, Dhankuta.
2. National Grain Legumes Improvement Program, Rampur.
3. National Hill Crops Improvement Program, Kavre.
4. National Maize Development Program, Rampur.
5. National Oil Seeds Development Program, Sariahi.
6. National Potato Development Program, Khumaltar.
7. National Rice Improvement Program, Parwanipur.
8. National Sugarcane Development Program, Jitpur.

9. National Temperate Horticulture Development Program, Marpha.
10. National Tobacco Development Program, Dhanusha.
11. National Wheat Development Program, Bhairahawa.

Disciplinary Divisions

1. Agricultural Marketing Research and Economic Analysis, Lalitpur.
2. Central Disease Investigation and Research Laboratory, Kathmandu.
3. Central Livestock Development Center, Khumaltar.
4. Division of Agriculture Botany, Khumaltar.
5. Division of Agriculture Engineering, Khumaltar.
6. Division of Agronomy, Khumaltar.
7. Division of Animal Breeding, Khumaltar.
8. Division of Animal Nutrition, Khumaltar.
9. Division of Entomology, Khumaltar.
10. Division of Plant Pathology, Khumaltar.
11. Division of Pasture and Fodder, Khumaltar.
12. Division of Soil Science and Agricultural Chemistry, Khumaltar.
13. Farming Systems Research and Development Division, Khumaltar.
14. Farm Management Division, Khumaltar.
15. Seed Testing and Improvement Program, Khumaltar.
16. Socioeconomic Research and Extension Division, Khumaltar.

Farms/Stations

1. Bhairahawa Agriculture Farm, Bhairahawa.
2. Bhairahawa Fisheries Development Center.
3. Central Goat Farm, Bandipur.
4. Dhankuta Agriculture Station, Dhankuta.
5. Doti Agriculture Farm, Doti.
6. Fishery Research and Training Center, Janakpur.
7. Hardinath Agriculture Farm, Hardinath.
8. Indra Sarowar Fisheries Development Research Project, Kulekhani.
9. Jumla Horticulture Farm, Jumla.
10. Kabre Agriculture Farm, Kabre.
11. Karnali Sheep Farm, Jumla.
12. Khumal Agronomy Farm, Khumaltar.
13. Kirtipur Horticulture Research Center, Kirtipur.
14. Mushroom Production Program, Khumaltar.
15. Nepalgunj Agriculture Station, Nepalgunj.
16. Nucleus Potato Seed Farm, Nigale.
17. Parwanipur Agriculture Station, Parwanipur.
18. Pokhara Fisheries Development Center, Pokhara (including Ginger Program).
19. Pokhara Horticulture Research Center, Pokhara.
20. Pokhara Livestock Development Center, Pokhara.
21. Rampur Agriculture Station, Rampur.
22. Rasuwa Horticulture Farm, Rasuwa.

23. Rasuwa Pasture Development Farm, Dhunche.
24. Sariahi Horticulture Station, Sariahi.
25. Surkhet Agriculture Station, Surkhet.
26. Tarahara Agriculture Station, Tarahara.
27. Trishuli Fisheries Development Center, Trishuli.
28. Vegetable Research and Seed Production Center, Khumaltar.

Pilot-Testing and Demonstration

The FSRDD was created in November 1985 in the Department of Agriculture with the main objective of identifying environment-specific technologies by integrating different components of the Nepalese farming system (crops, horticulture, livestock and agro-forestry) for the benefit of small and resource-poor farmers.

FSRDD, in 1987/88, had five sites, each roughly representing the mid-hills of 5 development regions. The mid-hills are emphasized because until very recently, little attention could be given to research and technology development for hill farming due to accessibility problems and variable agro-ecological conditions in the hills. The five sites are:

1. Khandbare in Sankhuwasabha District (Eastern Region).
2. Naldung in Kavre District (Central Region).
3. Pumdi Bhumdi in Kaski District (Western Region).
4. Kotjari in Rabum District (Mid-Western Region).
5. Patan in Baitadi District (Far-Western Region).

In addition to these sites, work has also been initiated at the Rampur Agriculture Station (Chitwan District) and Belachapi Farm of the National Tobacco Development Program, Janakpur to demonstrate the farming system approach.

FSRDD (now called the Central Farming Systems and Outreach Research Division), has begun many studies at the five sites such as Component Technology Trials (CTTs), Cropping Pattern Trials (CPTs) and group-visit studies.

In collaboration with crop programs and the disciplinary divisions, the Component Technology Trials are conducted to identify specific technologies (varieties/fertilizer rates/pesticide use, etc.), which can fit into the farmers' cropping systems. The trials are replicated within and/or across farms. They are conducted under the direct supervision of the technical staff. The CTTs provide an opportunity for testing and verifying at a given location the new technology generated by the research stations. The technology identified is further tested in CPTs before final recommendations are made.

The objective of CPTs is to increase and sustain the annual production and the total income of small farmers from a given area by introducing component technology into their cropping systems. The cropping pattern trials include both improved versions of existing cropping patterns and alternative cropping patterns, that are usually made more intensive by introducing additional crops to the existing patterns and/or by introducing new technology not currently practiced by the farmers.

The CPTs are usually conducted in 500-1,000m^2 areas. Trials (demonstrations) are conducted in five farms, using each farm as one replication depending on the crops and land types. The crop in each cropping pattern is grown in sequence in the same parcel of land during the year by testing new technology (variety/fertilizer/pesticide, etc.). The results from these trials are compared with the farmers' traditional pattern to verify the socioeconomic feasibility of the improved practices. It is important to assess how the farmers will adopt the improved technology. The CPTs are normally managed by farmers under the supervision of site staff. The agronomic and economic performance of some improved practices are shown in Tables 3, 4, and 5.

Table 3. Cropping-pattern performance at Khandbari under a partially irrigated lowland ecosystem, spring, summer and winter crops, 1989-90.

Cropping pattern	Farmers' practice	Improved practice	
	R-W-Fallow	R-W-Dhaincha S. canabina	R-W-Dhaincha S. rostrat
Spring			
Variety	-	S. canabina	S. rostrata
Fertilizer (NPK kg/ha)			
Grain yield (kg/ha)			
Green biomass (kg/ha)	-	19,500	8,130
Summer			
Variety	Manipure local	Khumal-4	Khumal-4
Fertilizer (NPK kg/ha)	0:0:0	40:20:0	40:20:0
Grain yield (kg/ha)	2,169	29,998	2,702
Straw yield (sun dried) (kg/ha)	2,991	3,914	3,344
Winter			
Variety	UP262	UP262	UP262
Fertilizer (NPK kg/ha)	60:30:0	60:30:0	60:30:0
Grain yield (kg/ha)	1,475	1,771	1,847
Straw yield (sun dried) (kg/ha)	2,614	3,137	33,450
Annual total yield (kg/ha)	3,644	4,769	4,549
Economic analysis			
Gross return (Rs/ha)	26,265	34,454	32,591
Material cost (Rs/ha)	2,127	3,510	3,510
Labor and power cost (Rs/ha)	10,465	10,855	10,855
Total variable cost (Rs/ha)	12,592	14,365	14,365
RAVC (Rs/ha)	13,673	20,089	18,226
% Change in RAVC		46%	33%
MBCR		4.6	3.56

Notes: R = Rice.
W = Wheat.
RAVC = Return above variable cost.
MBCR = Marginal benefit-cost ratio.

Table 4. Agronomic and economic performance of the cropping pattern tested at Naldung, 1989-90.

Cropping pattern	Farmers' practice Rice-wheat-fallow	Improved practice Rice-wheat-fallow
Summer	Rice	Rice
Variety	Taichung 176	Khumal - 4
Fertilizer (NPK kg/ha)	20:30:0	60:30:0
Grain yield (ton/ha)	1.70	3.32
Straw yield (ton/ha)	2.50	4.50
Seed rate (kg/ha)	50	50
Winter	Wheat	Wheat
Variety	RR - 21	Annapurna - 1
Fertilizer (NPK kg/ha)	40:0:0	80:40:0
Grain yield (ton/ha)	1.48	3.62
Straw yield (ton/ha)	1.58	4.09
Seed rate (kg/ha)	150	130
Economic Analysis		
Gross return (Rs/ha)	16,340	32,520
Material cost (Rs/ha)	1,643	2,990
Labor & Power cost (Rs/ha)	3,360	3,360
Total variable cost (Rs/ha)	5,003	6,250
RAVC	11,336	26,270
% change in RAVC		131.72
MBCR		12.97

Notes: RAVC = Ratio above variable cost.
MBCR = Marginal benefit-cost ratio.

Table 5. Cropping-pattern performance at Patan under lowland irrigated conditions : Winter and summer crops, 1989-90.

Cropping pattern	Farmers' practice R - W - F	Improved practice R - W - F	R - W - F
Winter	Wheat	Wheat	Wheat
Variety	RR 21	RR 21	Annapurna-1
Fertilizer rate (NPK kg/ha)	53:16:0	80:40:0	80:40:0
Grain yield (kg/ha)	2,320	2,465	3,126
Straw yield (kg/ha)	3,480	3,650	3,625
Summer	Rice	Rice	Rice
Variety	Paunji	Paunji	Khumal-4
Fertilizer (NPK kg/ha)	21:6:0	80:30:0	80:30:0
Grain yield (kg/ha)	4,249	4,980	5,647
Straw yield (kg/ha)	6,800	6,142	6,890
Economic analysis			
Gross return (Rs/ha)	22,222	24,775	29,747
Total variable cost (Rs/ha)	1,673	3,720	3,720
RAVC/Rs/ha	20,550	21,054	26,027
MBCR		1.24	3.67
Increase in RAVC (%)		2.00	26.00

Notes: R = Rice
W = Wheat
F = Fallow
MBRC = Marginal benefit-cost ratio
RAVC = Ratio above variable cost

Training

Middle-level workers/officials are trained in crop diversification, agriculture extension and other aspects of crop production by the Central Agriculture Training Center under the Department of Agriculture. Some staff members are trained at workshops and seminars in other countries. The training is more on farming systems than on crop diversification per se.

Support Services

The Agriculture Inputs Corporation supplies the fertilizer, pesticides, fungicides, and agriculture equipment through its branch and sub-branch offices in the districts. The Agriculture Development Bank with its branch offices supplies credit to the farmers in general for various commodities such as crops, livestock, horticulture, etc. In some districts, the farmers become members of the local cooperative societies which could have easier access to credit, fertilizers and markets. However, not all cooperative societies are functioning well. Farmers with little capital and small parcels of land are organized into Small Farmer Groups under the Small Farmer Development Program of ADB and they get their credit and other agriculture inputs through this organization.

This program has been quite successful in Nowakot, Rupendehi, Nawalparasi and other districts where it has been launched.

PROBLEMS IN PROMOTING CROP DIVERSIFICATION PROGRAMS

To promote crop diversification, markets and adequate labor should be available. In townships like Janakpur, Birgunj, Bhadrapur, Biratnagar and Nepalgunj, winter crops such as maize (for green cob) is grown profitably by the farmers. Wheat or mustard is also grown depending on profitability. The farmers definitely need to be guided each year as to which crop will be more profitable. This is especially true for the Terai districts next to the Indian border where such a service is lacking.

In areas such as Bhairawa and Kapilvastu, where land and irrigation water are available to the farmers, the limiting factor for a second crop or crop diversification is the unavailability of adequate manpower during the peak period of harvesting and preparing the land, and sowing the second crop. The farmers in this area are dependent on migrant laborers from India.

The major problems facing crop diversification in Nepal are: (i) limited irrigated area in the country; (ii) inadequate manpower where land and water resources are available; (iii) lack of proper marketing and forecasting services for suitable second crops; (iv) weak inter-departmental cooperation in areas where irrigation is available; and (v) absence of appropriate arrangements for better research on crop diversification in the different locations.

APPROPRIATE STRATEGIES TO PROMOTE CROP DIVERSIFICATION

Crop diversification in agriculture is the need of the day. Some of the strategies to promote crop diversification are:

1. Development and implementation of a proper cropping-system plan to maximize cropping intensity.
2. Development of appropriate mechanization techniques to address labor shortages during times of peak labor requirements.
3. Better coordination between the staff of the Departments of Irrigation and Agriculture to implement crop diversification programs. This coordination and integration should start at the village level and extend up to the national level.
4. Arrangements to address marketing problems. Where a crop diversification program has yielded good results, arrangements should be made whereby the farmers will get the maximum farm-gate prices. Improved marketing, transport, and storage facilities are very important factors in promoting crop diversification.
5. Supply of agricultural inputs such as seeds, fertilizers, plant protection materials and equipment where and when the farmers need them.

6. Provision of adequate manpower and transport facilities for researchers in the farming system research, and socioeconomic research and extension divisions.
7. A definite identification of the demand for certain agricultural commodities and consideration of crop diversification in a rice-based irrigation system to meet that demand.

Research-Extension Linkages

From the above strategies, it is quite clear that extension staff need to know the demands and the problems faced by farmers. The research staff should be able to address these needs. There has to be better linkages between researchers and extension staff in Nepal.

The two agencies involved in extension and research are the Agriculture Department and NARC, respectively. At the field level, the farms and stations under NARC (given in Table 4 above), have their outreach programs in command areas surrounding the farms. The Agriculture Department has Agriculture Development Offices in all 75 districts. There is a need for better linkages at this level, at the regional level and at the departmental level. At the Ministry level, there should be clear-cut policies for providing water for the second and third crops. Some major irrigation channels and systems are closed for repairs when there is a critical need for water for the second and third crops. Policies should be formulated in such a manner that repairs and maintenance of irrigation channels should be done between the irrigation of the second and third crops.

To improve the research-extension linkage in the field, there are monthly meetings between research and agriculture extension staff. At the district level, there are also monthly meetings of the Production Committee where research findings and farmers' field programs are discussed.

At the regional level there are quarterly program reviews where both research and agriculture extension staff from all regions are present. Annually, there is a budgeting and program planning workshop attended by national level staff both from the Department and the Ministry. This too is conducted in all five regions.

At the national level, two workshops are held in summer and in winter, in which the latest research findings on all agriculture crop commodities are presented in the presence of representatives from all farms and stations; national, regional and district level staff of agriculture extension divisions; and consultants and foreign experts working on various projects. At such workshops, programs are planned for the next fiscal year and budgeting is done according to these programs. The Agriculture Information Division of the Ministry of Agriculture further strengthens the research-extension linkage by publishing research material in simple language. They also produce video films on agriculture and other audiovisual products. Every morning, there is a 15-minute radio program on seasonal commodities over Radio Nepal, for farmers. Experiences of successful farmers are highlighted in interviews with them and agricultural events of major significance are given publicity over the radio.

CONCLUSIONS AND RECOMMENDATIONS

There should be better coordination between the Ministries of Water Resources and Agriculture. This coordination should be improved at the departmental, regional, district and field levels. Wherever water is provided for irrigation, the farmers must be encouraged to increase their cropping intensity. Depending upon local market needs, crop diversification should be adopted in such a manner that the farmers would be able to readily sell their produce and reap high profits. Programs or projects with the above-mentioned criteria have a high chance of success.

Role of National Institutions and Agencies in Crop Diversification

NARC provides technological packages of practices but does not do extension work. The Agriculture Department conducts agriculture extension programs in all the 75 districts of the Kingdom. These two organizations are assisted by the Agricultural Development Bank (ADB) through cooperatives, and the Small Farmers' Development Program (SFDP), to supply the credit. The Agriculture Inputs Corporation (AIC) provides various agriculture inputs. Each of these national institutions has its own strengths and weakness in promoting crop-diversification in rice-based irrigated systems.

NARC is an autonomous organization created to expedite research activities in Nepal. It has ample funds and relatively adequate facilities provided by its donors such as Winrock International and USAID. However, it is relatively new and is still short of manpower.

The Department of Agriculture is a well-established organization, covering every district of the country. It has successfully implemented various projects over the past three decades. However, it has not been able to keep up production with the population growth of the country.

The ADB has two decades of experience in providing credit to the farmers of Nepal. With the observation that only rich farmers who had plenty of resources got credit, the SFDP was organized and implemented in several locations of the country. The ADB has facilities to train its staff to be more effective in their job.

The AIC has experience in supplying various agricultural inputs to various parts of the Kingdom for approximately two decades. However, there has been complaints by farmers at times about the timing of fertilizer supply for major crops. Farmers have also complained about the quality of seeds supplied.

Role of Other Countries and International Agencies

There are several international agencies supporting Nepal in its agriculture development projects. Those that are involved in agronomy or crop diversification are as follows:

1. Asian Development Bank.
2. International Maize and Wheat Improvement Center.
3. International Rice Research Institute.
4. International Development Research Center (Canada).
5. International Institute of Tropical Agriculture.

6. German Agency for Technical Cooperation.
7. Overseas Development Agency of U.K.
8. United States Agency for International Development/Nepal.
9. Winrock International Institute for Agriculture Development.
10. Food and Agriculture Organization, Rome.
11. United Nations Development Program/FAO for Nepal.
12. United States Department of Agriculture, USA.
13. World Bank.

These agencies have helped Nepal in agricultural development work such as developing infrastructure and manpower, providing germplasm of various crops, doing base-line studies in various districts, monitoring programs and evaluations, developing information management systems and repairing and maintenance of buildings and equipment.

More specific for farming system research and crop diversification, the Agriculture Research and Production Project (ARPP) funded by Winrock International Institute for Agricultural Development and USAID/Nepal has helped in addressing the goal of increasing the sustainable productivity of small Nepalese farmers. This approach seeks to increase whole farm production, including livestock, agro-forestry, and the important food and cash crops. In order to achieve this goal, farmers must have access to improved technologies. For this purpose, the technologies must be developed, updated, adapted and disseminated effectively.

At the national level, ARPP has helped NARC in improved administration and management of the overall agricultural research system through comprehensive support to research planning, coordination and management as well as by developing operational and development plans for research stations.

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