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Death of *Kuhl* Irrigation System of Kangra Valley of Himachal Pradesh: Institutional Arrangements and Technological Options for Revival

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ABSTRACT

The analysis of three Kangra *kuhl* irrigation networks suggest that these irrigation systems, though under stress during the seventies, were still operative and persisting till late eighties and supporting predominantly the age old paddy cultivation practices in the area. The *kuhl* irrigation system gradually came under acute stress during nineties and became almost defunct. Each *kuhl* is governed by a set of rules and the institutional arrangements of *kuhl* network demands more participatory labour, rather male labour intensive activities for the sustainability of the system. The opportunity of non-farm employment to the water users in the area rendered the *kuhl* irrigation system with declining participation of the communities and to virtual collapse of the system. The paddy lands are now without irrigation water in the *kuhls*. Water User Associations lacked motivation and resources as well as recognition. The emergence of land allottees, migrants and the establishments of new households and the institutions in the area for water use from the Government or local authority triggered the initiation of the stress in *kuhl* network in the 1970s. The non-farm employment and the male power outflux resulted in poor water enforcement of water rights within the village. The supplementary irrigation sources could not be maintained and the paddy cultivation started declining and ultimately has gone out of cultivation. Farmers adjustments are in the form of keeping land fallow during *kharif.* Wheat cultivation as *rabi* crop has been mechanised with the entry of small tractors for sowing of wheat crop. *Kharif* fallows have given rise to dairying enterprise with one or two jersey cows. The per capita milk production and availability of milk has increased on these households. *Kuhl* system induced farm mechanisation in favour of dairying has taken place displacing paddy cultivation. The adverse environmental effects are in terms of low availability and the availability of downstream as supplementary source of irrigation has dwindled. *Kuhls* used to run on 340 to 350 days annually on their own in 1989 have been running only for 25 to 50 days under strict watch and ward at the actual user level in mid- and lower clusters. The Government efforts has resulted in the creation of new middle cluster in these *kuhl* networks without ensuring the running the system. The vegetable cultivation at small scale is being supported by ground water/hand pumps meant for drinking water. With the defunct of the *kuhl w*ater systems, increasing stress is on the use of ground water. Even in this sorry state of affairs, the Government has taken over the authority of two *kuhls* and made the *kuhls* concrete/*pucca*. The difficult route of *kuhl* has been made smooth with the concretisation but there is no water availability. Mere concretisation of *kuhl* is the wastage of MGNREGA funds. Alternative rules and arrangements need to be framed for participation, water use and adequate sensitisation of users in ensuring its continuous flow. The *kuhls* need arrangements for making water flow regular. Since paddy cultivation has gone out of scene, the water rights need to be redefined. The rights for continuous flow of the water has no relevance at present time, the rotational pattern for water use even for paddy crop would also help in sustaining the system and ensuring cultivation of agricultural lands. The *kuhl* committees also need to be advised on sound ecological principles to agree to these terms to ensure the survival of the *kuhl* system. The creation of joint storage capacity at diversion sites for contiguous networks and generation of water based non-farm employment opportunities would help in the revival of the system on sustainable basis.

Keywords: Kuhl irrigation system, Water Users Association, Institutional and technological options

JEL: Q11, Q15, Q16

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I

INTRODUCTION

A number of studies like Bottrall (1981), CGIAR (1983), OECD (1983), USAID (1980 and 1983), and Hotes (1984) have highlighted that the benefits of large scale irrigation schemes are generally far below expectations. National objectives of irrigation development (*e.g.* self-sufficiency in food, earnings from exports or savings from imports, higher rural incomes) are seldom realised. Taking lessons from it, participation of local community at distribution end of large scale irrigation projects was widely advocated, and as a result the role of water user associations and other local management initiatives were initiated to reduce the inefficiency in water use and system management. However, the failure of central and large scale programmes do not imply that the local and community level management will be successful. There remains much ambiguity on state and local community level relations, patterns of investment and resource use, and the awareness creation mechanism on efficient natural resource management. The present paper is an attempt to analyse the sustainability aspect of the famous community managed gravity flow irrigation system of Kangra valley of Himachal Pradesh, the unique *kuhl* irrigation network, which came into existence by the beginning of British colonial rule in Kangra in 1850. This irrigation system comprises approximately 715 large *kuhls* and around 2500 small *kuhls* (Baker, 1994). These *kuhl* irrigation networks are now under increasing stress and are in a very dilapidated condition. This unique Asian irrigation system worked well till the eighties and subsequently in a short period of 30 years, persistent negative changes became clearly visible, and there is a virtual collapse of the network. To revive the system, the Government of Himachal Pradesh is also making interventions in the form of taking over the system and making the *kuhl* structure concrete. However, such corrective measures may not be based on sound ecological and sustainability principles, and may lack social acceptance. A detailed study of the entire *kuhl* network would be important to address the concern of the sustainability of the system. The present paper is an attempt to analyse the institutional arrangements for water use in three contiguous *kuhl* irrigation systems, and the factors responsible for the sustainability of the systems. Specifically, the paper was prepared with the following objectives: (i) To analyse the functioning of the complex *kuhl* (hill) irrigation system in reference to the institutional arrangements associated with it. (ii) To analyse the factors responsible for making the irrigation system unsustainable and defunct and (iii) To analyse the efficacy of technological interventions being carried out for revival of *kuhl* irrigation network.

II

DATA AND METHODOLOGY

The paper is based on a study carried out at two points of time in a cluster of villages irrigated by three *kuhl* irrigation networks of Kangra valley in Himachal

Pradesh. The first study was carried out in 1988-89 as part of the Ph.D. programme of the first author. During 2012-13, a rapid appraisal survey was also conducted in a self motivated exercise. Palampur *tehsil* of the district was purposively selected as it has *khads* (torrents or small rivulets or tributaries of river Beas) that have more than 30 major *kuhl* irrigation networks originating from them. One *khad*/rivulet (*Awah Khad*) having more than 50 such networks was selected, and three contiguous networks (*Pantul, Daei and Bharul Kuhl*s) originating from *Awah Khad* were finally selected to understand the community level institutional arrangements for the functioning and water distribution pattern as well as interdependence amongst these irrigation networks. The *kuhl* networks were further grouped into clusters comprising one to four villages/sub villages/hamlets for understanding the inter and intra village relations, the role of water user associations in the use of water and in the functioning of the network. The information on functioning of the system and water use pattern in inter and intra clusters was compiled by interviewing the users in a group of 4 to 6 users at both the points of time of the study. The information pertaining to socio-economic status, land use and cropping pattern, farm productivity and profitability was compiled by interviewing 20 farmers, both water right holders for *kharif* crop (WRHKh) and non-WRHKh per *kuhl* network at both the points of time. The secondary information about *kuhl* networks and their statements of institutional arrangements was obtained from the Palampur *tehsil* headquarters (Office of Palampur Tehsildar, 1899). Information about the soil quality was obtained from the analysis of soil samples from command areas, analysed at Soil Testing Laboratory, Palampur. Simpler tabular analysis was used to present the results. Section III of the paper presents the description of the *kuhl* networks in Kangra district, while Section IV discusses the institutional arrangements describing the relations and people participation in the network. Section V gives a description of the factors responsible for the death of the irrigation system and Section VI describes the measures for ensuring the sustainability of the system.

III

RESULTS AND DISCUSSION

Description of the Kuhl Networks and Unique Paddy Cultivation Practices

The Palampur valley of Kangra district in Himachal Pradesh was once known for plenty of water (as it derives its name from a latin word '*Palam'* means plenty of water) and thus for irrigated agriculture and also for paddy cultivation. It is geographically located at the southern slopes of the *Dhaula Dhar* range of the outer Himalayas which fall precipitously away from the valley below so that the mountain appear from a distance to rise almost perpendicularly (Parry,1979). The valley is served and drained as well, by a series of rapid torrents (locally known as *khads)* which receive most of their initial supply of water from the melting of snow. The prominent among them are *Binwa*, *Awah*, *Neugal* and *Baner*. These *khads* are the major sources of irrigation water in the valley where from the water is conducted with gravitational flow to the cultivated area, through numerous narrow cuts like canals locally known as *kuhls*. These *kuhls* emerge from both sides of the banks of the *Khads* and traverse its way through very rough course at numerous points to the command cultivated area located 10-15 kilometers away from the head works, and the irrigated area by these networks is charged with both land revenue and water revenue (Douie, 1899). *Kuhls* are not the same in terms of size, length and coverage of area for irrigation. *Kuhls* vary in terms of the vastness and the slope/gradient of the cultivated area, productivity and the water-holding capacity of the soil of the cultivated area. The *kuhls* also vary in terms of the availability of alternative post-monsoon sources of water, the scale and scope of coordination required for managing the *kuhls,* and the degree of social and economic inequality among the *kuhls*. Almost all the networks also capture the seasonal *kuhl*-water (the small seasonal *kuhls* locally known as *chow)* to supplement the main *kuhl*-water supply particularly the distantly located lower portion of the command area at the middle and/or tail end when the monsoon sets in and there is enough water for diversion to the cultivated fields. The lower portion of the *kuhl* command area disengaged from the main system when the monsoon season sets in (Coward, 1990), and the seasonal *kuhls* meets the requirements of irrigation water which largely captures water from the base flow of ground water.

The *kuhl* networks selected for study are *Pantul*, *Bharul* and *Daei* networks (Table 1) which arise from the left bank of *Awah Khad*. These three networks have diversion site/head works one after another at a same place (100 to 300 meters away from one another). The command area of these networks comprises 4 to 6 village clusters representing 10 to 16 hamlets located contiguous to one another in such a way that the command area of one village is located on a flat surface having gentle slope and it gets separated from its contiguous village by a small drain (about 20 to 50 ft deep) originating just a kilometer or two from upside of the village. While *Bharul* network is towards East of other two networks, *pantul* and *daei* networks are having command area at about 10 to 12 kms below the diversion site. The command area is located one after another with *pantul* command area being at upside of the *daei* command area. Although all these three networks have one common upper most cluster, these networks differ its course. While *Bharul* network command area is gradiently located one after another, *daei* and *pantul* networks after irrigating the upper most cluster (in addition to *bharul* network) traverses, in an intertwined fashion, a long stretch of uncultivated area (in 1989) and then convert into 6-7 distributaries at a mid point about 2 to 3 km upside the command area. While the length of the segment from headworks to last point of the command area is 8 to 12 kms in these networks, the total length of the *kuhl* main channel and its distributaries varies from 33 km in case of *Bharul* network to 51 kms in case of *Daei* network.

Each network has also supplementary source of irrigation water during monsoon period.

TABLE 1. LOCATIONAL AND TOPOGRAPHICAL DESCRIPTION OF SELECTED *KUHL* NETWORKS

Kuhls (1)	Hamlets (No.) (2)	Clusters (No.) (3)	Common clusters (4)	Longest segment of *kuhl* (km) (5)	Total length of *kuhl* (km) (6)	Command area/ cluster location (7)	Relative network location (8)
Bharul	12	4, (UM,U, M, L)	1	10	33	Serially located along the gradient and in proximity to UM cluster	Emergence from left bank, Intertwined in upper portion and east of *Pantul* and *Daei*
Pantul	10	7 (UM,U, EE,E,C,W,EW	1	8	39	Contiguous but separated by 20-30 feet deep natural drains, and approx. 6 km away from UM cluster	Intertwined with *Daei* in upper and lower portion and towards the West of *Bharul* network
Daei	16	6 (UM, EE,E,C,W,EW)	1	12	51	Contiguous, gradiently below *Pantul* command area, and separated by 20-50 feet deep natural drains. Approx. 9-10 km away from the UM cluster.	Traverses through *Pantul* command area

Note: UM, U,M,L,EE,E,C, W,EW stands for upper most, upper, middle, lower, extreme east, east, central, west and extreme west side clusters. WRHKh stands for water right holders for *kharif* season, i.e., for paddy cultivation.

Table 2 presents the extent of command area of each *kuhl* network. These networks have *haar or dhani* command area varying from 75 ha to 146 ha and *lahr* areas varying from 32 to 76 ha. The cultivated area located along the banks of the river/*khad* or otherwise having flat surfaces with good clay content and water-holding capacity are locally referred as *"haar" or "abbal nehari or dhani"* areas. These areas follow rice-wheat cropping system. For these areas, *kuhls* are the main source of irrigation water for paddy planting in May and June. *Kuhl* command areas has also undulating and not so plain cultivated surfaces on ridges and plateau tops. These areas also include those areas which were earlier uncultivated, barren or surplus lands along the *kuhl* network even in higher, middle or lower clusters (Sharma, 2000), and have been distributed by the Government to allottees (Government of Himachal Pradesh, 1974). These areas are having higher sand content in the soil, low water holding capacity, highly degraded or eroded or having comparatively very low organic content and are considered less fertile areas, follow generally less water requiring maize-wheat cropping system and are locally referred to as "*lahr*" areas.

These *kuhls* also irrigate these "*lahr*" areas or Government allotted areas mostly on rotational basis.

TABLE 2. EXTENT OF PADDY CULTIVATION IN *KUHL* NETWORKS

	WRHKh cultivated area covered (ha)			Other area covered (ha)			Supplementary *kuhls* (Nos/ area irrigated per *kuhl* in ha)			Avg. holding size (ha)	
Kuhls	1989	2013	Per cent change	1989	2013	Per cent change	1989	2001	2013	WRHRh	Others
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Bharul	75	12	-84.00	32	25	-21.87	8 (6.2)	2	2	0.68	0.40
Pantul	94	4	-94.74	42	34	-19.05	5 (5.6)	2	1	0.66	0.31*
Daei	146	19	-86.98	76	60	-21.05	11 (7.1)	5	4	0.71	0.44

Note: UM, U,M,L,EE,E,C, W,EW stands for upper most, upper, middle, lower, extreme east, east, central, west and extreme west side clusters. WRHKh stands for water right holders for *kharif* season, i.e., for paddy cultivation.

The cropping pattern in *har* or *dhani* areas used to be paddy-based system comprising two-year paddy-wheat-paddy-linseed (linseed as zero-tillage crop) predominant cropping sequence with wheat and linseed grown simultaneously in such a way that the area under these crops was interchanged every year. The preponderance of rice crop during *kharif was* attributable to clayey soils and fielded-to-field application of irrigation water that leaves no option to any farmer in the area to grow anything other than rice. Since all the farmers needed water for the cultivation of paddy, the distribution of water becomes more problematic during *kharif* sowing of paddy crop when demands for water were highest and supply of irrigation water, both from rainfall and stream diversion is low. Paddy planting period is short in the valley (as delayed planting results in low yields due to low ambient temperature during ripening of the crop). For successful raising of paddy crop on these lands, it is important that the crop be sown in time and vital interculture operation "*hod*" be performed at appropriate stage of the crop by the time monsoon sets in. Hence, paddy sowing in the valley is carried out mostly during May or early June. Consequently, three typical or unique paddy sowing techniques emerged in the valley, *viz*., (i) Dry seed broadcasting- (DSB), (ii) Sprouted seed broadcasting on puddle fields – (SSB) (locally called *maach*); and (iii) transplanting-TSP (Sharma, 1990). The selection of a particular planting technique depends upon the availability and reliability of *kuhl* irrigation water as well as the location of the fields with respect to the *kuhl* channel and availability of male manpower in the family (Sharma, 1990). Since continuous flow of irrigation water is required for paddy cultivation, the farmers in *dhani* area has rights to use continuous flow of *kuhl* irrigation water as per statement of rules contained in a book at *tehsil* headquarters. *Kuhl* water to different villages and also to individual farmers within a network is distributed proportionally as per these rules. These farmers have been referred as water right holders for *kharif* (WRHKh) while farmers in *lahr* areas or other than paddy lands do not have the rights for *kharif* and irrigation water within the village is used on rotational basis for pre-sowing *kharif* irrigations as well as for *rabi* crops.

These *kuhl* networks and the paddy cultivation, as represented above, were quite functional till late eighties. Constant to decreasing returns to scale were operative under different paddy planting techniques (Moorti *et al*., (1996), and the availability of irrigation water was becoming a major constraint in paddy cultivation. By 2013, the *kuhl* network became dead, did not flow during summer and *kharif* seasons and the paddy cultivation was abandoned. Paddy area to the extent of 84 to 95 per cent in different *kuhl* networks got reduced and rendered *kharif* fallow. In the absence of paddy cultivation, the supplementary source of irrigation water (seasonal *kuhls*) could not be used and hence, gradually reduced and some of them got abandoned.

IV

FUNCTIONING OF THE COMPLEX *KUHL* (HILL) IRRIGATION SYSTEM

Each *kuhl* network is managed by a set of rules called ‘water rights” which become operational during *kharif* season and the distribution of water between and within *Kuhl* irrigation system at the time of paddy planting till all the interculture operations are performed, is carried out accordingly. By late eighties, the availability of irrigation water was highly varied among the village clusters even within the single *kuhl* network and so were the rice cultivation techniques. Since all the farmers needed water for rice cultivation, the distribution of water then used to become more problematic during *kharif* sowing period when demands for water were the highest and supply of irrigation water both from rainfall and *kuhl* was low. Within the *kuhl* system, the common uppermost cluster had the first claim to use irrigation water for the *kharif* sowing using SSB technique. With a time lag of 7 to 10 days, the paddy sowing in upper, middle and lower clusters used to get started. It is a statement of irrigation water rights that the uppermost cluster will use water at will while there is a proportional allocation of water for other clusters downstream. Considering the reliability of the availability of irrigation water, a suitable paddy planting technique was adopted. As sowing proceeds down the *kuhl* irrigation, a duel pattern of water distribution used to exist, *i.e*., the irrigation water of *kuhl* was demanded on rotational basis as well as on continuous supply basis for paddy planting at the same point of time within a network. The continuous flow was need for SSB while rotational basis was followed for DSB. When the major interculture operation, *hod* (an intercultural and thinning operation in which about one month old standing rice crop (in both DSB and SSB techniques) is ploughed down in standing water) got completed in lower reaches, sufficient reconfiguration in *kuhl*-network used to take place. The lower reaches having access to seasonal *kuhls* goes disengaged from the main *kuhl* network when the monsoon sets in and the water distribution in the reconstituted network switched to a continuous flow in an amount proportional to the area served., TSP was followed in lower clusters when sufficient water was available in seasonal *kuhls* with the onset of the monsoon.

A critical look at the Table 3 reveals that availability of irrigation water as well as rice cultivation was highly varied among the village clusters even within a single *kuhl* network. The upper most cluster used to grow entire paddy by SSB while 67 per cent of paddy cultivation in middle and lower reaches was DSB. By 1989, all the *kuhl* networks were operational. Subsequently, the number of developments took place in nineties and thereafter. Besides the topographical (one *kuhl* irrigating many villages and one village getting irrigated by more than one *kuhl*), climatical (sowing of paddy early to avoid low temperature in during grain setting) and agronomical factors (different paddy planting techniques), the other socio-economic factors also came in to existence which proved more detrimental for the system. By 2013, all the *kuhl* networks are defunct/dead for varied reasons.

V

FACTORS RESPONSIBLE FOR THE DEATH OF *KUHL* IRRIGATION SYSTEM

(i) *Subsistence Agriculture, Low Crop Yields and Emergence of Dairying Enterprise*

The holding size of WRHkhs is small and vary from 0.66 to 0.71 ha. Though there exists unequal land distribution among upper castes and lower caste farmers, the variation is quite less in these networks. The agriculture is of subsistence level in the networks. The net farm income in itself was very meager, negative in some cases. With annual production of about 3.5 tonnes of food grains on an average, if carried out successfully, the outflux for non-farm employment was high. With the usurping of irrigation water by migrants, government allottees or state agricultural universities (SAU), the community managed *Kuhl* is in a dilapidated condition and water rights of actual land users have lost meaning as the system has become non-operational. Consequently, land owners preferred to keep their land fallow. As a result the cropping pattern in the command area has changed. The cumbersome paddy cultivation by WRHKhs has declined. With the passage of time, the paddy lands were left uncultivated during *kharif* season. The pasture grown in the uncultivated area gave impetus to the very meager dairying activity on individual farm fields. The farmers were left with one option of growing wheat crop in *rabi* season. The entry of small tractors in valley areas while facilitating wheat cultivation wiped out the rearing of the bullocks completely. Consequently, the area under paddy has been reduced and paddy-wheat cropping sequence has gradually been replaced by *kharif* fallow (for fodder/grazing)-wheat. Fallow-wheat cropping system has reduced drudgery to both men/women to a great extent. The livestock component of the farming has gained importance and milch animals have increased not only in numbers but in quality too with the availability of fodder and grazing facilities in those lands which were once famous for paddy cultivation.

TABLE 3. INTRA-VILLAGE WATER DISTRIBUTION PATTERN OF *KUHLS* – CHANGES OVER TIME

		1989					2013			
			Rice planting technique used		Water distribution pattern					
Category* of village cluster (1)	AvDP (2)	Cropping pattern (3)	Technique (4)	Time (5)	At sowing time (6)	After inter-culture operation (hod) (7)	Cropping pattern (8)	Reduction in year 1989 rice area (per cent) 9)	Crop planting techniques in use (10)	Water distribution pattern (11)
Upper most and Upper cluster	8**	R-W (80 per cent) R-L (20 per cent)	SSB (100 per cent)	Mid-May	Continuous flow	Continuous and at will	R-W (70 per cent), F-W (30 per cent)	UM- 15 per cent U- 30 per cent	SSB-40 per cent DSB-35 per cent TSP-25 per cent TOW-100 per cent	Continuous and at will
Middle, Lower and Contiguous clusters @@	5***	R-W (50 per cent) R-L (50 per cent)	DSB (67 per cent)	May end to mid June	Rotational	Continuous and Proportional. 50 per cent area disengaged after rainy season	R-W (20 per cent), F-W (80 per cent)	M- 85 per cent L-65 per cent	DSB-60 per cent , TSP-40 per cent	- For *kharif*, no regularity. - for wheat, rotational but for limited irrigations.
		R-W (80 per cent), R-L (20 per cent)	SSB (30 per cent)	Mid June to end June	Continuous and Proportional	Continuous and Proportional	F-W (80 per cent), F-B and O (20 per cent)	M-100 per cent L-100 per cent	–	-do-
		R-W (100 per cent)	TSP (3 per cent)@	Early-July	Continuous and Proportional flow	Disengaged	R-W (10 per cent) F-W (90 per cent)	M-100 per cent L-50 per cent	TSP-100 per cent	Disengaged, Rotational from supplementary *kuhl*

Sources: Sharma, 1990, 2000; Sharma *et al.*, 1994; and Survey and Communications in 2013.

Notes: R-W, R-L, F-W, F-BandO, SSB, DSB, TSP and TOW refers to rice-wheat, rice-linseed, fallow-wheat, fallow- barley and oats, supported seed broadcasting, dry seed broadcasting, transplanting and tractor operated and sown wheat, respectively. AvDP refers to average distribution points per cluster.

* - The classification of villages is as per the location of the village with respect to irrigation network. The elevation of village clusters and of their command areas declines as one proceeds along the irrigation network and water flows with gravitational force.

** - Mostly individual farm fields.

*** - a group of 5 contiguous villages in Pantul and Daei *kuhl* located at the same altitude but separated by seasonal creeks. These hamlets are irrigated by 6 branches of Kuhls emerging out at a single or multiple points in the middle reach portion of the *kuhl*.

@ - Transplanting in lower cluster is done when water supply is too meager for sowing rice in time. The meager supply of water is them used for nursery raising and crop is transplanted when sufficient water is available after rainy season has set in.

@@ - The middle cluster was virtually non-existent on Pantul and Daei *kuhl* network. The upper stretch was consisting of mostly tea orchards, pasture lands and govt. lands which have been allotted, sold and made cultivated lands now. These areas now act as upper clusters.

(ii) *Institutional Arrangements and Declining People Participation*

These selected *kuhl* irrigation networks are under community management. Each network has its own water user association (*kuhl* committee) responsible for its functioning and management which discharges its functions through independent set of rules and regulations. Each network thus, demands strong participation from its users for its annual maintenance and to ensure the flow of large volume of water during peak periods. However, the availability of water is low in tail-end clusters while the burden of maintenance of the main *kuhl* is higher on the farmers of tail-end and middle-reach villages (Sharma, 1990). The cleaning of the *kuhl* has to start from the tail-end and the farmers from these areas have to participate in cleaning the *kuhl* up to the headworks. Under such conditions of unequal distribution of contribution of labour for maintenance, the farmers lost interest in participation in the maintenance with the increase in non-farm employment among the villagers. The water user associations or the *kuhl* committees appoint a water master (*Kohli*) for enforcing the rules for the distribution of water, solving water disputes as well as for maintenance and repair of the system. However, the *Kohli's* authority has also been eroded. Now the coordination between the head and the tail end farmers has decreased because of increase in non-farm employment.

(iii) *Absence of Male Manpower for Night Guard*

Keeping in view the subsistence agriculture in the area, the demand for non-farm employment was quite high. On account of the pull of non-farm employment, the effective male manpower of water user households remain outside the locality. On the other hand, it was necessary to guard the *Kuhl* during odd night hours to save the water from theft by other village clusters or from other networks (night visits up to the head works were made all along the length of the *Kuhl*). The difficult operation of night guard was performed by the male manpower of the farming community. As a result the paddy cultivation which was generally cumbersome became almost difficult on those farm holdings which lacked in effective male manpower. These farming units were first to abandon the paddy cultivation.

(iv) *Increasing Non-Farm Employment and Decreasing People Participation*

The WRHKhs in the networks (comparatively better developed in terms of human development indicators even in early seventies) went outside the villages/valley to earn a livelihood and support their family back through money orders (a typical money-order economy). Gradually, the people from lower caste strata and the labourers also preferred non-farm activities compared to agricultural operations implying thereby that small-scale low-value agriculture has reduced to a subsidiary source of employment generation for labour. A study based on NSS on employment and unemployment on Kangra district (Sharma *et al.*, 1999) also highlights that the incidence of rural non-farm employment was found increasing in Kangra district varying from 29.35 per cent in 1971 to 36.56 per cent in 1991 and the distribution of incremental work force in non-farm activities has increased from 22 per cent during seventies to 52 per cent in eighties. The trends of increase in non-farm employment are continuing till date, highlighting the scarcity of labour for agricultural operations. With increasing income levels and the development of human indicators, the preference for drudgery reducing enterprises such as use of tractors for wheat sowing and abandon of cumbersome paddy planting has increased. Increased non-farm employment has affected *kuhl*s in 4 ways: decreased participation in *kuhl* maintenance, increased inequality and conflict between head-end and tail-end farmers in terms of water consumption and contributions for repair and maintenance, decline in the authority of the *Kohli* and his ability to enforce rules, and changing cropping patterns (Baker, 1994).

(v) *Entry of New Water Users and Increase in Command Area*

The *kuhls* command area lies just 3 to 8 kilometers away from the Himachal Pradesh Krishi Vishwavidyalaya, Palampur. When the SAU was established, it started using water at will from these *kuhl*s, especially the pantul and daei. Subsequently, an agreement with the pantul *kuhl* water user association/committee was made by the University which was more pro-university and detrimental to the interests of the farmers. As per agreement, SAU agreed to guard the water in upstream areas and use water at will. After the agreement, the volume of water as well as its frequency of running was reduced considerably. The establishment of SAU in the uncultivated area through which the pantul and daei *kuhl* passes, has emerged as an artificial and unbearable upper cluster to the network.

In addition to the establishment of SAU, the government allottees and the migrants have also settled as new water users in upstream areas using water at will and making network more stressed and unbearable to the water right holders at middle and tail-end villages. As also highlighted earlier that the land owned by lower caste category households was once uncultivated land and belonged to permanent pastures, dilapidated tea orchards or community land category and with its allotment to them has now been converted to cultivated land. The cropping pattern on new land holders was initially maize-wheat which gradually changed to paddy-wheat (Table 3) consequent upon usurping the irrigation water of WRHKhs. The “new cultivated land” thus formed; put a great demand for irrigation water. Despite the fact that these “new land owners” have no water rights during *kharif* and particularly for paddy cultivation, these households are growing paddy and using water as per their will for they are located suitably with respect to the irrigation source. The *kuhl* irrigation source has to pass through their fields to reach to water right holders. As a result the *Kuhl* irrigation system went increasingly under stress and rendered the paddy cultivation on the small holdings of water right land holders (or on the so called Abbal Nehari land) almost difficult. As a result, the paddy lands are being kept fallow and the cropping pattern has undergone a tremendous change. The Government policy of land allotment to landless people errored in respect of using *kuhl* irrigation water and in sustaining the system for posterity.

(vi) *Entry of Tractor into Hill Harming*

With increase in mechanisation everywhere, the tractor has also found access to cultivate the small fields in the kuhl command area as early as in 1999 and it has proved a boon for cultivating *kharif* fallow lands for wheat crop sowing. The advent of tractor for cultivation in the area has provided an alternative for not to rent out the land and also to keep the land cultivated without any fear of loss of land. Also the social taboo of keeping land fallow during *kharif* get eliminated as the land gets cultivated at least once in a year. These factors thus prompted the farmers to avoid paddy cultivation.

VI

INSTITUTIONAL AND TECHNOLOGICAL OPTIONS FOR REVIVAL OF THE *KUHL* IRRIGATION SYSTEM

As complex local arrangements exist for water distribution and maintenance of every type of community *kuhl* irrigation network, these rules worked out the broad relationships among various village clusters as well as individual farmers, on the basis of area irrigated, during peak periods of rice sowing. Though these rules suggested precision and symmetry both, however, the formal allocation of water was neither matched by precision in measuring the actual flow of water not based on the actual water requirements of the area (Coward, 1990). Technological interventions are required for the actual water measurement and distribution amongst broad groups or village clusters. For this, restructuring of the water use rules is required, such as the provision of imposing fines for rendering the *kuhl* in-operative, recording of information pertaining to the running of the system, devising ways to ensure people participation and link it with non-farm employment generation, and devising ways for reducing need for watch and ward, and for mobilising funds.

The selected *kuhl*s are interdependent to one another and the water of one system is also used in another command area at peak periods by the farmers. The head works of these *kuhl*s are very delicate and very often washes away with the flooding in the *khad*. Sometimes the washing away of the headworks takes months to repair. This was the case with daei *kuhl* which remained dead for almost a year. The institutional arrangement in *kuhl* management could not reduce the high degree of risk and uncertainity associated with the frequent breakdown of the systems and hampering predictable supply of water. The storage capacity needs to be imparted to *kuhl*s networks as these irrigation networks are without any storage capacity as per *kuhl* network management rules according to which the *kuhl* if made pucca or provided with some storage structure will capture a large volume of water limiting the availability of water to the originating network downstream. Since storage structure is lacking, there is a considerable correspondence between snow melt, the amount of rain fall that has occurred, the condition of the bank at the head work/diversion site and the volume of stream of water available in the *khads* for diversion. The option of making one diversion site for three or more contiguous networks need to be explored which would reduce the burden of maintaining 3 or 4 different diversion sites at a delicate portion of the *khad*. The Himachal Pradesh Minor Canal Act of 1976 authorise the Irrigation and Public Health Department of the State to assume the control and/or management of any minor canal/*khul* if the owners of *khul* consents thereof (Government of Himachal Pradesh, 1976). Though, the control and management of some *khuls* in the vicinity have been taken over by the IPH Department with limited success, the network was not provided with any storage capacity nor any deterrent to unlawful usage of water in upper or mid reaches. The larger sized diversion site would act as a reservoir and render storage capacity to the networks for meeting the limited peak period requirements as well as provide number of opportunities for inter network water transfer. The other technological option is to provide the storage capacity at seasonal source of supplementary irrigation water. These options will also give ample opportunities for encouraging cold water aquaculture, sport fishing integrated with the *kuhl* irrigation system (Sharma *et al*., 1994). The area being near to Palampur city and other national institutions, water based tourism be promoted. The water user associations need to be made aware and their capacity need to be developed on these lines. This will provide the ways for generating additional income to make the system viable as well as to provide the non-farm employment to the local people.

In respect of *kuhl* development, the Governmentt of Himachal Pradesh is laying more emphasis on taking over the management of *kuhl*, making it concrete with MGNREGA funds or from other funds without giving more emphasis on rendering storage capacity to the system. The *daei* and *bharul kuhl* networks have been taken over by the Government and made them concrete. While the entire kuhl has been made concrete with the investment of lots of funds, the *kuhls* are without water for more than 2 years. Unless the employment opportunities and people participation is generated in running the network, mere creation of the infrastructure would not serve the purpose. While in the case of drinking water, the Government is gradually handing over the motorised hand-pumps to the community for operational maintenance, the reverse is true for *kuhl* irrigation. The revival of this age old community management system needs in-depth understanding of relations between villages, within villages and between networks, are the prime movers for encouraging people participation.

The *kuhl* command area has now been developed with good road and telecommunication network. It is now convenient to reach head-works within 20 minutes by using a vehicle, the points which were once inaccessible. The infrastructure so developed need to be utilised for developing a sound ICT based system of *kuhl* management on co-operative lines for giving the strength to this age old system.

VII

CONCLUDING REMARKS

Topographical, climatological agronomic, institutional and socio-economic factors are responsible for rendering the cultivation of paddy difficult and making it unproductive in *kuhl* command areas of Kangra valley. The abandonment of the paddy resulted in making the *kuhl* system non-functional. The revival efforts of these networks such as making *kuhls* concrete would prove futile unless sound system for promoting adequate people participation in ensuring the predictable supply of water in the *kuhl* network is developed. The technological interventions such as making head-works of two or three contiguous networks common in order to reduce the cost of maintaining three different head works as well as to impart storage capacity to the *kuhl*s will help in maintaining a regular flow of *kuhl* water. The generation of storage capacity at headworks will also give rise to community aquaculture, water sports and non-farm employment. *Khad*-based major works require that there must be a platform to conduct inter-network interactions for encouraging people participation, discuss broad-based projects, and seeking grants. The use of ICT need to be explored for developing sound *kuhl* management system.

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