Contribution of Irrigation to Sustaining Rural Livelihoods: Nepal case study

KAR Project R7879

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Report OD/TN 113
March 2002

Imperial College London

HR Wallingford

DFID Department For International Development

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Summary

Contribution of Irrigation to Sustaining Rural Livelihoods: Nepal case study

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The report describes work undertaken in Nepal under KAR project R7879, whose purpose is to reduce poverty in rural areas. The project will provide information for policy makers, to help governments ensure that irrigated agriculture secures productive livelihoods for the poor. The project also aims to build the capacity of irrigators through the provision of targeted training and promotional material.

Three small, farmer-managed irrigation schemes were investigated, one in the central inner Terai, (Janakalayan), and two in the central hill districts (Kalleritar and Yampaphant), to assess how irrigation has affected farmers, and others whose livelihoods are linked to irrigated agriculture. Relatively young schemes, 15-20 years old, were selected so that a reasonable understanding of conditions prior to development was possible. National and regional statistics for key parameters, such as land distribution and household size, indicate that the selected schemes are representative of conditions in the central Terai and middle hill regions. The schemes are, however, all reasonably close to major roads and are therefore not fully representative of remote areas.

Over 80 percent of households on each scheme own irrigated farms of less than two thirds of a hectare. Land renting and sharecropping are relatively uncommon. Estimates of productivity and income before the advent of irrigation confirm impressions from field investigations that most households would have formerly subsisted well below the Nepalese 'poverty line'.

The main benefit of irrigation development on these schemes has been the cultivation of additional spring or winter crops, in addition to higher, and less variable, yields of all crops formerly grown under rain-fed conditions. Valued in constant prices, average household income from agriculture has increased by at least 100-175% on the different schemes.

Average incomes at Janakalayan and Yampaphant have now risen above the poverty line, substantially in the latter case. At Kalleritar, incomes are still below the line. A principal reason for the difference appears to be the lower total output from smaller farms at Kalleritar, and a less commercial approach to production of irrigated crops and livestock. Intensified production, based on higher inputs, is necessary to escape poverty. On all schemes, households which were often unable

to meet their own food requirements before irrigation, are now producing regular surpluses for sale. Better family health is attributed by farmers to changes in food and diet and to higher income, which allows them to pay for medical services/medicines. Benefiting from greater stamina, people are working harder and longer than they did before the introduction of irrigation.

Cash is also used to meet costs of education, transportation, diverse foodstuffs and house improvements. Many households have installed wells, biogas plants and sanitation.

Differences between irrigating farm households and those primarily dependent on labouring are apparent. Labourers, who often receive their wages in both food and money, benefit from increased demand for labour and a better food supply. On the two hill schemes, labour demand has principally been met by fuller employment for household members, and a modest increase in employment opportunities for nearby marginal and landless households. On the Terai, seasonal employment is available for migrating gangs of labour from marginal and landless households.

Agricultural goods and service providers and general traders have established viable businesses centred on the schemes, reflecting local farmers' increased spending powers.

Access to markets and services has improved with the construction of a main road near all schemes. All three sell produce to distant markets, including Kathmandu. The roadside is a focus for local businessmen and a market place. Rural electricity supply has followed the road.

Reflecting a national trend, parents are increasingly willing to invest in their childrens' education. Numbers of farm children now attend colleges elsewhere. Their parents do not expect them to return to the scheme, but to seek employment elsewhere in Nepal. Consequently, it can be expected that demand for paid labour will increase in future, broadening the benefit of irrigation to landless families and other communities reliant on paid work.

According to farmers, soil fertility has declined on all schemes, a common perception in Nepal. The reduction may be linked to limited use of purchased inputs, some of doubtful quality, and of manure. Irrigation, by increasing the productivity of existing farmland, has substantially contributed to reduced pressure on the forests.

Overall, the study of three small, farmer-managed schemes, indicates that irrigation has been an effective tool for poverty reduction. It also demonstrates that irrigation is most effective as a principal part of a package of rural development measures, with multiplier effects from other development factors like markets, roads, agricultural extension services, rural electricity supply, schools and health posts/hospitals. Yampaphant scheme, in particular, illustrates how a productive irrigated area can become a focus for other services and infrastructure.

Two further aspects favoured the relative success of these schemes. It was important that, with the partial exception of the tail block of Kalleritar, water was adequate, so there were relatively few conflicts over water. Intra-community relationships were also relatively harmonious, without major social conflicts.

In summary, it appears that well-planned small scale developments of the type investigated will improve household food security and incomes without significant adverse effects, will increase demand for locally-provided goods and services, and create employment for both landed and landless households. Important pre-conditions to achieving significant reductions in poverty are a viable minimum farm size, good water supply, access to markets and credit, and diversification of crop and livestock enterprises. To implement change, complementary measures are needed. They include programmes of cross-sectoral rural development targeted to deprived regions throughout the country, and in particular, the establishment/active encouragement of informed and resourced agricultural services, whether based in the private or government sectors.

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1. INTRODUCTION

Studies of three small-scale irrigation schemes were made in Nepal from September to October 2001. Two of the schemes were located in the central hill districts, Kalleritar and Yampaphant, the third scheme was located in the central inner Terai, Janakalayan. Qualitative and quantitative data were collected to assess how irrigation has affected the lives of farmers and others whose livelihoods are linked to irrigated agriculture. The study adapted DFID's Sustainable Livelihoods methodologies to identify the impacts of irrigation on the five development capitals – physical, social, human, financial and natural over the lifetimes of the three schemes. This report documents the findings from the fieldwork in Nepal.

This report is an interim output of Project R7879, "Contribution of Irrigation to Sustaining Rural Livelihoods". The project has the purpose of seeking to help governments reduce poverty in rural areas in developing countries by providing information for policy makers to ensure that irrigated agriculture secures productive livelihoods for the poor. The outputs of the project, as set out in the logical framework, are outlined below:

Output 1 Literature review.

Output 2 Information for Policy Makers to assist governments with planning strategies.

Output 3 Training and promotional material for irrigators.

Output 4 Dissemination activities.

Output 1 was completed as report number ODTN 109, "Contribution of irrigation to sustaining rural livelihoods: Literature review" in 2001. Primary research for the project was conducted on case-study irrigation systems in Bangladesh and Nepal. Three farmer-managed schemes (FMIS) in Nepal, and three villages in Bangladesh, grouped around "clusters" of privately-owned shallow tubewells (STWs), have been investigated.

This report complements the research carried out in Bangladesh, documented in report number ODTN 114, "Contribution of irrigation to sustaining rural livelihoods: Bangladesh case study". The findings from the literature review and the lessons learnt from both country studies are intended to provide the basis for Output 2, identifying relevant information and recommendations for Policy Makers.

Chapter 2 of this report sets the study in the context of the current irrigation development and policy environment of Nepal. A brief methodology of the research is then followed by a description of the scheme characteristics. Chapter 3 provides a summary of the characteristics of the farm household sample. Chapters 4 to 8 describe the findings of the survey, each chapter titled according to the framework of the five capitals: financial, physical, human, social and natural. Chapter 9 summarises the findings and presents general conclusions of the study.

2. BACKGROUND

2.1 Irrigation development in Nepal and policy environment

In assessing the impact of irrigation development on peoples' livelihoods it is also necessary to consider the influence of the policy and institutional environment over the same period. However, detailed information on precise policy developments and their influence on rural communities is difficult to obtain.

Nepal is amongst the world's poorest countries. Because of its rugged terrain, only 17% of Nepal's total land area is suitable for farming, yet 81% of the population relies mainly on subsistence farming (CARE 2001). Many communities, especially in the rural areas, suffer from problems associated with poverty, including low levels of parental care, low literacy rates, widespread nutritional deficiencies, and scant access to safe drinking water and sanitary waste disposal.

Roughly half of the population of Nepal live below the poverty line. The Nepal Living Standards Survey (NLSS), conducted by the Central Bureau of Statistics (CBS), provides the most recent estimate of poverty both at national and regional levels using household consumption expenditure data. Using the NLSS data, the National Planning Commission (NPC) estimated that around 42% of the population is living below the poverty line. The poverty line was estimated to be NRs 4,404, based on a daily per capita calorie requirement of 2124 (average price level prevailing in 1995/96 and a factor to account for non-food expenditures) (CBS 1996). Another definition, which fixes the poverty line at US$150 per capita per annum, suggests that 71% live in poverty, and even up to 78% in rural hill areas (CBS 1996).

Apart from rural-urban migration to the Kathmandu valley, internal migration is characterised mainly by the movement of population from the hill region to the inner Terai and Terai regions (Task Force on Migration 1999). Prior to 1961, the Terai was characterised by a preponderance of international immigrants as compared to internal migrants. However, since then, internal migrants, mainly from the adjoining hill districts, have dominated migration to the Terai. This followed the malaria eradication programme in the Terai in the late 1950s. Other factors affecting in-migration to the Terai included the development of a market for land as a commodity, the implementation of landholding ceilings and a policy of encouraging settlement.

Nepal has surplus water resources for both surface and groundwater development. Of 1.8 million ha available for irrigation, surface water infrastructure covers about 0.9 million ha and groundwater use, 168,000 ha. Nepal is making use of less than 8% of its total water resource potential, but in some hill regions pressure on land and water use may already be limiting (Koirala and Thapa 1997).

The development of irrigation in Nepal can be categorised into four phases of development (Shah 2001):

1. Prior to the mid-1950s, farmers developed numerous irrigation facilities in the hills and in the Terai using their own resources. These systems were primarily for supplementing irrigation of main crop paddy during the monsoon season, and were managed by farmer established community groups who developed their own rules and norms.

2. From 1956 to 1970, emphasis was on the construction of infrastructure in the form of government-financed medium and large projects. Extensive development of diversion weirs and main canal distribution systems followed the traditional farmer-developed model of run of the river diversions to provide supplementary irrigation in the monsoon season.

3. The 1970s and early 1980s saw more intensive development of command areas through the expansion of irrigation infrastructures and rehabilitation of farmer built and managed systems.

4. From the mid-1980s to the present, emphasis has been placed on more integrated development of land and water resources. This has incorporated the following:

- renovation and expansion of farmer-managed systems with beneficiary participation,
- groundwater development where surface supplies were seasonal,
- use of other forms of improved agricultural technology, and
- involvement of NGOs as implementing agencies.

Land use management strategies seek to integrate agriculture, forestry and irrigation into a common platform for rural development.

The current policy framework for agricultural development in Nepal has been prescribed by the Agriculture Perspective Plan (APP) of 1995, which is based on a strategy that relies on agriculture as the "engine" of both economic growth and poverty alleviation. It follows that irrigation is included in the prioritised or 'packaged' approach to public policy and investment, along with fertiliser, roads, power, credit and agricultural technology. In fact, more than half of the total public investment in APP's priority inputs was allocated to irrigation, but with emphasis that the type and quality of irrigation is critical to achieving the growth objectives.

Although irrigation has been the main focus of investment programmes in agriculture in Nepal for more than forty years, the APP argues that the emphasis has been on expanding supplementary monsoon irrigation. It cited that a "mere" 18% of Nepal's arable land had year-round well-controlled water. This was identified as being essential to the high-intensity agriculture underlying the green revolution and its strong multipliers on growth in other sectors. The relative lack of well-controlled, year-round water supplies was thus given as a prime reason why agricultural growth rates in Nepal have been low. The very low rate of adoption of both year-round irrigation and fertiliser use means that although individual adopters experience improved yields there is little impact on aggregate production (APROSC and JMA Inc. 1995).

The APP also argues that under Nepal's rainfall regimes, the returns to other key public investments such as roads or farmer investment in inputs such as fertiliser will remain low and potentially uneconomic. This will be the case as long as land is unirrigated, or only seasonally irrigated and hence still heavily dependent on annual rainfall. It is proposed that it is the high density of income generation in a modernising agricultural sector that makes infrastructure investment profitable.

With regard to social development, a national goal in Nepal is to eradicate illiteracy and provide basic and primary education to all by the end of the century. School classes one to ten are now free throughout Nepal and teacher training, improved school facilities and promotion of primary and vocational education are areas of emphasis under government policies and programmes in the education sector (NepalNet 2001).

In order to make recommendations for strengthening the non-formal education sector, a high level education commission was formed by the government in 1990, known as the National Education Commission. Realising the rapid growth of Non-Formal Education (NFE) activities, the commission constituted the National Non-formal Education Council. With the proliferation of NFE activities, educational opportunities started to expand and reach the people in remote parts of Nepal. With the growing number of Government Organisations (GOs), Non Government Organisations (NGOs) and International Non Government Organisations (INGOs), people started becoming aware of the importance of education and started participating in education. Thus, NFE began playing a vital role in the expansion of education in Nepal. Apart from the government, many international agencies started taking a keen interest in expanding these NFE activities through local NGOs (NepalNet 2001).

Nepal has also made specific policy declarations to integrate women in development since the early 1980's. The focus of action, however, has been on credit, employment, education and health. In addition, institutional mechanisms specific to women have been set up, such as the women and development division of the Ministry of Local Development. Women's right to property and land have improved a little and punitive measures against violence to women have been strengthened. However progress is poor in relation to regional and international statistics. Attention to women's participation in decisions in the rural

and agricultural sector is needed. The Ministry of Women, Children and Social Welfare recently launched an empowerment programme called 'Jagriti' with a focus on women's social and economic development, but it seems this is yet to affect the areas studied.

In considering the policy environment it should also be noted that the 11 years since multi-party democracy replaced an authoritarian monarchy has been a period of great political instability and often periods of sharp economic recession. May Nepalis are likely to feel that their lives have got worse during this period and this may 'colour' their perceptions as reported by the survey investigations.

2.2 Methodology

Qualitative and quantitative data were collected on three irrigation schemes (Janakalayan, Kalleritar, Yampaphant) to assess how irrigation has affected the lives of farmers, and others whose livelihoods are linked to irrigated agriculture, including labourers, and agricultural goods and service providers.

The following activities were completed over the period October-December 2001:

- Questionnaire survey of farm households (60 per scheme). (For data on farming practices and output the reference period covered the following seasons: monsoon 2001, spring 2001 and winter 2000/2001).
- Questionnaire survey of other stakeholders (5 labourers, 5 general merchants, crafts and tradespeople, and 5 suppliers of agricultural goods and services per scheme).
- Focus group interviews.
- Key informant interviews (including officials in the local offices of government ministries – irrigation, agriculture, rural development, forestry and WUA officers, older people from farming and the general community).
- Review of relevant records on schemes, including relevant policy/legislation with implications for scheme performance to date and in the future, and of relevant secondary data sources.
- In-depth investigation by a "process investigator" resident on each scheme for 6-8 weeks, using a range of data collection methods including semi-structured interviews, case study observation and other informal appraisal methods.

Sample selection procedures are described in Annex 1.

2.3 Scheme characteristics

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

The Kalleritar scheme is situated in the Mahabhart hilly region in the southern part of Dhading district of Nepal. It is approachable via a 30 minute trail (accessible for pedestrians only) and suspension bridge from Baireni, which lies on the Kathmandu-Pokhara Highway (Prithivi Highway), about 50 km from Kathmandu. The scheme comprises four villages, namely Foshretar (head section), Gahate and Kalleritar (middle section) and Ghartitar (tail section). It is separated from its neighbouring villages by the Trishuli River and steep hillsides. To the north lies the hill village of Dumrechaur which was where many of the scheme residents originated. The command area is about 82 hectares in total, consisting of river terrace parallel to, and about 50 metres above, the Trishuli River. The irrigation supply is diverted from a tributary stream of the Trishuli, and flows along an 11 km contour canal to the command area.

The Yampaphant scheme is located on the Prithivi Highway between the market towns of Anbu Kaireni (10km) and Dumre (5km). The region is hilly and although Yampaphant is termed a plain, the command area has a mild 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, with an average altitude of 450m. The irrigation

supply comes from streams originating from springs in the hills to the south which also supply the neighbouring village of Satarasaya Phant.

There are two irrigation canals supplying water to an irrigated area of 37 hectares. The upper canal is the longer of the two and is just over 3 km in length. Both canals have existed for over 100 years, and the areas supplied by these original canals are named Jaishi Phant and Baraha Phant. Baraha Phant is the area supplied by the head section of the lower canal and has a total area of 15 hectares, whilst Jaishi Phant is land supplied by the upper canal and the tail section of the lower canal, with an area of 9 hectares.
In 1988 the 'Hill Food Programme Project' extended the upper canal, moving its offtake 0.2 km further upstream, and rehabilitated both existing canals, providing almost 2 km of lining. The new offtake location and higher altitude of this first portion of the canal gave the scheme greater command, enabling some previously rainfed upland plots to be irrigated. This added a further 13 hectares of irrigated land to the village, referred to as Pakho Phant. Part of the old canal feeding Baraha and Jaishi land could no longer be used and a division structure was constructed after the first section of canal, enabling the old section of Baraha canal to be fed in rotation with the new canal section. This rehabilitation also resulted in increased supply to both Baraha and Jaishi Phants. For the purposes of the study the Pakho land and its farm households have been taken to provide an example of the introduction of irrigation, with some comparison of the situations before and after irrigation possible from respondents' recall information. Baraha and Jaishi land and respondents provide an example of a traditional hill irrigation scheme that has been rehabilitated and provided with improved water supply.

Figure 1 shows the location of the three schemes, more detailed maps of village locations and scheme layout can be found in Annex 5.

Figure 1 Location of schemes in Nepal

3. FARM HOUSEHOLD SAMPLE CHARACTERISTICS

3.1 Land distribution

Farming provides the primary source of livelihood for the majority of households resident at the three schemes. Interviews and simple wealth ranking exercises conducted by the process investigators revealed that households generally perceive the amount of land owned to be the main determinant and indicator of wealth, and this particularly applied to the amount of irrigated land owned.

Table 1 Total irrigated and dryland holdings of sample households (hectares)

	Janakalayan		Kalleritar		Yampaphant (pakho)	
	Irrigated	**Rainfed**	**Irrigated**	**Rainfed**	**Irrigated**	**Rainfed**
Mean (ha)	0.86	0.34	0.43	0.15	0.59	0.31
St. dev.	0.75	0.34	0.31	0.11	0.38	0.24
Median	0.66	0.20	0.36	0.10	0.48	0.28
Maximum	4.40	1.02	1.37	0.36	1.48	1.02
Minimum	0.03	0.14	0.03	0.03	0.13	0.05
Sample size (n)	60	6	60	11	40	18
Percentage of sample with additional plots	57%	10%	27%	18%	73%	45%

Note: additional plots are irrigated plots on other commands or dryland. For Yampaphant pakho households, additional irrigated plots may be on jaishi or baraha land of the same command or on neighbouring commands.
Source: questionnaire survey.

Table 2 Percentage of different sized agricultural landholdings owned by region

Region/holding	<0.5ha	0.5-2.0ha	>2.0ha
Mountains	41.6	44.3	14.1
Hills	45.8	47.6	6.6
Terai	33.2	47.1	19.7
NEPAL	40.1	47.0	12.8

Source: Nepal South Asia Centre (1998)

Comparison of Tables 1, 2 and 3 shows that the distribution and size of land holdings for the sample households are representative of those for the surrounding districts and regions, although holdings at Kalleritar were slightly smaller than the district and regional average.

Table 4 shows that on all three study schemes the distribution of land ownership is skewed with the majority of households (over 80 percent) having irrigated holdings of less than two thirds of a hectare. The median size holding on all three schemes ranges from 0.25 hectare for Kalleritar to 0.35 hectare for Janakalayan. However, for some households total holdings of irrigated land are larger as land may also be owned or cultivated on neighbouring irrigation commands. Table 1 shows that Janakalayan households have relatively more land than Kalleritar or Yampaphant. Fifty-seven percent of sample households had additional irrigated land on one or more other commands, so that the median total irrigated holding was 0.66 hectare. Ten percent of the sample also had dryland plots, although these are generally smaller than irrigated plots (median 0.2 hectare).

Table 3 Average land holding size in Nepal by region in 1991/92 (hectares)

Region and district	Average holding size (ha)
Central Mountain	0.65
Central Hill	0.66
• Nuwakot	0.75
• Dhading	0.73
Central Terai	1.08
• Chitwan	0.81
Nepal	0.96

Source: National Sample Census of Agriculture (CBS 2000).

Table 4 Distribution and size of land holdings within the command area of study irrigation schemes

Holding size		Janakalayan		Kalleritar		Yampaphant	
Bigha	Hectare	No. of households owning land	Cumulative % of households owning land	No. of households owning land	Cumulative % of households owning land	No. of households owning land	Cumulative % of households owning land
<1	<0.677	117	82.4	178	89.5	83	85.6
<2	<1.355	19	96.8	20	99.5	11	96.9
<3	<2.033	4	98.6	1	100	3	100
<4	<2.710	1	99.3	-	-	-	-
<5	<3.388	1	100	-	-	-	-
Statistics		Population	Sample	Population	Sample	Population	Sample
Number		142	60	199	60	97	60
Mean (ha)		0.50	0.54	0.33	0.37	0.37	0.36
Median (ha)		0.35	0.44	0.25	0.31	0.30	0.29

Note: Yampaphant population figures are monsoon paddy area which approximates land holding in most cases.
Source: WUA lists/process investigators, and questionnaire survey.

Kalleritar households are comparatively 'land poor' as irrigated holdings are smaller on average, both within the command and in total. Only 27 percent of the sample had additional irrigated land outside the command, and while 18 percent had rainfed plots these again tend to be smaller than those of Janakalayan households. Data is incomplete with regard to additional irrigated land for *jaishi* and *baraha* households at Yampaphant, but for *pakho* households the endowment of irrigated land per household falls between the other two schemes, although cultivation of dryland plots is relatively more common, with plot sizes comparable to those of Janakalayan.

Given dependence on farming as the main source of livelihood and the lower productivity of rainfed compared to irrigated agriculture, prior to irrigation development the landholdings of at least 80 percent of rural households were barely adequate for subsistence needs (Table 5).

Table 5 Minimum landholding (ha) necessary to earn a poverty line income from agriculture in Nepal

Condition	Valley floor (ha)	Hill slopes (ha)
Rainfed	1.39	2.08
Partial irrigation[1]	0.63	1.21
Full irrigation[1]	0.41	0.85

[1] Assuming current technology (1989)
Source: Master Plan for Irrigation (1989), cited in Koirala and Thapa (1997).

3.2 Land tenure

The majority of farming households on the three schemes are owner-cultivators. Tenants paying a cash rent for the use of land were found to be rare, with only one known example at Yampaphant. Sharecropping is also not common, although at Kalleritar some of the wealthier and longest established irrigating households with the largest land holdings lease part or all of their land to sharecroppers. In a wealth ranking exercise at Kalleritar the ability to use sharecroppers to cultivate land was cited as one identifying characteristic of wealthier households.

Table 6 Land tenure characteristics of scheme and sampled households (number of households)

	Janakalayan		Kalleritar		Yampaphant	
	Population	Sample	Population	Sample	Population	Sample
Owner-cultivator	142	59	199	58	97	57
Tenant	0	0	0	0	na	1
Sharecropper	5	1	40	2	na	2

Source: questionnaire survey.

Sharecropping tends to occur when the owner of the land cannot cultivate by himself/ herself and the land is given for a temporary period (one season or one year) to the cultivator on the basis of sharing 50 percent of the crop yield (Table 7).

Table 7 Usual terms of sharecropping

Items	Cultivator	Owner
1.Labour	100%	-
2.Fertiliser cost	50%	50%
3.Insecticide cost	50%	50%
4.Seed	50%	50%
5.Land tax	-	100%
6.Water charges	-	100%
7.Output	50%	50%

Land tenancy for payment of a cash rent has been discouraged by state regulation that protects tenancy rights to the potential disadvantage of the landowner. Rents are regulated and once a tenant has cultivated the land for a minimum period, the tenancy becomes permanent in law. The tenant can either remain on the land indefinitely or sell the tenancy right to someone else. Hence, the more common practice is to enter into sharecropping, which will usually be for one season only, with only an oral agreement.

An alternative (not observed in the study schemes) is the *theka* (contract) system, by which the cultivator will be allowed to cultivate land for one season only, again with just an oral agreement. The rent, to be paid either in cash or kind, is fixed by the landowner, and even if the crop fails, the cultivator has to pay the agreed amount.

3.3 Household composition and labour availability

Table 8 shows that household composition is similar across the three schemes in terms of the proportion of adults engaged in farmwork. Yampaphant may have a slightly higher proportion of older residents now who are at least partly dependent on younger family members. The data emphasises that most adults are engaged in farming as their primary occupation. More households in Yampaphant and Kalleritar have adult household members living and working away than in Janakalayan, with the corresponding potential for a higher level of remittances.

Table 8 Household dependency and labour availability characteristics of sample households

	Janakalayan			Kalleritar			Yampaphant		
Household members	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Adults >16 years	5.3	12	1	4.1	10	2	4.6	9	1
Children <16 years	3.6	11	0	2.8	6	3	2.3	7	0
% adults that do farm work	80%	100%	0%	80%	100%	0%	60%	100%	0%
Dependency ratio[1]	1.5	6	0	1.4	5	0	1.8	5.5	0
% of households with 1 or more children	92%			92%			90%		
% households with 1 or more children engaged in farm work	13%			8%			13%		
% hholds with adult working away[2]	13%			20%			27%		

Notes:
[1] Dependency ratio is the number of children and non-working adults resident in the household per adult who does farm work. (This definition does not allow for non-farm work by adults still resident in the household, although this is of relatively less importance in rural Nepal).
[2] Percentage of sample households with one or more adults living and working away from the scheme.
Source: questionnaire survey.

It is also noticeable that although most households include children under 16 years of age, only a small proportion (8-13 percent) report that children are regularly engaged in farm work. This corresponds with data on school attendance (Table 34 in section 6.3) and indicates that households are well motivated and financially able to ensure that children receive schooling. Similarly the incidence of children being employed in the family business for the other household categories (agricultural goods and service providers) was very low.

3.4 Origins and migration

There has been considerable in-migration and settlement in all three schemes. At Janakalayan, 65 percent of the farming household heads (or spouses) interviewed had migrated to their current settlement. All of these migrants had been farming as their main source of livelihood prior to migration, and most had come from the hill regions. This corresponds to the established pattern of internal migration in Nepal since the late 1950s (Hasnip et al. 2001). Most of these migrants arrived before the current irrigation scheme became operational in 1982. 85 percent arrived more than 10 years ago and 64 percent more than 20 years ago.

Around 1945, members of the Tharu caste, who had traditionally practised transhumance brought their cattle into the area on a seasonal basis. In the 1950s and 1960s poor farmers from the hill areas also settled and cleared the remaining forest. The higher population led to the exploitation of the remaining forest to supplement the rain-fed cropping. Demand for irrigation was strong and the farmers initiated construction themselves through mobilisation of their own resources (process investigator, Janakalayan).

Table 9 shows that the "push" factors of drought, low productivity, land scarcity and remoteness in their previous farming were important reasons for migration, combined with the "pull" factor of the knowledge that land and better farming opportunities were available in the Terai. Moving together with relatives was the main other reason given for migration. (One later migrant also moved because irrigated land was available, and another because of gaining a job with the Forest Department).

Table 9 Reasons for migration to the area of the scheme and the percentage of respondents who had migrated for each reason.

Reason	Janakalayan	Kalleritar	Yampaphant
Landless prior to migration	0	0	0
Inadequate land for family needs	21	9	0
Natural disaster (flood/drought)	44	2	0
Rainfed farming only	3	0	92
Low production	44	2	54
Infertile soil	59	2	13
Distance from a road	18	83	54
Knowledge of better opportunities elsewhere	23	5	67
Marriage	3	2	0
Other	15	0	0

Source: questionnaire survey.

In-migration has been more localised at Kalleritar and Yampaphant. At Kalleritar, 77 percent of households had migrated to their current settlement during the lifetime of the household head. Again all had been farmers before migration and most moved from higher elevation villages in the immediately surrounding area. Overall migration was slightly later than for the Terai scheme, but still mainly before the current irrigation scheme was fully operational (around 1988). 66 percent arrived more than 10 years ago and 27 percent more than 20 years ago. Eradication of malaria in the late 1960s allowed people from the hill villages to move down into the valley and cultivate more extensively. However, Table 9 suggests that the factor primarily driving migration in this area was the desire to reduce remoteness. This may be associated with the difficult terrain, and particularly the construction of the nearby Prithivi Highway to Kathmandu in 1967 and river crossings over the Trisuli River in the 1970s.

At Yampaphant settlement within the command area has been established for a longer period and only 40 percent of households had migrated there within the lifetime of the household head. As at Kalleritar, all migrants were farmers before moving and again mainly came from higher elevations in the surrounding area. "Pakho" land was irrigated after the scheme's construction in 1998 but as noted above the "jaishi" and "baraha" land had less effective irrigation for a long period prior to this date. Also relevant was the construction of the nearby sealed road from Pokhara to the Prithivi Highway in 1972. Ninety-two percent of migrants arrived more than 10 years ago and 71 percent more than 20 years ago. Table 9 suggests that the lack of irrigation and low productivity of rainfed farming at higher elevations were the main "push" factors for migration to Yampaphant, combined with the "pull" factors of the road and better farming opportunities.

4. FINANCIAL CAPITAL

Financial "capital" consists of the financial resources that people use to achieve their livelihood objectives. The definition used here includes flows as well as stocks and it can contribute to consumption as well as production. There are three main forms of financial capital: savings in cash, bank deposits or liquid assets such as livestock and jewellery; loans obtained from formal or informal credit-providing institutions; and regular inflows of money including earned income, pensions, transfers from the state, and remittances.

This section assesses the extent to which irrigation development has enhanced the financial capital of stakeholders. This occurs through the direct benefits of increased farm productivity gained by farm households and increased employment for farm labour, and through indirect benefits generated by linkages with the local economy.

4.1 Irrigation impacts on cropping

For farm households the main improvement in financial capital in the form of incomes arises from the dramatic impact of the introduction of irrigation on farming options and opportunities (Tables 10 and 11). Prior to irrigation development the majority of households could cultivate only one main staple crop a year, typically rainfed maize or paddy in the monsoon season, supplemented by a following drought resistant pulse or oilseed crop; most commonly blackgram and mustard. Winter vegetable cultivation was limited to small homestead gardens or low-lying plots. With irrigation three crops a year are the norm, with farmers opting for spring season early paddy and winter season wheat as additional staple crops to monsoon paddy where water supply is adequate. Alternatively, where market access encourages it, farmers may choose to grow higher value vegetable crops, as is particularly the case in the Yampaphant scheme.

Table 10 Percentage of sample households growing crops before and after irrigation development

	Spring crops				
	Maize	**Early Paddy**	**Potato**	**Tomato**	**Other veg.**
Janakalayan					
Before irrig.	3%	-	-	-	-
After irrig.	-	100%	2%	-	-
Kalleritar					
Before irrig.	18%	-	-	-	-
After irrig.	93%	2%	5%	8%	-
Yampaphant 1					
Before irrig.	30%	-	-	-	-
After irrig.	88%	-	-	88%	83%
Yampaphant 2					
Before rehab.	9%	-	-	-	-
After rehab.	82%	5%	-	55%	82%

	Monsoon crops						
	Lowland / irrigated paddy	**Upland paddy**	**Millet**	**Maize**	**Groundnuts**	**Chilli**	**Veg.**
Janakalayan							
Before irrig.	3%	-	-	97%	-	-	-
After irrig.	100%	-	-	-	-	-	-
Kalleritar							
Before irrig.	12%	77%	20%	87%	43%	2%	-
After irrig.	97%	-	-	2%	-	12%	3%
Yampaphant 1							
Before irrig.	-	95%	23%	55%	-	-	-
After irrig.	100%	-	-	-	-	-	63%
Yampaphant 2							
Before rehab.	-	91%	14%	68%	-	-	-
After rehab.	85%	-	-	-	-	-	36%

	Winter crops							
	Mustard	**Lentils**	**Blackgram**	**Veg.**	**Maize**	**Wheat**	**Millet**	**Potato**
Janakalayan								
Before irrig.	98%	7%	3%	5%	80%	28%	3%	-
After irrig.	93%	-	-	93%	77%	95%	-	95%
Kalleritar								
Before irrig.	25%	62%	82%	37%	-	-	-	-
After irrig.	10%	-	-	60%	-	100%	-	82%
Yampaphant 1								
Before irrig.	18%	23%	98%	5%	-	-	-	-
After irrig.	3%	-	-	100%	-	95%	-	95%
Yampaphant 2								
Before rehab.	36%	14%	91%	-	-	-	-	-
After rehab.	9%	-	-	91%	-	70%	-	90%

Source: questionnaire survey
Notes: Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation.

Table 11 Summary of cropping pattern changes at scheme level

Scheme	Before scheme	Current
Janakalayan	Predominantly rainfed maize in the monsoon season followed by a drought resistant mustard, pulse or millet crop. Some households able to grow a winter crop of maize or wheat.	Almost universal cultivation of two paddy crops (early then monsoon), followed by a combination of mustard, maize, wheat and vegetables including potato.
Kalleritar	Predominantly rainfed maize in the monsoon season with some rainfed paddy, groundnuts and millet. Some winter pulses (especially blackgram), mustard and some vegetables.	Spring maize with a little early paddy and vegetables. Near universal paddy in the monsoon, with a little maize and vegetables. Wheat and vegetables, including potato, now the predominant winter crops.
Yampaphant (Newly irrigated area, and area with improved water supply)	Rainfed or poorly irrigated paddy in the monsoon season with some millet and maize. Blackgram and other pulses and mustard in winter.	Maize, tomato and other vegetables widely grown as spring crops, also a little early paddy. Near universal paddy in the monsoon, plus continued vegetable production. Near universal vegetables, including potato, and wheat during winter.

Source: questionnaire survey.

4.2 Irrigation impacts on crop yields

Cultivation of additional spring or winter crops is the main direct benefit of irrigation for farm households, but irrigation can also result in higher and less variable yields compared to equivalent rainfed crops. The data for Kalleritar and for the *baraha* and *jaishi* sections of Yampaphant scheme in Table 12 provide some evidence for higher and less variable yields in the monsoon season for irrigated paddy compared to rainfed paddy. For the more recently irrigated *pakho* land at Yampaphant there is also some evidence for higher and less variable yields for the irrigated compared to the rainfed crop, although the magnitude of yield reduction in poor years shows no change. This may be due to the unreliability of irrigation supply in some years or other causes of crop failure unrelated to water supply such as disease or pest attack.

Yields for rainfed and irrigated maize on the three schemes are not directly comparable as the season in which maize was grown changed with irrigation. Prior to irrigation, maize was the main monsoon season crop in Janakalayan, but is now grown mainly as a winter crop. For all the other cases maize was also grown as a monsoon crop prior to irrigation, but since irrigation has been grown as a spring crop. For these cases the data suggests that average yields of the irrigated spring crop are higher than the yields achieved by the previous rainfed monsoon crop. There is little change in the variation in yield suggesting that the irrigation supply in the spring season is often unreliable, or that other factors determining yield remain important. (Yields for *baraha* and *jaishi* farmers, aggregated as Yampaphant 2 in Table 12 were not significantly different for all crops, $P<0.01$).

Tables 13 and 14 show that yield estimates from the farm household survey are generally comparable to those from the Nepal Irrigation Sector Review (NISR), and to regional and district statistics for the cited years (latest available data from CBS 1998 and CBS 2000). For paddy average yields before irrigation reported by the survey respondents are comparable to these area averages, whereas yields reported with irrigation are notably higher. Paddy yields for Yampaphant appear high in comparison, but this scheme is exceptionally intensively farmed by Nepali standards.

Compared to tables 13 and 14, Kalleritar also shows superior yield performance in maize production both before and after irrigation, although this is not the case for the other schemes. This yield level is surprising as this is the least developed of the three schemes, but maize has been almost universally grown at Kalleritar as a main crop, both before and after irrigation. Over 90 percent of growers use improved seed,

urea and compost on maize at this scheme, which is comparable with usage for paddy here and elsewhere (see Table 17). The generally good yield performance at Kalleritar may also result from more intensive cultivation of the generally smaller holding per household.

Table 12a Expected average yields for monsoon paddy and range of variation, farm household estimates (kg/ha and percentage variation)

	Monsoon paddy				
	Expected average yield, kg/ha		Expected variation, mean %		Respondents
	Mean	St. dev.	Good year[a]	Bad year[a]	N
Janakalayan					
Before irrigation	not grown	-	-	-	-
After irrigation	3194	938	+38%	-38%	56
Kalleritar					
Before irrigation	**2105**	1100	**+61%**	**-46%**	48
After irrigation	**3332**	1161	**+42%**	**-38%**	60
% change	**+58**				
Yampaphant 1					
Before irrig.	**2142**	398	**+47%**	-45%	39
After irrig.	**4239**	575	**+27%**	-45%	40
% change	**+97**				
Yampaphant 2					
Before rehab.	**2482**	491	**+32%**	**-48%**	20
After rehab.	**4501**	410	**+18%**	**-37%**	19
% change	**+81**				

[a]Paired mean values in bold are significantly different, P<0.01 [1].

Table 12b Expected average yields for maize and range of variation, farm household estimates (kg/ha and percentage variation)

	Maize				
	Expected average yield, kg/ha		Expected variation, mean %		Respondents
	Mean	St. dev.	Good year	Bad year	N
Janakalayan					
Before irrig.	1730	725	+39%	-47%	33
After irrig.	1491	469	+37%	-46%	26
% change	-14				
Kalleritar					
Before irrig.	2491	1327	+41%	-38%	60
After irrig.	2783	1193	+42%	-43%	60
% change	12				
Yampaphant 1					
Before irrig.	896	176	+39%	-36%	40
After irrig.	1262	283	+34%	-40%	40
% change	41				
Yampaphant 2					
Before rehab.	965	134	+37%	-33%	20
After rehab.	1480	191	+23%	-35%	19
% change	53				

[1] According to T-test for matching paired observations and Wilcoxon matched-pairs signed-ranks test (a robust non-parametric test, not requiring the assumption that the variables are normally distributed).

Table 12c Expected average yields of early paddy and range of variation, farm household estimates (kg/ha and percentage variation)

	Early paddy				
	Expected average yield, kg/ha		Expected variation, mean %		Respondents
	Mean	St. dev.	Good year	Bad year	N
Janakalayan					
After irrig.	3175	929	+37%	-39%	57
Kalleritar					
After irrig.	not grown	-	-	-	-
Yampaphant 1					
After irrig.	not grown	-	-	-	-
Yampaphant 2					
After rehab.	8257	Na	+6%	-31%	1

Table 12d Expected average yields of wheat and range of variation, farm household estimates (kg/ha and percentage variation)

	Wheat				
	Expected average yield, kg/ha		Expected variation, mean %		Respondents
	Mean	St. dev.	Good year	Bad year	N
Janakalayan					
After irrig.	1616	744	+41%	-44%	25
Kalleritar					
After irrig.	2568	1047	+45%	-43%	60
Yampaphant 1					
After irrig.	2162	412	+30%	-35%	39
Yampaphant 2					
After rehab.	2320	382	+31%	-34%	19

Notes for Tables 12a – 12d:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation.
Source: questionnaire survey.

In the three schemes wheat has only been grown since irrigation development. Yield performance for Janakalayan is comparable with the average for the central Terai region (though low compared to the NISR estimates), whilst yield performance for the other two schemes is superior to the surrounding central hills region. At Janakalayan the current main crops are early and monsoon paddy, and wheat is grown as a low input crop by only some farmers in the winter. Only 50 percent of wheat growers here used fertiliser, compared to 80-90 percent for early and monsoon paddy.

Table 13 Comparison of crop yields for rainfed and irrigated conditions, kg/ha

	Paddy	Maize	Wheat
Hills			
Rainfed	2100	1160	1900
Irrigated	2500	1500	2200
Percentage change	19	29	16
Terai			
Rainfed	2200	-	2100
Irrigated	3400	-	2500
Percentage change	55	-	19

Source: Nepal Irrigation Sector Review (Siddiq 1999)

Table 14 Yield of cereal crops in study scheme districts and regions, 1997/98 and 1998/99, kg/ha

District/Region	Paddy		Maize		Wheat	
	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
Chitwan	2598	n/a	2115	n/a	1765	n/a
Central Terai	2466	2215	2103	2119	1566	1832
Dhading	2054	n/a	1548	n/a	1653	n/a
Central Hills	2732	2887	1700	1724	1656	1686

Source: 1997/98: (CBS 1998), 1998/99: (CBS 2000).

The yield statistics in Table 14 are aggregated from data on irrigated and rainfed areas. Table 15 shows that the irrigated yields achieved on the three study schemes may still be below potential. However, the yields achieved in Janakalayan are comparable to those reported for the same crops for the Terai, for example in Gill (1996) and Asian Development Bank (1999). Yields achieved in hill irrigation systems are inherently more variable and dependent on location specific conditions. However, the farmer estimates of average yields for Kalleritar and Yampaphant are comparable with those reported for rehabilitated farmer managed hill irrigation systems by Parajuli, Sharma et al. (2001).

Table 15 Yield potentials in the hill region under irrigation, MT/ha

Crop	Potential	Attainable
Paddy	4-4.5	3-3.5
Maize (spring)	4.5-5	4-4.5
Wheat	3.5-4	2-2.5

Source: World Bank (1990)

4.3 Changes in input use

The development and use of irrigation has been associated with increased and more intensive use of agricultural inputs on each of the three study schemes, particularly for the main monsoon paddy crop. Use of chemical fertilisers or pesticides was very rare prior to irrigation (Table 16), but is now widespread for most major crops (Table 17). Only nitrogenous fertiliser (urea) is commonly used across all schemes, with other nutrients only commonly applied at Yampaphant. Imbalanced use of nitrogenous compared to other fertilisers is common in Nepal because of its more heavily subsidised price, more widespread availability and farmer conviction of its merits, given the easily visible effects in the form of lush green growth. Use of urea is profitable even without subsidy (except in remote hill areas with high transport costs), and current usage is constrained by availability and farmers' cashflow rather than subsidy levels. Farmers have also become more convinced of the merits of phosphoric and to a lesser extent potassic fertilisers (given the relatively potassium rich soils of the Terai), but again current usage is constrained by availability, farmer knowledge, and by farmer cashflow and credit access (APROSC and JMA Inc. 1995, Gill 1995, Gill 1996).

Table 17 also suggests that the more intensive and diversified cropping pattern at Yampaphant, which includes a much greater proportion of high value vegetable crops, is associated with a further intensification of input use. Usage of improved seed, pesticides, urea and other fertilisers, as well as both manure and compost, and hired labour is generally higher for all crops.

Table 16 Percentage of farm household respondents using inputs before irrigation

Input	Janakalaya n	Kalleritar	Yampaphant 1	Yamphaphant 2
Chemical fertiliser	2	23	3	0
Pesticides	2	5	3	0
Hired labour	67	40	35	40

Notes:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation
Source: questionnaire survey.

Compost is commonly used as an organic fertiliser on all three schemes, and manure from livestock is commonly applied to the fields in Yampaphant but only rarely in the other two schemes (Table 17). Tractors are commonly used for land preparation in Janakalayan but not in the two hill schemes where lack of road access, topography and small, fragmented and irregular plots inhibit this. The use of contract labour for the major agricultural tasks such as harvesting is also a feature of agriculture in the Terai, which is not commonly present in the hill region.

Table 17a Percentage of farm household respondents using inputs for spring crops since irrigation (figures 2000/2001)

Input	Early paddy Janakalayan	Maize Kalleritar	Maize Yampaphant
Improved seed	83	93	100
Pesticides	83	14	26
Tractor ploughing	93	0	2
Contract farm labour	50	2	0
Daily hired labour	22	34	15
Fertiliser – urea	85	98	42
Manure	2	5	98
Compost	77	98	100
Other chemical fertiliser	2	0	2

Table 17b Percentage of farm household respondents using inputs for monsoon paddy since irrigation (figures 2000/2001)

Input	Janakalayan	Kalleritar	Yampaphant
Improved seed	90	91	100
Pesticides	87	57	100
Tractor ploughing	93	0	2
Contract farm labour	52	2	0
Daily hired labour	23	40	88
Fertiliser – urea	90	97	100
Manure	0	14	91
Compost	73	100	100
Other chemical fertiliser	2	0	40

Table 17c Percentage of farm household respondents using inputs for winter crops since irrigation (figures 2000/2001)

Input	Janakalayan			Kalleritar			Yampaphant		
	Wh	Vg	Po	Wh	Vg	Po	Wh	Vg	Po
Improved seed	42	20	21	87	56	51	100	100	100
Pesticides	23	20	26	20	44	31	15	98	100
Tractor ploughing	74	54	51	0	0	0	2	2	2
Contract farm labour	5	0	0	0	0	0	0	0	0
Daily hired labour	19	5	5	28	17	8	10	85	14
Fertiliser – urea	51	25	32	90	64	55	100	100	86
Manure	2	2	2	8	17	8	94	88	86
Compost	25	7	11	93	67	63	100	100	100
Other chemical fertiliser	0	0	0	2	0	0	90	90	73

Notes:
wheat (Wh), vegetables (Vg), potato (Po)
Source: questionnaire survey.

4.4 Irrigation impacts on crop income

Table 18 presents indicative estimates of the annual gross income per hectare generated by a commonly adopted cropping pattern on each of the schemes before and after scheme development. The figures are only indicative as actual gross income per hectare gained by farmers varies widely with choice of crops, actual yields and prices achieved. Compared to the crop choice in Table 18 blackgram may actually have been a more common winter crop than mustard for Kalleritar and Yampaphant prior to scheme development but data to value this was incomplete. Also, with irrigation some head and middle reach farmers with adequate water supply in Kalleritar grow early paddy rather than maize as a spring crop, and can thus be expected to achieve a higher gross income per hectare. For purposes of comparison cereal crops have been included for the current situation in Yampaphant, whereas most farmers devote much of their land to a range of vegetable crops in addition to these. Vegetables grown include tomato, cucumber, cauliflower, potato, aubergine, beans, and radish. Gross incomes achievable per hectare are highly variable, ranging from Rs20000 to Rs1.5 million (approximately equivalent to $250 to $18,850 USD at the time of survey Oct 2001 and according to crop budgets prepared by the process investigator with farmer respondents). Revenues from crop production actually achieved on the Yampaphant scheme are thus much greater than shown in Table 18.

The figures in Table 18 are based on farmers' expected average yields (Table 12 above) and crop sale prices reported in the survey (see Annex 4). Comparison with the higher yield potential figures in Table 15 also suggests that these estimates are well below the potential achievable for irrigated cropping. It should also be noted that a large proportion of the output of cereal crops is retained for own consumption. Preferably this should be valued at the replacement cost when purchased at the time of consumption, when prices may be higher than those received after harvest. Thus for a number of reasons the range of increase in gross income per hectare from before to after scheme development in Table 18 (100-175%) can be seen as a conservative estimate[2]. Despite these limitations the figures serve to illustrate the transformation in the scale and intensity of farming as an economic activity brought about through the introduction of irrigation.

[2] In the absence of reliable crop price data for the before irrigation situation, 2001 prices have been used to value before irrigation production. Depending on prevailing world prices and domestic "agricultural terms of trade" output may have been relatively more or less valuable to farmers at that time.

Table 18 Estimated annual gross income per hectare, before and after scheme implementation (at constant prices, 2001 Rs/ha)

Scheme	Before scheme: Monsoon Winter	Gross income, Rs/ha	Current: Spring Monsoon Winter	Gross income, Rs/ha	% increase
Janakalayan	Maize Mustard Total	13600 12000 **25600**	Paddy Paddy Wheat Total	28200 28200 13600 **70000**	173
Kalleritar	Maize, Mustard Total	17500 12000 **29500**	Maize Paddy Wheat Total	19600 35300 19000 **73900**	151
Yampaphant	Paddy Mustard Total	24600 12000 **36600**	Maize Paddy Wheat Total	9800 47100 16500 **73400**	101

Notes: gross income estimates for major crops calculated from respondent yield estimates and reported prices from farm household survey. Gross incomes and production costs for minor crops (mustard) from crop budgets prepared in group interviews by process investigators.
Source: questionnaire survey and process investigators.

Actual household incomes derived from irrigated cropping also depend on production costs. Annex 4 presents some estimates of the net income per hectare generated by the same cropping patterns before and after use of irrigation. The figures should only be taken as indicative as detailed cost of production data was not collected in the farm survey because of the volume of other information collected. Cost of production data for the main crops in Nepal available from other secondary sources also tends to be highly variable suggesting that input use itself is very variable. This is not surprising given the wide variation in agro-climatic conditions, and with regard to other factors such as infrastructural provision and remoteness.

Despite these limitations the estimates of net returns per hectare in Annex 4 tend to confirm the expected situation that the introduction of irrigation is associated with increases in input use and thus costs of production, but also higher yields and higher net returns.

4.5 Irrigation impacts on labour use

It is expected that irrigation will result in higher and more continuous employment for farm labour but the farm household survey did not provide a clear picture of the impact of irrigation development on hired labour use (Table 19). Only responses from Janakalayan suggested that the number of hired labourers employed had increased in aggregate over the previous ten years.

However, at all three schemes the introduction of irrigation has clearly increased farm labour requirements. Labour is now required for three crops during most months of the year, whereas before irrigation it was only necessary for one or two crops during a period of approximately six months. Most farm households had surplus labour prior to the use of irrigation, and irrigated agriculture has provided fuller employment to the farm households' own labour, possibly reducing the need for seasonal migration in search of work. Some households also overcome labour constraints through traditional practices of labour exchange.

Table 19 Percentage of farm household respondents reporting change in use of hired labour for the period 1991 – 2001

Change in hired labour use	Janakalayan	Kalleritar	Yampaphant 1	Yampaphant 2
Increase	50%	14%	45%	10%
Decrease	8%	62%	45%	85%
No change	42%	24%	10%	5%
Respondents (n)	48	37	40	20

Notes:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation
Source: questionnaire survey.

At Yampaphant farmers did report a steady rise in the opportunity for labour in the focus group interview, estimating demand to have doubled over the last ten years. Both neighbouring upland farmers and landless groups have benefited from this increase in the opportunity for waged employment. Similarly, farmers at Janakalayan reported a labour shortage during certain periods, for example, during the paddy harvesting season, when about 30 – 40 percent of the total labour requirement for paddy harvesting is fulfilled by labour from the adjoining Terai districts. Focus group interviews confirmed that farmers used to have about six months free time, which has been reduced to almost nothing since irrigation due to the higher labour requirement.

For both Kalleritar and Yampaphant hired labour is drawn from the immediate local area (surrounding hills), and this has not changed as a result of improvement and expansion of the irrigation scheme. For Janakalayan, 61 percent of those hiring labour reported that this was drawn from other districts and only 39 percent that it was drawn from the immediate local area. This compares to figures of 8 percent and 92 percent respectively for the period before irrigation, showing that the use of local labour has decreased and the use of contract labour from other districts has increased since irrigation.

Wage rates for farm labour were consistently reported as Rs100 per day for male labour on all three schemes. Wage rates for female labour were slightly more variable, ranging from 40-50 Rs per day at Kalleritar and Yampaphant to Rs80 at Janakalayan. In all cases from one to three meals would also be provided during the day for labour.

Table 20 shows that the majority of farm household respondents (household heads) do not generally work as paid labour on other farms. Incidence of this is most common at Janakalayan where 10 percent of respondents also worked as labourers on other farms throughout the year. In all cases in Table 20 such work was undertaken within the irrigation schemes, as opposed to rainfed land or other irrigation schemes.

The survey of labourers revealed that 80 percent of respondents thought that opportunities for work had increased since irrigation. The only scheme where any of the labourers (60%) thought that opportunities for work had not increased was at Janakalayan, though this contradicts with the findings of the focus group interview. This response is, however, in keeping with the average number of days worked by the interviewees, which are less at Janakalayan than at Kalleritar and Yampaphant (Table 21). This could be the result of increased use of contract labour at Janakalayan, particularly during the harvesting season when labour shortages were emphasised in the group interview. This situation may have reduced the amount of work available for local labourers. Contract workers stay at the scheme for around 20 days and are paid R3000/bigha for threshing or harvesting (process investigator).

Table 20 Percentage of farm household respondents also working as farm labour for other households according to season

	Janakalayan	Kalleritar	Yampaphant 1	Yampaphant 2
Spring	10	2	5	0
Monsoon	10	2	5	0
Winter	10	2	5	5
Respondents	60	60	40	20

Notes:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation
Source: questionnaire survey, October 2001.

Table 21 Average days worked per year by labourers

	Yampaphant	Kalleritar	Janakalayan
Min	150	60	90
Average	230	151	98
Max	300	365	120

Source: labourers questionnaire survey (sample size = 5 per scheme).

A case study of Tritha Kourala (process investigators report, Yampaphant) illustrates a situation whereby a labourer/sharecropper since irrigation now has the opportunity to undertake 12 months work (health permitting), whereas before irrigation it was only possible to find enough work for 6 months.

4.6 Livestock

Table 22 shows that the keeping of livestock is common for the majority of households, particularly in Kalleritar. Buffalo are kept by most households for the production of dairy products, followed by goats and cattle.

Table 22 Percentage of farm household respondents owning livestock and mean number of head owned

Livestock	Janakalayan		Kalleritar		Yampaphant 1		Yampaphant 2	
	Percentage owning	No. owned	Percentage owning	No. owned	Percentage owning	No. owned	Percentage owning	No. owned
Cow	40	1.9	72	1.8	53	1.8	35	3.7
Bull	10	1.7	70	2.1	30	1.9	30	2
Buffalo	67	2.2	98	1.7	98	2.1	85	2.2
Goat	77	3.4	95	4.4	45	3.6	45	2.3
Chicken	30	4.3	47	3.4	0	0	0	0
Pig	8	7.8	0	0	0	0	0	0
Respondents	60		60		40		20	

Notes:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation
Source: questionnaire survey.

Table 23 Percentage of respondents keeping livestock since irrigation

Change in livestock numbers	Janakalayan	Kalleritar	Yampaphant 1	Yampaphant 2
Increase	25%	34%	25%	10%
Decrease	41%	3%	8%	25%
No change	34%	63%	67%	65%
Respondents	59	60	40	20

Notes:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation
Source: questionnaire survey, October 2001.

Table 23 shows a rather mixed pattern regarding trends in livestock numbers following the introduction of irrigation. At Kalleritar there is relatively little production for the market because of the relative inaccessibility of the village. There has been some increase in production for own consumption with the adoption of improved breeds, and those reporting an increase in livestock numbers attributed this to increased availability of fodder crops and crop residues used as animal feed. Similarly at Janakalayan some households have intensified production and in some cases have increased livestock numbers because of the availability of improved breeds and the increased production of fodder However, in this case some also cited the market incentive of producing milk for sale. Reasons for a decrease in livestock numbers were primarily the loss of dry season grazing land to irrigation, plus the loss of access to grazing lands in the nearby National Park, and less time to supervise grazing. Similarly at Yampaphant some farmers have intensified livestock production, making use of improved breeds and increased fodder production to supply the market. Others have reduced animal numbers because of labour and grazing land constraints, but in most cases will still be meeting own consumption needs from a reduced number of improved animals.

Overall it appears that irrigation development has tended to encourage the intensification of livestock production. On the one hand less labour is available for supervising grazing (children are increasingly at school) and less dry season pasture is available. On the other hand more fodder and crop residues may be available for stall feeding. Some households may reduce livestock numbers to the minimum needed for own consumption, while others may seek to specialise to a greater extent in supplying dairy and meat products to the market. In both cases the availability of improved breeds (well suited to stall feeding and only limited free grazing) and appropriate veterinary care are important complementary inputs.

Table 24 Reported income from livestock, 2000/2001, NRs

	Janakalayan	Kalleritar	Yampaphant
Mean income from all livestock, NRs	5155	2243	30992
Maximum	50000	29000	400000
Minimum	0	0	0
Standard deviation	9705	5262	53469
Sample (n)	60	60	60
% sample reporting some livestock income	48%	38%	88%
Mean income reported	10666	5850	35085
Minimum	300	400	2000
Number households reporting some livestock income	29	23	53

Table 24 shows that both the proportion of farmers reporting income from the sale of livestock products and the income gained were both much higher at Yampaphant than the other two schemes. Kalleritar reported the lowest incomes from the sale of livestock products despite relatively high levels of animal

ownership (Table 22), indicating that livestock there are mainly kept for own use rather than to produce for sale.

4.7 Other sources of income

Twenty-three percent of farm households at Yampaphant reported an income from fruit trees, and the average amount gained was Rs2500 per year. Income from fruit trees was not significant at Kalleritar or Janakalayan.

Eight and seven percent of farm households gained an additional income from sharecropping land at Kalleritar (average Rs9000 per year) and Janakalayan (Rs7500 per year) respectively. At Yampaphant 13 percent of households gained an income from renting land. The rent was universally reported as Rs40000 per hectare and the average rental gained per year for this group was Rs19900.

Table 25 covers income sources other than those discussed above and provides some indication of the extent to which income sources for the farm household as a whole are diversified. Incomes from these sources were very variable and thus the mean figures given are purely indicative. It is notable that around 20-25 percent of farming households have family members in salaried employment. Gaining an income from dryland farming was more common in the hills than the Terai. Yampaphant households do not appear to gain additional income from casual labouring. Other sources of income in the table include renting land or accommodation, or providing tractor and bullock hire services.

Table 25 Percentage of farm households receiving income from other sources and mean income earned from that source (Rs)

Income source	Janakalayan		Kalleritar		Yampaphant 1		Yampaphant 2	
	%	Mean income (Rs)	%	Mean income (Rs)	%	Mean income (Rs)	%	Mean income (Rs)
Dryland agriculture	5	300	15	4396	20	10750	25	16900
Salaried employment	23	46750	7	48000	28	52500	20	130000
Small business	20	100150	3	5100	10	28750	0	0
Occasional labour	13	68750	8	5000	0	0	0	0
Pension	0	0	0	0	5	38000	10	81000
Remittances	7	50000	2	15000	0	0	20	101250
Other	12	32350	2	2000	5	18500	0	0
Respondents (n)	60		60		40		20	

Notes:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation
Source: questionnaire survey, October 2001.

Table 26 summarises the income earned in aggregate from these other "non-farm" sources (NB includes dryland cropping). Both Tables 25 and 26 show that households at Kalleritar have the least diversified livelihoods, the majority (65%) being dependent on their irrigated plots and livestock for income. Janakalayan has the highest proportion of households reporting other income sources (62%), although the mean additional income gained is less than at Yampaphant, where salaried employment of household members and remittances provide large contributions to household income.

Table 26 Mean household income from other sources, and percentage of households gaining non-farm income (Rs)

	Janakalayan	Kalleritar	Yampaphant
Mean income from other sources	25065	6260	31750
Maximum	130000	90000	350000
Minimum	0	0	0
Standard deviation	34808	16557	59357
Sample	60	60	60
% sample reporting some 'other income'	62%	35%	52%
Mean income reported	40646	17884	61452
Minimum	1000	960	4000
Number reporting 'other income'	37	21	31

Notes:
Other sources exclude irrigated cropping, cash and share rents, livestock and tree crops, but include dryland cropping, casual farm labour and all other income sources.

Comparison of the three schemes may thus provide some evidence that progression in terms of intensification and commercialisation of irrigated farming is also associated with a growing contribution of non-farm income to total household income, and greater livelihood diversification. This certainly appears to be the case for Yampaphant scheme, when compared to Janakalayan, and particularly when compared to Kalleritar.

It can be estimated that non-farm income makes up approximately 45 percent of household income at Janakalayan, 25 percent at Kalleritar and 40 percent at Yampaphant. This compares to a national average of 39 percent (CBS 1996).

4.8 Irrigation impacts on household income

Table 27 presents some approximate estimates of the impact of irrigation on household income for the three schemes. These should be treated as indicative only for the median farm holding size cited. The income estimates before irrigation are based on farmer assessments of crop output before irrigation (approximately 1986/87 for each scheme), valued using prices prevailing in 2001. These are an overestimate in so far as they are based on gross rather than net crop income (however, use of purchased inputs and hired labour was low at that time), but an underestimate in so far as any livestock income has been neglected. Non-farm or other income is estimated based on the national average of 39 percent of household income (CBS 1996), but it is likely to have been less in this earlier period. The estimates of income per capita before irrigation for the three schemes are comparable to those cited for 1987 for similar farm size categories by the Nepal Rastra Bank (1988), confirming that they may be of the appropriate order of magnitude.

The income estimates after irrigation are based on the farmer survey data and prices prevailing in 2001, with deduction of estimated crop production costs (Annex 4). Income at Yampaphant is underestimated as it is based on cereal crops only and actual income from the production of vegetable crops will be higher.

Acknowledging the need to be aware of the data limitations discussed above, Table 27 suggests that household incomes before irrigation for the median farm size on all three schemes would have been well below the published poverty line income for Nepal (estimated as NRs4404 in1995/96, equivalent to NRs5564 in 2001 prices as shown in Table 27). After irrigation this income estimate had risen above the poverty line for Janakalayan and Yampaphant, but remained below it for Kalleritar. The income estimates for Janakalayan and Kalleritar also remain below average income estimates from the Nepal Living

Standards Survey of 1996 (all comparisons in 2001 prices), although the figure for the hill region in particular is biased by higher urban incomes in Kathmandu (CBS 1997). Table 27 thus suggests that the increased cropping intensity and yields for the main cereal crops with irrigation makes a significant contribution to higher incomes, but as illustrated in particular by the case of Kalleritar this alone may not be sufficient to escape from poverty. Diversification of cropping into higher value cash crops, and also increasing the intensification and commercialisation of livestock production, can bring greater increases in income as exemplified by the case of Yampaphant. It has also been observed that such improvements in farm income may also be associated with growing diversification and increase in sources of non-farm income. Household incomes and the potential to escape from poverty are, however, clearly constrained by farm size for a large number of rural households. The median farm sizes cited here are generally regarded as small or marginal in terms of farm size classification (Nepal Rastra Bank 1988).

Table 27 Household income estimates before and after irrigation, NRs at 2001 financial prices[9]

	Janakalayan	**Kalleritar**	**Yampaphant**
Median landholding (now irrigated), ha	0.66	0.36	0.48
Current household size, mean number of members	9	7	7
Before irrigation			
Gross crop income per year per ha	25600	29500	36600
Gross crop income per year per household[1]	16896	10620	17568
Other income (estimated)[2]	10802	6790	11232
Total household income	27698	17410	28800
Income per capita	**3078**	**2487**	**4114**
After irrigation (2001)			
Net crop income per year per ha	37000	45400	44900
Net crop income per year per household[3]	24420	16344	21552
Livestock income[4]	5155	2243	30992
Other income[5]	25065	6260	31750
Total household income	54640	24847	84294
Income per capita	**6071**	**3550**	**12042**
Poverty line, Rs/capita[6]	5564	5564	5564
	Terai	**Hills**	**Hills**
Average per capita income in 1996[7]	9251	10654	10654
Average per capita income in 1987[8]	2767	4173	4173

Notes:
[1] For the reported cropping pattern (Tables 10 and 16b) and median holding size (Table 1).
[2] Based on national average of 39% of household income (CBS 1997).
[3] For the reported cropping pattern and net return estimates (Table 10 and Annex 4).
[4] From Table 21b.
[5] From Table 22b.
[6] Poverty line estimated to be NRs4404 for a daily per capita calorie requirement of 2124 at the average price level prevailing in 1995/96 and a factor to account for non-food expenditures (CBS 1996).
[7] Nepal Living Standards Survey, 1996 (CBS 1997).
[8] For marginal farms in the Terai (<1.02ha) and small farms in the hills ((0.21-0.52ha) (Nepal Rastra Bank 1988).
[9] All data expressed in 2001 NRs using a price index for agricultural GDP (CBS 2001).

4.9 Credit and savings

Table 28 suggests that at Yampaphant the positive cashflows generated by irrigated cash crops have greatly reduced the need for both production and consumption credit. At Kalleritar and Janakalayan the picture is more mixed and interpretation is difficult given a failure in the survey to distinguish between production and consumption needs. It is likely that those reporting an increased need for credit are reflecting the need to purchase inputs for more intensive crop production, whilst those reporting a decreased need are reflecting the improved levels of food security achieved with irrigated production.

Table 28 Percentage of farm household respondents reporting change in the need for credit since respondent started use of irrigation

Need for credit	Janakalayan	Kalleritar	Yampaphant 1	Yampaphant 2
Percentage of households citing increased need	39	19	5	0
Percentage of households citing decreased need	14	15	86	89
Percentage of households citing no change	47	67	8	11
Respondents (n)	59	54	40	18

Notes:
Yampaphant 1 = *pakho* land/farm households; introduced irrigation.
Yampaphant 2 = *baraha* and *jaishi* land/farm households; rehabilitated and improved irrigation
Source: questionnaire survey, October 2001.

The survey revealed no significant change in the pattern of credit use by source before and after irrigation, whilst bank deposits, cash and loans to others were the main forms of savings reported.

4.10 Expenditure

Table 29 presents rankings of expenditure from the farm household survey. Interpretation is difficult as there is little consistency between the three schemes. One observation that can be made from the rankings is that households in Janakalayan and Kalleritar spend little on purchasing food whilst it is a major expenditure for Yampaphant households. Yampaphant households may be buying more staple foods as they have become more specialised in producing vegetables as cash crops, whereas Janakalayan and Kalleritar farming households tend to be more self-sufficient, producing firstly for subsistence and only selling any surpluses.

Table 29 Aggregate rankings of expenditure by farm household respondents (highest expenditure is 1, lowest is 5)

Expenditure	Janakalayan	Kalleritar	Yampaphant
School fees & other costs	4	3	1
Health care	2	1	3
Purchased food	5	5	2
Clothing	1	4	4
Festivities	3	2	5

Source: questionnaire survey.

4.11 Results for other household types

Labourer households

All 15 labourer households (five on each scheme) surveyed lived in the immediate local area of the scheme. They all had the characteristics of being either landless or cultivating only a small area of rainfed

land. Thus their primary source of livelihood was agricultural labour within the selected irrigation schemes, or agricultural labour combined with their own dryland cultivation. Of the 15 labourer households surveyed, 11 (73%) owned some rainfed land, area owned ranging from 0.15 to 1.25 ha. Holdings were generally smallest for labourer households at Janakalayan (0.17 ha each for four out of five households).

At Kalleritar and Yampaphant all respondents in the labourer survey originated from the local area, whilst those at Janakalayan had migrated to the area from hill districts. In all cases occupations prior to working on the selected schemes had been as agricultural labourers or sharecroppers elsewhere. Those at Janakalayan were most dependent on the income from labouring on the scheme rather than their own rainfed land.

The responses of labourer households indicated that hours worked per day in farm labour and wage rates had not significantly increased with the introduction of irrigation. Wage rates reported by the 15 labourer households surveyed ranged from Rs40-100 per day plus the provision of 1 or 2 meals.

Only 4 of the 15 labourer households considered that they were better off after working on the irrigation scheme, the rest felt there was little change. Three of these cited increased employment and income as the reason for improvement, whilst for the fourth improvement was because two sons had found employment elsewhere (at a hotel in India).

The income sources of the 15 labourer households surveyed were much less diversified than those of the farmer households reported in Table 24 above. Labourer households primarily gain income from farm labour on the irrigation schemes or from their own dryland plots. Other occasional labouring was the next most important source of income, and from 15 only one instance each of salaried employment and engagement in a small business were reported.

None of the 15 labourer households surveyed reported that they were able to make any savings. Four of the five households at Janakalayan reported that they remitted money to other family members in the hill district. This was the case for only one respondent at Yampaphant and none at Kalleritar.

Agricultural goods and service providers

Table 30 shows the occupations of those households surveyed.

Table 30 Primary occupation of other survey respondents (providers of agricultural goods and services)

Occupation	Janakalayan	Kalleritar	Yampaphant
Tailor	2	1	1
Blacksmith		1	
Carpenter		2	1
Shopkeeper	3	1	1
Petty trader	1		2
Miller		3	1
Farm input supplier	4	2	4

Notes:
Shopkeepers = those selling daily goods and necessities, e.g. pulses, rice, oil, toothpaste, soap, clothes; teashops.
Petty trader = those selling vegetables.
Farm input supplier = those selling fertiliser, seed, veterinary medicines, farm equipment, pesticides, rice mills, 2-wheel tractors.
Source: questionnaire survey.

All the people surveyed were self-employed, and the majority were located within 1 km of the scheme, except for Yampaphant where more than half were more distant (more than 1 km). Most (70 percent) had been farmers before they entered their present occupation, and 63 percent had migrated to the schemes. Forty-seven percent of those migrating had done so before the use of irrigation in the area. Migrants were mainly attracted by the business opportunities created by the increased productivity in the irrigated area, by access to roads or had migrated with existing farmer clients. The availability of land for homes was also a factor in attracting two households to Janakalayan (Terai). Sixty percent of agricultural goods and service providers also owned or farmed land on the schemes in addition to their occupation.

A clear majority reported that their customers were mainly farmers on the selected or neighbouring schemes. Most (77 percent) entered into transactions with farmers that involved some element of credit to the farmers, and most found that they were usually repaid on time.

Eighty percent reported that they were able to make a steady income through the year by supplying services to farmers, and for the other twenty percent spring and monsoon were the difficult seasons. It is expected that in winter farmers would have most money to spend from the monsoon harvest. Seventy-seven percent reported that the business was adequate to support their family. Other sources of income for these households were mainly dryland or irrigated farming, with a few examples of pension or remittances. Seventy-seven percent stated that they had become better off by taking up this occupation, the remainder reported that their situation had not changed. Reasons for improvement were generally the level of business activity, which provided an adequate flow of income. Individual reasons given included that as farmers' incomes have increased they have tended to spend more money on clothes (tailor) and on rehabilitating their houses (carpenter). Also as farmers produce more vegetables, there are more to buy and sell in other markets (general merchant). Fifty-three percent were usually able to save from their income; savings mainly being in cash or bank deposits.

Thirty-six percent of the suppliers of agricultural goods and services who were interviewed currently sell different goods to when they first started at the scheme. An increase in demand for agricultural inputs has resulted from the increased purchasing capacity of farmers since irrigation. The suppliers have therefore tended to earn more money, which they have put back into the business in the form of new products and equipment. Although there is competition at each of the schemes, the suppliers all admit to having a good relationship with their competitors.

Over 80 percent of respondents believed their workload had increased over the past ten years. The reasons given include:

- running the business is work which has to be done in addition to traditional agricultural and household work;
- the population increase in the area has led to an obvious increase in business;
- more agricultural instruments are required to cope with the new, more intense cropping pattern associated with irrigation.

Other members of the community, such as blacksmiths and basket makers have also experienced an increase in income over time (process investigator report, Yampaphant).

Only one respondent felt that he had not benefited from the presence of irrigation (Yampaphant). He thought that as farmers' incomes increased, they chose to go elsewhere for their clothes/tailoring.

5. PHYSICAL CAPITAL

Physical capital can be described as the basic infrastructure and producer goods needed to support livelihoods. This may include affordable transport, secure shelter and buildings, adequate water supply and sanitation, clean affordable energy and access to information (communications). Producer goods are tools and equipment that people use to function more productively.

According to the 8th Plan, the Nepal government is committed to the development of rural infrastructure. Necessary infrastructure will be built for the development of rural irrigation, drinking water, electricity, communications, rural industry and tourism. The aim is that through the provision of the basic facilities of life, such as suspension bridges, schools and health care, the environment in the villages will be made attractive enough for the villagers to lead their lives comfortably in the rural areas (National Planning Commission Secretariat 1992). In 1992, approximately 50 percent of landholdings in Nepal were reported to be irrigated (CBS 2000).

5.1 Scheme profiles

Figure 2 illustrates the pattern of infrastructure development on the three schemes over time. Kalleritar's infrastructure development has been heavily influenced by the irrigation system, the construction of suspension bridges improving the scheme's accessibility to the road and to some extent the road itself. Of the three schemes, Kalleritar has the least advanced and developed physical infrastructure, for which its relative distance and inaccessibility from the road may be a contributing factor.

Of all the physical capital developments, the combined influences of the road and the irrigation scheme have had the most significant effect on the village of Yampaphant. Although its physical capital is of a comparable level of development to that of Janakalayan, Yampaphant is the most entrepreneurial of the three schemes. In particular, access to both input and output markets and the influence of the Lumle Agricultural Research Centre (LARC) has encouraged farmers to try new technology and techniques. For example, as indicated in Figure 3, Yampaphant farmers are by far the highest owners of crop sprayers (76 percent). They also have the highest number of biogas units.

Figure 2 Pattern of physical infrastructure development

	Kaleritar	Yampaphant	Janakalayan
1967	Road		Secondary school
1968			
1969			
1970			
1971		Primary school	
1972		Road	
1973			
1974			Road
1975	Cable car		
1976			
1977			
1978			
1979	Suspension bridge		
1980			
1981			
1982			Irrigation
1983	Drinking water (Ghartitar)		
1984			Canal lining
1985			
1986	Rice mill		
1987			
1988	Irrigation	Irrigation	
1989	Primary school (Ghartitar)	Shop	First biogas unit
1990	Primary school (Foshretar)		Health post
1991			
1992	Rice mill (Foshretar)		
1993		Drinking water supply	Shop	Rice mill
1994	Suspension bridge	Electricity supply	Flood protection bund	Rice mill
1995	Drinking water (Foshretar)	Tea shop	Food shop	Drinking water (Gahate)	First biogas unit	
1996	Drinking water (Kaleritar)			
1997			Biogas programme	
1998		Rice mill	Bridge	
1999		Clothes shop	Electricity	
2000	Electricity (Kaleritar)	Agrovet shop	General shop	Vegetable marketing stall	Telephone	
2001		Tea shop	Tea shop	Tea shop		

Similarly to Yampaphant, development at Janakalayan has been influenced by the major physical developments of the road (east-west highway) and the construction of the irrigation system, and also the construction of major flood protection works along the nearby Rapti River in 1994. This has had a significant effect in increasing crop production by reducing damage to crops from flooding during the monsoon.

Janakalayan is topographically different from the other two schemes as it located on the plains of the Terai, and is thus more suited to intensive agriculture, whilst farmers tend to have larger plot sizes. This presents more favourable conditions for the mass production of cereal crops over the other two schemes. It is more conducive to the use of agricultural machinery, and tractors in particular. A high percentage of farmers use tractors for ploughing (93 percent for paddy compared to none at Kalleritar and 2 percent at Yampaphant).

5.2 Housing

There has been an increase in the number of households across the schemes, which has accelerated since irrigation (see Table 31). The eradication of malaria has also facilitated this pattern of settlement, although eradication occurred in the 1960s and significant migration to the schemes did not generally begin until the 1980s. At the two hill schemes farmers used to farm by day and return to houses at a higher elevation at night. Extra produce grown as a result of irrigation then made it increasingly difficult for farmers to carry their harvest up the hill (for security) and then subsequently to market.

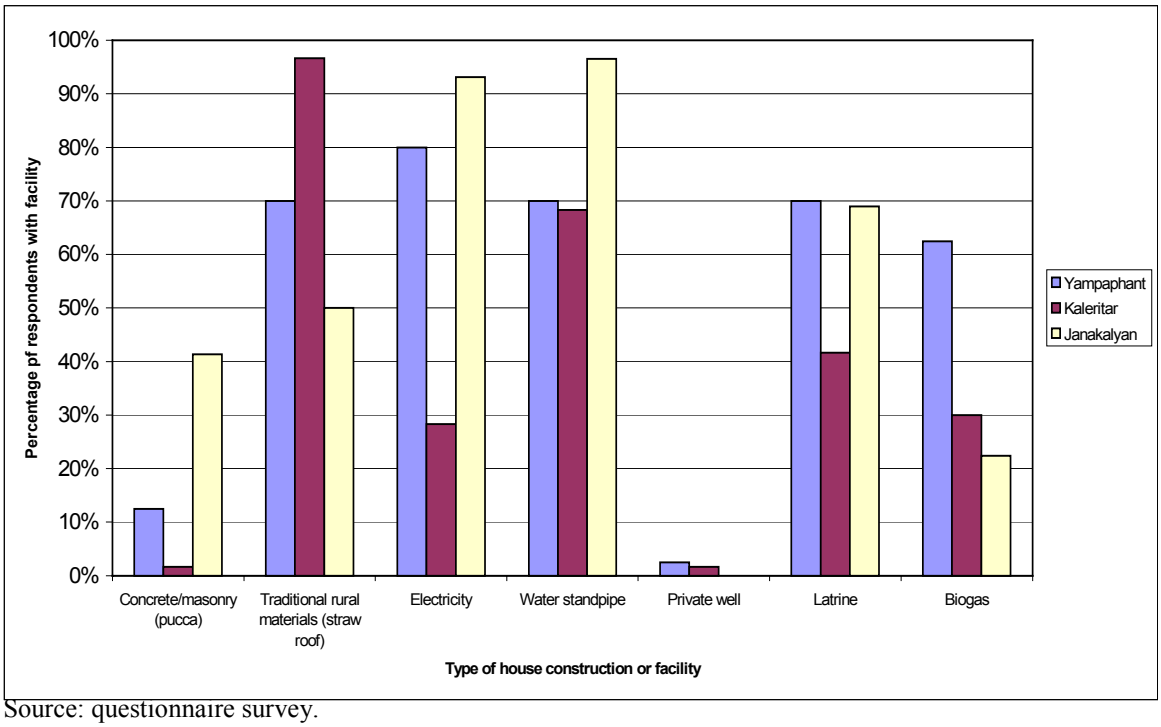
Table 31 also shows that the number of households existing and the timescale over which they were developed are similar for all three schemes. Farmers in Kalleritar and Janakalayan have on average lived on the scheme since around the time irrigation commenced. Yampaphant farmers, however, have on average lived on the scheme since a period five years before the introduction of irrigation.

Table 31 Changes in the number of households in the 1950s, 1980s and 2001

	Kalleritar	Janakalayan	Yampaphant
Before irrigation (~1950s)	32	17	35
At the time of Irrigation (~1980s)	55	Na	60
October 2001	199	142	115

Source: questionnaire survey and process investigators report

About 50 percent of farmers across all schemes reported having made improvements to their house (new roof, walls or room) since living there. Figure 3 depicts key physical assets associated with farmers' homes across all three schemes as indicators of housing and living standards.



Source: questionnaire survey.

Figure 3 Construction of family home and the presence of associated household facilities

For most of these indicators households at Janakalayan appear to have the most developed physical capital. A majority (97 percent) of Kalleritar farmers construct their houses using traditional rural materials. Suitable locally available materials negate the need for concrete construction as farmers have access to good quality brick, clay mortar and local slate for the roof. The fact that most houses are constructed from traditional rural materials at Kalleritar is not therefore necessarily a good indication of wealth. As on the other schemes, half the respondents had made improvements since living in the house. One carpenter on the scheme commented on an increase in work over time: "as income increases with irrigation, people start to rehabilitate their houses" (questionnaire survey). On average households have been resident for 12 years.

At Kalleritar fewer farm households have electricity (28 percent) compared with the other two schemes. However, 60 percent of households in the middle reach of the scheme do have an electricity supply because the government recently provided a line. Significantly, although currently only 30 percent of respondents have a biogas unit, 34 have been built since 1998 suggesting a recent increase in uptake of this technology.

Comparable to Kalleritar, 70 percent of Yampaphant respondents owned houses constructed from traditional rural materials. Less brick and stone are locally available at Yampaphant, and as a result most houses are constructed from timber. The availability of such timber has decreased and it has become more expensive since the formation of the forest management group. On average households have been resident for 18 years, as migration to the location increased after the road was constructed but before irrigation development.

Houses in Yampaphant are on average bigger than on the other two schemes. Yampaphant farmers have an average of 4 rooms in their house compared to 2.5 on the other schemes. Eighty percent have direct metered access to an electricity supply and the remaining houses have access from the metered houses. A high proportion of respondents (63 percent) have biogas plants.

Janakalayan has a similar level of physical infrastructure development to Yampaphant, with slight differences in coverage of water supply and electricity. Yampaphant's location as a hill town and the

comparative difficulty in establishing such network systems in the hill terrain and may explain why, although general coverage is good, the final 20 to 30 percent of properties still lack these facilities. Handpumps for drinking water supply are much easier to locate and cheaper to construct on the plains than the piped supply found in Yampaphant.

Yampaphant has by far the largest number of respondents (63 percent) with biogas units, suggesting that interaction with LARC may have encouraged a greater propensity to adopt new technology. There may also be a link between the influence of LARC and livestock farming as 60 percent of Yampaphant farmers own either a cow, bull or buffalo, compared to 53 percent of Kalleritar farmers and only 30 percent at Janakalayan. Livestock are needed to provide fuel for biogas and the varying emphasis on livestock farming may correspond with the difference in uptake of biogas across the schemes.

A high percentage of Janakalayan respondents (43 percent) have constructed concrete houses, replacing traditional materials. This is due, in part, to the lesser availability of traditional building materials in the Terai region; a lack of stone and restrictions on timber use mean that concrete is often the only alternative to stick and mud construction. Concrete houses are, however, expensive to build and are considered a symbol of wealth within the community.

At Janakalayan a direct electricity supply is common (92 percent) and use of biogas is relatively low (23 percent). About half of the farm household respondents identified "a change in housing and living conditions" as the main reason for a general improvement in their health.

For all three schemes all labourers interviewed had fewer physical assets than the average farmer. Labourers tend to come from outside the schemes and from poorer, generally low-caste, villages (see section 7.1 for further explanation of caste). Significantly, none of the labourers interviewed had access to a latrine or biogas unit. Most did, however, have access to a good source of drinking water.

As a higher income group, agricultural goods and service providers across the three schemes had, as can be expected, a high number of physical assets. A majority owned *pucca* or concrete houses, with an average of over four rooms. Nearly all possessed biogas, an electricity supply, water and latrines.

5.3 Water and sanitation facilities (primary health)

All three schemes have a high percentage of households who have access to a good clean water supply. Piped supplies to shared tapstands serve Kalleritar and Yampaphant whereas farmers in Janakalayan get their drinking water from private handpumps. Compared to national statistics, shown in Table 32, all three schemes have comparatively good access to water and sanitation facilities.

A very high number of respondents in Kalleritar (93 percent) profess to having access to a good clean water supply. There are 26 tapstands in total so a number of households therefore share a water supply. In some instances farmers have built their own tapstands but 80 percent received outside assistance. About 50 percent of households possess a latrine. This is considerably less than the other two schemes but still high compared to a national average. A large number of those with latrines funded the construction themselves. The relatively low number of latrines maybe due in part to a lack of outside assistance. A high percentage of head end farmers (80 percent) do have a latrine as a result of specific local intervention by the NGO *NEWAH*.

Table 32 Percentage of rural households with access to selected sanitation indicators (1991 and 1996)

Indicators	1991	1996
Sources of drinking water		
Piped water	16 %	29%
Well water	12%	7%
Hand pump	26%	33%
Spring	33%	21%
River	9%	7%
Stone tap	3%	2%
Other	1%	1%
Toilet in the house		
Yes	17%	18%
No	83%	82%
Mean person per room	NA	3.5

Source: (Nepal South Asia Centre 1998).

Of the three schemes, Yampaphant farmers had the strongest opinion that the provision of the drinking water supply had improved their health to some degree. Seventy percent of Yampaphant respondents have access to a water standpipe for drinking water and 70 percent have a latrine. Both these water supply and sanitation facilities were provided as a result of external programmes coming to the village soon after irrigation (water 9 years ago, latrines 11 years ago). Unlike Janakalayan, farmers did however, have to contribute cash for both facilities.

Water and sanitation provisions are widespread in the community of Janakalayan. Almost all respondents (97 percent) have access to a good source of drinking water through a private handpump. Some of these handpumps lack proper concrete aprons and are therefore liable to contamination. A large number of farmers, 70 percent, have a latrine. On average, farmers have had access to both these sanitation facilities since irrigation (water for 11.5 years and latrine for 4 years). Nearly everyone with these facilities stated that they did not have to pay for them, which may account to some degree for their prevalence.

5.4 Local services and access to services

Alongside irrigation, the most significant development common to all schemes is the construction of the main road which provided improved access to markets and services. One Yampaphant farmer stated that "the family made the final decision to live and farm in Yampaphant in 1975, following the construction of the highway and the subsequent availability of facilities" (questionnaires). In the case of Kalleritar the construction of the new suspension bridge connecting Kalleritar to the market of Baireni is of parallel significance to the road.

Currently all three schemes sell produce to markets at a significant distance, including Kathmandu. Without the road, the size of their markets would be significantly reduced. Since road construction many farmers visit other market centres such as Kathmandu for shopping and health facilities. In many cases, the road reduced journey time from days to hours and has therefore made the journey feasible.

The road may have even encouraged irrigation development itself by providing easier access for construction and materials. In a similar way, increased accessibility to the schemes via the road has encouraged other developments that have yet to reach more remote areas of Nepal, such as electricity and drinking water. The road has also provided a focal point and market place for local businessmen to open up shops.

Across the schemes, agricultural goods and service providers state that their businesses have been better off since the introduction of irrigation. Many have in fact only started their business since irrigation

provided the demand. Carpenters in particular suggested that the demand for work has increased since irrigation. In many cases carpentry by its nature will be associated with improvements to physical capital, especially in works such as house extension. New rice mills have been constructed and are operating on all three schemes as the increased demand for milling has made the business sustainable. Farmers used to travelling some distance to a mill, or the time consuming practice of grinding by hand, now have the option of a more convenient mill.

Access to markets imposes few constraints to the intensification and commercialisation of farming at Janakalayan and Yampaphant. Janakalayan is located about 6 km from the nearest market (Parsa bazaar), but all weather road access is relatively good. The majority of farmers take their surplus produce to the market themselves using bicycles or local trucks. About 8 percent reported selling paddy to traders who come to the village. At Yampaphant the main form of marketing is to sell to traders who come to purchase at the roadside market point for the village. At Kalleritar the majority of households (83 percent) take their surplus produce to market themselves; a walk of about 4 km on average.

Of the three schemes, Kalleritar is the least accessible, but although it is half an hour by trail, across a suspension bridge, to the main Prithivi highway, its proximity and access to this major road has a major influence on village life. In spite of the fact that both Yampaphant and Janakalayan are closer to the road, Kalleritar was the only scheme where a majority (58 percent) of farmers stated that the main reason for leaving their former place and coming to live in Kalleritar was the fact that their former dwelling was too far from the road. However, the fact that Kalleritar farmers have to carry all their produce half an hour by foot to the nearest market at Baireni poses a significant marketing constraint in comparison to the other two schemes.

Local shops, clinic and school have a high percentage usage amongst Kalleritar farmers. There is not a local hospital or bus service but farmers do travel from Baireni bazaar on the Prithivi highway and Kathmandu is only an hour's bus journey from this point. The principle reason given for an improvement in health was the provision of medical services and immunisations. Although there is no health post within the scheme itself the neighbouring village has a health post and a drug scheme, where Kalleritar farmers get subsidised medication.

When Kalleritar farmers were asked the reason why more children are going to school now than were before irrigation 65 percent of those interviewed said it was because the community had built two new schools. The community had mobilised the resources and carried out the construction of these schools themselves.

Most Yampaphant farmers profess to using local shops, schools and buses and even health clinics in neighbouring towns. Only 50 percent, however, make a longer journey to the nearest hospital, often Kathmandu. They appear to have a much higher motivation to travel to hospital than Kalleritar farmers who have to make a similar length of journey. This is perhaps related to ability to pay for both travel and healthcare.

The number of shops and services has increased over recent years across all schemes. Yampaphant in particular has shown a dramatic increase in the number of shops constructed over the last three years and about 10 new shops have opened, mostly along the highway. This may indicate an increase in the spending power as the income of local farmers has increased through irrigation.

Janakalayan is 6 km south of the market centre of Parsa bazaar which may account for the fact that not many shops have developed within the scheme itself. Most services, except the school, are only available in Parsa. A local shop may not be able to compete against the market centre. It is a cultural requirement that women should learn to ride a bicycle before they are married. This may account for the high proportion (75 percent) of farmers owning a bicycle (see Figure 4). The flat terrain means that Parsa bazaar is readily accessible by bicycle.

Table 33 Time taken (minutes) to travel to school and drinking water supply

	Average travel time in minutes		
	Kalleritar	**Yampaphant**	**Janakalayan**
Primary school	10	9	10
Secondary school	44	4	11
Drinking water supply	6	4	0

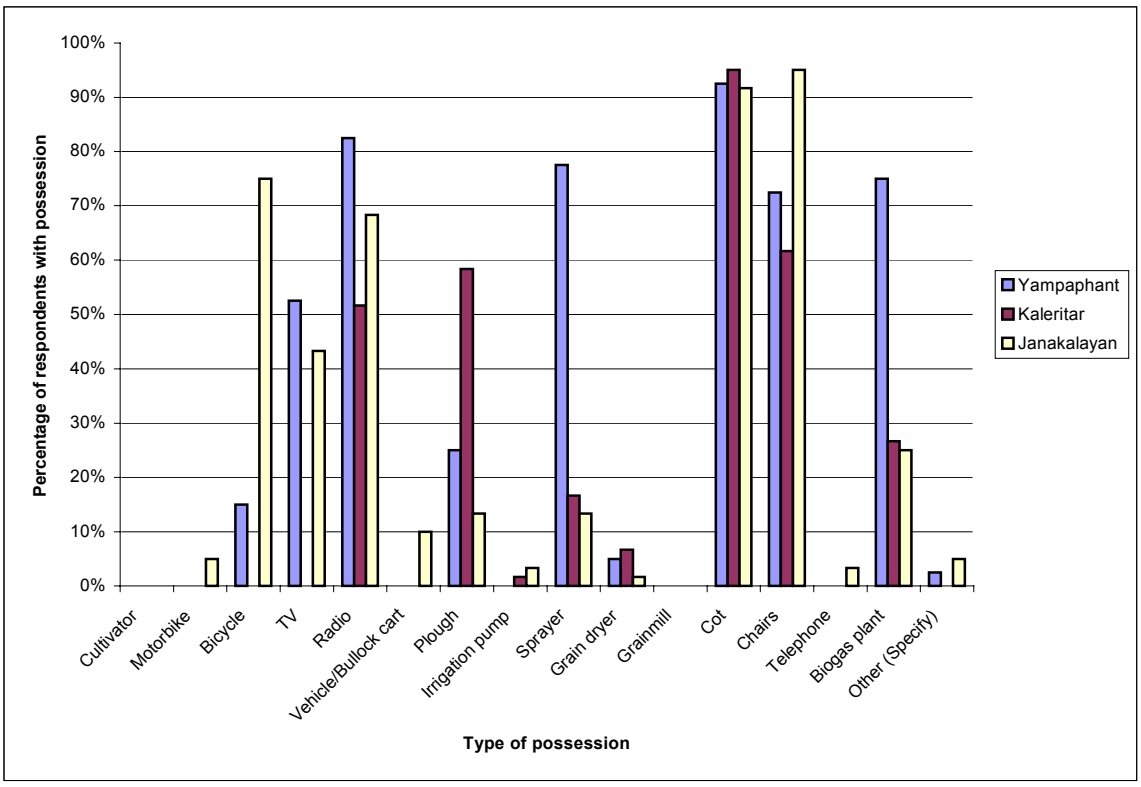
Source: Questionnaire survey.

Table 34 National average access time for rural households to reach service facilities

Facility	**Hours**	**Minutes**
Primary School	-	25
Health Post	1	17
Commercial Bank	2	58
Market Centre	3	8
Local shop	-	41
Periodic market	4	51
Paved road	5	17
Dirt road (vehicle passable)	3	39
Dirt road (vehicle impassable)		32
Bus stop	4	4

Source: (CBS 1996).

Apart from the time taken by Kalleritar households to get to a secondary school (Table 33), all three schemes have better access than the national average to most facilities (Table 34). On all three schemes, the time taken to reach both health posts and commercial banks is the longest compared to other facilities but still well below the national average given in Table 34.



Source: questionnaire survey.

Figure 4 Percentage of farmers owning different possessions across all three schemes

5.5 Irrigation canal

Canals on all three schemes are of a similar size and have a comparable amount of lined and unlined sections. The irrigation system infrastructure on all schemes was in a good state of repair. This suggests that local ownership of schemes of this size helps to keep the scheme in a good condition. In addition, all three schemes have received outside assistance for construction and rehabilitation of their irrigation systems.

All three schemes had a similarly high number of farmers participating in the repair of the intake and desilting of the canal. Interestingly no respondent on any scheme stated involvement in preventative maintenance of their canal. Of the three schemes Janakalayan had the highest number of farmers (90 percent) co-operating in water distribution, with Kalleritar 7 percent and Yampaphant 8 percent.

Kalleritar is the longest canal at 11 km and has the largest number of advanced structures including aqueducts, super passage, culverts, covered canal, outlets and chute drops. Most farmers (87 percent) agreed that their irrigation system was in a fair condition. This is a significant statement as Kalleritar has the longest and most complex system of the three schemes. The fair condition of the canal system indicates a well organised and committed farmer group.

A majority of Yampaphant farmers (98 percent) agreed that their canal was in a fair condition. There was evidence of farmers getting together to mobilise resources for repair but the mobilisation and organisation of the water user association was not as strong as that in Kalleritar.

A majority of respondents in Janakalayan (68 percent) stated that the canal was in a good state of repair. Process investigations indicated that Janakalayan farmers have the greatest degree of ownership of all the three schemes. They had fought for the scheme to be built, mobilising the resources for construction themselves. They had eventually received outside assistance for rehabilitation but had not initially relied upon it.

6. HUMAN CAPITAL

Human capital represents the skills, knowledge, ability to acquire labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives. Health, nourishment and education are all indicators of human capital.

6.1 Food and diet

Irrigation, which allows the farmers to grow a reliable and plentiful monsoon paddy crop and also to diversify into cash crops such as vegetables, has contributed not only to an increase in the quantity of food available for household members, but also to the quality of foods eaten. All farmers have reported that their staple food has changed from maize to a combination of rice and wheat and more households are eating vegetables and fruit. Many households, which were often not able to meet household requirements before irrigation, are now producing food surplus to household needs (see Figure 5).

There is a notable difference between schemes with regard to the current ability to produce surplus (Figure 5). Over 70 percent of farmers interviewed at Yampaphant and Janakalayan have been producing a surplus to sell, whereas at Kalleritar this figure was only 30 percent.

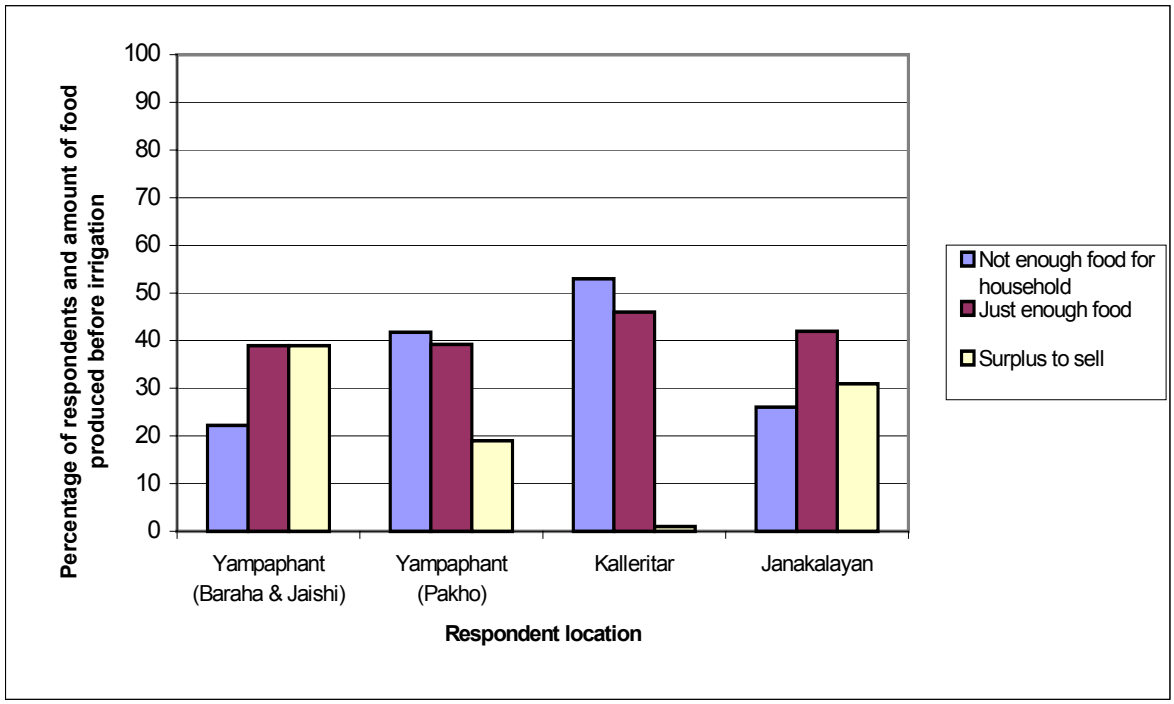
6.2 Family health

At all schemes, the majority of farmers thought that family health had either stayed the same or had improved since irrigation commenced. Only 7 percent and 5 percent of farmers at Kalleritar and Janakalayan, respectively, thought that family health had deteriorated since irrigation, citing reasons of a hotter climate and pollution. Responses suggest that improvement in family health has been more widespread at Yampaphant and Janakalayan than at Kalleritar. Figure 6 shows the results of the farmer questionnaires.

It can be seen from Figure 7 that a change in food and diet, followed by a change in income and change in the ability to afford medical services are the three main reasons given for better family health. Clearly these changes must be closely associated with the direct benefits of irrigation for farming households, i.e. the production of regular food surpluses or cash crops provides increased incomes that can be used in part to meet medical expenses. However, there are other independent factors or reasons, as shown in Figure 7. Such factors are less easily or directly attributable to irrigation and relate more to rural development interventions as a whole (e.g. developments in physical capital as described in section 5).

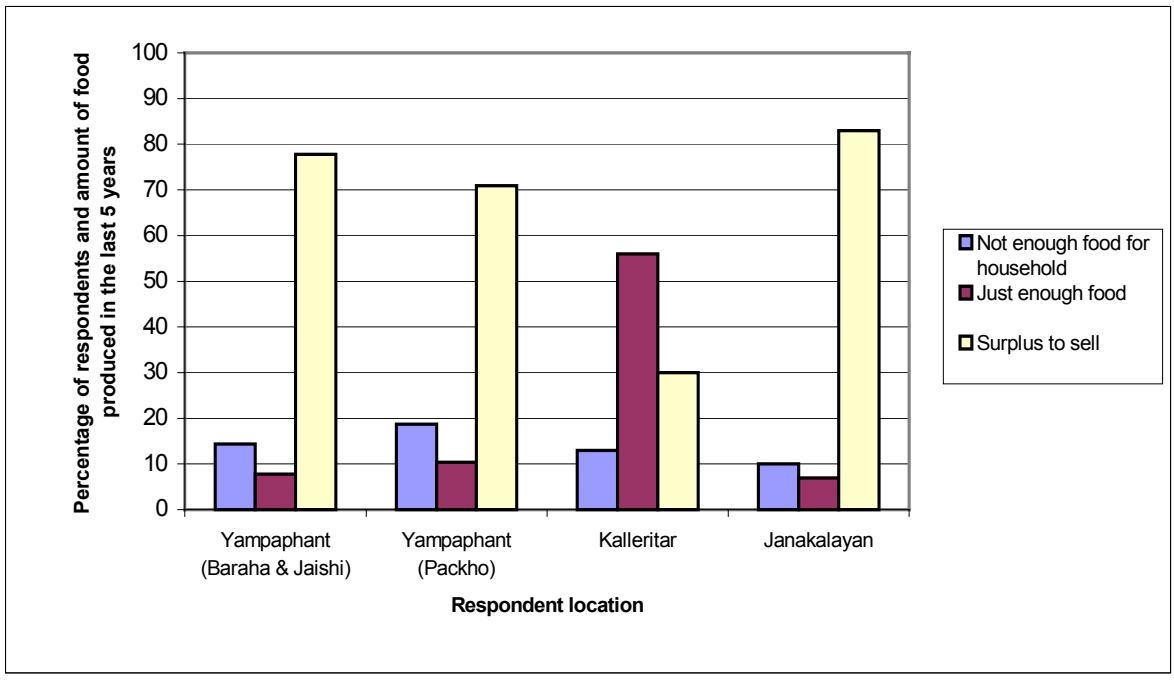
The process investigators also found evidence to support the findings from the survey. For example, at Yampaphant it is reported that the amount spent on healthcare had significantly increased with increased income and that many farmers, both landed and landless, were now able to pay for medical treatment in Dumre, Anbu Keireni or even in India.

Figure 7 also reveals differences between the schemes with regard to respondent perceptions as to the cause of better family health. For example, Yampaphant farmers clearly associated improvement with food, diet, income and the ability to afford medical assistance. Whereas at Janakalayan improved housing and living conditions were seen as most important, corresponding with the observation above that it was the most advanced and developed scheme in terms of physical capital.



Source: questionnaire survey.

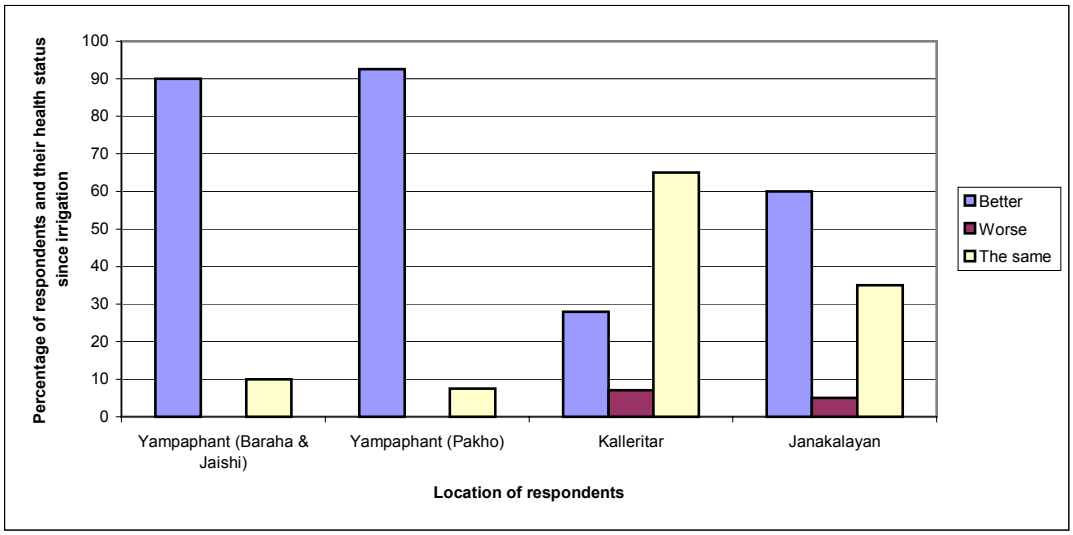
a) Five years before irrigation



Source: questionnaire survey.

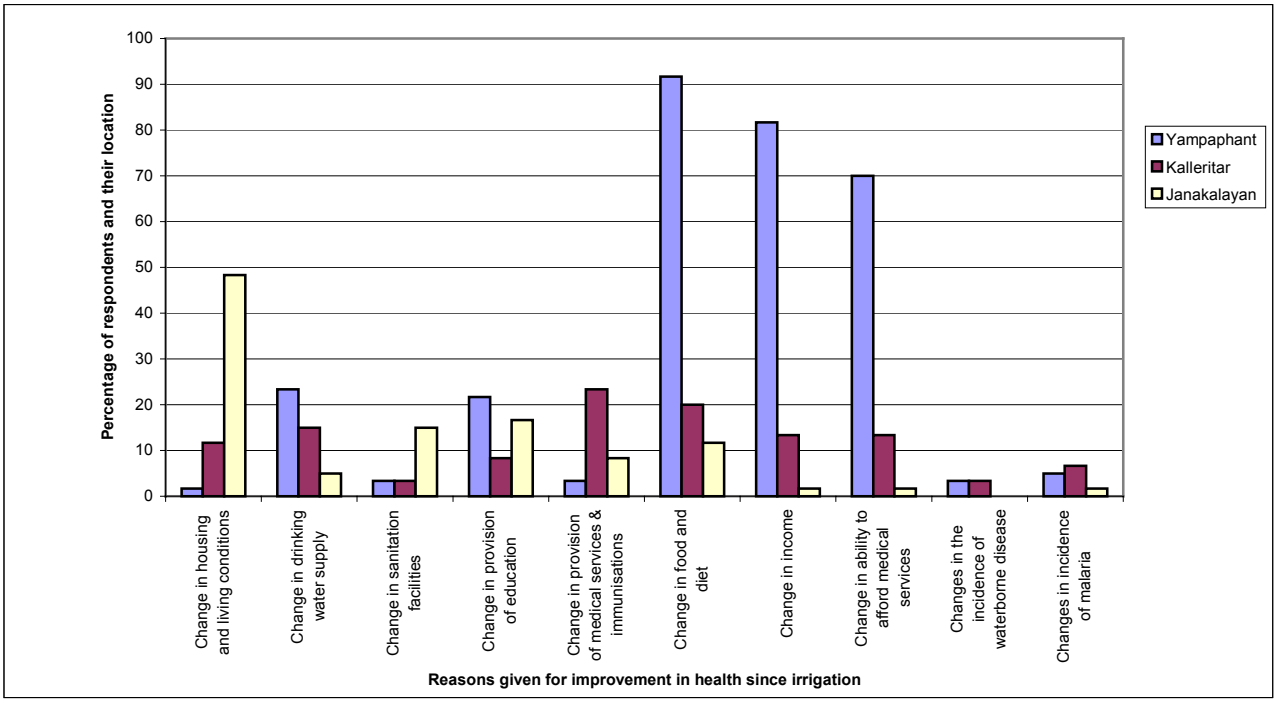
b) Last five years

Figure 5 Food production before (a) and after (b) irrigation



Source: questionnaire survey.

Figure 6 Family health since irrigation (percentage of farmer responses)



Source: questionnaire survey.

Figure 7 Reasons given as to why family health has got better since irrigation (percentage of farmer responses)

6.3 Education and literacy

At all schemes it appears that the number of children attending school has increased since irrigation. At the focus group interviews literacy levels of 75 percent at Kalleritar and Yampaphant, and 65 percent at Janakalayan were reported. Table 35 highlights the change that has taken place from one generation to the next at all three schemes in terms of the numbers attending school and college. Whereas on average only

34 percent of respondents went to school, 72 percent of their school age children currently attend school, contributing to a rise in the overall literacy level. It has also been reported that schools have seen a rise in the number of girls attending (process investigator, Yampaphant), and at the secondary school in Janakalayan there are more girls than boys enrolled - 475 girls and 412 boys (process investigator, Janakalayan). The lack of gender discrimination in education observed at the three schemes was also found by an IRC community water supply management study carried out at Yampaphant. They found that the literacy rate of the younger generation at Yampaphant (below 40 years of age) was nearly 100 percent (IRC 2001).

Table 35 Percentage literacy levels and type of education undertaken by respondents & their children

Respondents		**Kalleritar**		**Yampaphant**		**Janakalayan**	
No education – illiterate		12%		10%		20%	
No education – literate		58%		48%		37%	
School		29%		37%		37%	
College/campus		1%		5%		6%	
Children							
Children at School		74%		68%		74%	
Girls	Boys	52%	48%	48%	52%	51%	49%
Children at College/campus		18%		46%		20%	

Source: questionnaire survey.

The national literacy level is around 48 percent for the age group above six (1998), which is lower than the literacy levels reported at the three schemes. However, the rising trend in the number of children attending school observed at the three irrigation schemes is comparable to the rising trend for the whole country (Table 36). The Government of Nepal increased its budget for education in the 1990's with the aim of increasing literacy levels in the country. Many rural areas have since benefited from new schools, more teachers and increased enrolment rates (NepalNet 2001).

Table 36 Trends in education – Nepal

No. of schools	**1976**	**1981**	**1991**	**1996**
Primary	8768	10628	18694	21473
Lower secondary	2289	2786	4045	5041
Secondary	520	918	2079	2654
No. of students				
Total students	907000	1701896	3658083	4279493
Primary	644000	1388001	2884275	3253050
Lower secondary	189000	169564	378478	726300
Secondary	74000	144331	395330	290143
No. of teachers				
Total teachers	32146	46288	99127	114051
Primary	20775	29134	74495	82645
Lower secondary	7932	12245	13005	16821
Secondary	3439	4909	11627	14585

Source: (NepalNet 2001)

Nepal had a literacy rate of 2 percent in 1953. This had increased to 40 percent by 1990 (55% male and 25% female). Since then, the literacy rate above 6 years of age increased to 48 percent in 1996 and to 42 percent above 15 years of age (NepalNet 2001). Non-formal literacy and education programmes for school age children and adults are increasingly common, especially in rural areas. For example, at Kalleritar there

is a non-formal literacy class run in the evenings from 8pm until 10pm, attended by 14 females and 4 males (process investigators, Kalleritar). Evening classes are suitable for adults (especially females) who are not able to attend classes during the day due to other commitments, such as farming, childcare and other household or business responsibilities. Such classes have therefore contributed to raising community literacy levels.

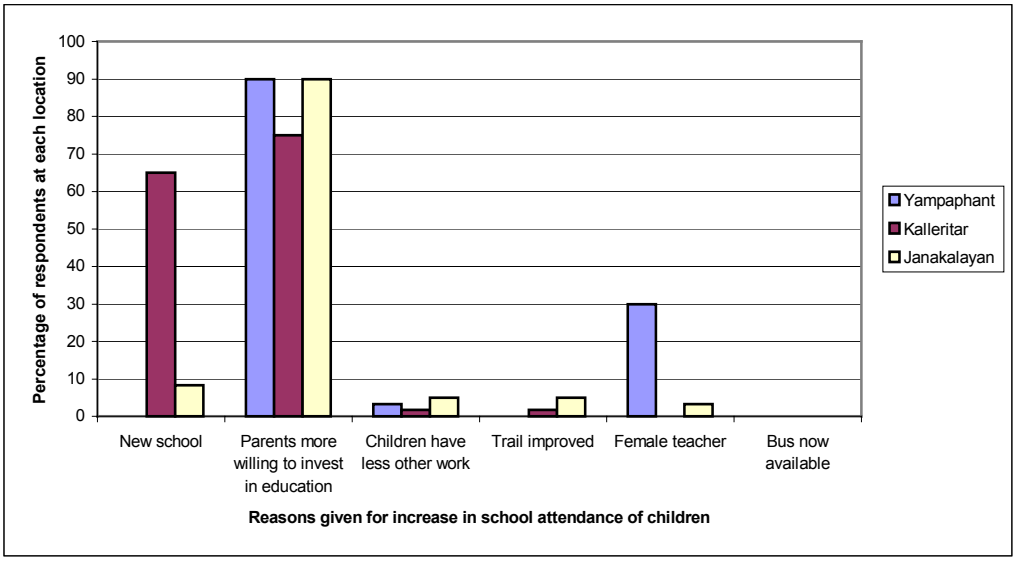
National statistics also report the literacy levels to be lower in the Terai than in the hills or mountains (Table 37). This corresponds with the focus group interviews which cited a similar trend, with literacy levels found to be 10 percent lower at Janakalayan than at Kalleritar or Yampaphant.

Table 37 Literacy rates in Nepal

	Literacy
Mountain	28%
Hill	46%
Terai	33%

Source: (CBS 1999)

98 percent of farm household respondents, who thought that more children attend school now as compared to before irrigation. The majority of these attributed this increase to the fact that parents are increasingly willing to invest more in educating their children. This willingness to invest in education could stem from: households having more money than they used to, as a direct consequence of increased crop surpluses; and/or the effects of education and training leading to increased awareness of the importance of education (Figure 8).



Source: questionnaire survey.

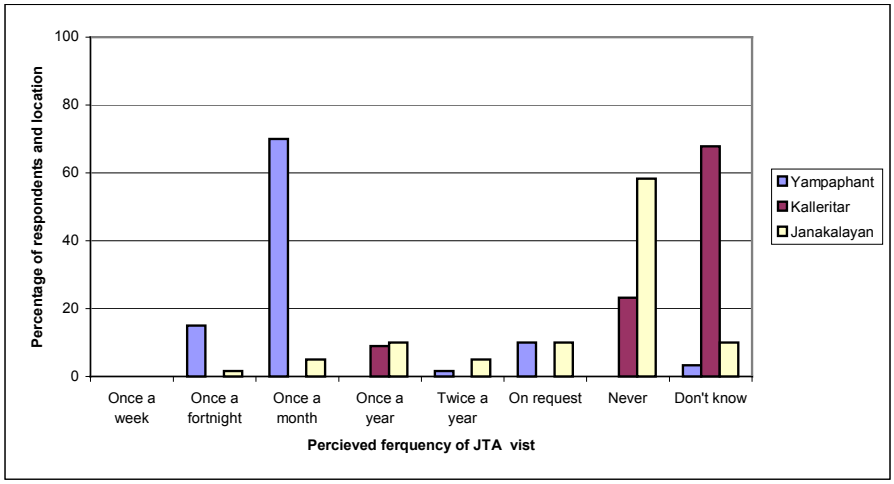
Figure 8 Percentage of respondents and their reasons given as to why more children are attending school now, compared with before irrigation

At Yampaphant, for example, the whole community agreed to pay for two extra teachers at the local school, highlighting an increased willingness to invest in education (process investigator, Yampaphant). New schools have also been built in Kalleritar and Janakalayan, and although this may stem more from government initiatives for rural development and eradication of illiteracy than the existence of irrigation, community members were motivated and financially able to participate in the building work.

As a consequence of the increasing trend to educate children on the three study schemes, more are now attending further education (college/university) elsewhere. At Yampaphant, for example, 46 percent of respondents have children away at college (Table 35). These children are not expected to return to the scheme, but to look for employment opportunities elsewhere in Nepal. A similar trend can be observed at Kalleritar and Janakalayan. To the extent that out-migration of educated children in this way has reduced farm household labour availability, it has increased the demand for paid labour and therefore helped broaden the benefits of irrigation to landless families primarily reliant on farm labour for employment.

6.4 Training, knowledge transfer and information exchange

Both farm household survey and process investigators identified considerable variation in access to training and agricultural knowledge transfer between the three schemes. Figure 9 reveals a large variation in the frequency of agricultural extension visits between the schemes. At Yampaphant the vast majority of farmers recall seeing a Junior Technical Assistant (JTA) at least once a month, whereas at the other two schemes, most farmers either do not know whether a JTA ever visits or confirm that this never happens.



Source: questionnaire survey.

Figure 9 Percentage of respondents with their perception of the frequency that a JTA visits their scheme

Both experience of training and knowledge of where training is available are also very different between the schemes. At Kalleritar most of the respondents do not know where they can get agricultural training and only 3 percent could remember having received any agricultural training in the past. At Yampaphant, on the other hand, over half of the farmers interviewed knew that they could get training from the Agricultural Development Office, Agricultural Sub-Centre, the District Agricultural Office and the Veterinary Office. Half could remember receiving useful agricultural training including improved cultivation, fertiliser use, vegetable production, Integrated Pest Management (IPM), banana and orange cultivation, seedling growing and rearing of livestock. At Janakalayan two thirds of farmer respondents did not know where they could get agricultural training and only 20 percent had received any training in the past.

Farmers at Yampaphant have also gained skills which can be attributed to the research and extension efforts carried out by Lumle Agricultural Research Centre (LARC), which used the area for trials for a number of years (1987 – 1998). Research was carried out from 1987 to 1998, mainly in agronomy and horticulture and farmers adopted crops after they had experienced that the new crop variety was profitable[1].

[1] LARC established an off station at Yampaphant which carried out Farming Systems Research (FSR), a participatory research method that analyses the practices of farmers to determine their needs, problems, constraints and potentials in order to prevent rural degradation.

Lack of agricultural training in Kalleritar has left farmers lagging behind the other two schemes in terms of vegetable/ cash crop selection and marketing skills. The lack of a formal market system means that surpluses are currently carried to the roadside and sold by individual farmers to passing lorry drivers on an ad hoc basis. A formal marketing system would greatly improve farmers' ability to sell their produce effectively. Kalleritar farmers have experimented with the production of tomato and chillies as cash crops with limited success. Training on vegetable selection according to soil type, water supply and market conditions would be beneficial on all three schemes and would improve the yield and quality of produce.

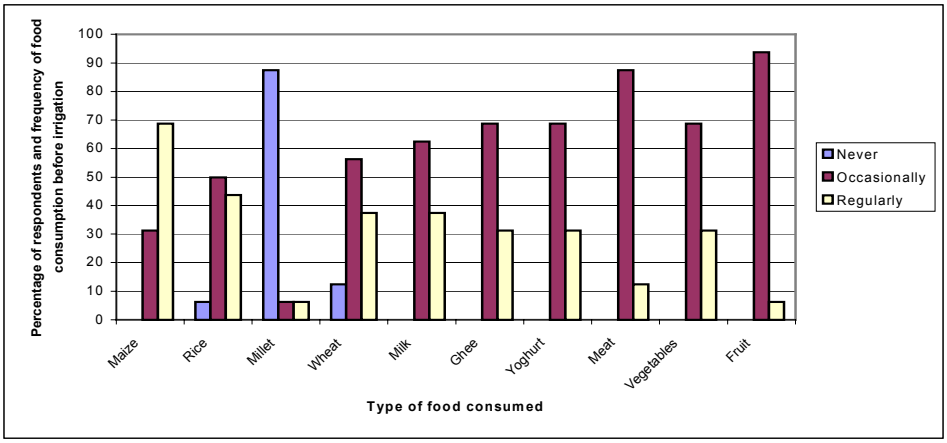
A lack of knowledge on the appropriate use of pesticides and fertilizers was apparent at all three schemes. Insufficient time between pesticide application and harvest presents a potential health risk to those consuming the produce. Education in the correct timing of applications could reduce these health risks. Farmers expressed an interest in receiving training in IPM. Use of IPM could also negate these health risks.

6.5 Impacts on labourers, and agricultural goods and service providers

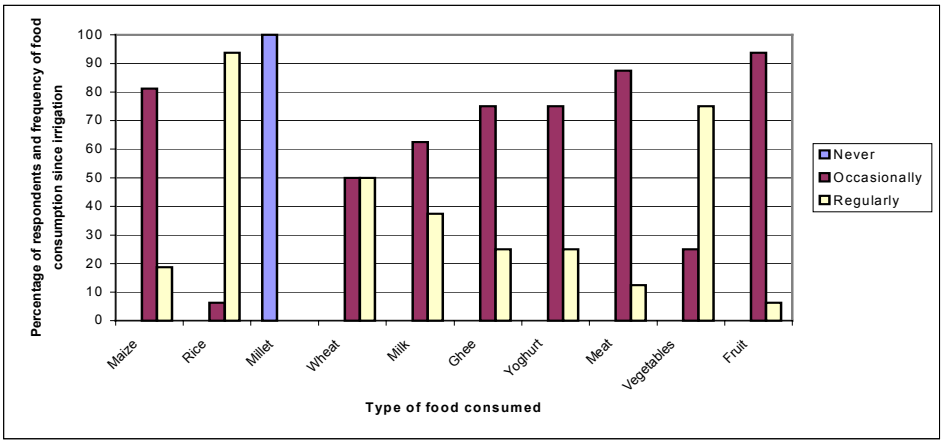
Irrigation has also had an impact on other members of the community, such as labourers, and agricultural goods and service providers.

6.5.1 Food and diet

A similar change in diet to that outlined for farmers was also found to be typical for all other groups interviewed. For example, Figure 10 shows an increase in the consumption of rice and vegetables and a reduction in the consumption of millet. The results were similar for all household categories. Labourers, who often receive their wages in both food and money (nearly 70 percent of labourers interviewed), benefit from the change in the variety of crops grown with the introduction of irrigation, as well as the general increase in demand for farm labour. Suppliers of agricultural goods and services have gained financially from irrigation as farmers increase demand for their products and therefore have more money to spend on food. Traditional bartering or exchange arrangements also remain common at the schemes, for example, the blacksmith at Kalleritar receives paddy and maize in exchange for his services (process investigators, Kalleritar).



(a) Before irrigation



(b) After irrigation
Source: questionnaire survey.

Figure 10 Foods eaten before (a) and after (b) irrigation (general merchants, crafts and trades people)

6.5.2 Education

Table 38, which shows the education level of respondents and their children, shows a similar trend to that of the farmers. There has been a dramatic increase in the number of children attending school, for example, only 7 percent of the labourers interviewed went to school, yet 64 percent of their children currently attend school. Over half have attributed this to an increasing willingness to invest in their children's education, and a third due to a new school.

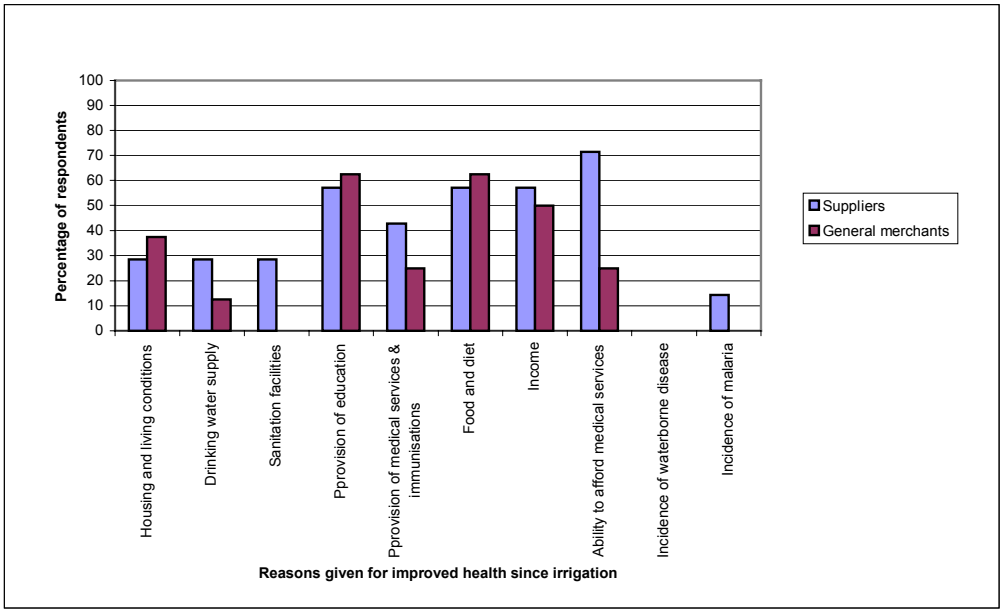
Table 38 Percentage literacy levels achieved, type of education received and reasons given for increased school attendance by respondents and their children

	Labourers	Suppliers of agricultural goods and services	General Merchants, etc.
RESPONDENTS			
No education – illiterate	67%	0%	13%
No education – literate	27%	29%	63%
School	7%	64%	25%
College/campus	0%	7%	0%
CHILDREN			
Children at School	64%	65%	74%
Girls / Boys	57% / 43%	55% / 45%	43% / 57%
Children at College/campus	0%	29%	6%
Think that more children attend school now	93%	93%	100%
REASONS			
New school	33%	29%	21%
Parents more willing to invest in education	60%	86%	63%
Children have less other work	0%	0%	0%
Trail improved	0%	0%	0%
Female teacher	7%	14%	16%
Bus now available	0%	0%	0%

Source: questionnaire survey.

6.5.3 Family health

Half of the suppliers and general merchants interviewed thought that family health had improved since before irrigation, whilst half thought there had not been a change.



Source: questionnaire survey.

Figure 11 Reasons why family health is perceived to be better than before irrigation

The reasons given as to why the family health of general merchants and suppliers is perceived to have improved are shown in Figure 11. Education, income (ability to afford medical services), food and diet are again important contributing factors. All of the labourers perceived their families' health to be the same as before irrigation (the reasons for this are unclear and would require further investigation).

7. SOCIAL CAPITAL

Social capital refers to the institutions, relationships and norms that shape the quality and quantity of a society's social interactions. There are a number of key sources of social capital: families, communities, businesses, civil society, public sector, ethnicity and gender. Social capital is not easily measured, as it relates to many resources and processes, including the less tangible resources upon which people draw, networks and complex patterns of obligation, membership of groups and relationships of trust, reciprocity and development and sharing of knowledge.

The impact of increased farm productivity and higher agricultural incomes on social capital is hard to measure. People may spend more on ceremonies, health and education but affluence reduces the need for informal help between neighbours. On the other hand, improved education raises the potential for, and the effectiveness of, communication. Better levels of understanding and greater access to information encourage people to work together to achieve their development objectives. As more girls are educated, the allocation of responsibilities and benefits changes and should ultimately smooth some of the early distortions that may stem from the introduction of irrigation, particularly those resulting from intensification and year round cultivation which often disadvantage women through increased workloads to a greater extent than men. The improved individual skills resulting from formal and informal education also have a community as well as a private value.

The following sections therefore describe the changes that may arise from a number of related development efforts and the synergy between them. Among these changes, respondents cite irrigation development as a major influence.

7.1 Socio-economic character and ethnicity

The caste system is important in Nepal, and heavily influences people's expectations. At Kalleritar, there are three major groups: Brahmin (57%), Chetri (20%) and Nawar (14%); and others (8%). These groups make a relatively isolated population separated by hill and river from other communities and arrived at by a trail. Brahmins hold their land in the upper reach of the canal system while Chetris have their land in the middle section.

In Kalleritar, land holding in the irrigated area by different ethnic groups corresponds closely to their proportion in the population. This seems to imply relatively equitable land holding, but in matters of literacy and business, distribution is different (Table 39). Interestingly although only 9% of Brahmin households are involved in business they own 44% of the businesses. This is largely because they are the largest group in terms of numbers.

Table 39 Kalleritar ethnic groups and distribution of economic activities

	Brahmans	Chetri	Newar	Other
Total Numbers	674	241	163	99
% of total population	57	20	14	9
% Irrigated land owned	55	23	13	9
% Households involved in business	9	15	16	10
% of all businesses owned	44	30	17	9
% Literacy	70	62	52	47

Source: process investigator, Kalleritar.

Although a breakdown by caste is not available for Yampaphant, Brahmin and Chetris are also the dominant groups here, whereas at Janakalayan the three major groups are more evenly represented: Brahmin (39%), Tharu (37%) and Chetri (20%), with Namar and Tamang less than 5%. The Tharus traditionally grazed cattle in the area seasonally, but became more permanent in the 1940s. By the late 1950s the area was substantially deforested and the land degraded.

Agriculture remains the major occupation throughout the communities. Members of lower castes may not all have direct access to land but they follow trades heavily dependent on the success of agriculture for their survival, or they provide farm labour. There is a broad similarity in the composition of the communities. People from different castes do not necessarily mix freely. However, overall they regard irrigation as a benefit in terms of food availability and employment, not only to the direct users but also to others in the communities.

Social co-operation in production is illustrated by the continued use of the *parma* system of labour exchange, which facilitates neighbourly help in the major agricultural tasks on all three schemes. The additional labour needed for irrigation has increased demands on the *parma* system which is now so over-stretched that it no longer meets the needs of the community. Hired labour is needed, drawing people in on a seasonal basis and spreading benefits beyond the irrigating villages.

The Water Users Associations (WUAs) also facilitate co-operation in water management and regular operation and maintenance (O&M). O&M for the irrigation scheme is generally undertaken by mobilising farmers on the basis of landholding and charging fees according to area of paddy grown. In the case of emergencies, such as the quick repair of damage to the canal by floods, Yampaphant farmers were found to divide the cost of the repair equally between household. Labour could be contributed as an alternative to cash for those who chose.

7.2 Changes in social capital

In Kalleritar, before irrigation, five percent of the population obtained income from non- agricultural work. Despite apparent increases in prosperity since irrigation, this figure has remained largely unchanged, limited by the low potential for non-agricultural income. However, many families have had children take up jobs in Kathmandu. The survey figures for income generated outside the agricultural sector, however, do not include people who have migrated to Kathmandu (and elsewhere) to work, unless remittances have been reported. These people represent a significant move of livelihood strategies away from agriculture. Social capital is also affected by people who have come in to the area with artisan skills, such as blacksmiths, tailors and carpenters.

Case Study: Blacksmith (low caste), Gopal Bishwokarma, aged 38

People from Kalleritar used to have to visit neighbouring Dumrechaur (an upland village) 45 minutes walk away to the nearest blacksmith. Eventually the villagers at the tail end provided him with a small piece of land and a house so that he was more accessible to service their agricultural equipment. There were problems about the move but now he provides a service for 40 households who pay him in–kind yearly and allocate food to him at festival times.

He has been able to bring up and educate his children with his work and with a little extra he makes from carpentry is able to keep buffalo, one cow and one calf. According to him, in Dumrechaur he had difficulty fulfilling his family needs. He always had to search for work in neighbouring villages. Now he can get enough food for his family and can fulfil their other basic needs. He still has 0.76 ha land in Dumrechaur.

Process Investigator, Kalleritar, November 2001

In- migration of this type adds to the social dimension of villages and increases the capacity of communities to achieve change within their own habitat or environment. Skilled artisans report in the survey case studies that they have experienced increased livelihood standards since moving to the irrigated areas, which implies that the local irrigators have generated a demand for their services that has continued to grow as their production has grown and their methods intensified.

Taking into account the blacksmith's experience (see box above), a simple headcount of livelihood sources may well result in an underestimation of social benefits. Social gains that come indirectly from the introduction of irrigation, such as the education of low caste children, can easily be missed in a normal cost benefit exercise. They are likely to be included in an evaluation of the school but the income that makes it possible for the children to attend relies on the continued success of the irrigation scheme. The example of the incorporation of a blacksmith has another social dimension, in that it allows local people to have access to a greater range of goods and services with which to fuel development.

Similarly, in Yampaphant the increased development of non-farm business since irrigation has supported a change in outsiders' perception of the community from a poverty ridden village to a middle class one. The Yampaphant community has also had a series of difficult learning experiences in developing a payment system to sustain their domestic water supply but have prevailed and taken forward both that and the dairy co-operative showing well developed organisational skills (IRC 2001). In Yampaphant the milk co-operative is an important development that is closely linked to the development of irrigation. It has brought a new dimension to the agricultural base of the area as well as increasing the potential for better diet and increased social activity. Many other committees have sprung up, some from local initiatives and some at the instigation of district authorities or LARC.

At Janakalayan, irrigation work seems to have attracted landless people to the area and it has now come about that they are allocated non-irrigated land, considerably improving their situation. This would not have been possible if the original community had not already benefited from increased food-security from

irrigation. The facilities now available in the village such as bio-gas, electricity, roads, telephones, school, rice mill and shops have had an impact on the social environment, freeing time and easing communication.

7.3 Informal networks

Before irrigation a major change to more formal systems seems to have taken place when land registration facilitated the buying and selling of land. Irrigation brings with it a demand for communal organisation for operation and maintenance, however these communities already had a history of organising the regular upkeep of tracks and trails and remedying the damage caused by landslides and floods. Irrigation may have formalised these functions but it is likely that a good base of communal action existed to build on.

Traditionally the *parma* system ensured that sufficient labour was available for the major agricultural tasks. The survey suggests it was widely used, and that there was a social willingness to assist people who were in difficulty in the community. The system is still widely used but the intensification of irrigation has increased the demand for labour to such an extent that *parma* arrangements, despite expanded use, can no longer provide enough labour. At all the schemes, but perhaps Yampaphant to a greater extent, the *parma* system has been greatly expanded but this has still not been enough. In addition to the extended use of *parma* arrangements, irrigators need hired labour to assist with land preparation, weeding and harvesting.

Committees were not unknown before irrigation, but there were fewer of them than at present. The main activities were educational and the villages had school committees; 4H, an American backed agricultural NGO was active in extension aimed at improved rain-fed agriculture; and religion based groups existed. Information on the networks that formerly facilitated barter and market links is not available and certainly with the lower production level possible on rain-fed land it is likely that these were limited in importance.

Generally increased incomes can reduce the need of families and individuals for support from neighbours and relatives and can reduce the willingness to assist. This probably arises from the perception that it is now more possible for people to help themselves, rather than a reduction in human concern. The move from informal to formal networks is often accompanied by increased transparency. Although this does not guarantee that equality is increased it does give greater opportunities to address inequity within a formal framework. In many cases, the members of a group accept and support a situation that appears inequitable to the outside observer because other important functions are served by the arrangement. An example of this might arise in a situation where some farmers have the advantage of enough water to crop three times in the year while other farmers can only crop twice. However if the advantaged farmers employ the farmers who are not themselves cropping, the benefits are spread and in a way that a provides a risk free income, albeit lower, for the disadvantaged farmers. It is beyond the scope of the present study to investigate these issues more fully, however, it is encouraging that the benefits of irrigation are clearly spreading beyond the people with direct access to irrigable land

7.4 Formal networks and committees

The link between the formation of committees and the existence of irrigation is difficult to disentangle. The Water User Associations, which are clearly directly related to irrigation and were often formed early in the committee era, may have had a positive influence on the general trend of committee management. However, it must also be recognised that the formation of committees is also driven by outside forces such as aid agencies. Yet the continued increase in committee activity suggests positive experiences have encouraged local people to adopt committee management more readily.

There has been change in the amount of leisure time and in its use. Leisure time is less due to the more intensive agriculture now practised since irrigation and the extended year-round growing season. Old leisure activities such as singing, dancing, and card playing may have been encroached by work and focussed committee activity. It is not clear from the surveys where people place committee meetings along the leisure – work scale. Before committees were so popular, much ‘business’ was conducted in social settings such as tea shops, local meeting places and temples, but was probably seen as leisure, whereas the formality of a committee puts these activities in a different category. Direct comparison of the

effectiveness of the newer committee-style organisation and the former, looser arrangements, is difficult. The pace of production has accelerated since the introduction of irrigation and clearly both the quantity and diversity of produce is greater, demanding more frequent and far-ranging transactions. Formal committees therefore may be a necessary development to sustain these higher levels of production.

If social capital can be measured by committee formation then there is plenty of evidence to suggest that great strides have been made (Table 40).

In Kalleritar, Yampaphant and Janakalayan the original WUAs were established between 1982 and 1988. Water rotations and other rules and regulations are widely known and observed. Conflict is rare and farmers have developed a system of fines to enforce the rules. Communities are experienced in collective works such as school building, temple building, and keeping their tracks in good repair, and are well practised in establishing contributions which are appropriate to the various households through the process of wealth ranking. At Kalleritar, three additional sub-committees were formed in 2001, involving a total of some thirty people in committee work. It is clear from Table 40 that there are significant numbers of people involved in a wide range of committees. It is not clear, however, how this has, or has not, redistributed participation and decision-making among village households.

Committees cover a wide spectrum. The presence of the forest committees is strongly linked to a reduction in deforestation. Greater awareness of the importance of the forest is linked to irrigation development and the subsequent reduction in the reliance on the forest for food and animal fodder. Reduction of degradation is also linked to the availability of bio-gas, and more recently electricity, which have greatly reduced demand for fuel wood. There is still a keen interest in the medicinal forest plants, particularly among women who dominate these committees.

Table 40 Committees active in the selected irrigation schemes, with the date they were established

Committees	Kalleritar	Yampaphant	Janakalayan
WUA	1988 registered 1990	1982	1982 (144 members in general assembly)
Subcommittees	2001 regulate field level		
Forestry	1995 and 2001 (no outside prompting or support) 1997 women revamp forest committee	1991 and still active, meeting 2-3 times/year	1997 in response to many years of forest degradation.
Buffer Zone	1997		1997 receives money from adjacent national park and decides budget
Milk co-operative	1993 onwards: milk collection and sales	1997	1991 (217 members) 2000 offshoot to telephones
Drinking water committee	1983 originally 1995 expanded with NEWAH and community participation	1992 no women involved originally, reformed 1996	
Mothers Club		1996/7 linked to child welfare, family planning, path & road improvement, environmental issues and raising funds for an ambulance	
Mens savings clubs			2000 (30 members)

Table 40 Committees active in the selected irrigation schemes (continued)

Women's savings clubs			1998 Annapurna (21) 2000 Sagarmatha (42)
Farmers Saving club			1996 (12 members)
Buffalo Club		Active, date of establishment unknown	
Fodder committee		1990-93 became superfluous	
Vegetable market/product committee	2001 (JTA introduced)	1990-99 developed in conjunction with LARC	
Seed committees	2001 (JTA introduced)		
Informal Education	1990 in village at the head section and 2000 in village in the middle section of the canal		
School committee	1989/90	1971 now raises funds for teachers	Private school established 1999
Religious group		Active, date of establishment unknown	
Catering committee	2000		

Source: process investigators.

The various Drinking Water Committees have a clear management function which is carried out for each location in the way best suited to their situation. These committees are prime examples of social capital increases and demonstrate good organisational skills, particularly in respect of fee collection and maintenance. Although promoted separately from the use of water for food, irrigation has increased the ability of the households to pay for their drinking water.

The school committees organised the building of schools and generally predate irrigation, however, it is clear that more children attend school nowadays, with most families reporting that almost all children of school age attend school. This increased demand has led to an expansion in the schooling on offer in the communities and in some places to community funding of additional teachers. Again this could not have been contemplated at the income levels possible from rain-fed agriculture. There is a marked increase in the numbers of girls attending school as detailed in the section on human capital (see Section 6.3).

Milk co-operatives /dairies were generally established some years after irrigation. The co-operatives organise collection and sale of milk, in some cases from a shop, thus providing market access. The catering committee organises food for festivals and ceremonies. The various savings groups, although primarily serving a financial function, also provide a forum for social exchange and learning. There has been a notable increase in savings group activity at Janakalayan in the last few years.

However the links between the activity of the committees and groups and their outcomes are not well explained. More detail of how things worked before irrigation is needed to be able to identify if committee formation accelerates development and/or heightens or decreases the exclusion of poor people. Where information is available it seems that women and poor people are inadequately represented at this level. In further studies it would be helpful to work specifically with groups of poor people to identify their viewpoint and their perception of the constraints to greater participation.

It can be claimed that the success of irrigation development has increased farmer confidence to embark on other development activities and make use of credit. On the other hand the social vulnerability of some groups may have increased. Women, due to their increased workload, marginal farmers, who are bought

out by richer farmers are mentioned in this context. The relatively high land values that prevail now may make it attractive to the poor to sell their land if they can reliably earn income in alternative employment.

Interviews with labourers confirm that, since irrigation was established, they are confident of finding work throughout the year, whereas work used to be seasonal only. Diverting children from the labour market to schools has also increased the demand for paid labour. Nonetheless, people talk of a widening gap between rich and poor which may arise from the continued dependence of most of society on agriculture for work. The farmer who can gain extra irrigated land will create significantly more family wealth than the farmer who sells his land and must rely on selling his labour. As a labourer, he/ she has no further benefit from high land values. Diversification can also widen the range of income possible from a given area of irrigated land. Adoption of vegetables has helped one individual member to buy cows with good milking rates, increasing his business profitability further. Irrigation has made it possible to grow enough paddy to meet individual needs and encourage diversification. Where food markets function well, entrepreneurial farmers become confident to buy paddy rather than grow their own, focusing their attention on more profitable crops.

7.5 Gender concerns

The 1998 Human Development report refers to the gender empowerment measure (GEM)[3] in Nepal as being abysmally low at 0.191 in 1996, in relation to achievements at regional and international levels, reaching just over half the average for developing countries in that year. The increase in female education enrolment in the irrigating villages is therefore a very positive development.

Typical in all the schemes are accounts of increased workloads for men and women and an appreciation that women's workloads have increased particularly. The main reason is the change from seasonal agriculture to year-round agriculture. There have been other changes in workloads. The adoption of HYV (High Yielding Variety) crops has increased the work involved in harvesting and transplanting whilst the associated increase in water use has reduced the need for weeding. Annual weeding workload has, however, probably increased due to the additional crops grown in the year. The woman's working day was longer than the man's before irrigation and this still appears to be true. The intensity of female work remains greater because of the combination of agricultural work, child care and domestic provision, particularly when children are young. The lengthening of female work hours is often cited as a factor in restricting women's mobility, increasing already high dropout rates of girls from school (to assist the mother) and pressurising sons to marry early to gain helping hands for the family (Nepal South Asia Centre 1998).

In general, the shortage of labour at all schemes has increased the use of hired labour. The general increase in work demanded in irrigated farming is one factor and the increased number of children going to school, and thus taken out of agricultural labour is another. Table 41 illustrates that the education of girls on these irrigation schemes is well above the national averages.

The survey revealed that most children are at school and significant numbers are in further education. This implies a good rate of enrolment in secondary education compared to the national net enrolment averages for 1995 (Table 42), and a vast increase from the previous generation locally.

[3] GEM - Gender Empowerment Measure, is a composite index measuring gender inequality in three basic dimensions of empowerment, namely economic participation and decision-making, political participation and decision-making and power over economic resources.

Table 41 Percentage of boys and girls on irrigation schemes who attend school or college

Children	Kalleritar	Yampaphant	Janakalayan
Youngsters at college/campus	18%	46%	20%
Children in school	74%	68%	74%
% of children in school who are Girls	52%	48%	51%
% of children in school who are Boys	48%	52%	49%

Source: questionnaire survey.

Table 42 National school enrolment figures

	Primary	Secondary
Children in school	67.5	17
Boys	79	23
Girls	56	12

Source: (Nepal South Asia Centre 1998).

The increased demand for paid labour that has been created has spread the benefit of irrigation to landless families in the community and to people from other communities. In some places poorer farmers supplement the agricultural income from their own plots by spending some of their time as hired labour. There is however wage discrimination and men can earn more than twice the daily wage of women (Table 43).

Table 43 Wage differences among labourers

	Kalleritar	Yampaphant	Janakalayan
Male daily wage (Rupees)	100	110	125
Female daily wage (Rupees)	80	40-50	80

Source: questionnaire survey.

Increased time spent on work leaves less time for leisure activity and for maintaining social support networks. Whilst neighbours and relatives still figure highly among information sources, the *parma* labour sharing system where farmers donate their time, is still in place but no longer able to fulfil the farmers' needs. Although leisure time has been encroached, greater affluence means more money for ceremonials and more children in school to benefit from the social activities there.

The large numbers of committees and activities replace former social interaction to some extent. Women have, however, not always been fairly included in irrigation management committees, do not generally participate in management and maintenance and are not directly employed. On the other hand women have taken a major role in forestry committees where men have minimum involvement. There are also groups specifically for women, for example mothers' groups and women's savings groups. Separation can reduce dominance issues but may lead to a polarisation of men and women's influence in the short term. The views of men and women on the schemes are not easy to analyse from the information available in the survey and process investigators reports. It is therefore not easy to assess the sustainability of any changes to, or influence of external pressures on, gender disparity. It is notable that in the last few years at Janakalayan two women's savings groups have been established. This is evidence of a growing desire among women to control cash assets and goes some way to redress women's general lack of control over finances.

8. NATURAL CAPITAL

Evidence from the three data collection processes (questionnaire surveys, key informant interviews and process investigation) is used to examine the direct and indirect impacts of irrigation on the environment in the three case study schemes.

The *direct* impacts of the construction and subsequent operation and maintenance of irrigation on the natural capital stock can be analysed by determining the implications of changes in the status of the components of natural capital for levels of productivity of resource use. Positive impacts include an improvement in agricultural productivity levels as a result of improved access to soil moisture, whereas negative impacts such as waterlogging and reduced soil fertility can be considered as contributing to a lowering of productivity levels.

In situations of increasing population size, it is likely that the effective demand for food will increase and that this will, in the main, have to be met by increased domestic production. Production increases in the absence of irrigation may be feasible by the extensification of agriculture onto more marginal lands, or by further intensification on existing rainfed land. Different forms of technical change will be associated with different environmental impacts. The *indirect* impacts of irrigation investment can therefore be considered through the ***net*** impact on farming practice. For example, a labour using agricultural modernisation strategy (such as irrigation investment) may also reduce the pressure on the use of natural resources in other agricultural and/or non-agricultural activities. In this project, the use of natural resources under a "without irrigation scenario" was not investigated. However, it is possible to use recall information (before and after irrigation) and data on farmers' perceptions to interpret potential impacts on the natural capital stock in the absence of irrigation.

8.1 Direct impacts

The direct impacts of irrigated agriculture are considered under the following headings: (a) availability of water, (b) quality of available water, (c) soil erosion and the intensity of land use; and (d) the fertility of soil.

Before investigating these impacts, it is of interest to note the farmers' list of factors that they believed had had a negative impact on agricultural productivity since investment in the irrigation schemes. In Table 44, the proportion of farmers in each scheme indicating the impact of each potential reason is presented.

Of note is that no farmers listed either poor water supply or poor water availability as affecting production levels adversely[4]. Poor drainage and soil erosion were identified as having an impact, but only by a small minority of farmers. Bad weather was a factor listed by most farmers in Yampaphant and Janakalayan, but this did not affect production levels in Kalleritar. In all three schemes, the factors of most relevance emerge as being pest damage and, to a lesser extent, decreased soil fertility, both of which are related to farming practice.

[4] There is however a potential inconsistency in that shortage of irrigation water was listed under "other" by the Yampaphant Pakho farmers.

Table 44 Factors having a negative impact on crop production, (proportion of farmers stating that the factor had a negative impact %)

	Yampaphant (Baraha and Jaishi)	Yampaphant (Pakho)	Kalleritar	Janakalayan
Poor water supply	0	0	0	0
Poor water quality	0	0	0	0
Decreasing soil fertility	25	15	73	45
Crop pests	100	98	75	100
Poor drainage	0	5	0	7
Bad weather	90	90	0	93
Soil erosion	0	2.5	2	0
Other (Specify)	0	7.5	5	0

Source. questionnaire survey.
Sample sizes: Yampaphant Baraha = 10; Yampaphant Jaishi = 10; Yampaphant Pakho = 40; Kalleritar = 60; Janakalayan = 60.

8.1.1 Availability of water

In all schemes water availability is adequate in the monsoon and winter seasons. In Yampaphant, most farmers responded that availability was adequate most of the time or sometimes. In Kalleritar, water availability was found to be poor during the spring season, particularly in the tail reach, whilst in Janakalayan it was always adequate.

Examining the response to water scarcity it is interesting to note that 94 percent of farmers across the schemes reported that they had ***not*** been in conflict over access to water. Instead, the response appeared to be reflected in the pattern of crop rotation, with land being left fallow during periods when irrigation water was scarce. In the following table, all interviewed farmers in Kalleritar left land fallow during the spring. A similar pattern is also followed by the Yampaphant *pakho* farmers where water is sometime inadequate during spring.

Table 45 Percentage of farmer respondents leaving land fallow

	Yampaphant (baraha and jaishi)	Yampaphant (pakho)	Kalleritar	Janakalayan
Monsoon	0	23	33	0
Winter	0	48	0	14
Spring	5	48	100	0

Source: questionnaire survey.

8.1.2 Quality of water

Farmers in Yampaphant and Kalleritar stated that there was not any sediment/ sand in the irrigation water whereas 50/58 respondents in Janakalayan said there was. The differing perceptions are likely to be related to the type of scheme. Janakalayan takes sediment rich water from the Rapti River.

The water tests from Kalleritar (Annex 1) appear to confirm the process investigator's observation that water becomes harder as one moves down the scheme. This may have soil management implications. Total solids appear to show that sediment load is higher in drainage water than in canal water. Similar differences in the amount of phosphorous in samples may be related to the levels of sediment. These findings are also reflected in the samples from Yampaphant and Janakalayan.

8.1.3 Soil erosion and land use intensity

In all schemes the intensity of land use has increased. Soil erosion has been identified as potentially contributing to a reduction in available land for agricultural use. When asked whether soil erosion was considered to be a problem around the schemes, the responses were mixed (Table 46). The majority of farmers from Janakalayan and those from the baraha and jaishi areas of Yampaphant perceived no soil erosion problems. A greater proportion of the respondents farming land in the steeper areas of pakho in Yampaphant and Kalleritar perceived a problem with soil erosion.

Table 46 Farmer perceptions of problems of soil erosion in the area around the schemes (percentage of respondents)

	Yampaphant (baraha and jaishi)	Yampaphant (pakho)	Kalleritar	Janakalayan
Soil erosion is perceived to be a problem	15	50	48	20
Soil erosion is not perceived to be a problem	85	50	52	78

Source: questionnaire survey.

Irrigated agriculture is often charged with contributing to greater amounts of soil erosion. This assertion appears to be supported by farmers' views on the relative levels of erosion with and without irrigation. Table 47 suggests that the number of farmers in hill irrigated areas (such as Kalleritar and Yampaphant) who believe that there would be less erosion without irrigation is greater than those who believe that there would be more erosion. Interestingly, the majority of farmers believe that there is no causal relationship between irrigation and the amount of soil erosion. This is especially true of the lowland farmers in Janakalayan.

Table 47 Farmers' perceptions as to whether there would be more or less soil erosion without irrigation (proportion of farmers responses%)

	Yampaphant (baraha and jaishi)	Yampaphant (pakho)	Kalleritar	Janakalayan
More soil erosion	0	0	5	0
Less soil erosion	55	48	20	0
Makes no difference	45	50	73	95

Source: questionnaire survey.

One reason for the perception that there would be less erosion in the hillside schemes in Yampaphant and Kalleritar is the increased incidence of landslides since the schemes have been established. In Yampaphant, a 500m length of hillside along the road is susceptible to landlsides due to increased seepage during the monsoon period (less absorption by grasses etc). A drainage canal has been installed in order to help prevent the extension of the slip and a block of trees has been planted to stabilise the hillside. There is currently no regulation as to where irrigation can take place. Government advice is that irrigated agriculture should not be undertaken on slopes greater than 30 degrees, but it does occur on slopes of 45 degrees; monitoring is undertaken by a separate Ministry. Guidelines are used by the Department of Environment who have to approve all development projects.

There is however, some debate as to the relationship between irrigated agriculture on terraced land and the stability of those terraces. Gill (1995), for example, suggests that the topography in Nepal is relatively recently formed and is therefore still relatively unstable. He contends that even in the absence of irrigated agriculture, landslides are occurring. It could be argued therefore that although irrigated agriculture may contribute to increased instability, the relationship is not a strong as presented evidence may suggest.

8.1.4 Soil fertility

In all schemes, farmers reported that soil fertility was a major factor in negatively affecting productivity levels (see Table 44). In Kalleritar farmers reasoned that differing levels of fertility depended on the soil type, but that fertility levels had declined over the past four years as a consequence of the continuous use of urea (process investigator, Kalleritar). A similar finding was recorded in Yampaphant where soil fertility had been observed to be falling over the past three to five years due to increased fertiliser use. Indiscriminate use of urea at Kalleritar was also raised during the focus group interview. Problems with acidity can be attributed to DAP and Urea use. The intensification of input use in Yampaphant is illustrated in Table 48, which records sales from the supplier of the majority of inputs.

Table 48 Sales of supplies/ inputs in Yampaphant, Rs

Fiscal Year	Fertiliser	Insecticides	Pesticides
2052/53	75263	28223	18815
2053/54	117160	43935	29290
2054/55	144692	42926	28617
2055/56	202611	75979	50653
2056/57	281843	105691	70461
2057/58	274414	102905	68603

Source: process investigator, Yampaphant.

On each scheme a series of soil tests were conducted. Soils from adjacent plots of irrigated and upland land were tested in order to discover whether fertility levels differed. The small sample sizes make interpretation difficult, but some interesting insights can be derived.

Soil samples were taken as a general indication of soil properties from selected locations in each of the three study schemes. Two samples were taken from Janakalayan, one from an irrigated field and the other from a nearby un-irrigated (upland) field. For Yampaphant, three samples were taken, one from an un-irrigated field, one from the old (or Baraha) irrigated area and one from the newly irrigated, Jaishi area. For the Kalleritar scheme, six samples were taken of irrigated and un-irrigated soil from farmland each of the three village areas, head (Foshretar village), middle (Kalleritar village) and tail (Ghartitar village).

The soil tests from Kalleritar (see Annex 1) indicate significantly different soil texture analysis between the adjacent plots in the three sections (less so in Ghartitar). These differences probably explain much of the difference in nitrogen, phosphorous and potassium (N, P and K) availability. Texture and the binding capacity/availability of cations are related making it difficult to draw any solid conclusions. With this fact in mind, however, the results from Foshretar and Ghartitar indicate higher levels of organic matter on cultivated land, but marginally less in the case of Kalleritar. In the case of Ghartitar this is probably explained by a higher level of sand in the texture test on the upland soil. However, the range of organic matter (OM) seems quite narrow. Also the difference between OM and N is high - a rule of thumb is a ratio of about 20. One might also expect a higher level of OM to be associated with higher available K, which seems to be the case. It may be concluded that on the cultivated land OM is being maintained.

In the Janakalayan samples, the textures are very similar. P and K content are greater in the upland soil, but acidity is marginally higher. The soil tests from Yampaphant provide a mixed picture, which may again be related to the differing textures. All soils are relatively acidic. Levels of P are greater on new cultivated land than on upland or old cultivated soils. Levels of K are highest on upland soils and significantly lower on the old land in comparison with newly cultivated land.

In Janakalayan, an additional factor affecting soil fertility is flooding. The construction of embankments on the Rapti River have reduced the incidence of flooding. On balance this is seen as being positive because of reduced crop damage, but questions remain as to whether silt deposit in limited floods was

beneficial in terms of maintaining fertility (perhaps from the first flood of the season). In some schemes, this limited flooding is still allowed to occur in some places.

8.2 Indirect impacts

The interest here is to investigate the net impacts of investment in irrigated agriculture on the natural resource environment by comparison with alternative strategies to increasing agricultural production.

From the available information, it would appear that the main positive impact upon the natural capital stock relates to the use of the forest resource. A combination of factors that can be related to the investment in irrigation have contributed to a reduction in the pressure on the resource. Although this combination of factors makes the establishment of a causal link between irrigation investment and improved forest condition difficult, it can be argued that in the absence of irrigation the condition of the forest would be poorer as a result of; agricultural extensification; a greater reliance on the forest resource for livestock related activities and for fuelwood collection; and a lower level of social capital (in this case manifested in forest committees).

Data from the farmer questionnaires (Table 49) reveals that in all schemes the condition of the forest has improved following the introduction of irrigation. In Yampaphant, farmers were convinced that the condition of the forest would be worse if the scheme had not been built. In the other two schemes farmers' responses provide a less conclusive, but still positive, link between investment in irrigation and improvement in the forest condition.

Table 49 Farmer perceptions of the relationship between investment in irrigated agriculture and the condition of the forests, (percentage of respondents)

	Yampaphant (baraha and jaishi)	Yampaphant (pakho)	Kalleritar	Janakalayan
The current condition of forest is:				
Improving	100	100	75	82
Deteriorating	0	0	15	0
No change	0	0	5	15
Without irrigation the forest would be:				
Better	0	10	3	7
Worse	100	90	35	0
Makes no difference	0	0	60	58
Would there be more damage to the forest without irrigation:				
Yes	100	100	28	2
No	0	0	13	10
Don't know	0	0	58	87

Source: questionnaire survey.

The forest resource is used by the community in a number of important ways, i.e. (i) use of timber for construction; (ii) collection of fuelwood; (iii) collection of fodder (grass and foliage) for livestock; and (iv) cleared for the expansion of agricultural activities.

(i) Use of timber
As populations have increased, and incomes have risen as a consequence of investment in irrigated agriculture, the demand for building materials has increased. In all schemes, the response has been the formation of forest committees and to restrict exploitation by introducing fees for timber used in construction.

At Kalleritar it was reported that before the irrigation system, there was no regulation of forest use and there were high levels of deforestation. A forest committee was established which has introduced a series of user fees and penalties. If an individual cuts a protected tree, they will first be warned by a committee member. If the individual offends again, the committee will impose a penalty of Rs. 50, and between Rs.100 and 500 for a third offence (process investigator, Kalleritar).

A similar system operates in Yampaphant, where a charge for wood of R100/tree is imposed by the committee. Although a forest committee has been established in Janakalayan, it is the establishment of the Chitwan National Park, rather than the investment in irrigation, which is probably the major contributory factor in reducing the use of forest land. Individuals are not allowed to collect wood, gravel or sand from within the park. This has been cited as being a problem for construction.

The establishment of forest committees was, in part, related to government and donor funded programmes promoting community forestry. The establishment of committees is an enhancement of social capital as discussed above.

(ii) Collection of fuelwood

Since the establishment of the irrigation schemes, the collection of fuelwood has fallen. Table 50 demonstrates the reduction in fuelwood use by families in the Kalleritar scheme. In all reported cases there has been a reduction in collection of at least 50%.

Two reasons may lie behind this observation. The first reason relates to increased amounts of time devoted to working in irrigated agriculture which have reduced the opportunity for collection. A second reason relates to the introduction of biogas which has displaced the requirement for the use of wood for cooking. Wood is still used to boil milk (as this tastes better) and to cook cattle feed. In Kalleritar biogas is used by 21% of households.

There appears to be a relationship between the installation of biogas and irrigated farming in that farmers are more confident to take loans as a result of the increase in resources for investment generated by the intensification of agriculture. In some schemes, this has been facilitated by donor funding, for instance in Kalleritar, Danida subsidised biogas construction (Rs14000 loan over 6 years with low interest) and provided free technical support.

Table 50 Degree of firewood use before and after construction of biogas units per household per year

Name of Farmer	Fire wood use (bundles)		Family size
	Before	After	
Khatiwada Tej Pd.	50	10	5-6
Khatiwada Kala	73	30-40	6
Khatiwada Yadu	50	20	
Tiwari Bhikaji	40	20	14
Khatiwada Naresh	104	52	5

Source: process investigator, Kalleritar.

Before biogas was introduced, in Kalleritar, 50 bundles of wood were collected per household per year; the average is now 10 – 20 bundles. It is not clear, however, what the relative contribution of biogas use, as opposed to the change in farming practices, has had in the reduction in fuelwood use.

In Janakalayan, where restrictions on forest use are stricter, biogas is used in 50 percent of households (10 years ago only two households had biogas). Biogas is constructed following a payment of Rs1500 to the Buffer zone committee. There is also a Rs20000 construction cost. Of the remaining households, 20 percent use dung on sticks and 30 percent use kerosene and/or electricity for cooking.

It should be noted that biogas use tends to be associated with lower altitude regions because of the higher average temperature required for the system to operate.

(iii) Forage collection

A similar pattern emerges for the use of forage from forest lands. In all schemes an increase in the intensity of crop production, the reduced availability of time for forage collection and grazing supervision, and less free grazing areas in the dry season have resulted in a reduced number of livestock of improved breeds and in greater use of stall feeding.

Table 51 demonstrates the reduction in forage collection from the forest area in the Kalleritar scheme.

Previously, all households collected grass every day of the year. Table 51 illustrates that most households have reduced their collection, some by over 60 percent. In Yampaphant it was observed that the purchase of feed from other regions, including, for example, Chitwan, is an increasing trend.

Table 51 Collection of grass and foliage before and after the establishment of the Kalleritar irrigation scheme

Name of Farmer	Grass collection (number of days on which grass collected)		Livestock Number	Remarks
	Before	After		
Khatiwada Tej Pd.	365	215-245	Buffalo (2) Bull (2) Goat (6)	Use Straw and Dry maize plant for 60-70 days
Khatiwada Kala	365	300	Buffalo (2) Bull (2) Goat (6)	Use Straw and Dry maize plant for 60-70 days
Khatiwada Yadu	365	110	Buffalo (2) Cow (3) Goat (6)	30% reduction in collection of grass & foliage from the forest since irrigation
Tiwari Bhikaji	365	325	Buffalo (7) Cow (2) Bull (6) Goat (16)	Use Straw and Dry maize plant for 40 days
Khatiwada Naresh	365	104	Buffalo (2) Goat (2)	Relatively rich household Collect 2 bundles/ week
Paudel Ram Maya	365	240	Buffalo (1) Cow (1)	Relatively poor household Collect 5 bundles/ week
Pariyar Kanchu	365	365	Buffalo (1) Goat (1)	Relatively poor household

Source: process investigator, Kalleritar.

In Yampaphant, information was collected on the time spent by women and men on different activities during the day. This revealed a reduction in the time spent collecting wood and/or grass from the forest since the establishment of the irrigation scheme, with a notable reduction in the workload of women (process investigator, Yampaphant). A similar picture emerged in Kalleritar, where women were the main collectors of wood (process investigator, Kalleritar).

(iv) Land clearance for the extensification of agriculture

In attempting to determine whether investment in irrigation has resulted in a reduction of pressure on resources in the surrounding area it is useful to consider whether irrigation has absorbed labour that would otherwise be devoted to crop production in upland areas.

Migration to the irrigated areas has occurred mainly due to higher levels of cropping intensity (therefore labour requirement) on lowland irrigated land. Traditionally, Kalleritar farmers lived high up in the surrounding hills of the area. With the establishment of the irrigation schemes, many

households migrated closer to their irrigated land to reduce daily travel times. Another facilitating factor was the earlier eradication of malaria in that area. The process investigator reported that the outward migration from the hills has not however resulted in increased average land size in the hill area because of counterbalancing increases in the remaining population due to a high rate of population growth. However, the evidence reported above suggests that changes in farming practice have reduced the pressure on resources in comparison with a no migration scenario. There is little evidence of extensification of agriculture into forested area and hence there has been a reduction in the potential for erosion in these areas.

In the Yampaphant scheme, families from the higher ground, where farm sizes are not sufficient to satisfy household consumption needs in the absence of irrigation, contribute their labour to farmers within the scheme on a seasonal basis. Again, it could be contended that their alternative strategy would be to expand agricultural activities in the marginal hill areas by clearing forest. This evidence is in line with that reported by Shively (1999) who investigated the impact of irrigation development on the forest in the Palawan region of the Philippines.

In the Terai, the pattern of labour use differs in that seasonal labour tends to be drawn in from bordering regions of India. Whilst this may have beneficial impacts on the environment in areas where the labour comes from, it is less clear whether the use of labour sources from within the Terai region would have a beneficial impact to the extent observed in Yampaphant and in Kalleritar.

9. CONCLUSIONS

Care was taken at the outset to ensure that farming is the main livelihood for the majority of households on each of the three selected irrigation schemes. The area of land owned by families is the main determinant and indicator of wealth. Analysis of farm size distribution, farm productivity and estimates of income before farmers started to irrigate, shows that households were clearly very poor. The average income would have been below the national average. For the majority, income would have been well below the published 'poverty line', defined in terms of the minimum daily calorie requirement per capita.

On all three schemes, the majority of households (over 80 percent) hold irrigated lands of less than two thirds of a hectare (median farm size ranges from 0.25-0.35 hectares). The largest farms are small by world standards (maximum recorded irrigated holding varies from 1.35-4.40 hectares at the three schemes). Most farmers are owner- cultivators; land renting or sharecropping are relatively uncommon. Thus, the direct benefits from improved agricultural productivity go to relatively large numbers of poor farming households, without disproportionate gain by large farmers or landlords.

1. The main direct impacts of irrigation development are increased cropping intensity and opportunities for crop diversification. Prior to irrigation development, the majority of households could cultivate only one main staple crop a year, sometimes supplemented by a following drought-resistant pulse or oilseed crop, and perhaps winter vegetables in small homestead gardens or low-lying plots. Households were thus mainly subsistence or semi-subsistence producers, rarely having significant surpluses to sell, and with a low level of participation in both output and input markets. With irrigation, two crops of rice, plus a winter crop, are common where water supply is adequate; alternatively, maize/vegetables in spring, followed by monsoon rice plus a winter crop, where there is some constraint in water supply. Higher and less variable yields are achievable under irrigation. 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 use of purchased inputs, and where market access encourages it, farmers have diversified into higher value crops such as vegetables.

   The impact of higher and less variable yields on **financial capital** is evident. Valued in constant prices, annual gross incomes per hectare have increased by some 100-175% over the lifetime of the schemes. Per capita incomes for scheme residents have also risen above the poverty line for Janakalayan and (substantially) for Yampaphant, but remained below it for Kalleritar, where per hectare output is similar but family landholdings (median 0.36 ha.) are significantly smaller. It appears that the holdings are too small to be viable as the sole family enterprise.

   Comparison with the more substantial rise in average incomes for the Terai and Hill zones over a parallel 10 year period (Nepal Living Standards Survey, 1996) emphasises that cereal production in smallholder agriculture is not a big income earner, set against other sectors of the economy. However, it provides a secure and sustainable livelihood. The returns to high value cropping, such as vegetables at Yampaphant, compare favourably with other financial endeavours.

2. Comparisons between the three schemes show a notable difference in ability to produce regular farm surpluses. The more intensive and higher value cropping at Yampaphant represents a further stage in irrigation development compared to the other two schemes. Over 70 percent of farmers interviewed at Yampaphant and Janakalayan have been producing a surplus to sell, whereas at Kalleritar, where landholdings are smaller and road access less direct, the figure is only 30%. Kalleritar farmers are thus the least able to profit by cash cropping, leaving them lagging behind the other two schemes financially and with less money to invest in infrastructure, education and healthcare. Higher gross and net incomes per hectare were achieved at the other two schemes by greater integration with input and output markets, better access to information and adoption of improved agricultural technology.

Irrigation has also produced higher and more continuous employment for farm labour. Most farm households had surplus labour before they took up irrigation. Irrigated agriculture has thus provided fuller employment to households' own labour, possibly reducing the need for seasonal migration in search of work. There is also evidence of increased employment for marginal farming or landless households primarily dependent on agricultural work. This labour is drawn from the surrounding upland, in the case of Kalleritar and Yampaphant, and from seasonally migrating contract labour at Janakalayan.

Irrigation development has also tended to encourage intensification of livestock production, with the adoption of improved breeds, and stall-feeding rather than free grazing. Some households have reduced livestock numbers to the minimum needed for their own consumption, while others are becoming commercial, producing dairy and meat products for the market.

Agricultural goods and service providers report improved demand for, and profitability of, their services. The number of shops and services has increased over recent years at all schemes, indicating an increase in spending and market participation by the local farmers.

3. Irrigation also plays an important role as a catalyst for infrastructure development. In all three schemes, an increase in the development of **physical capital** such as electricity, biogas, shops and services has followed the development of irrigation. The construction of the Prithivi highway in 1972 (Yampaphant and Kalleritar) and the East-West Highway in 1974 (Janakalayan), preceded irrigation at each scheme and probably played a lead role in encouraging the development of further physical infrastructure at each location. In the case of Kalleritar, the construction of a suspension bridge significantly improved access to the Prithivi highway. Whilst of primary importance in the development of the three schemes, infrastructure clearly does not generate higher incomes in isolation. The synergies between irrigated agriculture and roads have been effective in promoting improved livelihoods.

   Financial gains from irrigated production have provided farmers with capital to spend on improved infrastructure and may have encouraged new development initiatives in their area. Increased production has also both encouraged, and responded to, the development of market opportunities. Irrigation has improved farmers' access to markets and other services. Without irrigation, farmers on all three schemes would have had little or no surplus to sell. They would not now be able to make effective use of the access to market provided by the road. Local shops and services, which have appeared in response to demand, would be fewer. 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.

   Irrigation has also encouraged farmers to build and develop infrastructure themselves. Housing development has increased across the three schemes, and living standards have improved. Direct improvements to houses include additional rooms, new roofs, biogas units, latrines and drinking water supplies. Access to public and commercial transport is easier; drinking water wells, electricity and numbers of individual biogas plants now ease life at all schemes.

4. Improvements in **human capital** at all three schemes include better family health - partly linked to improved and more secure diet – increased enrolment of children in school and an increase in literacy. Not all of these are directly linked to irrigation development, but it is clear that they are the result of a process of economic and social development in which irrigation plays a key part.

   Irrigation has helped improve the diet and health of all members of the community: directly, through the production of more, diverse foods, and indirectly as a consequence of greater incomes (farmers, service providers and farm labour). Apart from food and health, increased incomes tend to be spent on education, housing improvements, clothing and other household goods. The investment in education

has contributed to better education and literacy, but also to an increasing loss of younger people to further education and non-agricultural employment. The absence of the young has reduced the available family labour, creating additional opportunities for paid labour.

5. The impacts of higher agricultural incomes on **social capital** are hard to quantify directly. With greater affluence, people tend to spend more on ceremonies, health and education. Greater wealth may reduce the need for informal arrangements for assistance between neighbours. On the other hand, improvements in education can potentially improve inter-personal communication, encouraging people to co-operate to achieve their development objectives. As more girls are educated, the benefits of irrigation are likely to be felt equally by men and women. In the early years following irrigation, crop intensification and year-round cultivation can burden uneducated women to a greater extent than men. Formal social capital has been strengthened, as measured by the numbers of active interest groups and committees. The changes are encouraged by a number of development initiatives acting together. Irrigation, by improving the general standard of nutrition and income - thus permitting people to attend to issues other than basic survival – has had a noticeable impact. People are working harder and longer than they did before the introduction of irrigation, and are able to do so because they enjoy greater stamina and improved well-being. They are prepared to put up with the loss of leisure time in exchange for increased prosperity. Identified group activities, and formal organisation to achieve goals, imply developed social capital and an acceleration in the pace of development.

   The figures for education of children suggest that national education policies benefit by irrigation development. It is likely that greater education of females will create pressure for greater human equity in future.

   The social value of infrastructure such as roads, paths and bridges, schools, health posts, meeting halls and temples should not be underestimated. People are better able to participate in such projects on the proceeds of irrigation. Cultural observances, catering committees and an increased ability to fund ceremonies, are seen as positive indicators of strong social capital.

   Both formal and informal social relationships provide means to broaden the distribution of the gains from irrigation, and to help build up other assets. Reciprocal exchange of labour (*parma*), under which households mobilise labour from other households to supplement their own family labour, can help to meet some of the increased labour requirements of irrigated cropping, while formal networks and groups are important mechanisms to exchange information and manage shared resources. For example, the Mothers Group at Yampaphant disseminates messages about the importance of education, children's welfare and diet, whilst the forest committee promotes sustainable use of the resource.

6. Formal irrigation has brought a water supply which is generally adequate and reliable during the main growing seasons. In these schemes, there are relatively few conflicts over the use of water. Sampling reveals some small decline in the quality of water as it passes through the schemes.

   Potentially more significant for **natural capital** is the intensification of agriculture linked to irrigation. Farmers believe that soil fertility has declined on all schemes. Although the evidence from the soil tests is inconclusive, it does appear that acidity in the soil, associated with the over-application of urea, is increasing. In the Terai region, it is also possible that a reduction in the incidence of flooding, due to the construction of flood protection works, is contributing to a reduction in the fertility of soil, as silt and nutrients brought by flood water are excluded. In the hill regions, there is some evidence of soil erosion and instability of agricultural terraces.

   Against such negative impacts, it is important to set a real reduction in the pressure on marginal lands, with the intensification of irrigated agriculture in areas of higher potential. Such development strongly supports government policy to protect the forests. Pressure on forests has markedly decreased since irrigation and the general condition of the resource has improved.

It is concluded that the net impact of irrigation upon the natural capital stock has been positive at these schemes

7. The analysis of the impacts of irrigation has demonstrated clear linkages not only between the capitals - which provided a basis for analysis of impacts - but also the synergies and inter-linkages between different types of rural development.

   There are clear links between developments in physical and human capital: an irrigation scheme needs to function well to sustain production and farming populations. Schools, shops, health posts and roads are needed to support the improved livelihoods which increased agricultural production makes possible. Roads, tracks and electric lighting promote social capital, making it easier for people to travel to meetings, ceremonies, classes and to participate in events after dark. Other government and NGO programmes in the areas surrounding the schemes have contributed to the development of social, human and financial capital, as well as the conservation of natural capital. Improvements in housing, and use of services such as transport and healthcare, are clearly linked with the ability to pay. In this respect, differences between schemes can be linked to local productivity and income.

   With greater education and human capital, an increasing number of farming households receive remittances from a family member working elsewhere and thus increase their financial capital. Higher incomes appear to have led to a change in priorities for many farmers, who now encourage their children, once educated, to move from agriculture into higher paid, non-agricultural employment.

8. The success of farming at Yampaphant is the consequence of exceptional assistance and training to farmers in the past, particularly from the Lumle centre, and of well-developed marketing arrangements. At Janakalayan, farmers have also received some support and training. Rice is in strong demand on the Terai and road communications are good. At Kalleritar, where progress has been less marked, farmers have had infrequent contact with extension agencies. Farms are significantly smaller (median 0.36 ha.) so that, whilst per hectare output is comparable with the other schemes, family incomes are substantially less. Vehicles cannot get direct access to the scheme, so all inputs and outputs must be carried from/to the main road. In spring, there is some shortage of water in the tail reaches. The obvious benefit derived by farmers from sound agricultural advice emphasises that all three schemes would profit from further training in the cultivation of irrigated vegetables/ cash crops.

   The benefits of irrigation appear to have been broadly experienced across the farming populations, a fact which is attributable, in part, to reasonably harmonious social relationships. Physical conditions across each scheme do not vary greatly; except for the tail reach at Kalleritar, where the water supply is sometimes short.

9. Overall, it can be concluded that **small scale** irrigation development on these three schemes, which are owned and managed by farmers, has been an effective tool for poverty reduction. Those with the smallest holdings (many at Kalleritar) and landless farm labour have benefited, but not to the same extent as farmers holding 0.5 ha, (median size for Yampaphant) and 0.66 ha (Janakalayan). Substantial benefits have also been experienced in the rural non-farm economy, where many small scale enterprises and trades have profited from farmers' greater disposable incomes. The benefits of irrigation appear to have been broadly experienced across the farming populations. Although there are caste and ethnic differences within the communities, they have not played a major role in overall outcomes.

Irrigation appears to be most effective as a part of a package of rural development measures. At Yampaphant, where there is a good road and where farmers have received training in agronomic practices, irrigation appears to have contributed most to livelihoods. Farmers appear to have been more enterprising than at the other two schemes. Irrigation will have a multiplier impact in the local economy if complementary elements are in place, for example, market systems, roads, schools and formal extension training. Given the dependence of the majority of rural households on crop production, there are few

alternatives to irrigation that can bring the same scale of improvement in farm incomes in a relatively short time.

Although the mechanisms for poverty reduction will be similar, the impacts of irrigation on livelihoods at larger government-run schemes will no doubt show some quantitative differences from farmer-managed schemes. Nonetheless, the results of the study support some of the key propositions underlying Nepal's Agriculture Plan (APP). In particular, the APP states that " the returns to public investments such as roads, or farmers' investment in agricultural inputs, will remain low and potentially uneconomic if land is unirrigated (or only seasonally irrigated). Without year-round irrigation and fertiliser use, although individual adopters may experience improved yields, there will be little impact on aggregate production leading to greater market orientation and higher incomes. It is thus 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".

Despite these positive conclusions, the three schemes, with the possible exception of Yampaphant, operate at levels of productivity that remain significantly below potential. In particular, once landholdings are divided and fragmented to the extent prevailing at Kalleritar (median size 0.36 ha), it is very hard for a family to subsist on farming as its sole enterprise. In innovative irrigation projects elsewhere in Nepal, land holdings sufficient to provide a family with a sustainable living were allocated at the outset. Land reform issues have otherwise generally not been pursued in Nepal.

In summary, it is likely that well-planned small scale developments of the type investigated will improve household food security and incomes without significant adverse effects, will increase demand for locally-provided goods and services, and create employment for both landed and landless households. Important pre-conditions to achieving significant reductions in poverty are a viable minimum farm size, access to markets and credit, and diversification of crop and livestock enterprises. To implement change, complementary measures are needed. They include programmes of cross-sectoral rural development targeted throughout the country, and in particular, establishing/encouraging informed and resourced agricultural services, whether in the private or government sectors.

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Annexes

Annex 1

Sampling procedures

Annex 1 Sampling Procedures

Farm Household Survey

Janakalayan

Investigations covered the main command area of approximately 91 hectares, and not the smaller area of 25 hectares that offtakes closer to the canal headworks. Within the 91 hectares there is no clear division in terms of head, middle and tail reaches. Most of the land receives a good supply from canal branches, and only areas where the end of the main canal feeds tertiary farm channels could be considered a "tail" section. Land tenure is predominantly owner-cultivator, with no tenants and only a small number of sharecroppers. There were 125 farm households and for sampling these were listed and odd numbers selected to provide the desired sample of 60. It was confirmed that the WUA prepared the list of landholders in clusters by village/sub-village areas and hence this procedure should have provided representative coverage across the command area without bias arising from the sequencing of the list. Where a sharecropping household was cultivating the land of a selected landowner, then the sharecropping household was interviewed.

Yampaphant

There were 63 farm households in total, 21 in the original command area (*jaishi* and *baraha* land) and 42 for the 'new' system (*pakho* land). Thus the survey was effectively a census of farm households.

Kalleritar

The scheme consists of three *thars* or terraces and thus three clear Head, Middle and Tail blocks. Unauthorised water users irrigating about 15 hectares at the head of the canal were not included in the survey. Farm households were randomly selected according to the stratification in the table below.

Sample selection:

	Households	Approximate area, hectares	Sample
Head	23	22	11
Middle	55	25	22
Tail	63	35	27
Total	**141**	**82**	**60**

There were no leasehold tenants on the scheme but some sharecroppers. Where a sharecropping household was cultivating the land of a selected landowner, then the sharecropping household was interviewed.

Labourers; Suppliers of agricultural goods and services; General merchants, crafts and tradespeople.

5 households representative of each category were purposively selected on each scheme.

Annex 2

Conversion factors used

Annex 2 Conversion factors used

Area:
1 hectare = 19.66 *ropani*
1 *ropani* = 16 *aana*
1 hectare = 1.477 *bighas*
1 hectare = 30 *katha* (approx.)
1 *bigha = 20 katha*
1 *bigha* = 400 *dhur*
Source: (CBS 2000)

Weight:
1 *muri* paddy = 50 kg
1 *muri* maize = 65 kg
1 *muri* wheat = 65 kg
1 *muri* = 20 *pathi*

Annex 3

Soil and water Tests

Annex 3 Soil and Water Tests

ENVIRONMENTAL ASSESSMENT & MATERIAL TESTING DIVISION
Nepal Bureau of Standards & Metrology, HMG, Accredited Laboratory

CHEMICAL ANALYSIS REPORT OF KALLERITAR IRRIGATION

Date: 26 Nov. 2001

WATER TEST

Sample No.	Description	pH	mg/l			
			T. Solid	T. Hardness as $CaCO_3$	NH_3	Phosphorous
1	Water from Head section of main canal	7.5	179.8	177.6	0.04	5.0
2	Water from cultivated land in Foshretar	7.2	777.2	180.1	0.08	22.5
3	Water from cultivated land in Kalleritar	7.8	181.1	192.7	0.04	7.5
4	Water from cultivated land in Ghartitar	7.2	403.2	190.2	<0.04	15.0
5	Water from Tail section of main canal	7.5	168.8	200.2	<0.04	10.0

SOIL TEST

Sample No.	Description	pH	Org. Matter %	N %	P m/kg	K mg/kg
1	Upland soil from Foshretar	5.7	2.0	0.01	2.5	40.0
2	Cultivated land soil from Foshretar	5.3	3.0	0.01	12.5	50.0
3	Upland soil from Kalleritar	5.2	2.8	0.13	12.5	80.0
4	Cultivated land soil from Kalleritar	5.6	2.0	0.10	15.0	30.0
5	Upland soil form Ghartitar	4.6	1.5	0.01	12.5	40.0
6	Cultivated land soil from Ghartitar	5.6	3.0	0.08	10.0	40.0

Texture Analysis

Sample No.	Description	Clay %	Silt %	Sand %
1	Upland soil from Foshretar	41.7	26	32.3
2	Cultivated land soil from Foshretar	29.7	24	46.3
3	Upland soil from Kalleritar	25.1	30	44.9
4	Cultivated land soil from Kalleritar	43.1	24	32.9
5	Upland soil form Ghartitar	31.7	12	56.3
6	Cultivated land soil from Ghartitar	31.7	42	26.3

ENVIRONMENTAL ASSESSMENT & MATERIAL TESTING DIVISION
Nepal Bureau of Standards & Metrology, HMG, Accredited Laboratory

CHEMICAL ANALYSIS REPORT OF JANAKALAYAN AND YAMPAPHANT IRRIGATION

Date: November 21 2001

WATER TEST

Sample No.	Description	pH	mg/l			
			T. Solid	T. Hardness as $CaCO_3$	NH_3	Phosphorous
1	Water from Janakalayan Upstream canal	7.2	275.7	160.1	<0.04	<5.0
2	Water from Cultivated land Janakalayan	7.0	383.6	191.4	0.04	15.0
1	Water from Yampaphant Upstream	7.5	183.6	203.9	<0.04	10.0
2	Water from cultivated land outlet Yampaphant	7.4	392.1	196.4	<0.04	5.0
WHO Guidelines		6.5-8.5	1000	500	1.5	-

SOIL TEST

Sample No.	Description	pH	Org. Matter %	N %	P m/kg	K mg/kg
1	Janakalayan Upland soil	6.2	2.4	0.06	24.0	60.0
2	Janakalayan Cultivated soil	6.5	2.5	0.08	15.0	40.0
1	Yampaphant Upland soil	5.8	2.8	0.11	1.3	140.0
2	Yampaphant New Cultivated soil	5.9	2.6	0.06	24.0	120.0
3	Yampaphant Old Cultivated soil	5.9	2.3	0.08	2.5	60.0

Texture Analysis

Sample No.	Description	Clay %	Silt %	Sand %
1	Janakalayan Upland soil	25.9	31.4	42.7
2	Janakalayan Cultivated soil	25.9	35.4	38.7
1	Yampaphant Upland soil	37.9	35.4	26.7
2	Yampaphant New Cultivated soil	25.9	17.4	56.7
3	Yampaphant Old Cultivated soil	29.9	35.4	34.7

SOIL SAMPLING TEST IN YAMPAPHANT

S. No.	Name of land owner	pH	Name of land area
1.	Teka Lal Lamichhane	6.3	Jaishi
2.	Kesab Prasad Ghimire	6.4	Jaishi
3.	Tanka Lal Lamichhane	6.3	Jaishi
4.	Ram Nath Battarai	5.8	Pakho
5.	Ram Nath Battarai	6.1	Pakho
6.	Ram Nath Battarai	6.3	Pakho
7.	Pashupati Panta	5.9	Pakho
8.	Chhabi Lal Ghimire	6.0	Pakho
9.	Chhabi Lal Ghimire	5.5	Pakho
10.	Sarswoti Dhakal	6.1	Pakho
11.	Bhim Prasad Ghimire	6.8	Pakho
12.	Khil Prasad Lamichhane	6.7	Pakho
13.	Chet Nath Bhattarai	6.7	Pakho
14.	Khil Prasad Neupane	6.0	Pakho
15.	Nabin Prasad Neupane	6.4	Pakho
16.	Seshmani Upadhya	6.5	Baraha
17.	Khadga Kumar Shrestha	5.9	Baraha
18.	Sher Bahadur Ghimire	6.5	Baraha
19.	Sher Bahadur Ghimire	6.1	Baraha
20.	Nanda Lal Bhatta	6.2	Baraha
21.	Hem Bahadur Rana	6.3	Baraha
22.	Bhumi Nanda Lamichhane	6.2	Baraha
23.	Parashu Ram Ghimire	6.3	Baraha
24.	Hari Lamichhane	6.1	Baraha
25.	Khil Prasad Lamichhane	6.7	Baraha
26.	Lila Prasad Lamichhane	6.4	Baraha

Annex 4

Summary of costs and returns for main crops

Annex 4 Summary of costs and returns for main crops

Cost and returns of main crops grown at Janakalayan
NRs/ha at 2001 financial prices

	Season	Monsoon			Winter		
Before irrigation							
	Crop	Maize			Mustard		
	Unit	Price	Yield	Value	Price	Yield	Value
Item							
Gross returns							
- Grain	kg	8	1700	13600	20	600	12000
- Straw	kg						
Gross returns per ha	NRs/ha			13600			12000

With irrigation (2000/2001)	Season	Spring			Monsoon			Winter		
	Crop	Early paddy			Paddy			Wheat		
	Unit	Price	Yield	Value	Price	Yield	Value	Price	Yield	Value
Item										
Gross returns										
- Grain	kg	8	3200	25600	8	3200	25600	8	1600	12800
- Straw	kg	0.8	3200	2600	0.8	3200	2600	0.5	1600	800
Gross returns per ha	NRs/ha			28200			28200			13600
Costs of production										
Total Costs per ha	NRs/ha			10500			10500			12000
Net returns per ha	NRs/ha			17700			17700			1600

Cost and returns of main crops grown at Kalleritar
NRs/ha at 2001 financial prices

	Season	Monsoon			Winter		
Before irrigation							
	Crop	Maize			Mustard		
	Unit	Price	Yield	Value	Price	Yield	Value
Item							
Gross returns							
- Grain	kg	7	2500	17500	20	600	12000
- Straw	kg						
Gross returns per ha	NRs/ha			17500			12000

With irrigation (2000/2001)	Season	Spring			Monsoon			Winter		
	Crop	Maize			Paddy			Wheat		
	Unit	Price	Yield	Value	Price	Yield	Value	Price	Yield	Value
Item										
Gross returns										
- Grain	kg	7	2800	19600	10	3300	33000	7	2600	18200
- Straw	kg				0.7	3300	2300	0.3	2600	800

Gross returns per ha	NRs/ha	19600	35300	19000
Costs of production				
Total Costs per ha	NRs/ha	6000	10500	12000
Net returns per ha	NRs/ha	13600	24800	7000

Cost and returns of main cereal crops grown at Yampaphant
NRs/ha at 2001 financial prices

Before irrigation	Season	Monsoon			Winter		
	Crop	Paddy			Mustard		
Item	Unit	Price	Yield	Value	Price	Yield	Value
Gross returns							
- Grain	kg	10	2300	23000	20	600	12000
- Straw	kg	0.7	2300	1600			
Gross returns per ha	NRs/ha			24600			12000

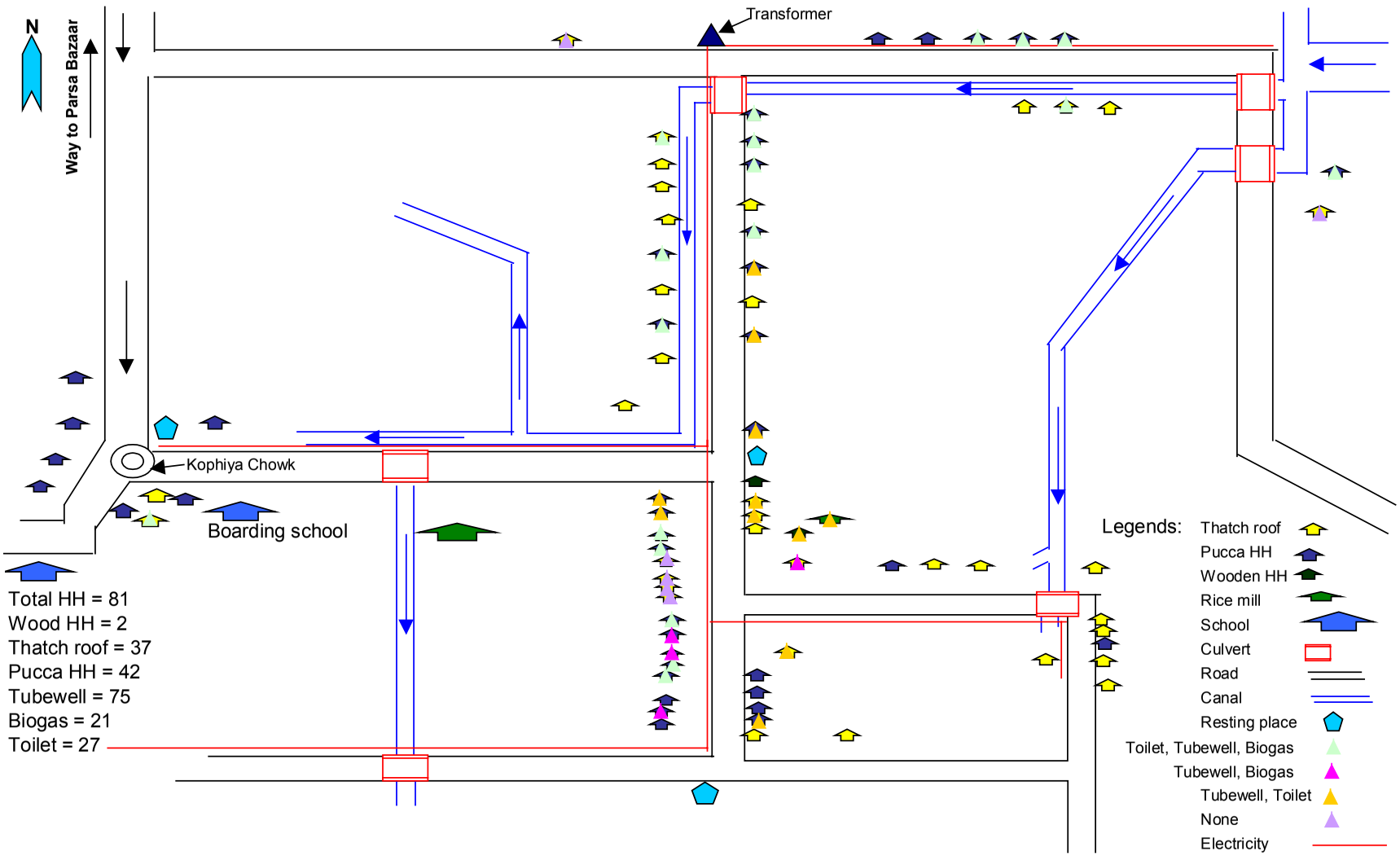
With irrigation (2000/2001)	Season	Spring			Monsoon			Winter		
	Crop	Maize			Paddy			Wheat		
Item	Unit	Price	Yield	Value	Price	Yield	Value	Price	Yield	Value
Gross returns										
- Grain	kg	7	1400	9800	10	4400	44000	7	2200	15400
- Straw	kg				0.7	4400	3100	0.5	2200	1100
Gross returns per ha	NRs/ha			9800			47100			16500
Costs of production										
Total Costs per ha	NRs/ha			6000			10500			12000
Net returns per ha	NRs/ha			3800			36600			4500

Data sources:

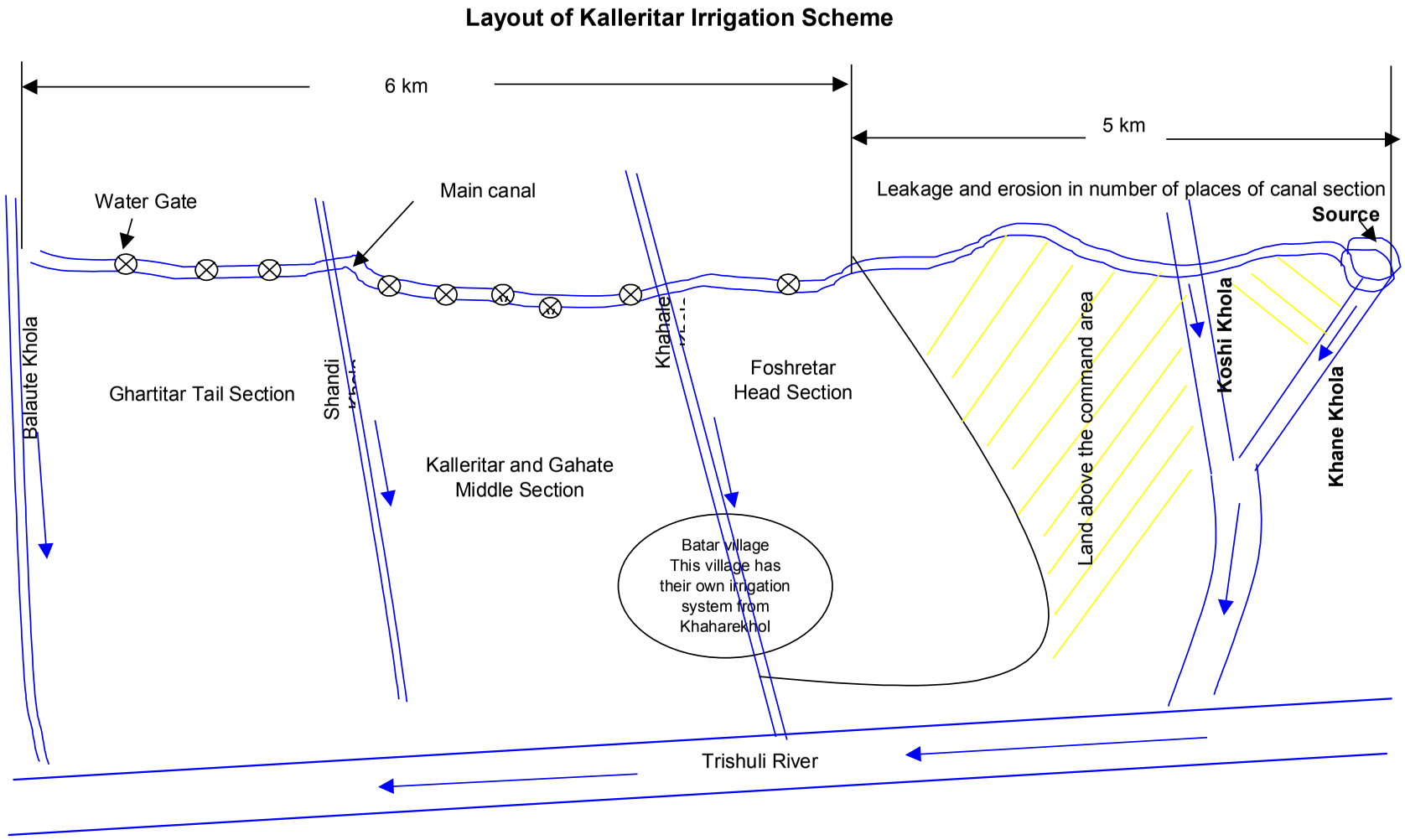
Farmer survey data are used crop/grain yields and prices, and data from process investigators for the value of straw/crop residues. Production costs are estimated using information from secondary sources for comparable locations and information collected by the process investigators. Gross returns per hectare can be considered to be accurate estimates for the schemes surveyed but net returns per hectare should be considered indicative only.

Annex 5

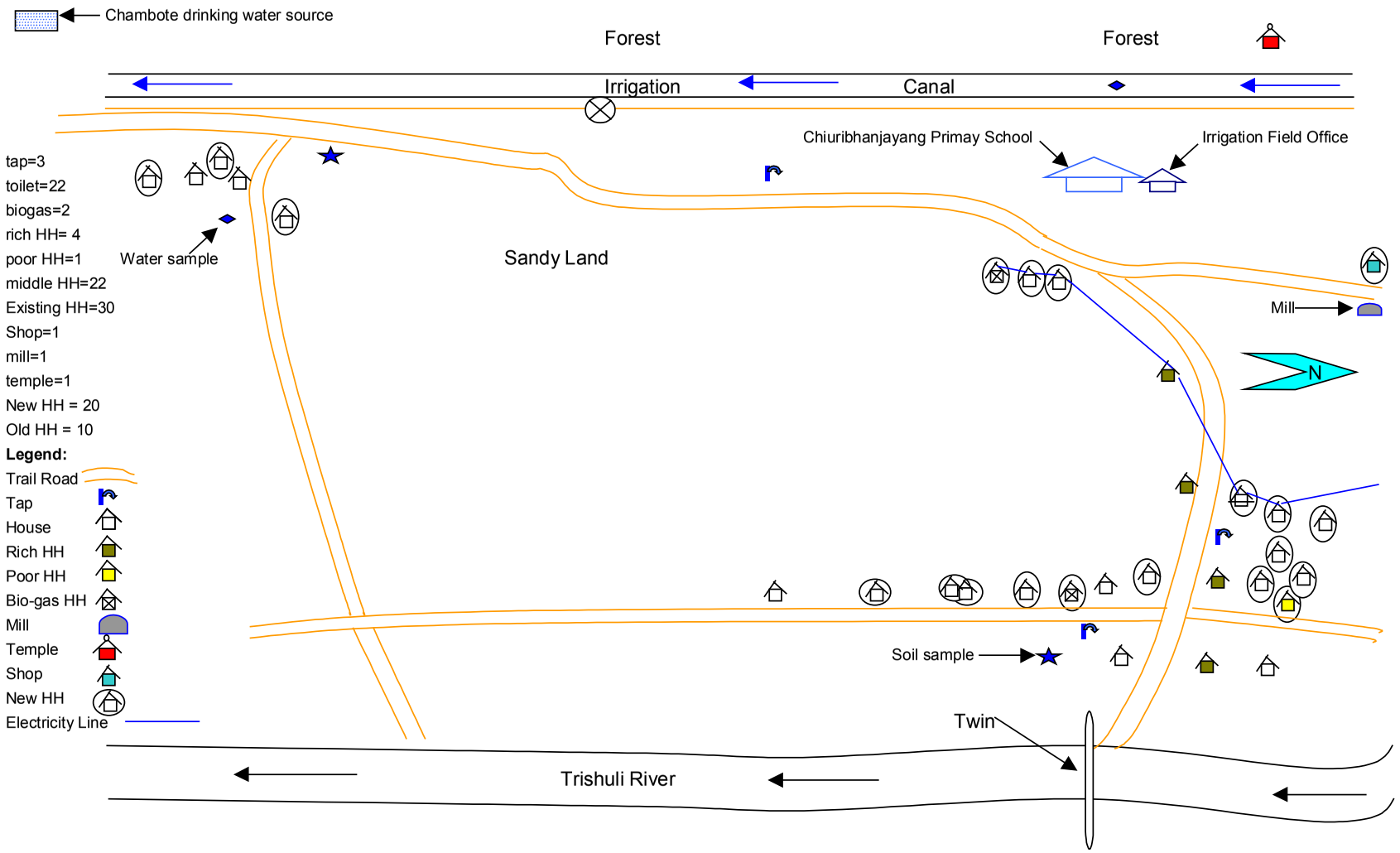
Village maps and scheme layouts



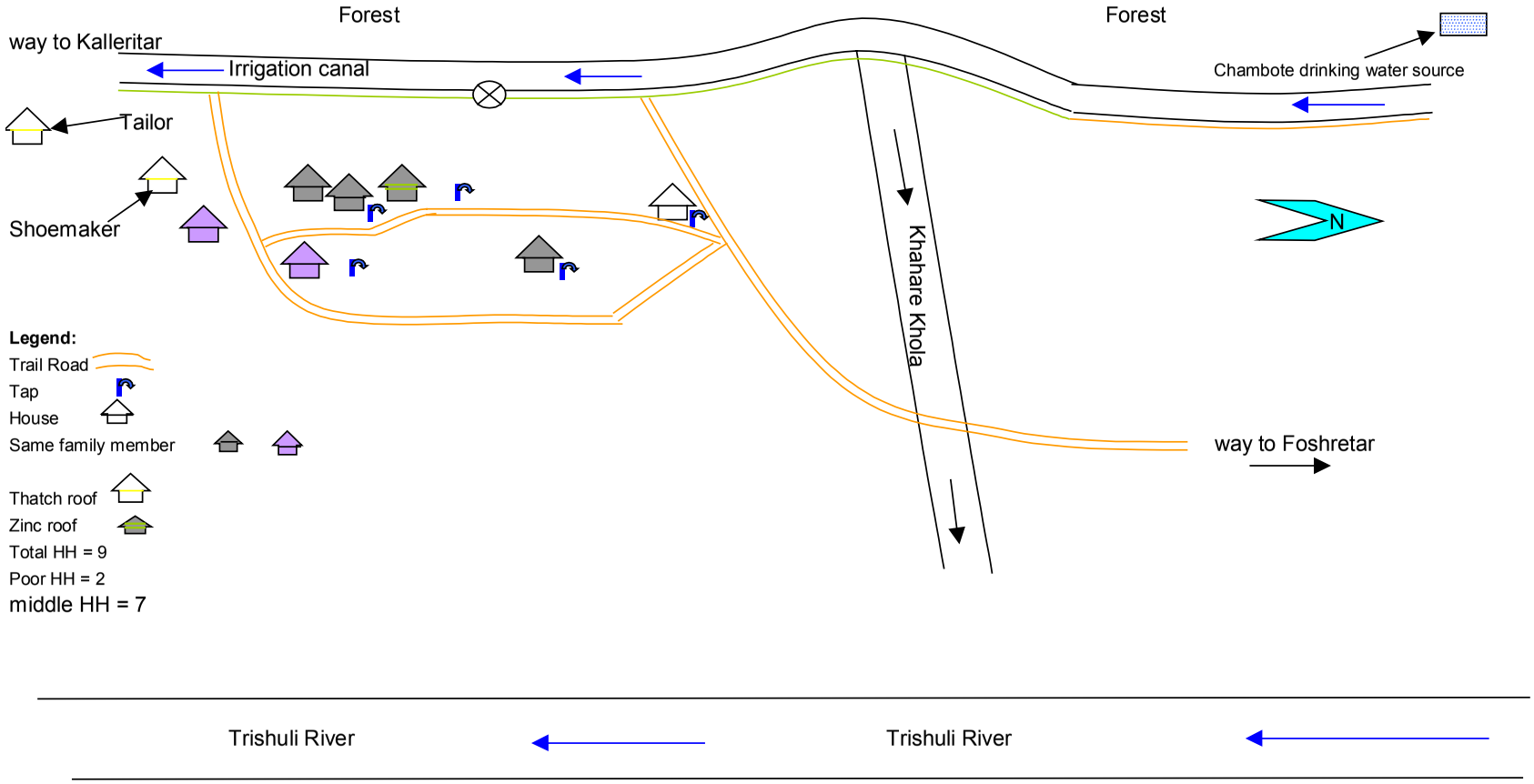
Janakalayan village map and scheme layout



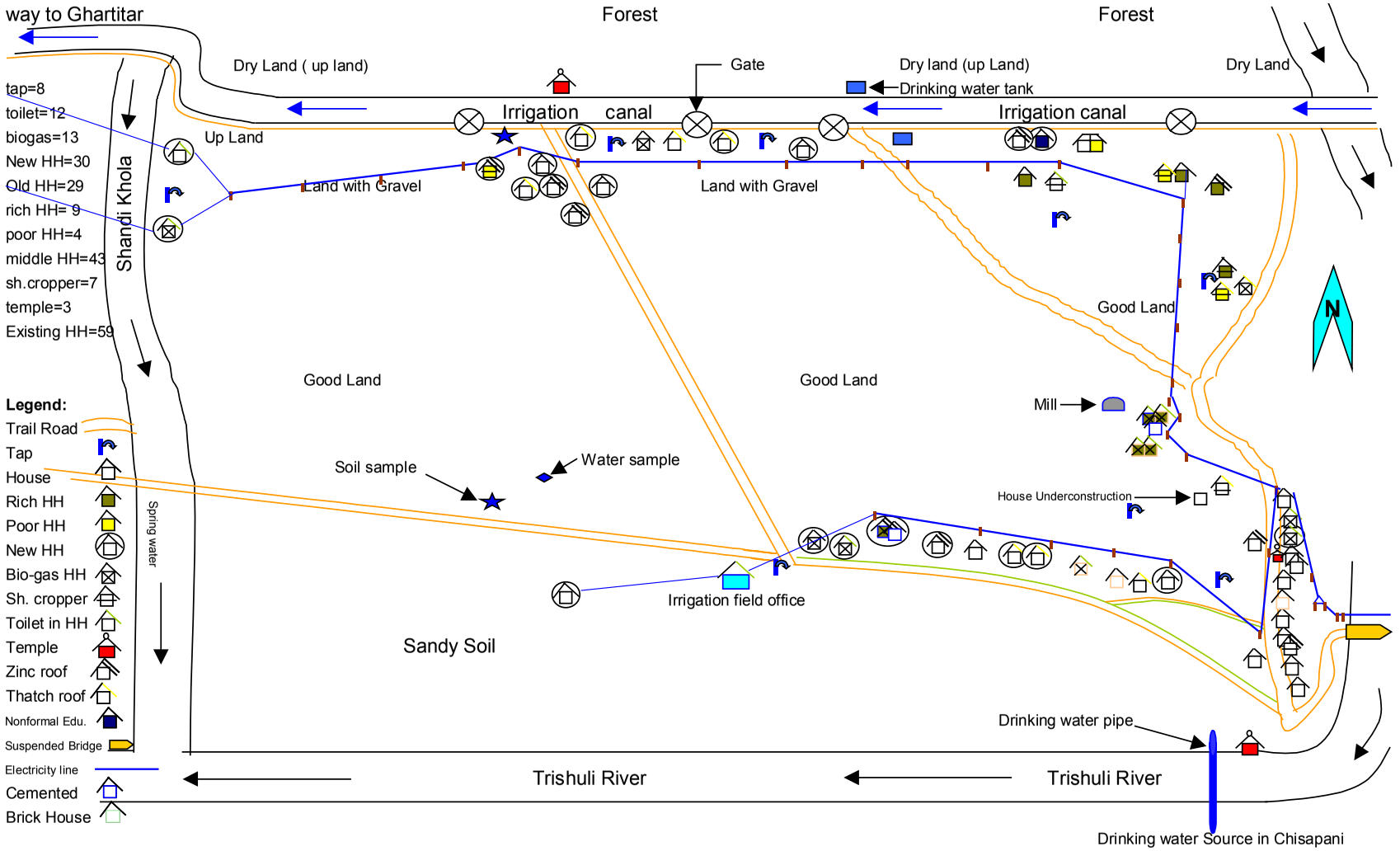
Kalleritar: Overall scheme layout



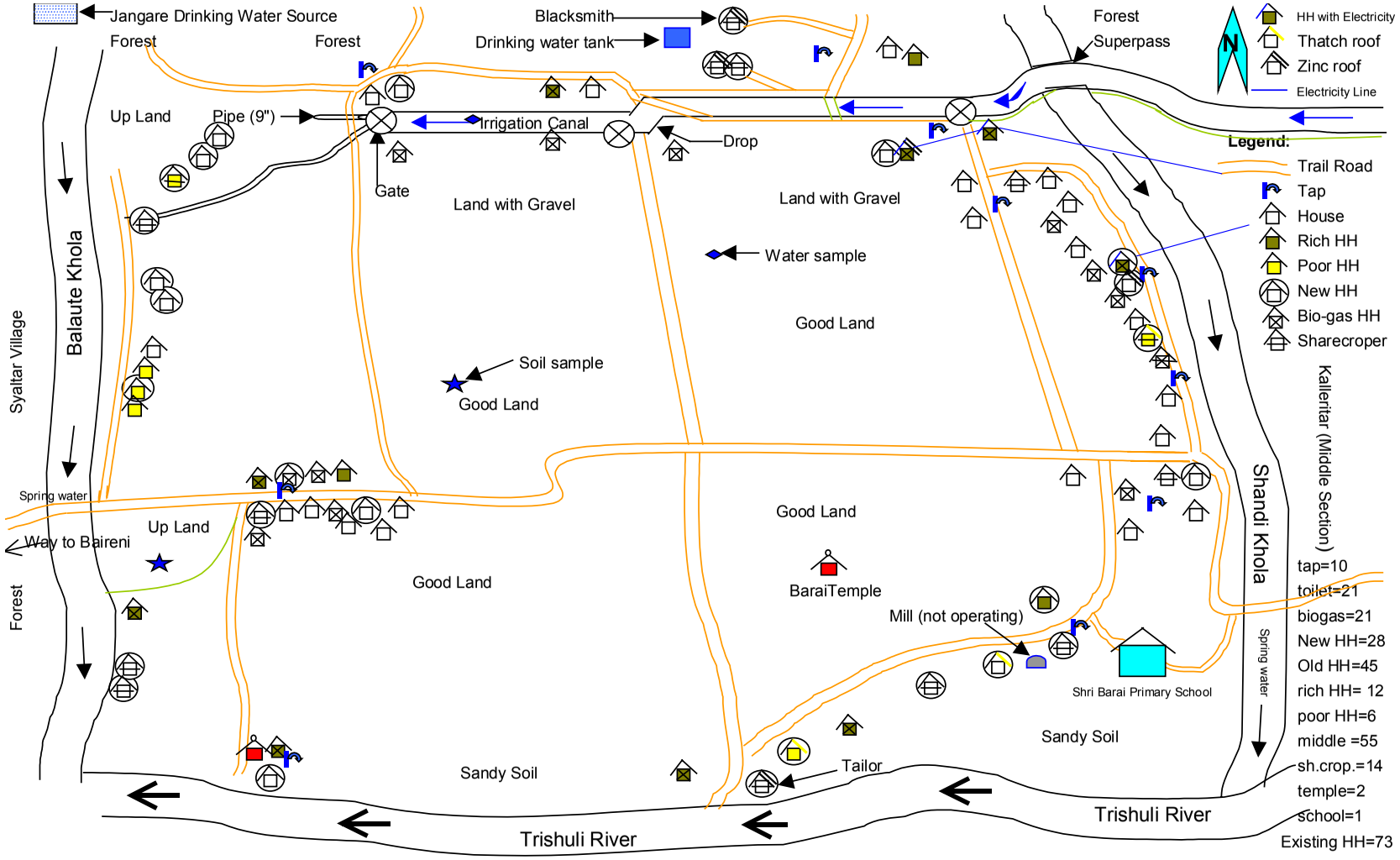
Kalleritar: Foshretar (head section) village and scheme layout



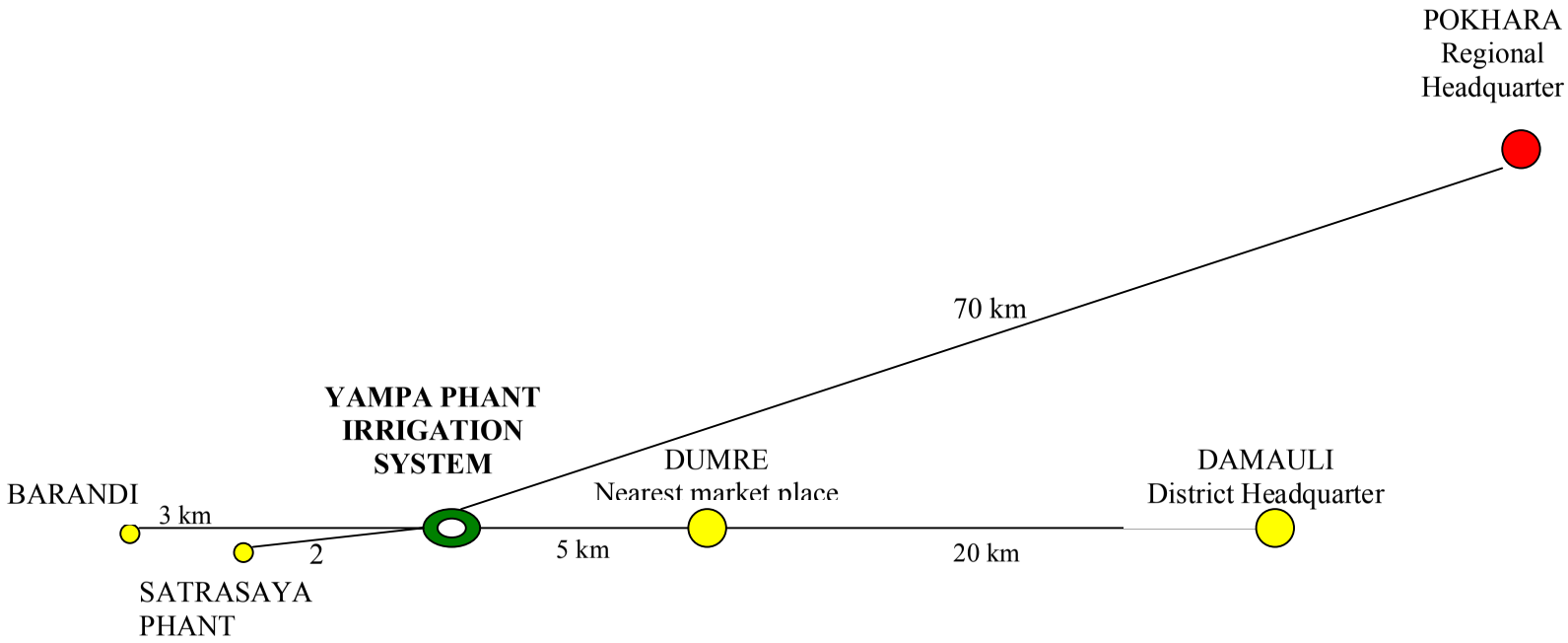
Kalleritar: Gahate (upper middle section) village and scheme layout



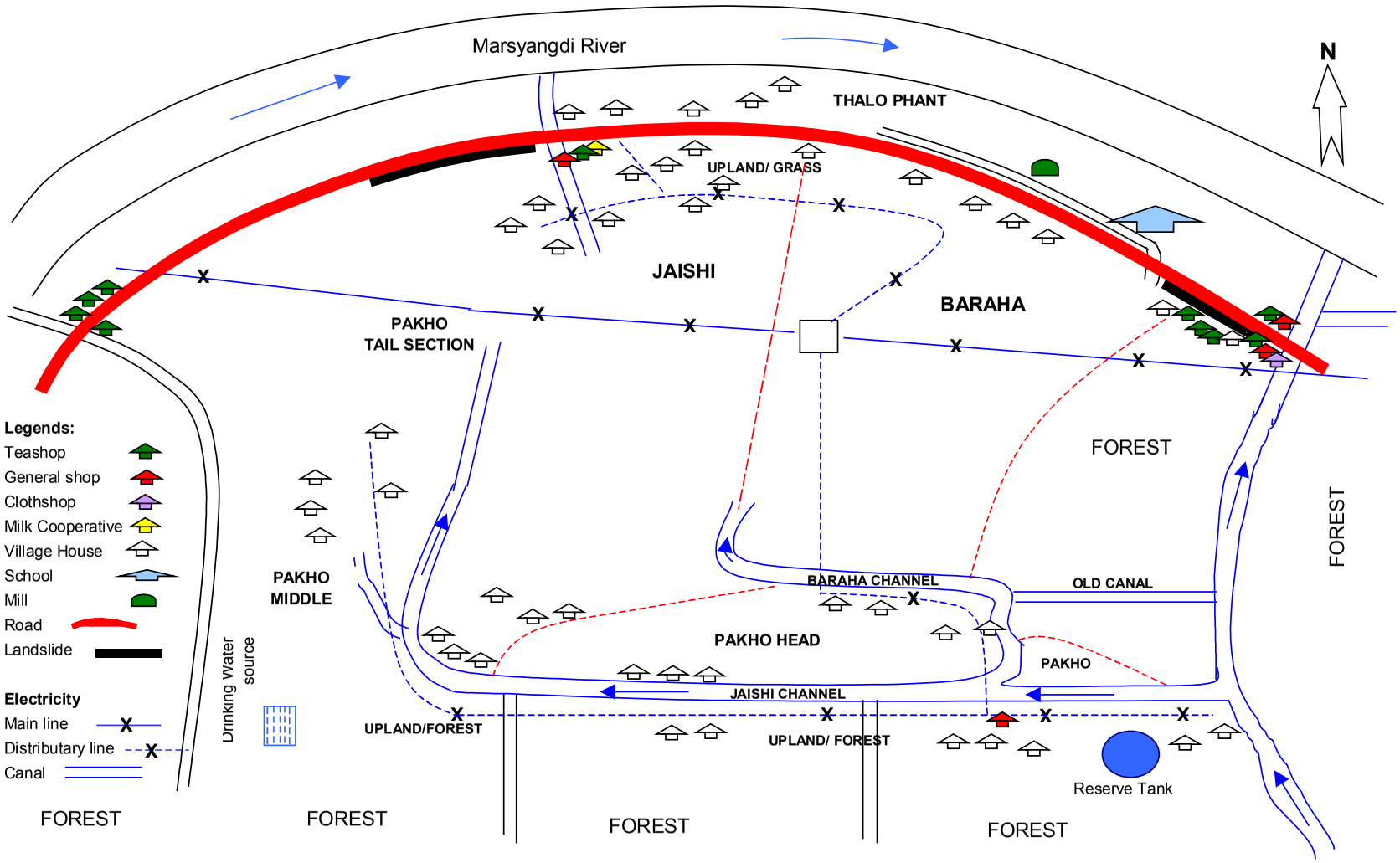
Kalleritar: Kalleritar (lower middle section) village and scheme layout



Kalleritar: Ghartitar (tail section) village and scheme layout



Yampaphant scheme location



Yampaphant village and scheme layout