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Economic Assessment of Terracing in Qinghai Province of China

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Introduction

In recent years, sustainable resource management has been recognized as one of the most important issues in marginal upland agriculture in Asia, particularly in areas where CGPRT crops are predominant. In this region, upland agriculture is a major source of household income and this agriculture is usually characterized by a fragile environment, inferior infrastructure and difficult access hampering development. As a result, low income and poverty still prevail among the rural population in these areas. Population pressure on the already limited arable land has resulted in cultivation of marginal lands and farmers experience problems in land conservation efforts and in increasing land productivity with proper farming technology. The adoption of appropriate resource management techniques is crucial to ensure the sustainability of agricultural development in these regions.

Qinghai Province is a typical marginal upland agricultural area characterized by harshness of climate conditions, poor natural resource base, fragile environment, low income level and backward economic development. Agriculture in Qinghai is characterized by its subsistence level and it is carried out under very poor and harsh conditions. Farmers totally rely on their limited resource base; they are not only short of purchasing power to buy products from outside of the region, but they also have many limits to moving out of this region to seek employment elsewhere. Therefore, sustainable agricultural development in this region means improving agricultural productivity while enhancing the resource base. Techniques which can improve agricultural productivity and enhance the natural resource base should be sustainable ones. In order to ensure sustainable agricultural development and to meet the challenge of feeding its ever-increasing population with very limited land and water resources, Qinghai developed a series of farming and resource management techniques to increase agricultural productivity, particularly grain productivity. Among these technologies, the most significant and effective one is terracing. Based on a

IN THIS ISSUE

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review of Qinghai natural conditions and resources, social and economic development and agricultural performance, this paper identifies the constraints to and prospects for sustainable resource management of marginal upland areas in Qinghai Province of P.R. China, and economically assesses the effect of terracing in Huangyuan County of Qinghai Province.

Agricultural development in Qinghai Province

Qinghai Province is situated in the northeast of the Tibetan Plateau bordering Tibet and Xingjiang to the west and Gansu and Sichuan to the east. Most of the province is located some 3,000 meters above sea level with the highest point of 6,860 meters and the lowest 1,650 meters. The province covers some 72 million hectares and ranks fourth in China, but only one million hectares of the province are classified as arable land and 580,000 ha of this are under cultivation. Over 400,000 ha (about 70%) of the cultivated land is located in the mountains.

Qinghai Province experiences a continental climate and falls within the semi-arid to arid climatic zone featuring long cold winters, cool summers, wide diurnal temperature changes, low levels of precipitation and high solar radiation. The mean annual temperature for most areas is below 0^{o}C. The regular annual total water resource is 63.1 billion cubic meters. The mean annual precipitation varies from just over 310 mm to 450 mm. The frost-free periods range from 30 to 160 days depending upon elevation.

Qinghai Province is one of the most underdeveloped regions in China. Its per capita GNP in 1995 was only 413 dollars, while the national average level was about one thousand dollars in the same year. In 1995, Qinghai Province had a population of 830 thousand living under the poverty line, which accounted for 17.3% of the total population. This province is also one of the regions with a high percentage of ethnic minorities. Of the total population of 4.812 million, 57.9% is Han nationality, 42.1% is comprised of minority communities numbering some 42 ethnic nationalities including Tibetans, Mongolians, Hui, Tu and Sale.

Agricultural development in Qinghai is limited due to low rainfall, subzero winters, limited areas suitable for arable crop production, lack of vegetation, and in more recent times a serious depletion of the resource base through sheet, till and gully erosion. Farming systems in Qinghai have remained much the same for centuries and low productivity of crops is evidence of the inefficiencies within the various production systems. The arable crops are limited to several varieties of wheat, highland barley, pea, broad bean, potato, rapeseed, oats, fruit and vegetables.

Qinghai is a low income and food deficient region in China. Agricultural production, including livestock production, is basically subsistence based and mainly for home consumption. As a result, grain production and its self-sufficiency have been regarded as an important foundation for sustainable social and economic development. In 1995, the total crop sown area was 568.81 thousand hectares in Qinghai, of which, food crops covered 384.25 thousand hectares, accounting for 67%, cash crops mainly rapeseed and broad bean covered 149.88 thousand hectares, accounting for 26% and others took 34.68 thousand hectares, accounting for 7%.

However, grain production was stagnant in recent years due to climate, natural resource and financial constraints. From 1991 to 1995, the total annual output of grain was 1.15, 1.19, 1.19, 1.17 and 1.14 million tons, respectively. The composition of grain was as follows: wheat accounted for 67.1% in 1991 and 60.86% in 1995; potato accounted for 7.2% in 1991 and 12.94% in 1995; coarse grains and other grain crops accounted for 25.7% in 1991 and 26.2% in 1995.

Per capita grain output is a very important indicator for food security, particularly in regions where the economy is less developed and peoples' purchasing power is very limited. Per capita grain output of Qinghai Province was much lower than the national average level. From 1991 to 1995, per capita annual grain output in Qinghai was 254.2, 258.9, 255.7, 248.4, 239.1 kg, respectively, while that for all China was 376, 378, 385, 371 and 385 kg, respectively.

According to the Ninth Five-year Plan for Social and Economic Development in Qinghai Province (1996-2000), the objectives of agricultural development policies in Qinghai are as follows:

- Increase the effective supply of agricultural products and improve food self-sufficiency. By 2000, the grain output should reach 1.35 million tons, the output of oil-bearing crops should be 225 thousand tons and the output of meat should be 220 thousand tons.
- Rely on agricultural technology progress to improve agricultural productivity.

Message from the Director

The Centre conducted an external impact evaluation in 1998 in cooperation with the ESCAP secretariat. The review was done by forty-three reviewers nominated by fourteen member countries out of eighteen requested and the World Bank. Review materials were provided by the Centre along with the questionnaire. Twenty-eight reviewers returned the questionnaire (65.1%), of which the majority gave a high level of evaluation to the Centre's past activities and achievements. The Centre's Research and Development (R&D) and Human Resources Development and Information Services (HRD/IS) programmes and their outcomes were found useful as, among others, references specifically for defining relevant research and administrative projects and assessing on-going projects and policies in the countries.

The reviewers also gave valuable advice and suggestions for the Centre's future programmes and management. The salient points are summarized as follows: (i) further strengthening of leading and coordination function in both R&D and HRD/IS programmes; (ii) widening of topic coverage - more attention on: country-commodity specific topics, sustainable and environment-friendly agriculture, post-harvest systems and marketing, small-scale farmers' economy and rural development; (iii) widening of region/country coverage and balancing of participation opportunity among member countries; (iv) continuation and strengthening of training activities - dissemination of updated and upgraded information and methodologies in database management and socio-economic policy analysis and planning; (v) expansion of distribution capacity of publications and information - more use of internet and website; and (vi) strengthening and effective use of cooperation/collaboration network with the partner countries and institutes.

The CGPRT Centre is encouraged by the high level of evaluation and those supportive and positive as well as critical advice and suggestions provided by the reviewers. The Centre will further enhance its pivotal role and coordination function to contribute to agricultural development in the developing member countries in the Asia and Pacific region. The Centre will further make efforts to strengthen its programme activities under both R&D and HRD/IS programmes.

The CGPRT, as a whole, will certainly make full efforts to operate and manage the institute efficiently and effectively in accord with the valuable advice and suggestions. In this context, the Centre expects strong support and cooperation from the ESCAP secretariat and member countries, especially from the prospective donor countries. Also, the Centre expects collaboration with the participating member countries and appropriate follow-up arrangements to effectively utilize the project outcomes and information in the countries.

HARUO INAGAKI

- Increase farmers' and herdsmen's' per capita income up to 1,310 Yuan RMB by 2000 and basically solve the problem of absolute poverty.
- Save water resources and improve water resource utilization efficiency.

Main constraints and potential for sustainable agricultural development in Qinghai

In order to achieve the objectives of agricultural development for Qinghai Province and to meet the challenge of feeding the ever-increasing population with limited land and water resources, terracing is regarded by the Qinghai Government as a significant technology for sustainable development due to the specific conditions of Qinghai Province. These specific conditions determine the main constraints to and potential for sustainable agricultural development in Qinghai Province.

Climatic constraints

There are a number of climatic constraints and these relate to the meteorological extremes and latitude of the study site. The harshness of the winter limits crop production to one crop per year, that is, 100% cropping intensity. The insufficient rainfall does not fully satisfy crop water requirements. The altitude also determines the length of the crop growing period in Huangyuan County, so varieties must be selected according to elevation as the available growing days decrease markedly with height. The timing of rainfall is also critical in rainfed crop production. Meteorological data show that the most reliable rains occur in late summer and planting is often delayed due to insufficient soil moisture. In most cases, climate constraints are beyond man's control.

Topographic and soil constraints

Because most land in Qinghai is located in mountain areas, the topography of Qinghai is a major constraint to crop production and limits development possibilities. Where development opportunities exist, they are associated with high environmental risks and high investment costs. In addition, the erosion potential of the soils in the agricultural areas of Qinghai Province is high because the loess soils have a poorly developed structure, are generally low in organic carbon (on arable areas at lower altitudes), lack cohesiveness, and have poor consistency. The soils are very prone to the erosive forces of wind, water, and the physical impact of humans and livestock. The potential for erosion is exacerbated by the cultivation of sloping land. In relation to the latter, all crop residues are removed from the field with the crop at harvest which leaves the surface of the soil bare and unprotected between September and April. Soil erosion is becoming a more and more serious constraint to sustainable agricultural development.

Water resources and utilization constraints

Qinghai Province is one of the typical dryland and desert provinces in China. Its regular annual rainfall is only 280 mm, in contrast to the national average annual rainfall of 648 mm. In addition, the spatial distribution of rainfall is uneven with a range of 155 mm to 540 mm; the temporal distribution of rainfall is also uneven and the rainfall in May-September is 84.6% of that for the whole year.

The capacity for utilizing water resources is poor

The annual used water resources make up only 4.5% of the total quantity of water resources, in contrast to the national average level of 30%. The total pooling capacity (capacity of reservoirs and ditches) is only 212 million cubic meters, making up only 0.58% of the total runoff and 12.8% of the total available water resources. In contrast, the national average level is 10% and 70%, respectively. Furthermore, the irrigation infrastructure in Qinghai is poor. The percentage of effectively irrigated cultivated land in the total area of cultivated land in Qinghai Province is only 30% while that for all China is 52%.

Institutional constraints

The capability for technology generation and technology dissemination at a formal institutional level is severely constrained by large extension ratios 500 to 1,500 farmers per extension agent, poor mobility of staff, complete lack of extension aids and extension material, and questionable recommendations especially for crop husbandry packages. There is no research of any nature being carried out within the prefecture and no ongoing demonstrations. Extension staff have not been trained in communication techniques or in the latest developments which have been identified by technology generation elsewhere in China. There is also no effective formal linkage between the various technical institutions - research, extension, universities, agricultural educators - farmers and government departments.

Finance constraints

The final major constraint to improved productivity in the project area is the availability of credit to small-scale resource-poor farmers for financing livestock and crop inputs, on-farm capital investments, and the acquisition of breeding stock.

Plentiful reserve farmland resources

The unused available reserve farmland resource is about 500 thousand ha, or 86% of the present cultivated land area. This means the cultivated land can be expanded by nearly 86% if conditions become suitable for reclamation.

However, the main restriction to reclaiming this reserve land is water shortage. The plentiful land resources and scarce water resources are the main characteristics of agricultural natural resources in Qinghai Province.

Water resources

Precipitation over the highland watersheds is sufficient to produce run-off which feeds a myriad of watercourses, streams and river flows. Where conditions are suitable, farmers have exploited natural resources to develop small-scale gravity irrigation schemes based on stream diversion. Larger streams with assured water are available in agricultural areas for harnessing, which would permit rainfed crop land to be converted into irrigation areas. It should also be noted that the spring cereals, oilseeds and potatoes have a high water response factor - over 1.2, i.e. they respond quickly to additional soil moisture in terms of yield increase.

Great margin means great potential

There is a great margin in agricultural productivity between dryland agriculture and irrigated agriculture. The margin of water efficiency between flat and sloping cultivated land is also great.

Plentiful human resources

The largest untapped potential in Qinghai is the large rural population that is solely dependent upon farming and grazing for survival. Farmers appear ready to contribute labour to development programmes if they do not impinge upon farming operations. Furthermore, the labour cost in Qinghai is lower due to the low farm income.

Terracing - significant technology for sustainable development in Qinghai Province

In order to overcome the major constraints mentioned above and fully tap the potential for agricultural production, great efforts were made to develop and apply new techniques for sustainable resource management and production. At present, major techniques applied in Qinghai Province include terracing, irrigation, interplanting techniques (wheat-maize interplanting model, bean-potato interplanting model), plastic film coverage technique, protection planting of potatoes, protection planting of wheat, balanced application of nitrogen and phosphate fertilizers, and rainfed farming techniques. Among these, irrigation and terracing techniques were used several decades ago and played the most important role in increasing agricultural production. They also had greatest implications for resource management and sustainable development. Due to difficulties in collecting data on irrigation, this paper will focus on economic assessment of terracing in Qinghai Province. In light of the time and human resource inputted in this study, Huangyuan County was selected as the case study site.

Terracing is regarded as a major sustainable resource management technique in Huangyuan County because it can improve efficiency of utilizing rainfall through improving water conservation and pooling capacity, improve irrigation conditions through leveling land and saving water in irrigation, control water and soil erosion, and increase output of agricultural products. In short, it can not only increase current agricultural productivity to meet the needs of the present generation, but it can also improve the agricultural resource base and environment by controlling soil and water erosion so as to meet the needs of future generations.

The practice of terracing went through three stages in Qinghai Province. The first stage is from 1950 to 1967 when terracing was done on a small-scale and wholly by framers. The second stage is from 1968-1981 when terracing in Qinghai was encouraged by the government-launched Movement of Agriculture Learning from Dazhai. The investment needed was wholly provided by collectives (townships and villages). The third stage is from 1982 to now when large-scale terracing was started combined with watershed management and funded mainly by governments at various levels and farmers.

The total terraced area by the end of 1996 in Huangyuan County was around 11,133 ha, making up 56.2% of total area of farmland and accounting for 90% of total land area of suitable for terracing. There are two main types of terracing in Huangyuan County. One is changing sloping dry land into terraced irrigated field; the other is changing sloping dry land into terraced dry field. Generally, the former occupies the greater part in total terraced area. Of the total terraced land in Huangyuan, the area of terraced irrigated field is 9,240 ha, accounting for

83%; the area of terraced field is about 1,893 ha, accounting for 17%.

Benefit-cost analysis for terracing in Huangyuan County

Due to the limit of time and the availability of data, benefit-cost analyses in this paper are conducted only for terracing projects completed in 1995. The analyses focus on direct economic benefits and costs as well as an assessment of environmental effects. The base period for analysis is from 1996 to 2010. Because there are two types of terracing in Huangyuan County with different economic results (transforming sloping land into terraced dryland and transforming sloping land into terraced irrigated land), analyses will be conducted separately for these two types of terracing. Since wheat is the major grain crop in Huangyuan County, wheat is taken as an example for assessing cost and benefit of terracing.

The cost for terracing in Huangyuan County consists of three components, i.e. the investment in terracing and related activities, the cost of land reduction, and the maintenance/operation cost.

The benefits from terracing in Huangyuan County mainly consist of the benefits from grain yield improvement, the benefit from water and soil conservation and the benefit from reforestation. In addition, there are some environmental benefits.

Although it is very difficult to assess environmental impacts of terracing in terms of economic benefit, the result is very positive. Terracing improves moisture content and granular structure of soil and helps to increase the number of microorganisms and the fertility of soil. In addition, reforestation after terracing will help control wind erosion and improve the environment and micro-climate. Terracing, as a key technology of resource management, will improve the natural resource base and is environmentally sustainable.

Based on the analysis and calculations, the total economic benefit gained from transforming sloping land into terraced dryland from 1996 to 2010 was US$ 391,240. Meanwhile the total cost was US$ 388,978 (Table 1). The ratio of benefit to cost is 1.00587, which means that the total benefit is very close to the total cost. Considering its environmental effect, construction of terraced dryland is economically feasible and environmentally sound. However, due to its less profitable nature, farmers are reluctant to construct terraced dryland and should be encouraged by local government.

The total economic benefit gained from transforming sloping land into terraced irrigated land from 1996 to 2010 was US$ 3,621,805 and the total cost was US$ 2,700,198 (Table 2). The ratio of benefit to cost is 1.34, which means the total benefit is 34% higher than total cost, and the construction of terraced irrigated land is economically profitable and environmentally sound. However, the construction of terraced irrigation land should be accompanied by the construction of irrigation schemes.

Conclusions and recommendations

Conclusions

There are many constraints to sustainable agricultural development in Qinghai Province, however, soil and water erosion, shortage of water resources and low efficiency of water utilization are decisive constraints to agricultural development. Terracing is one effective technique to overcome these constraints. Terracing played a great role in increasing agricultural production, particularly grain production in Huangyuan County, and made a significant contribution to the improvement of food security in Qinghai.

Terracing is a cost-effective method for managing and utilizing agricultural resources. It can produce significant economic efficiency, particularly when combined with the construction of an irrigation system. The result of B/C analysis indicated that terracing construction is economically profitable and sustainable.

Terracing combined with reforestation activities is not only conducive for controlling water and soil erosion, but also facilitates improving the micro-environment. It is environmentally sustainable.

For those people who have low income and few job opportunities outside the region, terracing can improve income and will contribute to poverty reduction and improvement of food security.

Recommendations

- The environmental effects of terracing such as water conservation should be advertised greatly, particularly for transforming sloping land into terraced dryland.

- Terracing should be more and more combined with improving irrigation systems so as to maximize its benefit.
- Sloping land with convenient irrigation conditions should be selected first for terracing.
- The practice of terracing combined with reforestation should be maintained so as to improve the natural resource base.

Table 1 Cost and benefit (US $) of terraced dryland from 1995 to 2010.

Year	Investment Interest	Maintenance Fee	Land Reduction	Soil Conservation	Forestry	Output Increase
1995	75,000	-	-	-	-	-
1996	5,250	-	16,500	133	-	5,598
1997	5,250	-	16,170	133	-	13,564
1998	5,250	-	15,846	133	-	24,649
1999	5,250	-	15,530	133	-	26,200
2000	5,250	342	15,220	133	1,338	27,680
2001	5,250	342	15,220	133	1,338	27,680
2002	5,250	342	15,220	133	1,338	27,680
2003	5,250	342	15,220	133	1,338	27,680
2004	5,250	342	15,220	133	1,338	27,680
2005	5,250	342	15,220	133	1,338	27,680
2006	5,250	342	15,220	133	1,338	27,680
2007	5,250	342	15,220	133	1,338	27,680
2008	5,250	342	15,220	133	1,338	27,680
2009	5,250	342	15,220	133	1,338	27,680
2010	5,250	342	15,220	133	1,338	27,680
Sub-total	153,750	13,762	1,231,466	1,995	114,718	1,374,491

BC Ratio = 391,240/388,978=1.00587

Table 2 Cost and benefit (US $) of terraced irrigation land from 1995 to 2010.

Year	Investment Interest	Maintenance Fee	Water Fee	Land Reduction	Soil Conservation	Forestry	Output Increase
1995	434,000	-	-	-	-	-	
1996	30,380	-	40,095	84,795	695	-	70,843
1997	30,380	-	40,095	83,099	695	-	149,854
1998	30,380	-	40,095	81,437	695	-	240,949
1999	30,380	-	40,095	19,808	695	-	249,034
2000	30,380	1,782	40,095	78,212	695	6,957	256,743
2001	30,380	1,782	40,095	78,212	695	6,957	256,743
2002	30,380	1,782	40,095	78,212	695	6,957	256,743
2003	30,380	1,782	40,095	78,212	695	6,957	256,743
2004	30,380	1,782	40,095	78,212	695	6,957	256,743
2005	30,380	1,782	40,095	78,212	695	6,957	256,743
2006	30,380	1,782	40,095	78,212	695	6,957	256,743
2007	30,380	1,782	40,095	78,212	695	6,957	256,743
2008	30,380	1,782	40,095	78,212	695	6,957	256,743
2009	30,380	1,782	40.,095	78,212	695	6,957	256,743
2010	30,380	1,782	40,095	78,212	695	6,957	256,743
Sub-total	889,700	19,602	601,425	1,189,471	10,425	76,527	3,534,853

B-C Ratio = 3,621,805/2,700,198=1.34

Economic Assessment of Selected Resource Management Practices for Efficient Use of Saline-Sodic Water in Arid and Semiarid Subtropical India

Mahander Singh[*]

Introduction

Land is the most precious of nature's gifts to mankind and the physical basis of biomass production and other supporting systems. Its availability, which was already limited, is further shrinking owing to burgeoning population pressure of human beings and animals alike**,** resulting in escalation in food, feed and fuel needs and diversion of agriculturally productive land to non-agricultural uses due to rapid industrialization and urbanization. The per capita net sown area in India, which was 0.38 ha in 1950, has shrunk to 0.20 ha in 1980 and is further estimated to decline to 0.15 ha by the advent of the new millennium. If this trend is any indication, it becomes imperative that we will be required to produce more and more food/feed/fuel/fodder from less and less land in coming years.

When the land resource is limited, water becomes of utmost importance for increasing crop productivity. Not only that, water is an effective resource for sustaining life and the environment. In view of its limited availability and competing demands it is imperative to utilize water with utmost efficiency. Water resource development and efficient use are necessary to meet the basic needs of biotic populations and to maintain a congenial environment. However, India has only 35% net irrigated area. Out this irrigated area about 51% is irrigated by groundwater sources (Table 1).

A survey of groundwater quality shows that 32-84% of aquifers have poor quality water. The use of this poor quality water for irrigation purposes affects soil health and crop growth adversely. There is thus a need to manage this water properly.

Table 1 Source-wise net irrigated area.

Source of Irrigation	Area ('000 ha)	Total Area (%)
Canal	17,290	35.4
Tank	3,348	6.9
Tube-well/ Well	25,012	51.3
Others	3,150	6.4

Objectives

The case study was undertaken to analyze the impact of land leveling, bunding, gypsum application and the sprinkler system of irrigation on the performance of pearl millet**-**wheat and pearl millet-mustard cropping systems under irrigation with saline and alkaline waters. The specific objectives of the study were:

- To analyze impact of the above mentioned techniques on crop production in farmers' fields under the semi-arid environment of the Indian sub-continent when saline or alkaline water is used for irrigation.
- To study economic aspects of these techniques for sustainable crop production.
- To study the impact of selected techniques on sustainability of natural resources.
- To identify constraints in adoption of these techniques.

Methodology

Site selection

Keeping in view the specific objectives of the study, the village of Karanpur in the district of Mathura on Farah-Achnera road was selected. The most important point which was considered in favour of Karanpur was that the village had an acute problem of saline and alkaline water for irrigation purposes. Moreover, an organization of Indian Council of Agricultural Research, i.e., Central Soil Salinity Research Institute, Karnal had initiated an Operational Research Project (ORP) in the village since 1993. The purpose of the ORP is to demonstrate the usefulness of suggested technologies for use of saline-alkaline waters for irrigation purposes on farmers' fields.

Data collection and analysis

The data on land use pattern, soil type and topography, water quality, rainfall pattern and climate, fertilizer use, irrigation, human population, literacy percentage, etc. were collected from the State Department of Agriculture (Government of

[*] Project Directorate for Cropping Systems Research, India. This paper is taken from Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture, Monograph No. 36, Bogor: CGPRT Centre.

Uttar Pradesh), Department of Economics and Statistics, Ministry of Agriculture (Government of India), R.B.S. College Bichpuri (Agra), Central Soil Salinity Research Institute, Karnal, Central Soil and Water Conservation Research and Training Institute, Dehradun and Board of Revenue, Mathura.

Two types of underground irrigation water exist in the village where the study was conducted. These are saline and alkaline waters. To achieve the objectives of the study, observations were conducted in the village. During the observations four different technologies applied on farmers' field were recorded. The technologies observed are: (a) leveling, (b) bunding, (e) gypsum application and (d) sprinkler usage. These improved technologies were compared to farmers' conventional technology in the study site.

Information on crop yields, cost of cultivation and other related variables from each type of farming practice was recorded. For economic analysis prevailing market prices of crops produced were taken into account. The operational cost for each technology was considered as an expenditure incurred by farmers on that particular technology. Operational cost includes cost of land preparation (including bunding leveling, gypsum application and sprinkler irrigation as needed), seed, seed sowing, fertilizer and manure, weed control, irrigation, and crop harvest and threshing. While calculating the economics of the technology, the fixed costs, which include rental value of land, interest on capital, depreciation cost, etc., were not taken into account.

The data were tabulated separately for pearl millet-wheat and pearl millet-mustard rotations. Comparison was made based on yield improvement on account of technology adoption over farmers' conventional practices. Benefit-cost ratios were calculated as gross returns divided by total operational cost. Here, gross returns means quantity of produce (including by-product also) multiplied by per unit market price of the produce.

Overview of the study site

The State of Uttar Pradesh lies between 23° 50' to 31° 28' N latitude and 77° 4' to 84° 38' E longitude, bounded on the north by Tibet and Nepal, on the north-west by Himachal Pradesh, on the west by Punjab, Delhi and Haryana, on the south-west by Rajasthan, on the east by Bihar and on the south by Madhya Pradesh. Uttar Pradesh shares 8.91% of the total area of the country.

The study site, i.e., Karanpur village, is located in Mathura district and falls under the south-western semi-arid agroclimatic zone of Uttar Pradesh which represents the semi-arid sub-tropical tract of the country. This zone covers six revenue districts, namely: Agra, Mathura, Aligarh, Etah, Firozabad and Mainpuri spread over an area of 22.41 thousand km^2 which is 13% of the total geographical area of Uttar Pradesh.

Biophysical characterization

The annual precipitation of the village ranges between 500 and 700 mm with an average of 620 mm which is much lower than the state average (Table 2). The maximum (65%) rainfall is received in the months of July and August. Precipitation exceeds evaporation during this period. September and October also experience a few erratic showers. The maximum mean relative humidity (80-85%) is recorded during August, while May is the driest month with a mean relative humidity of 30-35%. May and June are the hottest months when the maximum temperature shoots up as high as 43°C, while during January, the coldest month of the year, the minimum temperature dips below 0°C.

Table 2 Comparative annual rainfall of study site.

Location	Rainfall (mm)
India	1,388
Uttar Pradesh	987
Karanpur Village	620

The soils are of alluvium origin, light in texture, and sandy loam at the surface to sandy clay loam at subsurface. They are moderately drained and slightly to moderately alkaline in reaction. Soils are generally low in available N and medium in P and K status.

Farm practices

The major *kharif* crop of the study site is pearl millet (*Pennisetum glaucum*). Fodder sorghum (*Sorghum bicolor*) is also grown by a few farmers. However, some farmers also practice green manuring with *Sesbania aculeata.* During rabi season wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and mustard (*Brassica juncea*) crops are grown. The average cropping intensity of the selected village site is 117%.

Ninety-two percent of the cultivated area in the village is irrigated. The main source of irrigation is tube-wells. The water table depth fluctuates between 7 and 8 meters. Water quality parameters are given in Table 3. It is evident that the quality of the tube-well water is saline - alkaline. Many tube wells have high SAR saline water and the remaining have alkaline waters. Saline water with high SAR is found in the eastern part of the village and alkali waters in the western part.

A number of crop rotations are practiced in the village. However, pearl millet-wheat and fallow-mustard occupy the largest area. The following rotations are common:

- pearl millet-wheat
- pearl millet-barley
- green manure-wheat
- fallow-wheat/mustard/barley
- sorghum (F)-mustard/wheat
- pearl millet-mustard

The status of the two major fertilizer nutrients (N & P) use in the village is given in Table 4. The use of other nutrients is either nil or negligible. The use of herbicides, pesticides etc. is also not very common.

Table 3 Water quality at the study site.

Category	% of Tube-wells	EC_{IW} (dS/m)	RSC(me/l)	SAR_{IW}(minole/l)$^{1/2}$
High SAR saline waters	68	5.9-14.4	-	11.5-36.7
Alkali waters (high RSC waters)	32	2.5-3.0	4.8-12.8	9.8-17.9

Table 4 Fertilizer use.

Crop	Nutrient Use (kg/ha)		
	Nitrogen	Phosphorus	Potassium
Pearl millet	31	0	0
Wheat	110	54	0
Mustard	63	37	0
Barley	60	37	0

Socio-economic characterization

The total population of the village under study is 665 with a density of 257 persons per km^2 which is much lower than the state average of 470 persons per km^2 (Table 5). The literacy rate of the case study village is 49%, which is greater than the average for India (43%) as well as Uttar Pradesh (34%). It was further noted that among the literate the ratio of males to females was 74:26.

With respect to land holding size, the majority of farmers are classified as marginal (40%) followed by small (20%), sub-medium (20%), medium (15%) and large (5%).

The average income of families from different sources was observed to be quite low (Table 6). Only 13% of families had an annual income higher than Rs 11.00 thousand.

Table 5 Area, population density and literacy rate.

Location	Area	Total Population	Density (persons/km^2)	Literacy (%)
India	328.7 m ha	844 million	260	43
Uttar Pradesh	29.4 m ha	139 million	470	34
Case study site	258.6 ha	665	257	49

Table 6 Family income of farmers in case study site.

Income Group (Rs per annum)	Percent of Families
< 4,000	8
4,001-6,000	43
6,001-8,500	23
8,501-11,000	13
> 11,000	13

Effect of agro-techniques on yield, monetary returns and sustainability of natural resources

Yield and monetary returns

The four techniques improved the yield and farmers' income (Tables 7-11). The increase in yield due to these techniques over the fields where these techniques were not applied ranged from 27 to 122%, the highest being with gypsum. The benefit-cost ratios reveal that on average farmers may get a gross benefit of Rs 2.32 to 2.52 for each rupee invested in crop production due to adoption of improved techniques.

Sustainability of natural resources

Effects of land leveling, field bunding, use of gypsum, sprinkler irrigation, salt tolerant variety, green manuring, organic manure and fertilizer were

Table 7 Effect of leveling on grain and straw yields (kg/ha) of pearl millet-wheat and pear millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmer's practice	981 (2,453)*	2318 (2,898)	3299 (5,351)	1009 (2,523)	909 (455)	1918 (2,978)
Improved with leveling in saline water	1,475 (3,688)	3,530 (4,413)	5,005 (8,101)	1,310 (3,275)	1,320 (660)	2,630 (3,935)
Improved with leveling in alkaline water	1,390 (3,475)	3,590 (4,488)	4,980 (7,963)	1,280 (3,200)	1,308 (654)	2,588 (3,854)

* Figures within parentheses are straw yield.

Table 8 Effect of bunding on grain and straw yield (kg/ha) of pearl millet-wheat and pearl millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmer's practice	803 (2,008)*	2,616 (3,270)	3,419 (5,278)	850 (2,125)	809 (405)	1,659 (2,530)
Improved with leveling in saline water	1,160 (2,900)	3,180 (3,975)	4,340 (6,875)	1,260 (3,150)	1,180 (590)	2,440 (3,740)
Improved with leveling in alkaline water	1,204 (3,010)	3,205 (4,006)	4,409 (7,016)	1,204 (3,010)	1,275 (638)	2,479 (3,648)

* Figures within parentheses are straw yield.

Table 9 Effect of gypsum application on grain and straw yield (kg/ha) of pearl millet-wheat and pearl millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmers' practice	1,050 (2,625)*	2,587 (3,234)	3,637 (5,859)	780 (1,950)	603 (302)	1,383 (2,252)
Improved with leveling in saline water	1,730 (4,325)	3,790 (4,738)	5,520 (9,063)	1,520 (3,800)	1,205 (603)	2,725 (4,403)
Improved with leveling in alkaline water	1,809 (4,523)	4,009 (5,011)	5,818 (9,534)	1,710 (4,275)	1,360 (680)	3,070 (4,955)

* Figures within parentheses are straw yield.

Table 10 Effect of sprinkler irrigation on grain and straw yield (kg/ha) of pearl millet-wheat and pearl millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmers' practice	714 (1,785)*	2,410 (3,013)	3,124 (4,798)	920 (2,300)	820 (410)	1,740 (2,710)
Improved with leveling in saline water	980 (2,450)	3,435 (4,294)	4,415 (6,744)	872 (2,180)	1,420 (710)	2,292 (2,890)
Improved with leveling in alkaline water	1,008 (2,520)	3,360 (4,200)	4,368 (6,720)	955 (2,388)	1,328 (664)	2,283 (3,052)

* Figures within parentheses are straw yields.

demonstrated on the fields of 19 farmers. Data on soil pH in the beginning of ORP and after harvest of wheat in 1996 were collected. Out of 19 farmers, soil pH decreased in the field of 14 farmers within two years of application of improved techniques. Decreasing pH indicates that soils are becoming more neutral in reaction, thus there is a decrease in the soil degradation process. The data also reveal that continuous use of improved techniques may lead to long-term sustainability of soil health and crop productivity.

Further, improved irrigation systems such as sprinklers, because of their high irrigation efficiency compared to flood irrigation systems, need less

Table 11 Effect of selected techniques on monetary returns of two cropping systems.

Technology	Benefit Cost Ratio		
	Conventional Practice	Improved Practice in Saline Water	Improved Practice in Alkaline Water
pearl millet-wheat system			
Leveling	2.01	2.58	2.58
Bunding	2.12	2.57	2.30
Gypsum*	2.23	2.62	2.70
Sprinkler**	1.94	1.84	1.89
pearl millet-mustard system			
Leveling	2.73	2.62	2.58
Bunding	2.39	2.41	2.51
Gypsum*	1.90	2.32	2.62
Sprinkler**	2.47	1.96	2.36

Note: For calculating cost of gypsum application per year, it was assumed that gypsum is applied once in 3 years, thus the total cost of the gypsum was equally distributed over 3 years. The life of a sprinkler set was considered 10 years, thus the total cost of the sprinkler set was equally distributed over10 years. Land rent and depreciation are not included. The cost of leveling is calculated on a nine-hour basis.

water pumping which results in less addition of salts to soil and thus a delay in process of soil deterioration.

Irrigation with saline or alkaline water makes the soil less permeable to water. Because of this, a major part of rainwater flows away as runoff from the fields and causes flood-like situations in adjoining areas. Also, there is little recharging of natural aquifers due to impeded downward movement of water. Adoption of suggested technologies can cause improved permeability of soil which will result in increased water storage capacity of soil, less wastage of rainwater as runoff, more intake of water into the soil and increased recharge of aquifers.

Constraints to technology adoption

In spite of the higher benefits from the improved technologies, these technologies have not found favour of farmers due to the following constraints:

- Economic constraints: resource poor farmers, high cost of technology, small land holding.
- Social constraints: fragmented land holdings, low education, lack of community approach, agricultural labour shortage.
- Institution and infra-structural constraints: non-availability of inputs, poor extension services, incompatible loaning procedures.
- Technological constraints: lack of suitable implements.

Recommendations

Based on the findings of this study, the following suggestions can be made for consideration of government, farmers and researchers to make the use of saline/alkaline waters in crop production more efficient and to ensure the sustainability of crop yields, farmers' income and the environment.

Government

- Improved credit infrastructure is essential. As inferred from the status of land holding size and family income, the majority of farmers are marginal and small and fall into low-income groups. Because of this their purchasing power is poor and they are unable to purchase inputs and implements for adoption of unproved technologies. Therefore, specific efforts of government are needed for further strengthening of the banking infrastructure to extend adequate credit facilities to the farmers of problem soil/water regions of the country considering the importance of agriculture in the national economy.
  - Chargeable interest rates may be further brought down through suitable financial and banking reforms.
  - Repayment terms may be further liberalized for poorer sections of the society, as agriculture is highly risk prone in these areas. However, the recovery schedule should be adhered to, to smoothen the flow of credit in both directions.

- Considering the basic fact that most of our farmers are either illiterate or not conversant with complicated banking procedures, loan procedures need to be highly simplified to make them farmer-friendly.
- More functional autonomy with less political interference is needed for better functioning of Cooperative Credit Societies.
- Introduction of credit cards to farmers needs to be encouraged to reduce malpractice.

- Timely supply of inputs includes planting materials, agro-chemicals, etc.
- Efficient management of subsidies will prevent mortgages and maximize benefits.
- Land consolidation will facilitate adoption of improved technologies.
- Strengthening of the extension infrastructure will improve adoption of government programmes.
- Development of small irrigation and drainage grid systems will support water management.
- Education of farm families will assist adoption of improved technologies.
- Farmers' participation in planning and implementation of programmes would ensure greater acceptance and adoption of these programmes.

Farmers

- Farmers should develop banking aptitudes and habits to take full advantage of credit facilities extended by the banks.
- Farmers have many superstitions or social barriers about new things. Farmers should develop confidence to break these barriers.
- Government launched programmes should be taken in good stride and should be considered as important as their own programmes.

Researchers

- Research is needed to develop low cost technologies to bring down the cost of sprinkler and drip irrigation systems, bullock drawn land levelers and bund makers and other farm machinery.
- The non-availability of gypsum in the area is one of the constraints to its use. Therefore, locally available alternatives to gypsum are required.
- Animal dung, presently used for making dung cakes to meet household fuel requirements, can be saved for agricultural purposes by popularization of gobar gas plants and encouraging social forestry. However, there are certain flaws in the currently available designs of gobar gas plants and which need to be eliminated.
- There is a need to develop location specific salt tolerant crop varieties.
- Research on development of appropriate and profitable alternative farming systems like agro-forestry systems and silvi-pastoral systems is needed.

CGPRT Centre News and Activities

TRADELIB

Interim reviews of the project were conducted for Thailand in July 1998 and for Indonesia in September - October 1998. Dr. Boonjit Titapiwatanakun, the regional advisor, and Dr. Michio Kanai, the project leader, met with Thai and Indonesian researchers to discuss their country reports for the first phase of the project.

ECOPOL

The Economic and Policy Analysis for the Ecoregional Approach in South-east Asia (ECOPOL) project is designed to bring methodological and applied answers to the issue of sustainable income increase in rural areas. It deals with agricultural policies, economic policies having an impact on agriculture and agriculture-related sectors (agro-industry, trade, services and consumption mainly), and institutional policies. In 1998, the project proposal was finalised and field work started in Vietnam in June and later in Indonesia.

In Indonesia after consultation with CASER the project agreed to address the impact of the policies currently implemented to support agricultural development on income and on the use of natural resources in the less developed southern part of West Java. Contacts with West Java AIAT have led to an agreement to work together in this zone. The next step will be to meet local provincial institutions to set up a work program and to define precisely the issues to be addressed.

In Vietnam, after consultations with stakeholders at various levels, the link with the market was identified as one of the major problems affecting farmers' income and future rural development in the Red River Delta. Four provinces representing the main RRD agroecological zones, and three activities in each province according to the socioeconomic conditions, were selected. These are:

- Hai Duong in the intensive zone: pig, high-value vegetables, non-agricultural activities
- Nam Dinh in the coastal zone: high quality rice, pigs, non-agricultural activities
- Nam Ha in the lower zone: rice, aquaculture, non-agricultural activities
- Ha Tay in the intermediate zone: rice, pigs, fruits (longan).

For cost reasons, research will first develop in Ha Tay and Nam Dinh. VASI should be able to take charge, with its own funds, of one more province (Hai Duong) using the ECOPOL approach. Pretypologies of farmers have been done in Ha Tay and Nam Dinh. They should be revised and adjusted through field surveys in two districts per province and three villages per district.

HRD/IS

From 28 September to 2 October 1998, a hands-on training course on database management and analytical techniques for agricultural planning was held in Los Banos, the Philippines, co-hosted by the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development. The training modules included topics such as design, construction and management of relational and geographic databases together with thematic mapping. The demonstration was continued with the introduction of agricultural policy analysis approaches (e.g. ECOPOL) and tools (MATA). Further, the MATA interface was used to modify economic scenarios for analysis of the resulting impact. Fourteen participants attended the course, selected from the national agricultural research council, institutes and universities. The in-country course was well received and the participants appreciated the subject matter.

Announcements

1999 IIRR International Training Courses

The International Institute of Rural Reconstruction offers regular, international training courses on a range of topics. These courses are designed for development managers and leaders and focus on field experience and participatory approaches.

Rural Development Management
April 12 - May 7 and July 26 - August 20, 1999

For senior and mid-level development managers. This course covers development issues, managing sustainable and people-centered development programs and managing a development organization. It addresses aspects of project planning, implementation and evaluation. Participants are introduced to real experiences in rural development. The course is built around observations of village-level projects in the Philippines.

Training of Trainers on Sustainable Agriculture
June 21 - July 16, 1999

Designed for development practitioners who organize or conduct training activities on sustainable agriculture and related topics. This training workshop focuses on enhancing skills of the participants in sustainable agriculture development and management. Specifically, it covers training needs assessment, training design and evaluation skills for sustainable agriculture training. Participants develop their own training designs and present one of the topics they have developed.

Systems in Community-managed Health
August 16 - September 10, 1999

Participants analyze experiences in rural health from the viewpoints of villagers and development organizations. They determine what has worked and what has failed in efforts to help people influence their health service structure. They prepare action plans that their organizations can put into effect in promoting people-centered and community-managed health programs. Not a basic training on technical skills in field level facilitation, but a specially designed program to upgrade skills in analysis and synthesis.

Participatory Monitoring and Evaluation
September 13 - October 1, 1999

The participatory monitoring and evaluation (PM and E) course is designed for project managers, research study leaders and extension officers who have been managing and/or implementing community-based development. It will examine PM and E at the community, program and organizational levels. Selected cases will be presented and discussed. PM and E concepts and theories and methods, tools and techniques which have been tested and used in the field will be shared.

Food Security: A Program Manager's Course
September 20 - October 15, 1999

Designed for managers of food security programs. The course will focus on the design, implementation, monitoring and evaluation of programs aimed at alleviating hunger and malnutrition. Participants will discuss and analyze current food security issues, policies and trends. They will review and compare various strategies and approaches used in addressing food insecurity appropriate to their own local situations. The course will provide opportunity for participants to prepare action plans which their organizations can implement to improve existing program or pursue new interventions towards a more effective food security program.

Development and Management of a Training Program
October 4 - 29, 1999

This is a higher level course for trainers in development. It will focus on skills related to training program designing, training needs assessment and evaluating training programs. Training programs range from community-based training programs to NGO staff training programs. It will not be limited to the development of training skills as described above. More importantly, the development of the desired attitudes and trainer values will be given emphasis.

Financial Sustainability Straitegies for NGOs Workshop
October 11 - 16, 1999

For a team of 2-4 development managers from private volunteer organizations who are committed to create change strategies for financial sustainability of their service delivery. This six-day workshop emphasizes innovative ways to organize service delivery, making scarce resources perform and generate local earnings to support program benefits. It will also provide opportunity for participants to think critically about financial sustainability issues of their own organization. The workshop is only able to accept a limited number of teams from organizations in Nepal, Indonesia, Malaysia, Thailand, Philippines, Papua New Guinea and Vietnam .

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CGPRT Centre

The Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in the Humid Tropics of Asia and the Pacific (CGPRT Centre) was established in 1981 as a subsidiary body of UN/ESCAP.

Objectives

In co-operation with ESCAP member countries, the Centre will initiate and promote research, training and dissemination of information on socio-economic and related aspects of CGPRT crops in Asia and the Pacific. In its activities, the Centre aims to serve the needs of institutions concerned with planning, research, extension and development in relation to CGPRT crop production, marketing and use.

Programmes

1. Research, which entails the preparation and implementation of studies covering production, utilization and trade of CGPRT crops in the countries of Asia and the South Pacific.
2. Training of national research and extension workers,
3. Information and documentation which encompasses the collection, processing and dissemination of relevant information for use by researchers, policy makers, and extension workers.

Palawija News

Contributors are invited to submit concise summaries of significant social research related to CGPRT crops for publication. Figures (graphs or tables) may accompany the article. All articles are subject to editing to meet space limitations.

Please send all queries relating to articles in *Palawija News* to Publications Section, CGPRT Centre, Jalan Merdeka 145, Bogor 16111, Indonesia.

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