IRRIGATION CAN SUSTAIN RURAL LIVELIHOODS: evidence from Bangladesh and Nepal

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Sustainable livelihoods – a definition

The definition of what constitutes a sustainable livelihood is based upon that used by DFID in its sustainable livelihoods approach, (DFID, 1999)

"A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with, and recover from, stresses and shocks and maintain or enhance its capabilities and assets, both now and in the future, while not undermining the natural resource base."

The DFID approach uses livelihood assets, otherwise known as the five capitals, as a way of organising and representing the complex thinking about how livelihood opportunities are constrained or can be enhanced.

Findings of the studies in Bangladesh and Nepal are presented in terms of the five assets. In reality many of the impacts of irrigation will affect more than one of these assets. The surveys undertaken in both countries emphasise the importance of a package of rural development interventions for irrigation development to achieve its potential.

Livelihood assets

Human assets: the skills, knowledge, ability to labour and good health that are important to pursue different livelihood strategies.

Physical assets: the basic infrastructure (transport, shelter, water, energy and communications), the production equipment and means that enable people to pursue their livelihoods.

Social assets: the social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods.

Financial assets: the financial resources which are available to people (whether savings, supplies of credit or regular remittances or pensions) which provide them with different livelihood options.

Natural assets: the natural resource stocks from which resource flows useful for livelihoods are derived (e.g. land, water, wildlife, biodiversity, and wider environmental resources).

DFID (1999)

Irrigation can sustain rural livelihoods: evidence from Bangladesh and Nepal

Summary

This document is an output from a research project funded by the British Government's Department for Internatinoal development (DFID). It aims to provide information for decision-makers and policy-shapers to improve their awareness of the important role of irrigated agriculture to sustain rural livelihoods.

Six case studies of small-scale irrigation systems in Nepal and Bangladesh provide evidence that irrigation can sustain and improve rural livelihoods as part of an overall package of rural development measures. The document identifies pre-conditions and complementary measures to help ensure the real benefits obtainable from irrigation.

Lessons learned from the studies together with a workshop held in May 2003 are synthesised into policy recommendations that aim to maximise the benefit of irrigated agriculture and ensure that it secures sustainable livelihoods for the poor.

The overall conclusion is that irrigation development has sustained and improved rural livelihoods for large numbers of people in both countries. The more individual or "private" approach in Bangladesh contrasts with the more community-based approach in Nepal, but in both countries improvements are possible. In Nepal, irrigated agriculture is yet to reach its full potential. In Bangladesh the mono-culture of rice, while successful at present, raises doubts about continued soil fertility and has caused a loss of forest and wetlands, which are important to poor livelihoods.

Introduction

Irrigated agriculture can make an important contribution to food security, improved nutrition and rural prosperity. In a study of the whole of Asia, the FAO (1996) shows that yields per area for most crops have increased by 100–400 percent as a result of the combination of irrigation and improved seed and fertiliser technology. Food grain prices fell by 20 percent relative to the price index for all commodities.

This document uses studies in Bangladesh and Nepal to show the positive impact of irrigated agriculture on livelihoods (Angood et al 2002, 2003). By examining three typical rural communities in each country we hope to demonstrate what initiatives and policies have been most successful for sustaining livelihoods in these and other communities and in what ways they can be improved.

Irrigation development has been essential in allowing villagers in the six communities studied to grow enough food for home consumption. Furthermore, the aggregate impact of irrigated production in both Nepal and Bangladesh has helped to increase the supply of food, making basic foods affordable for a greater proportion of the population. Not only is irrigation an important tool in generating sustainable incomes but there are now greater and wider opportunities for employment in agriculture or in other jobs created to serve the agricultural community, a finding confirmed by others (see box). Hazell & Haggblade (1990) also show for India that an increase of Rs100 in irrigated agricultural output stimulates Rs105 worth of additional manufacturing output and Rs114 of additional tertiary output, a total non-farm multiplier of 2.19.

Irrigation development brings employment opportunities

During the 1980s, a public works project in Borletar, Nepal, used employment-intensive construction practices to provide irrigation to all cultivable land in the project area. Production potential increased by over 300 percent and income by over 600 percent making a considerable contribution to improved food security. Total labour demand has more than doubled overall, for both men and women.

Martens, 1989

The application of water to the land to produce crops, both food and fibre, can in most cases extend the growing season, giving the opportunity to grow more than one crop a year. It also allows the extension of agriculture into dry areas, taking advantage of land resources that would otherwise not be used. While expansion of agricultural area increased food supply in the early years, irrigation received much criticism from environmentalists particularly for causing water logging and salinity in arid areas. Awareness of the finite nature of water and the growing demand for fresh, clean water in the domestic and industrial sectors, has increased criticism for using water for irrigating low value crops.

Irrigation development has also been seen as costly and complicated, favouring wealthy landowners and large scale bureaucratic enterprises. There is a need to recognise the growing scarcity of freshwater and competition for its use along with the need to preserve freshwater ecosystems. Integrated Water Resource Management (IWRM) is now essential in many countries. Irrigation planners need to look closely at how water is applied and in some situations question whether further irrigation development is desirable and justified.

Overall, it is clear that irrigation can increase food production. However, irrigation is not just a means to increase food production: most countries can import relatively low-cost food. Of particular importance is the fact that irrigation development can offer opportunities for poverty reduction in rural communities. This in turn, as the studies show, can improve social and economic development and the creation of sustainable rural livelihoods.

This document is therefore addressed to decision-makers and policy-shapers to improve their awareness of the important role of irrigated agriculture in sustaining rural livelihoods.

Irrigation schemes studied

Bangladesh

The three study villages are situated in low-lying areas of similar topography near Mymensingh in the north-east of the country.

The village of **Talki** (pop. 3500) is located within Sherpur district and is accessible by road from the Sherpur district highway. Irrigation commenced in 1973 when the first deep tubewell (DTW) was installed. In 1984, shallow tubewells (STWs) were installed and widespread cultivation of irrigated crops began. In 1995, the sealed road was constructed which passes through the eastern part of the village and provides good transport and marketing facilities.

Mohanpur village (pop. 6000) is located 16 km from Jamalpur town. The village is near to the Jamalpur–Mymensingh highway and connected to it by three earth tracks. A DTW was installed in 1975, allowing cultivation of improved (dry season) paddy to commence that year. The first STW was installed in 1978 and the number of STWs in use has increased since then.

Borni village (pop. 5000) is located 9 km from Netrakona town. The village is connected to the Netrakona–Mohongonj sealed road by a 4 km raised earthen track that was constructed by the government in 1990 following severe flooding in 1988. The track is an essential access route to the village, which is bordered by three *beels* (largely perennial water bodies/wetlands.) Irrigated MV *Boro* (dry season) paddy production commenced in the village in 1977 with installation of the first DTW. The first STWs were installed in 1980 allowing the majority of farmers to grow irrigated improved paddy in the dry season. From 1985, superior improved paddy varieties became available and were cultivated intensively as farmers sought better yields.

Figure 1: Location of villages in Bangladesh

Nepal

Janakalyan irrigation scheme is located on the Terai plains, 6 km south of Parsa bazaar on the main east–west highway. The Janakalyan outlet is the seventh in a line of outlets on the Rapti River and supplies two command areas of 91 ha and 25 ha. Access to the scheme is by all-weather roads surfaced with aggregate.

The **Kalleritar** scheme is situated in the Mahabhart hilly region about 50 km from Kathmandu. Pedestrian-only access is via a trail and suspension bridge from Baireni, (approx. 30-minute walk) which lies on the Kathmandu-Pokhara (Prithivi) Highway. The scheme comprises four villages that are separated from their neighbours by the Trishuli River and steep hillsides. The command area is about 82 ha in total, consisting of a river terrace parallel to and about 50 m above the Trishuli River. Irrigation supply is from a tributary flowing along an 11-km contour canal.

Figure 2: Location of schemes in Nepal

The **Yampaphant** scheme is on the Prithivi Highway between the market towns of Anbu Kaireni (10 km) and Dumre (5 km). The command area has a gentle slope and is therefore terraced. The irrigated area is sandwiched between hills to the south of the village and the Marsangadi River to the north. The irrigation supply comes from streams originating from springs in the hills to the south, that also supply a neighbouring village. Two irrigation canals supply water to a total irrigated area of 37 ha. The 1988 'Hill Food Programme Project' extended the upper canal and rehabilitated both existing canals bringing some 13 ha of previously rainfed upland plots under irrigation and increasing the supply to the original command areas.

Irrigation's impact on livelihood assets – Bangladesh

Irrigation development in Bangladesh has had a profound impact on rural livelihoods through significant improvements in cropping intensity, grain production, (predominantly rice) household incomes, increased wages, employment and livelihood diversification (Hasnip et al, 2001).

Human assets

Cropping patterns since the introduction of irrigation have changed to favour increased rice production, increased cropping intensity and intensification of cultivation. Harvest and processing activities have created greater opportunities for labour, encouraging seasonal migration from less intensively irrigated areas.

There are now greater opportunities for the landless, who are usually the poorest in the community. Higher agricultural production has led to an increasingly mobile community and higher demand for processing, transport and marketing services. The services of rural mechanics are needed to fix agricultural equipment; blacksmiths, workshop owners and rice millers are in demand; and 'van' and rickshaw drivers move fuel, fertilisers, cereals and vegetables.

Figure 3: Women preparing rice for milling, Mohanpur, Bangladesh

Student enrolment has greatly increased. The driving forces are: increased income available to invest in education, increased awareness of the benefits of education, and the recent government-run food-for-education programme. School attendance has risen – particularly of girls and those from previously poor families. The number of schools has slightly increased with particular growth in the number of Madrasas (religious training centres), funded by richer members of the community. Literacy rates have increased faster than the trend nationally. Men remain generally better educated than women, but the educational level of women is improving

Although food production and household food security have improved dramatically, most households grow and consume few vegetables. Farm households continue to lack a well-balanced diet because of the focus on rice production. According to farmers' perception, however, health in the villages has improved. The reduction in overall food deficit and a greater income available for expenditure on food, healthcare and medicines have contributed to these improvements.

- Opportunities for landless people, involving inter-district migration for cultivation, have greatly increased, though labourers' social position will continue to limit their progress.
- New employment opportunities have arisen for non-farm occupations, e.g. rural mechanics, blacksmiths, rice mill and workshop owners, 'van' and rickshaw drivers.
- Increased income and government incentives have allowed families to invest in education. Student enrolment, literacy rates and women's educational levels are all on the increase.
- Health improvements have resulted from increased food production and security but improvements in diet lag behind.
- Training in agricultural techniques is needed to sustain improved and diversified cropping.

Despite the improvements in production, there is still a need for reliable training on irrigation and cultivation techniques, particularly for improved and diversified cropping. Information tends to be passed from farmer to farmer, which though important has its limitations. At present, the Block Supervisors, who could help provide relevant information, only visit at irregular intervals.

Natural assets

Irrigation is particularly attractive in Bangladesh because it allows cultivation in the dry months from November to March (*rabi* season) when there is no risk of flooding, although there is some risk of storms at harvest time. In low-lying, deeply flooded areas, cropping intensity is not likely to increase, but low yielding local *aus / broadcast aman* crops in the monsoon season may be replaced by High Yield Variety (HYV) *boro* rice. However, the area traditionally cultivated with pulses, oilseeds and spices in the *rabi* season is reduced.

The trend to mono-cropping of rice is partly due to attractive pricing, but also because farmers perceive there are greater risks and higher marketing costs for other crops. Different water management practices are needed to cultivate rice and other crops. Farmers within a command area must agree and co-ordinate cropping patterns and water use.

Year-round and extended cultivation of rice brings the potential for negative environmental impact, for example: lowering of the water table, reduction in groundwater quality and soil fertility, and loss of species diversity in former forest, *beel* and marginal areas. The exact changes remain to be quantified, but the trend appears to be real and calls into question the sustainability of a predominantly rice farming system. Increasing cultivation of these areas may also disproportionately affect the livelihoods of the poor by the loss of wild plants and fruit, fuel wood, fisheries and grazing land on which they have traditionally relied.

- Investment in irrigation helps to reduce the risks of crop damage by allowing cultivation at times of year when climatic conditions are less risky.
- The increased cultivation of irrigated HYV rice has adverse implications for soil fertility, reduces land devoted to other crops and increases need to diversify crops.
- Livestock numbers have declined, as grazing land is lost through the increased cultivation of forest, beel and formerly fallow lands. Animal fodder is also less available.

Livestock, kept mainly for agricultural and domestic purposes, particularly cattle and goats, has declined in number. The change is due to loss of fodder and grazing, linked to intensification of cropping and the growth of short HYV rice varieties that have fewer residues. Draught animals have been replaced by the increasing use of power tillers for land preparation. In consequence, there is less manure available for use both as fuel and fertiliser, potentially contributing to an increased pressure on forest resources for fuel wood and a decline in soil organic matter and fertility.

Financial assets

Increased crop yields and profits have bettered the economic condition for farmers. Shallow Tube Well (STW) irrigation enables farmers to grow HYV boro rice in place of a relatively low yielding, rain-fed aus-aman crop. Average boro yields of 4.5T/ha recorded at the time of the study were greater than average pre-irrigation aus yields of 1.3T/ha and aman yields of 1.7 T/ha. Severe hailstorms at the time of the study meant that the recorded boro yield was lower than potential yield. The average yield for HYV boro in Bangladesh in 1998-99 was 3.1T/ha (Bangladesh Bureau of Statistics 1999).

Financial gains through irrigation have helped to stimulate the local economy. An increase in the disposable income of farmers and labourers has allowed them to acquire a range of household goods, spend more on education, housing improvements, food, health care and medicines. The number of shops, crafts, trades, general merchants and service providers has increased in response to demand. The numbers of rice mills, power tillers and threshers attest to an increased ability to afford mechanisation.

Irrigation has helped all stakeholders to reduce their risks and vulnerability to shocks. Irrigated boro paddy provides more reliable yields. Farmers diversify their activities by using capital accumulated from increased rice production for enterprises such as intensive poultry farming and aquaculture. Farmers also invest in STWs to further reduce risks and assure an adequate supply of water. Landless labourers are also able to take up non-farm employment as mechanics or pulling rickshaws and ‘vans’, yielding an income less dependent upon the farming calendar. Bicycles are purchased and hire becomes more affordable.

Where land is unequally distributed, irrigation development initially favours farmers with larger land holdings. Small farmers can still benefit if access to water can be ensured. In Bangladesh, this has been achieved variously, by access to credit, appropriate irrigation equipment and water. Facilitating this environment for economic activity means that the benefits from increased production due to irrigation are more widely distributed, which in turn provides employment opportunities for the landless.

All three villages report an increase in the number of farm labourers, yet shortages of labour are reported at critical times in the season. Demand for labourers has, as a result, increased and led to higher wages.

- Irrigated agriculture becomes more profitable due to significant increases in production intensity and output.
- Purchasing power is increased in irrigated areas, that in turn stimulates the local economy.
- Reduction of financial risks as farmers use capital gained from an increase in rice production to diversify their activities, and labourers take advantage of opportunities in the non-farm sector.
- Wider access to credit, affordable equipment and water improves benefits to small farmers.
- Higher wages for labourers, as a result of increase in production intensity and a corresponding increase in demand for labour.

Physical assets

In all three villages, STW numbers have increased dramatically over the last ten years, superseding deep tube well technology. The rapid expansion of STW technology followed market liberalisation, which lead to the widespread availability of a range of affordable equipment.

Financial gains through irrigation have commonly been invested in infrastructure improvements, raising living conditions and standards in all three of the study villages. Improvements to houses are now common and include the addition of tin sheets for roofs and walls, latrine construction and Hand Tube Wells (HTW) for domestic water. Since the introduction of irrigation, a variety of shops, selling farm inputs (fertilisers, seeds, etc.) and agricultural produce, and rice mills have been built.

Besides irrigation, road improvements have made the largest contribution to the development of all three villages. Road development has greatly complemented irrigation, maximising its benefits by improving access to markets both for inputs and outputs. New and improved roads to all villages have enabled cycle/ rickshaw transport to develop.

Irrigation has stimulated mechanisation of agricultural processes and encouraged adoption of other technologies. Increased affluence has allowed widespread use of power tillers, whilst power threshers are

increasingly employed. Rice mills are now commonly used in place of hand milling. Farmers are investing more, and the resulting savings in time and effort can now be allocated to other tasks/employment. Women's release from agricultural tasks is opening up opportunities for small rural enterprises and a general expansion of economic activity in the villages.

Figure 4: Tubewell engine converted to rice husking machine, Talki, Bangladesh

- Market liberalisation helped stimulate irrigation development by making affordable equipment available, which further stimulated the up-take of shallow tube wells.
- Profits from irrigation have often been re-invested in household improvements, such as "tin" roofs, walls, latrines, HTW and greater expenditure on household possessions.
- Road development has improved the benefits from irrigation through improving access to market.
- Women have been released from agricultural processing with the introduction of threshing, rice husking machines and other technology associated with irrigation.

Social assets

Supportive activity between families in the villages is evident, as food security has increased. Overall, farmers described an increased ability to help those in need.

Generally in Bangladesh, irrigation has encouraged inter-district labour migration linked to the harvest. The combined effect of expansion in the farm and non-farm sectors in two of the three study villages has led to a reduction in seasonal out-migration in search of work. In these villages, labour requirements are now largely met from within, rather than from external sources. Seasonal out-migration continues in Borni village where the proportion of landless households is higher.

- Farming families are now more able and willing to help those in need.
- Combined expansion of farm and non-farm sectors can reduce seasonal out-migration in search of work.
- More immediate benefits accrue to larger land holdings. Special provision is needed to ensure that landless and marginal farmers share in the benefits.
- Small private enterprises have grown in response to demands for inputs, the sale of agricultural products, technology and services.

Religious influences have channelled some of the available additional resource into charitable and educational facilities, adding a new social dimension in managing community facilities.

Irrigation development initially favours those with larger land holdings. As stated earlier, with mechanisms to ensure adequate and reliable access to water, farmers on smaller holdings can also reap the benefits of irrigation. For the poorer sections of the community, the landless and marginal farming households, irrigation provides household food security and basic living standards rather than contributing to major livelihood enhancements.

The management of shallow tube wells requires little in the way of social organisation. Wide up-take of the STW technology has not generated a 'committee culture'. Nor is collective action to acquire inputs or sell paddy in the villages evident. Small private enterprises have grown up to respond to the commercial activity that irrigation development brings.

Figure 5: Tubewell engine converted to rickshaw/van

Irrigation's impact on livelihood assets – Nepal

Irrigation is an important component in the economic and social development of Nepal.

Prior to irrigation development the majority of rural households had incomes well below the 'poverty line', were mainly subsistence or semi-subsistence producers and had a low level of participation in the economy. In general, it was rare to have significant surpluses to sell as these households could cultivate only one main staple crop a year. Production was sometimes supplemented by a drought resistant pulse or oilseed crop, and perhaps winter vegetable cultivation in small homestead gardens or low-lying plots.

With an adequate irrigation water supply, it is now normal to grow three crops a year and higher, less variable, crop yields are achievable. The resulting improvement in household food security and production of regular surpluses has led to a growing commercialisation and orientation towards the market. Production has been intensified with increased purchase and use of fertilisers and pesticides. Where there is good market access, farmers have diversified to growing higher value crops such as vegetables.

Figure 6: Growing vegetables under irrigation, Yampaphant, Nepal

Human assets

Irrigation brings increased food security and the production of more food of wider variety each year and clearly improves family diet and health. Greater productivity also increases incomes for farmers and service providers and creates greater employment opportunities for farm labour.

Increased incomes are commonly spent on education, evident in the rise of the number of children now attending school and the increase in literacy levels. It is increasingly common for young people to move from the schemes as further education and non-agricultural employment possibilities have widened.

Not only are more children attending school but also there is a marked increase in the numbers of girls and women now receiving education. This is forecast to provide internal pressure for greater gender equity in Nepal.

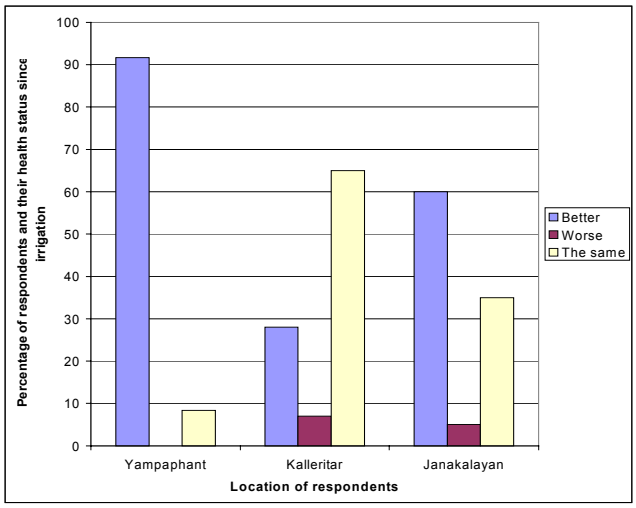

Figure 7: Family health since irrigation (based on farmer perceptions)

Hill farmers, recognising the potential for irrigation, and helped by the eradication of malaria during the 1960s migrated from the hills to lower elevation plains and valleys ripe for irrigation. Vulnerability to drought, low productivity, land scarcity and the remoteness of the hill districts provided the impetus to this migration. The "pull" of improved roads and river crossings, availability of land (particularly in the Terai), and the potential for irrigated farming added to the migration from the hills.

- Irrigation has increased food security and the quantity and variety of food, consequently improving health and diet.
- Employment opportunities for labourers have risen, as larger crop yields require more labour in the absence of mechanised farming.
- Increased income is commonly invested in education and has encouraged a rise in student enrolment, literacy rates and education of females.
- Eradication of malaria encouraged expansion in farming practice and was a precondition to irrigation development.
- Irrigation stimulates development of new skills associated with equipment production or local businesses linked to agricultural inputs or produce.

The intensification of irrigation demands more labour and draws in seasonal migrants, and a few permanent ones, particularly those able to offer artisanal skills needed for equipment production or the skills to run local businesses. These changes not only alter the social dynamics, but also extend the range of impact from irrigation communities to a much wider section of the population.

Natural assets

Irrigation investment contributes to the improved availability and reliability of water during the main growing seasons. In the schemes investigated there are relatively few conflicts over the use of water. The quality of water after passing through the schemes is not significantly worsened.

There is a perception among farmers, though, that intensification of agriculture due to irrigation can be detrimental to soil fertility. Certainly, over-application of urea (fertiliser) is giving rise to greater acidity in the soil, and in the Terai a reduction in flooding may mean that soil fertility is not being replenished by flood-deposited silt and nutrients. Similarly, there is some evidence of soil erosion, particularly in the form of landslides and terrace instability.

On the other hand, there is less pressure on marginal lands because agriculture can be more intense in irrigated areas. Pressure on the forest resource has decreased and its condition has improved. In the absence of irrigated agriculture, it is likely that agricultural lands would extend into marginal areas giving rise to more soil erosion on hillsides.

Overall, the net impact upon the natural capital stock has been positive and it is likely that a "without irrigation" scenario could well have resulted in long term decline in the stock of natural resources available to the local rural population.

- Irrigation has had a positive impact on natural assets.
- Irrigation reduces pressure on the surrounding forest resource and marginal lands.
- There is some evidence that irrigation can increase soil erosion and cause some loss of soil fertility through intensive cultivation practices.

Financial assets

In general, irrigated cultivation has given farmers on all three schemes some surplus production to sell. Gross incomes per ha. per year from irrigated crop production have increased by the order of 100–175 percent (constant prices). Farm household incomes for the median farm size on all three schemes were below the poverty line until the introduction of irrigation, when the income estimate rose above the poverty line for Janakalyan and Yampaphant, but remained below it for Kalleritar.

Increased production has both encouraged and responded to the development of market opportunities. Irrigation has also improved farmers' ability to access markets and other services.

The more intensive and higher value cropping at Yampaphant represents a further stage in irrigation development and demonstrates that much higher incomes per ha. are achievable if there is greater integration with markets, access to information and adoption of improved agricultural technology.

Financial gains as a direct result of irrigation have provided farmers with the capital to spend on infrastructure and may have strengthened their capacity to encourage new development initiatives in their area. Construction of roads has helped them make effective use of market access as evidenced by the number of new local shops and services.

Farmers' increased disposable income has enabled them to send their children to new schools, to use public transport, and to visit clinics and hospitals distant from their homes.

- Gross incomes for irrigated crop producers have increased and lifted rural incomes above the poverty line in most cases.
- Intensive and higher value cropping leads to higher incomes per hectare when there is timely and appropriate market information.
- Irrigators are using their increased financial resources to pay for local infrastructure improvements that can further improve their farming.
- Increased disposable incomes enable farming families to send children to school.

Physical assets

Irrigation can also be a catalyst for infrastructure development. In all three schemes, an increase in the development of physical infrastructure such as electricity, biogas and shops and services, has followed the development of irrigation. However, the construction of the Prithivi highway in 1972 (Yampaphant and Kalleritar) and the east-west highway in 1974 (Janakalyan), preceded irrigation and was important in encouraging the development of physical infrastructure at each location. In the case of Kalleritar, the construction of a suspension bridge significantly improved access to the Prithivi highway. While of primary importance in the development of the three schemes, such road and bridge building in isolation does not generate higher incomes and it is the combined effect with irrigation that has been significant.

Irrigation has also encouraged farmers to build and develop infrastructure on, and around, their land. There has been an increase in housing development since irrigation across the three schemes, and an improvement in living standards, such as additional rooms, new roofs, biogas units, latrines and drinking water supplies.

Irrigation development has also encouraged intensification of livestock production, with adoption of improved breeds and stall-feeding rather than free grazing. Some households concentrate upon crop production, reducing livestock numbers to the minimum needed for own consumption, while others are producing dairy and meat products for the market.

There are also obvious inter-linkages between human and physical assets. The irrigation scheme needs to be functioning well in order for farming to be sustainable and physical assets such as schools, shops, health posts and roads need to be available for improved farming to contribute to better livelihoods. It is likely though that

irrigation was the 'pull-factor' that initiated service provision in the areas around irrigation schemes.

- Irrigation can be a catalyst for infrastructure development and infrastructure investments enhance the impact of irrigation, for example development of roads encouraged the development of irrigation that in turn generated higher rural incomes.
- Farmers can afford to develop the infrastructure on and around their homes to improve living standards.
- Specialisation of farming activities is possible and more profitable under irrigation.
- Irrigation development attracts other developments that can enhance livelihoods.

Social assets

Irrigated farming is a major influence, allowing sufficient improvement in the general standard of nutrition and income to free people from the preoccupation of survival and allows them to attend to other development issues.

As irrigation has developed, the demand for, and profitability of, agricultural goods and services has increased. There are now more shops and services in all three schemes and an increase in spending and market participation by rural people.

People are better able to support infrastructure projects on the proceeds of irrigation. The social value associated with roads, paths and bridges, facilities such as schools and health posts and cultural focal points such as meeting halls, religious temples and ceremonies should not be underestimated. Improved roads and paths and electric lighting support increase social capital, making it easier for people to travel to meetings, ceremonies and classes and participate in events after dark. Cultural observance and ceremony is important and the formation of committees and the increased ability within the communities to fund ceremonies is a positive aspect.

Non-irrigation government activity and NGO programmes in the area, such as improvement to roads and access to transport, provision of drinking water, electricity and biogas, and developments in livestock production have also contributed to social, human and financial assets, as well as helping to conserve the environment.

Improvements in education raise the potential for, and the effectiveness of, communication. Better levels of understanding and greater access to information encourage people to pull together to achieve their development objectives. The improved individual skills resulting from formal and informal education also have a community, as well as a private, value. Education of girls is realigning the allocation of responsibilities in the home, smoothing out some of the early distortions from the introduction of irrigation that tend to disadvantage women through a greater workload.

Formal social assets in the irrigation communities studied have increased. There are now more active interest groups. Group activity and formal organisation has emerged to achieve goals through committees. This indicates both an increase in social capital and acceleration in the pace of development. Changes are encouraged by a number of development initiatives acting together to support the development efforts of local people. People are working harder and longer than they did before the introduction of irrigation, but have the stamina to do so, which was not apparently the case before irrigation was established. The loss of leisure is noted but, in general, the increase in prosperity is such that this is an observation rather than a complaint.

Figure 8: Community meeting to discuss irrigation scheme, Yampaphant, Nepal

Both informal and formal social capital can also facilitate broader distribution of the gains from irrigation, and help to build other assets. Reciprocal exchange of labour (*parma*), whereby households mobilise labour from other households in addition to their own family labour, can help to meet the increased labour requirements of irrigated cropping, while formal networks and groups are important for information exchange and management of shared resources. For example, at Yampaphant, the mothers' group disseminates knowledge on the importance of education and children's welfare and diet, and the forest committee promotes sustainable use of this resource.

- Irrigated farming is a major influence, freeing rural people from the preoccupation of survival and allows them to attend to other development issues.
- Increased food security and wealth from irrigation enables greater involvement in community-based projects to improve local infrastructure.
- Improved livelihoods are linked with increased observance of cultural ceremonies and greater community spirit.
- Social assets, informal and formal, can facilitate broader distribution of the gains from irrigation, and help to build other community assets.

Conclusions and recommendations

Conclusions

Small, farmer-managed schemes in Nepal and "clusters" of privately owned shallow tubewells in Bangladesh have been studied to see how irrigation acts as a mechanism to reduce rural poverty. Further investigation to identify outcomes on large, public irrigation schemes is recommended.

Care was taken at the outset to select schemes/groups where farmers were subsisting below the poverty line at the time when irrigation was introduced, so that real impacts and change could be documented. In all cases, it was determined that the principal income of farm households was derived from agriculture, rather than from remittances, pensions and alternative employment. Before the advent of irrigation, farmers owned small plots of land, too small to produce an adequate livelihood under rain-fed conditions.

Irrigation is an effective tool for poverty reduction

The studies, in Nepal and Bangladesh, have demonstrated the positive impacts of irrigated agriculture on social and economic development in poor rural settings, and have identified the processes involved in poverty reduction. Farmers, trades people, and to a lesser extent, landless labourers, all benefited. Since many factors were involved in the improvements detected in poor peoples' lives, all change could not be attributed to irrigation alone. In particular, good access to markets is essential for farmers who aim to progress beyond subsistence agriculture. In five of six schemes, paved roads had been constructed nearby. In all those schemes, the identified benefits were attributable to irrigated agriculture, as realised by the road infrastructure. The optimum benefits from irrigation also require that farmers master other innovations, like improved seed varieties and fertiliser technology. These points underline the need to plan integrated packages of rural support which include complementary drivers of development.

The findings support some of the key propositions underlying Nepal's Agricultural Perspective Plan, which concluded that:

--- *"the returns to public investments such as roads, or to farmers' investment in inputs such as fertiliser, will remain low and potentially uneconomic if land is not irrigated, or is only seasonally irrigated.*

Without year-round irrigation and fertiliser use, although individual adopters may experience improved yields, there is little increase in aggregate production, greater market orientation or higher incomes. It is the high density of income generation in a successful irrigation scheme that can most make infrastructure investment profitable and stimulate consumption and employment linkages in the local rural economy".

Benefits over rain-fed agriculture

The identified direct and indirect benefits of irrigated agriculture over rain-fed production may be categorized (*Hasnip , 2001, Smith, 2003)* as:

- Improved levels and security of production, employment and incomes for farm households and farm labour. These are direct effects derived from security against drought, water control, extended cropping season(s), improved yields and better production quality.
- Linkages to, and multiplier effects within, the rural economy. Improved farm productivity can lower food prices, yielding pro-poor and pro-growth benefits and improved nutrition. Irrigation provides a stimulus to supply of farm inputs, processing and distribution.
- Increased opportunities for diversification of livelihoods in the non-farm sector. Irrigation can stimulate diversification, improve livelihoods and reduce vulnerability to external shocks.
- Multiple uses of water supplied by irrigation infrastructure. Water can also be used for drinking, washing, household gardens, trees, livestock, rural industries, fishing and aquaculture.

Multiplier effects

The multiplier effects stemming from improved livelihoods include better family health and education. On the study schemes, where irrigated agriculture provides the main source of income, increased cash-in-hand appears to support Government policy to improve standards of education for both boys and girls.

In Nepal, increased incomes also appear to have helped farmers to educate their children. However, once the latter have completed their education, they are actively encouraged by their parents to move from agriculture into higher paid, non-agricultural employment. The trend produces an ageing resident farm population, but provides increased opportunities for landless labour.

Favourable pre-conditions will maximise benefits

Important pre-conditions to achieving significant reduction in poverty include a viable minimum farm size, access to markets and credit, access to water and diversification of crop and livestock enterprises. Social, economic and institutional factors must be favourable for irrigation schemes to be sustainable. Cohesive societies are more likely to succeed in the co-operative action required to operate and maintain community irrigation systems and contain any negative environmental impacts.

In Nepal, the systems investigated are generally of a scale that can be managed by farmers. Farmers on the study schemes were, on the whole, caring for their systems, contracting labour from outside for cleaning channels, as necessary. In Bangladesh, the technology of STW is well understood: pump suppliers and skilled mechanics from the private sector are readily available to

undertake necessary repairs at reasonable cost. Pump owners have a very strong incentive to commission timely repairs, to avoid losing income.

Environmental problems identified in both countries were mainly linked to actual, or potential, loss of soil fertility under rice mono-cropping. In Nepal, increased productivity per unit of land, which results from the introduction of irrigation, helps support government policy to secure forested lands.

Complementary measures will maximise benefits

Irrigated agriculture cannot function in isolation as an effective means for poverty reduction and an engine of growth. A complementary package of interventions and political will is needed.

In Nepal, investment across the country has been unbalanced, favouring the Terai over hill districts. The impact of government-supported irrigation has not been strong enough to reduce the percentage of the population living in poverty: it remains around 42 percent of the expanding population. In Bangladesh, the huge expansion of privately owned-and-managed irrigation in rural areas, combined with developments in other economic sectors, over recent decades have markedly reduced the percentage of the population living in poverty. (Statistical Yearbook of Bangladesh, Bureau of Statistics, 1999).

Given the high proportion of national populations living in rural areas, there are very limited options for the majority that can bring the same scale of improvement in incomes as can irrigation, in a relatively short period. In both countries, the studies show how productive irrigation schemes can become a focus for other services and provision of infrastructure.

Recommendations

Issues that need to be addressed, to sustain and improve the livelihoods of the poor in predominantly agricultural areas are summarised below. Participants from Nepal and Bangladesh at a workshop in Kathmandu highlighted these issues and recommendations for action. The May 2003 workshop confirmed many of the findings of the field investigations and recognised that some of the actions are common to several issues. The possible impacts of issues wider than the frame of reference of the study are considered in "Other issues".

Farm productivity

Irrigated agriculture potentially produces substantially greater net returns to the farmer, but also involves greater costs than rain-fed agriculture. It is therefore crucial that production techniques are substantially changed and upgraded to realise the full potential of irrigation. At present, in Nepal, crop yields across the board are generally low by world standards and contrast with those achieved in Bangladesh. Returns to the farmers are correspondingly lower. In Nepal, there is widespread mistrust amongst farmers about the quality of farm inputs.

Isolated small-scale irrigation can benefit farm households and labour as long as market access is adequate. Collective action to achieve economies of scale in marketing, transport and input purchase can have advantages. However, a higher density of farm intensification and income generation, that results in output increases that are large in aggregate, is more likely to stimulate linkages in the rural economy.

Improve Farm Production

- Improve/develop physical access to markets (rural roads).
- Provide upgraded information, training and extension services directly, or actively encourage private sector initiatives, possibly via agricultural training colleges.
- Publicity/campaigns to encourage diversification into higher value and cash crops.
- Encourage, where conditions are correct, integration of intensified livestock production into irrigated farming systems.
- Improve liaison between government ministries involved in rural development, NGOs and the private sector.
- Progressively and selectively provide an appropriate package of better-integrated multi-sectoral rural development measures
- Liberalise the import of irrigation equipment in Nepal.
- Establish quality standards for agricultural inputs. Agricultural colleges to provide testing services on request.

Rural finance

Small farmers are likely to require loans, formal and informal, to meet the higher costs of more productive irrigated agriculture. Credit systems to support increased use of inputs by all farmers, regardless of size, are needed. Formal arrangements in Bangladesh are, at present, more satisfactory than those in Nepal and the established models for providing micro-finance can have application elsewhere. The monitoring of the prices of agricultural outputs and inputs by Government would enable the impact on livelihoods to be assessed and early warning of negative trends to be detected.

Capacity building

Capacity building to strengthen rural institutions

In the face of many socio-economic and political pressures, farmers and their organisations need to maintain their strength and develop their managerial and technical skills.

Recommend:

- Institutional strengthening in response to demand. Strengthen management of farmers' organisations, aiming to promote transparency, clear accounting and collective decision-making. Registered associations requesting help could be reached under strengthened government programmes. Unregistered societies could be identified for possible future help.

Diversifying rural livelihoods

In Bangladesh, opportunities for the poor have come from the combination of rapid productivity growth in farm and non-farm rural sectors, the latter made up of commodity and service producers supplying production inputs and consumer goods. The process is reinforced when the purchases made by farm households are not internationally–traded items, and labour intensive to produce. Non-farm employment is vital to livelihoods in Bangladesh, as not all farm households have enough land to specialise as farmers.

Encourage livelihood diversification

Bangladesh:

- Continue encouraging private investment in rural enterprises as an engine of growth.
- Skills and income levels in the rural non-farm sector need to be raised for landless and marginal households to escape poverty.
- Reduce migration to cities by improving opportunities for rural industry and infrastructure.
- Conserve dwindling natural resources such as forests and fisheries, which are important to the livelihoods of the poor.

Nepal:

- Out-migration to urban areas is inevitable unless industry and skilled employment can be located in hill districts. Investment has been in naturally more favoured areas like the Terai where land, communications, and general infrastructure encourage an expanding non-farm rural economy.

In the relatively remote schemes in Nepal, it is important to support specialisation by farmers, providing infrastructure for market access and agricultural research and extension.

As in most parts of the world, after secondary education, young people increasingly leave their farms to seek employment in the cities, leaving management of the land to older people. However, the exodus provides opportunities for landless labour to augment the ageing farm population, and on the whole can be a positive development, provided alternative employment is available to youngsters. In the case of Nepal, the economy has not been growing sufficiently fast in recent years to meet raised aspirations.

In both countries, complementary investment in physical and human capital is needed to achieve better growth and poverty reduction in the farm and non-farm rural economies.

Environmental mitigation

Minimise adverse affects on the environment

Irrigated agriculture can potentially adversely affect soil, water and the environment in general. Such impacts as were identified on the schemes should be manageable by appropriate action as given below.

Bangladesh:

- Strengthen mandate/ resources of agencies concerned with the environment, to improve natural resource management.
- Adopt a more diverse agricultural policy to move away from 'cereals only' cropping.
- Establish and protect property rights to land, water and forest resources.
- Greater investment in research and extension targeted to more balanced and better-controlled use of inorganic fertilisers and increased use of organic matter.
- Support and facilitate growth of the rural non-farm economy to provide alternatives to natural resource-based livelihoods.

Nepal:

- Extend support and capacity building for community management of forests and other natural resources.
- Irrigation designers should be responsible for any slope stabilisation and erosion control measures in hilly areas.
- Greater investment in research and extension targeted to more balanced and better-controlled use of inorganic fertilisers and increased use of organic matter.
- Develop and promote integrated pest management measures to reduce growth in use of pesticides.

Water use and management

Promote efficient use of water

Recommend:

- Establish national guidelines on management of water serving multiple users, in consultation with all stakeholders and in accordance with accepted IWRM practice.
- Establish and guarantee rights to water sources in law.
- Harmonise water rights policy between national and district levels.
- Establish and support Water User Groups so that they can decide locally on operation and maintenance issues and water charging.
- Strengthen irrigation management and maintenance, with improved training packages and materials for water users.

Existing problems of water scarcity and decreasing water can only increase. Concerted actions are needed now, by government ministries and enterprises involved in water use, by large private users and by NGOs active in the provision of water. Initiatives at international level by e.g. the Global Water Partnership, to promote co-ordinated use and management of water, need to be translated into actions within individual countries

Poverty focus

Improve benefits to the poor

Despite the undoubted benefits of irrigation in securing and improving livelihoods, the poor were less likely to share in the benefits.

General:

- Need to establish and protect the property rights of the poor. Clear definition and safeguards should be pre-conditions to irrigation development.
- Information and education can help lower barriers to entry by the poor in non-farm employment and micro-enterprise.
- Improve access to credit by the poor, both seasonal farm credit and micro-finance, particularly in Nepal.
- Encourage active contribution from users in planning and implementation to improve the rate of success of developments.

Bangladesh:

- Women may benefit from on-farm diversification into livestock and other production.
- Improve security of property rights
- Conserve natural resources.

Nepal:

- Appropriate mechanisation can help to reduce women's workloads.
- Policies to improve the position of women may need special effort and resources in rural areas.

Other issues

Land holdings and rights

Even under the increased outputs obtainable with irrigation, landholdings which are too small may not yield sufficient output to raise farm livelihoods above the poverty line.

On an innovative development in Nepal, the viable land holding size was determined and those in the project area holding more than the determined size were supposed to sell it. Landless people within the project area were given the opportunity to own land, bought with wages earned during construction of the irrigation project. Land and water rights were separated: water shares were allocated to all beneficiaries within the project-influenced area; water could be traded with those who required more than the share. Such radical changes in the approach to implementation of irrigation projects are rare but potentially can have a big impact in reducing poverty.

Globalisation and trade

The viability of strategies to secure livelihoods through agriculture in developing countries will increasingly be affected by the process of globalisation and world trade agreements. Impacts will vary, depending on whether countries are self-sufficient or importers of food. The improvement in livelihoods, which was identified on the schemes over the last twenty years, took place against a background of declining world crop prices, in part the result of excess production under subsidies paid to farmers in western countries. Smaller countries such as Nepal and Bangladesh, in which agriculture contributes respectively 40 percent and 23 percent of GDP, have liberalised their economies, reducing or eliminating subsidies in agriculture. In contrast, India, the regional economic power, along with the United States and the European Union has continued to supply subsidies, particularly on agricultural inputs. The recent breakdown of World Trade Organisaion (WTO) talks in Cancun, principally over agricultural subsidies, indicates the increasing inter-dependence of national economies and the over-riding importance of food to developing countries.

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This document is an output from a research project funded by the British Government's Department for International Development (DFID). It aims to provide information for decision-makers and policy-shapers to improve their awareness of the important role of irrigated agriculture to sustain rural livelihoods.

Six case studies of small-scale irrigation systems in Nepal and Bangladesh provide evidence that irrigation can sustain and improve rural livelihoods as part of an overall package of rural development measures. The document identifies pre-conditions and complementary measures to help secure the real benefits obtainable from irrigation.

Lessons learned from the studies together with a workshop held in May 2003 are synthesised into policy recommendations that aim to maximise the benefit of irrigated agriculture and ensure that it secures sustainable livelihoods for the poor.

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