# Performance of Irrigation Systems in Hill Areas of Uttar Pradesh, India

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## ABSTRACT

AGRICULTURE IN HILL areas in India is largely dependent on rainfall. A small percentage of the cultivated area (averaging 10%) has however, always enjoyed irrigation facilities. These irrigation systems of the preplan period were built and managed by communities of irrigators. With the beginning of planning in India irrigation systems were created by the state in hills in the early fifties by the simple process of modernizing some of the existing traditional irrigation systems and creating new ones in easily accessible areas. The traditional systems exist in large numbers even today though they do not fit the description of "technical adequate" engineering systems and as such are not acceptable to the state irrigation departments. Hill irrigation systems are usually small in size (2 to 50 ha). FMIS fall in to the smaller-sized category and have apparently very simple design features.

## INTRODUCTION

Agriculture in hill areas in India is largely dependent on rainfall. A small percentage of cultivated area (averaging 10%) has however, always enjoyed irrigation facilities. These irrigation systems of the preplan period were built and managed by communities of irrigators. With the beginning of planning in India, irrigation systems were created by the state in hills in the early fifties by the simple process of modernizing some of the existing traditional irrigation systems and creating new ones in easily accessible areas. The traditional systems exist in large numbers even today though they do not fit the description of "technically adequate" engineering systems and as such are not acceptable to the state irrigation departments. Hill irrigation systems are usually small in size (2 to 50 ha). FMIS fall into the smaller-sized category and have apparently very simple design features. Table 1 gives an indication of the area covered by various categories of minor irrigation systems in the hill areas of India.

Information on Uttar Pradesh (U.P.) hills is not included in this Table as the publication does not separately show figures for U.P. hill areas. However, an irrigation potential of 33,200 ha had been created by state irrigation systems up to March 1985 and approximately twice as much area lies under private minor farmer-managed irrigation systems (FMIS). Similarly, in the Western

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Ghats hill region on the west coast of the Indian subcontinent a substantial area exists under the FMIS category.

*Table 1. Net area (in '000 ha) irrigated by various sources (1984–88) (provisional).*

| State/U.T. | Canals | | | Tanks | Wells, including tubewells | Other sources | Total |
|---|---|---|---|---|---|---|---|
| | Govt. | Private | Total | | | | |
| Arunachal | – | – | – | – | – | 22 | 22 |
| Assam | 71 | 291 | 362 | – | – | 210 | 572 |
| Himachal | 7 | – | 7 | 1 | 3 | 84 | 95 |
| J and K | 120 | 168 | 288 | 3 | 4 | 14 | 309 |
| Manipur | – | – | – | – | – | 65 | 65 |
| Meghalaya | – | – | – | – | – | 50 | 50 |
| Mizoram | – | – | – | – | – | 8 | 8 |
| Nagaland | – | – | – | – | – | 50 | 50 |
| Sikkim | – | – | – | – | – | 16 | 16 |
| Total | 198 | 459 | 657 | 4 | 7 | 519 | 1187 |

*Source:* Indian agriculture in brief, 1989. Ministry of Agriculture, Government of India.
*Notes:* Govt. = Government; U. T. = Union Territory

From Table 1, it can be seen that in these states and U.T.s, as against a total area of 198,000 ha covered by state irrigation systems, the area under private canals accounts for 459,000 ha. In addition 519,000 ha included under the heading "other sources" also represent private nongovernment systems. If the area covered by FMIS in the U.P. hills and Western Ghats is added, the FMIS provide irrigation to a total of nearly 1.1 million hectares. Little is known about these systems but it is certain that productivity levels of FMIS are on par with those of state systems.

## UTTAR PRADESH HILL AREAS

The hill region in the state of Uttar Pradesh (henceforth to be referred to as hills) lies in the Central Himalayas and covers nearly 53,000 km$^2$ which is nearly 15 percent of the total area of the state. Average landholding size of 75–80 percent of the landholders is less than 1 ha. Each holding is fragmented and may consist of between 5 to 10 small parcels distributed in various locations in a village or in more than one village. Nearly 10 percent of the total geographical area in the hills is currently under cultivation and, in recent times, marginal and range lands as well as forest areas have come under great pressure of encroachment due to population increase. Irrigation facility is available on average, to 10 percent of the cultivated area.

*The best class of cultivation and crops are found in villages of moderate altitude between 3,000ft and 5,000ft. having access on the one hand to good forest and grazing ground and on the other, to riparian fields in the depths of river valley. Here all the crops that can be grown in the himalayas grow to perfection. If favored with irrigation water these lands yield excellent crops (Atkinson 1992).*

## RAINFALL IN THE HILLS

Rainfall in the hills is substantial and well-distributed during the year. In most of the area the monsoon rainfall (July–September) is between 100 and 150 cm and the winter-spring rain (December-March) of the order of 20 cm and above. There are some pockets which experience higher precipitation. Even before the regular monsoons begin in July, rains are experienced in April and June. Germination and sprouting of upland (unirrigated) rice and other crops are very much dependent on rainfall during this period of the year which may be the first segment of effective monsoon. During the monsoon period, sufficient runoff is expected in the meteorological weeks 27 to 34 and somewhat lower in the later weeks.

Climatic water balance over the year for Almora, one of the cities in the hills (elevation 1,600 m), indicates that evaporative demand is higher than rainfall in February-May and October–December and less during rest of the year. It is in these two periods, respectively, that the dough formation and ripening of winter wheat and monsoon rice crops occur. A study of the monthly soil moisture balance for Almora for 26 crop years showed that the winter wheat crop faces a moisture deficit almost every year (25 out of 26) while the monsoon rice crop seldom faced it (2 out of 26). A scrutiny of dry spells during the winter wheat season indicated that irrigation was required during 8 out of 26 crop years.

## TYPES OF IRRIGATION SYSTEMS

Irrigation systems in the hills fall under the category of Minor Irrigation, i.e., systems with command areas under 2,000 ha. Generally, minor irrigation systems in the U.P. hills do not command areas larger than 300 ha and a majority of these cover between 10 to 150 ha. Many ancient privately managed gravity canal systems have been taken over by the Irrigation Department. Studies (R.C. Pant 1981) have shown that in the eight hill districts of U.P., FMIS cover an area which is more than twice that reported under government irrigation systems.

Lined gravity contour channels are the most common irrigation source in the hills. Other state-owned schemes include medium/small tanks, hydro-lift schemes, lift pumps and sprinkler systems. Privately owned small tanks and hydrams and gravity canals (partly lined - or plain earthen channels) are managed and operated either by individuals or groups of farmers. Irrigation channels rarely off-take from any major river stream for the obvious reason that this would call for construction of sophisticated diversion and control structures which are very expensive. The canals are fed from smaller perennial streams, which descend down hill slopes to meet the main drainage, and can be tapped at various elevations in their downward journey.

As may be expected from the above narrative, irrigation systems built by the state coexist with community/privately owned systems. State systems are run by an irrigation bureaucracy which builds new systems and thereafter takes on the responsibility of their operation and maintenance (O&M). A small irrigation fee is charged from the beneficiaries. Some of the FMIS may receive financial assistance from the state for their improvement but subsequent O&M responsibilities continue to be shouldered by the beneficiaries as before. No irrigation fees are payable to the state. A majority of FMIS, however, do not receive any financial or other support from the state or its institutions and are also totally free of any control or interference by the state.

## STATE IRRIGATION SYSTEMS

The state Irrigation Department has a widely scattered network of functionaries at field level. They are employed in the construction of new systems and O&M of the existing ones, distribution of water and collection of irrigation revenues. Since hill channels are prone to frequent serious damage during monsoons, their maintenance is very problematic. The hills belonging to Shivalik Range are fragile and, therefore, frequent landslides are quite common. An entire section of the irrigation canals is occasionally washed away and has to be rebuilt. The transportation expenses of materials and labor and supervision charges to the remote sites for comparatively little work are very high. The time-lag between the occurrence of damage and its repair may take months. Assessment and estimate of damage, sanction for repair, allotment of funds, actual work of repairs and running of irrigation channel are processes that consume much time. The unavailability of irrigation water in a system for long durations as a result of administrative delays reduces productivity considerably.

## FMIS

On the other hand, FMIS are generally earthen gravity canals which can be fed from a natural stream or spring by means of simple diversion structures. They are designed for least cost effort in maintenance. Damage to the system is usually such as can be repaired quickly. The systems are under constant pressure to deliver irrigation water to the beneficiaries who themselves operate the system and distribute the water. Repair to the damaged part of the system is carried out expeditiously.

In one of the valleys of the hills, there exists a unique system of management for FMIS locally known as *hara* (or contract) system. In this system of irrigation development or management, the community employs a contractor to build a brand new irrigation system from his own resources and operate it for a period of time of up to thirty years. During this entire period, the contractor receives a hara, which means share, of the total crop produced from irrigated land. For existing systems a similar contract is entered into at a reduced hara for O&M and irrigation functions. The efficacy of the hara system is to be viewed in the context of emigration from the hills which has been causing a severe drain on their manpower resources.

## THE HARA SYSTEM OF IRRIGATION

The hara system of irrigation first came to the attention of researchers in 1988. Hara means share and in this management system, a contractor who takes on the responsibility of providing irrigation to farmers claims as his entitlement a share of the crop. There is always a contract between the farmers and the contractor, occasionally a written and registered one. Currently existing contract systems have only unwritten agreements.

## MIGRATION FROM HILL AREAS

Emigration from the hills has been one of the recurrent features of U.P. hill areas. This was occasionally due to political reasons as happened between 1810 and 1825 in Garwhal District of the hills, which saw emigration of whole villages unable to cope with the usurious taxation policies of the conquering Nepali rulers. Climatic rigors faced in the subarctic conditions in villages in proximity of the great Himalayas occasionally resulted (1900–1901) in seasonal migration of 78 to 98 percent of the population to areas with warmer climates and better opportunities for employment or trade. In recent years, unemployment or partial/under-employment has created a push effect for migration of males in the age group 15–50 years. Outside of agriculture there are very few job opportunities. The manufacturing sector does not exist in rural areas and there are few jobs in the service sector, except in armed or paramilitary forces where representation of hill people is quite high.

It might be fair to assume that small landowners form the bulk of the migrants. The facts, however, indicate the contrary. In a survey of one of the most underdeveloped districts of the hills — Pithoragarh — it was found that compared to landless farmers or those owning less than 0.4 ha, those having comparatively larger holdings of 1 ha or more had a higher migration rate (Khanka 1989). Thus while farmers with landholdings of up to 0.4 ha had between 0.6 and 0.8 persons migrating per family, those with holdings of between 1 to 2 ha contributed between 2.33 to 2.75 persons per family.

Emigration has caused some distortions in the male-female ratio in the population. Thus in the age group 15–50, the number of females per thousand males was found to be 1,404 whereas in all other age groups it was between 800 to 900. Consequently, the average working hours per day for females are an inordinately long: 12 hours out of which 3.6 are spent in agriculture and 3.4 in tending cattle.

Partial employment leads to unproductive employment in the sense that the reduction in the number of people employed in agriculture as a result of emigration does not affect production. One ha land provides full employment to 1.77 person in the hills and results in maximum production. Members of a family in excess of this number may therefore be considered not to have been productively employed. If, as a consequence of emigration, money is to flow into the village, which actually does happen, then the emigration of unproductive agriculture labor is a positive and contributory factor to the well-being of a family.

# STUDY OF IRRIGATION SYSTEMS — PERFORMANCE INDICATORS

A study comparing the performance of state irrigation systems and FMIS was carried out under a grant provided by the Ford Foundation (India). The main performance indicators which were selected for the study were productivity, costs to the government and farmers, equity in water distribution, management efficiency in terms of timeliness of irrigation supply, and cost-effectiveness in maintenance and sustainability. Other points to be considered related to access to resources including loan funds and subsidy and assessment of their consequences.

As the study progressed it was observed that loan and subsidy issues were only marginally relevant. The state either fully funded a project, managed the resulting system and charged a very nominal irrigation service fee, or provided small-scale assistance to a very small number of individuals or communities to develop or improve irrigation systems. Management parameters turned out to be the most significant indicators of performance and clearly established the considerable impact they have on productivity and farm incomes.

The best managed system from among the eight systems studied — four each of state irrigation department and FMIS— turned out to be the one operating on the hara basis. A brief description of this system is, therefore, being given below.

# HARA SYSTEM OF IRRIGATION MANAGEMENT

This management system is peculiar to the Saryu Valley near Seraghat, a small village on the bank of Saryu River which at this location determines the boundary between Almora and Pithoragarh districts. The earliest of the contract systems came into being in 1894 and the most recent one in 1951. At present, two systems in Pithoragarh District and one in Almora District continue to be run by contractors. Two of the remaining four such systems which were taken over by the state Irrigation Department, have been severely damaged due to the construction of a road which runs in close to these systems at a higher elevation on the same hill face. A third one has barely started functioning after remaining out of commission for a decade. In this contract system evolved over the decades, the village community seeks a contractor to perform all irrigation functions — from capture and conveyance of water for irrigation, to actual delivery into each field. The O&M of the system is the total responsibility of the contractor. A typical contract is negotiated between the elected representatives of a community and other prominent persons of the village, on the one hand and a contractor on the other. In a written contract every eventuality of an irrigation situation is spelt out.

All hara systems have some common features:

1. There is a contract — written or oral — which determines the share of the contractor from each crop from irrigated land.
2. The contractor is selected by the village after calling a meeting which is presided over by the *Sarpanch* (elected village head). The person offering to take up the responsibility for the lowest hara is offered the contract.

3. In new systems, the hara rate is quite high initially but as time passes it is reduced. Also the first contract is usually for a long period, say 20 to 30 years. This enables the contractor to realize his investment costs.

4. The beneficiaries often try to run the system themselves. This usually happens at the end of a contract of long duration or one with a high hara rate.

5. The contractor must maintain the system at the highest level of efficiency and attend urgently to any damage to the physical system. He is also totally responsible to irrigate each field whenever required and as per rules framed by the community.

6. The contractor has to follow the sequence of irrigation determined by the community. Equity of water distribution is the concern of the community which orders the contractor to follow a mutually agreed schedule which is usually quite simple. If in one year irrigation is to start from head end to tail, then in the following year the order is reversed.

The following key points emerged from the study regarding contract-managed irrigation systems on the hara basis:

1. This management pattern is geared to efficient system operation to achieve high productivity which benefits both the farmer and the contractor. The entire irrigable command area is covered during each of the two main crops and even a third crop is attempted by both the farmers and the contractor.

2. Though the contractor runs the system much as he pleases, he works within guidelines already established and clearly defined either orally or in a written agreement. Some of these guidelines elaborate the duties of the contractor. At the same time, the contractor has great flexibility of operation.

3. A local contractor — one from among the irrigators — is more successful as he is amenable to the introduction of changes in operation, if needed. He is less likely to be cheated in hara collection by people of his own village. In all law suits involving a contractor and villagers, the former was invariably an outsider. On the other hand, a local contractor would rather resign his contract than proceed against delinquent farmers of his village.

4. The contract system is typical of Saryu Valley. Each of the two ID system of this area (Lweta and Jingal minor) has elements of the hara system in their management.

5. Beneficiary farmers invariably try to dislodge a contractor of long standing in the hope of getting a new contractor who will agree to a lower hara rate. Older systems have contract terms with progressively dropping hara rates

6. Whether oral or registered, terms and conditions of a contract are clearly known to all and are fully respected.

7. Successful hara-based systems invariably have sufficient water at the source. This results in overirrigation. Also, since the contractor does the entire work of irrigating fields, the farmers have little to do in the fields after plowing operations and broad-casting sprouted rice seeds in their prepared fields. Even though it is claimed by farmers that rice yields are as high under this practice as for transplanted rice, this is incorrect and unscientific. Very little area is under transplanted rice in most hara systems.

8. The contract system is appropriate where availability of agriculture labor is low and its cost high. Since per family landholding size in the hills is very small, family members have to migrate temporarily to earn an additional income. In the hara system, much of the work is performed by the contractor, obviating the need for hired labor.
9. A strong contractor may ignore the wishes of the less-articulate farmers causing dissatisfaction among them. A weak contractor is no more than a paid employee, who is also frequently cheated out of his hara.
10. The number of irrigation-related conflicts are reduced to a minimum as no cultivator is permitted to disturb an irrigation sequence which was agreed to in advance by the villagers or which has been in effect for a long time.
11. Since farmers pay for irrigation from their harvest, they make no investment for this activity at any time. This is an important consideration for the hill people who have very low incomes and rarely have ready cash.
12. The initial investment towards the cost of building a new system is borne entirely by the contractor, as are the O&M costs.
13. Detailed instructions regarding the duration of the irrigation to be provided in the various hamlets of a village are given.
14. The contractor is forbidden to give water from the system to any other village, without the prior consent of the village entering into a contract. On their part, the villagers may not bring water on their own or employ another contractor while the contract remains in effect. If the villagers violate this condition, they are liable to pay the costs incurred by the contractor.
15. The villagers surrender their right to transfer the system to the Irrigation Department. Any contrary action on the part of the villagers, or action taken by the ID to take over the system is considered illegal.
16. The contractor receives hara for a specified period. The share of different crops and vegetables grown in the irrigated land and other details such as those pertaining to default in payment by anyone, are given in detail in the contract.

While no one save the contractor is allowed to irrigate the fields, the contractor is not free to make any changes in the established irrigation sequence. He must not only be fair but must also appear to be so. Conflicts with clients can mean higher management costs and lower returns and ultimately loss of the contract. On the other hand, higher yields result in a happy client and happier contractor as he stands to collect larger absolute quantities as his share of the crop.

Contractor-run irrigation systems can be rated among the most user-friendly systems and that perhaps also represents a slight disadvantage. The clients become lazy and unthinking. However, under the circumstances created by migration of the male work force from the area, this innovative management method provides a much-needed service to the community.

## PERFORMANCE OF CONTRACT SYSTEMS

Performance of contract-managed systems under all parameters, e.g., productivity, equity of water distribution, net return of income to the farmers and management efficiency, turned out to be the highest among all the systems examined. System sustainability was never in doubt for contract-managed systems.

## SYSTEM OPERATED BY IRRIGATION COMMITTEE

Another FMIS which was run by elected representatives of beneficiary farmers had a very high level of equity in water distribution. The system suffers from insufficient water availability at the source, particularly during the hot summer months. Yet within the system, the location of a field whether, at head end, middle or tail end, did not affect water availability to the field. Productivity levels in this system were lower than those obtained under the contract system but quite satisfactory in the overall context of productivity of irrigated agriculture in the hills.

Insufficient water availability in state irrigation systems often leads to serious conflicts. In this system, shortages were handled by the committee quickly and effectively, by penalizing defaulters irrespective of their social or political status.

## STATE IRRIGATION SYSTEMS

In state-owned systems performance depended very much upon 1) length of the canal and 2) distance of the system from a motor road and district administrative headquarters. Long canals were difficult to operate and to maintain and suffered from highly inequitable water distribution between head- and tail-end sections of the system. Their productivity levels were nonuniform and varied between and within systems. Sustainability of the system was ensured by the injection of substantial funds by the state as well as by "voluntary" though unwilling labor inputs by beneficiaries, in critical maintenance activities. In this sense, therefore, some of the state systems could be considered to be jointly managed.

## CONCLUSIONS

Irrigation canals of short length (up to 3 km) appear to perform most satisfactorily under the conditions prevailing in the U.P. hills. As the average area of land held by an average family is small (less than 1 ha), and more than half of it is usually unirrigated, efficient performance of a system is reflected in productivity levels and in its uniformity across a system. This in turn affects net returns to farm family from irrigated agriculture.

Irrigation costs to the farmers represent another important parameter. Where these costs are high, farmers tend to neglect the system and community participation in O&M activities dwindles until it ceases altogether. Alternatively, the users of the system try to hand the system over to the state in order to pass the burden on to the state Irrigation Department. Such a transfer is not always and uniformly beneficial. Quite often, farmer distress and dissatisfaction with the system has been found to begin soon after the transfer has taken place.

Innovative O&M options such as the contract system, highlight the importance of system management as a critical parameter in performance evaluation. In backward areas within poorly developed economies, state intervention in the irrigation sector is a considered policy option and is designed to act as catalyst in development. Joint management of state-owned irrigation systems with the ultimate aim of turnover of the systems to the community is a desirable goal. Division of O&M responsibility between the state and the beneficiaries in such situations could spell out cost-sharing modalities. Costs to the farmers would determine sustainability of such systems and would therefore represent an important performance indicator.