Comparative Assessment of Farmer-Managed and Agency-Managed Groundwater Irrigation Schemes in Nepal

N. Ansari[56]

SYNOPSIS

NEPAL'S NATIONAL DEVELOPMENT plans have been targeting to turn rain-fed farming into irrigated agriculture in order to meet the food production needs. As surface water is not available everywhere and in required quantities all year round to increase the cropping intensity, responsible agencies of the government have been engaged in the development of groundwater irrigation schemes in the Terai and some inner valleys which have quite rich and rechargeable aquifers. However, various constraints are encountered in the implementation and management of groundwater development through deep tubewells (DTWs). On the other hand, during the last two decades a lot of shallow tubewells (STWs) have been installed by farmers themselves with the assistance of the Agricultural Development Bank of Nepal (ADB/N). The farmers draw water for irrigating their nonmonsoon crops and even during the monsoon period when the rains fail. The performance evaluation of these privately operated STWs has shown that the national average is only 2.0 hectare (ha) of irrigated extent per well as against 4.0 ha potentiality. It is because landholdings are smaller and neighboring or small landholdings do not have access to these private STWs. However, some operators do sell water to the neighboring farmers. Table 15.1 shows the present irrigation status of Nepal.

The agency-built and operated DTWs on large-project scale are performing better than the jointly managed DTWs on small scale, but the former is constrained by operation and maintenance (O&M) cost recovery. Recovery is so low that the sustainability of such schemes is at risk. The government policy is that at least O&M costs must be borne by the users but they are not willing to bear these costs. Hence, the agency has evolved a strategy to pass the O&M of the DTWs to the organized water user groups (WUGs) by stages. The sustainability issue and lessons learnt have been instrumental in changing many irrigation activities in Nepal. Now DTWs or community STWs are undertaken on the basis of meeting 75 percent of the costs by the agency. The remaining cost is shared by the users while the O&M is exclusively the responsibility of the users.

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56 Ministry of Water Resources, Nepal.

Table 15.1. Total irrigation coverage (net in '000 ha).

Region	Total cultivated area	Rain-fed area	Irrigated areas			
			Agency-managed schemes (AMIS)	Agency-assisted but FMIS	FMIS	Total
Mountains	227	193	–	15	29	44
Hills	1,055	867	15	28	153	196
Terai	1,359	638	252	161	308	721
Total	2,641	1,698	267	204	490	961

Notes: AMIS = Agency-managed irrigation systems (i.e., Department of Irrigation).
FMIS = Farmer-managed irrigation systems.

GROUNDWATER DEVELOPMENT FOR IRRIGATION

Need to Exploit Groundwater

Surface water is not available everywhere for supplying water to the potential irrigable areas. Also, existing gravity irrigation schemes are not able to meet the irrigation needs for multiple cropping. The climate is not favorable for farming all the year round to increase the cropping intensities. Hence, mostly the existing surface schemes fulfill the irrigation need as supplementary irrigation during the rainy season (monsoon) extending from June to September. Thereafter, the discharge of supply canals drops restricting water supplies to a limited extent of the command area for growing crops in other seasons. Under the circumstances, the exploitation of groundwater becomes inevitable. Fortunately, the Terai region and some of the inner valleys have rich and rechargeable aquifers both shallow and deep. In such areas groundwater can be harnessed for conjunctive use as well. In the areas where surface water is inadequate, groundwater will be the main source of irrigation. It is fully recognized that greater use of groundwater for irrigation would substantially raise the cropping intensities and incomes of the farmers. Now the farmers are being encouraged to install tubewells for supplementary irrigation of monsoon crops and full irrigation of dry season crops. Diversified cropping is introduced in tubewell schemes as there is an assured supply of water within one's control.

Historical Perspective

Surface Farmer-managed irrigation systems (FMIS) having a long history are very prominent in Nepal. Varied types of irrigation systems of all sizes have been built centuries ago. They are operated and maintained by the farmers own cooperative efforts. More than three decades ago groundwater use for irrigation was unknown except for some localized dugwells utilized for growing vegetables. But during the last two decades, the need to increase cropping intensities, has induced the farmers to install STWs of their own by tapping shallow aquifers, where available. There are some open dugwells also where static water table is high. Here farmers extract water by *suction* lift (centrifugal) pumps to irrigate the crops of their choice. Side by side with these

private STWs, government agencies have also developed quite a number of DTWs on a large-scale as well as on small-scale projects.

AGENCY- AND FARMER-MANAGED GROUNDWATER IRRIGATION SYSTEMS

Farmer-Managed Groundwater Irrigation Systems

Such systems mostly consist of STWs which are maintained and operated by the individual farmer or by a group of farmers. The ADB/N has played a pioneering role in the promotion of STW irrigation by providing financial assistance in the form of rural credit and technical assistance to a limited extent. ADB/N in accordance with its mandate has been involved in irrigation development since the 1970s. It has provided credit to individual farmers, small groups of farmers and communities mostly for installation of STWs and procurement of pumpsets. Besides treadle pumps and rower pumps, dugwells are being propagated in the Terai belt. Now thousands of hectares of farm lands are being irrigated utilizing the immense groundwater resources of the country.

Individual STWs

The government has fully encouraged the tubewell irrigation program by providing a subsidy to the farmers. The subsidy is administered by the ADB/N along with their lending. A short description of the program is given below:

- On the request of a farmer or a group of farmers, technical and geo-hydrological data are collected. The Groundwater Development Board (GWDB) under the Department of Irrigation (DOI) is responsible for groundwater exploration and groundwater resource evaluation. For any area, if sufficient data are not available then layer testing for shallow aquifers are done to assess the prospect of STWs.

- Then the applicant has to place all the documents and clearances for providing collateral to obtain the loan sanction. After the loan sanction, a loan agreement is signed between the farmer and the ADB/N.

- Pipes and other materials are supplied from the stock to the borrower farmer. If the field office does not have a stock, then a coupon is provided to acquire materials from the dealer. After successful drilling the value of materials is automatically converted into loan. If the farmer wants, he is given an additional loan for the pumpset.

- Specified drillers carry out drilling on work order from the ADB/N. Mostly the hand rotary drilling process is used. Depending on physical conditions of the Terai area average time taken is generally 5-10 days. One year's guarantee is provided by the driller during which period ten percent of the payment is retained. In general, drilling is tried at three places and if the attempts are unsuccessful it is considered to be a failure.

Community STWs

In small farmers' development program (SFDP) areas, small farmer groups are provided loans for STWs as community schemes. Farmers in one locality having at least 4 to 5 ha in holdings adjoining each other should form a group and approach the SFDP office for a loan and technical assistance for an STW unit. SFDP loan is provided on group collateral alone and the entire loan is recorded against the beneficiary group. The group repays the loan and the interest.

Group STWs

In areas where SFDP is not implemented, farmers with small landholdings form into groups for the purpose of obtaining loans for STW schemes. The process of getting a loan is same as in the case of an individual borrower. The collateral of each member is evaluated and loan instalment is divided among beneficiaries in proportion to the land irrigated. Loan amount is recorded separately for repayment. There are cases where a loan is taken in the name of one member of the group and divided among other members as well through internal arrangements. In the circumstance, ADB/N deals with one individual only.

Subsidy in Groundwater Schemes

Since the commencement of the implementation of groundwater tubewell schemes, subsidies have been provided by the government in various forms. In the initial days only drilling cost was subsidized. But during the last few years 40 percent of the total cost of the STW schemes including pumpsets is subsidized in case of individual schemes and 75 percent in the community schemes. Earlier, the subsidy was reimbursed by the government to ADB/N each year but now the total subsidy for irrigation is allocated in the national annual budget which is administered by the ADB/N and other agencies which implement the schemes.

Technical Characteristics

The depth of STWs varies by district and locality. Within 21 districts where STW irrigation schemes have been developed, the depth of wells vary between 8 to 50 meters (m) with an average of 20 m. Generally, the size of a bore is 4 inches (10 cm) in diameter and black casing pipes and strainers are used for these STWs. They tap shallow unconfined and semi-confined aquifers. All the STWs are drilled by simple indigenous methods like manual rotary, sludge and bogie. In case of DOI sunk STWs, rotary drilling machines were invariably used. The method of sinking a well depends upon the type of soil strata and depth up to which one has to go. All the wells are operated by diesel centrifugal pumps with horsepower (hp) capacities varying from 5 to 10 brake horsepower (bhp) (average of 6 bhp). In places where electric power is available farmers are desirous to electrify their units. In most districts the static water table drops down during the dry season when STWs are operated. But at the end of the rainy season it is recovered to the original status. It is estimated that by now more than 22,000 STWs are installed. Table 15.2 shows characteristics of STWs in summary form.

Agency-Managed Groundwater Irrigation Schemes

In the public sector groundwater exploitation for irrigation started in the 1970s. During 1975/1977 in the middle eastern Terai of Birganj area some 28 DTWs were installed with electric pumps in the northern part of Narayani Irrigation Project which is devoid of gravity water supply from the

canal. This includes rehabilitation of 14 DTWs drilled earlier and equipped with diesel engines. Earlier in 1968/1969 under the Minor Irrigation Program some DTWs were drilled and equipped with diesel-run turbine pumps in Sarlahi and Sirha districts and some artesian wells in Bhairahawa District. Birganj DTWs are equipped with submersible pumps with 25-30 m lifts capable of pumping 50-80 liters per second (lps). Here the net irrigable command area is 2,792 ha. All the main distribution canals are lined and have several division boxes.

Table 15.2. Characteristics of shallow tubewell units.

Valleys	Sample survey (1987/1988)	Sample survey (1990/1991)
Number of STW units	554	30
Number of pumpsets owned	352	30
Districts covered	18	6
Depth range (m)	8-50	8-35
Average depth (m)	60	47
Size of boring (casing)	10 cm	10 cm
Pumpsets	centrifugal (diesel)	centrifugal (diesel)
Horsepower range	5-10 bhp	5-8 bhp
Method of drilling	Manual rotary and rig machine	Manual rotary, sludge and bogie
Time to drill	5-10 days	5-10 days
Crops grown	Rice, wheat, maize and vegetables	Rice, wheat, maize and others
Hours of operation	119 hours	168 hours
Average irrigation per unit	2.18 ha	1.85 ha
Discharge (lps)	6-25	6-20
Cropping intensity	156% (19% increase)	241% (54% increase)

Note: STW = Shallow tubewell.

A large-scale tubewell irrigation scheme called Bhairahawa-Lumbini Groundwater Project (BLGWP) was undertaken during 1976/1983 in the western Terai where 64 DTWs, pumphouses and independent partially lined distribution channels for each well were constructed. The total irrigated area covered by the project was 7,600 ha. On an average, each unit commands a net irrigable area of 120 ha. All the units are equipped with electric pumps capable of drawing 83 to 140 lps. The depth of wells vary from 120-200 m. The water is discharged into a tank and then distributed into canals. The canals which are lined run approximately for about 400 m. Along the canal there are about 20-25 wooden slide gated turnout structures each controlling the irrigation of a 5 ha block. The cost of the project was Rupees (Rs) 256.22 million in 1984 and was financed by an IDA loan. This indicates a per hectare cost of Rs 33,000. Under the second phase of BLGWP some 38 DTWs have been recently brought under operation making altogether 102 DTWs units in the project area. Under the third phase, distribution of water will be done through buried pipe circuits.

Another large groundwater project was launched in 1971 with Japanese assistance in Janakpur Zone under the banner of Janakpur Agriculture Development Project (JADP). Under this program, exploitation of groundwater was concentrated only in three districts, namely, Dhanusa, Mahottari and Sarlahi where actual work on tubewells (TWs) started from 1985. Initiation of TW irrigation including site selection and deciding the number of wells to be drilled in an area, was solely accomplished by the JADP authorities. Although sites were proposed by the Japanese technicians, in practice the Ministry dictated site locations and plans of DTWs. Users came to the picture only when the question of land for pump houses and canals arose. Such lands were to be provided free of compensation. Due to dictated site fixations, drilling of DTWs was mostly done at places where utilization is not at its maximum. Influential people got TWs into their land and common farmers had no voice in any decision making. By the end of 1990 some 81 DTWs had been installed with a capacity to irrigate about 4,200 ha.

Another high potential area for groundwater development is Kailali and Kanchanpur districts of farwestern Terai where DOI has installed 82 DTWs. By now some 400 DTWs units are already installed in Terai districts capable of irrigating 28,000 ha. The details of their distribution is given in Table 15.3.

Table 15.3. Groundwater potentiality and exploitation.

Region	District	Potential of tubewells		Tubewells installed by 1990/1991		
		STW	DTW	By DOI	By others	Total
Eastern	Jhapa	10,546	12	6	1,533	1,539
	Morang	8,950	60	18	1,346	1,364
	Sunsari	3,400	153	53	1,762	1,815
	Udaipur	1,900	–	130	710	840
	Saptari	3,204	24	1,540	1,162	2,702
	Sirha	6,158	12	1,055	1,043	2,098
	Dhanusa	2,376	83		1,096	1,096
	Mahottari	3,344	88	16	625	641
Central	Sarlahi	3,780	139	–	1,321	1,321
	Rautabat	2,952	171	20	795	815
	Bara	2,971	242	–	1,357	1,357
	Parsa	2,598	154	–	200	200
	Chitwan	Investigation under progress		–	17	17
Western	Nawalparasi	2,112	45	2	194	196
	Rupandehi	3,204	227	–	1,222	1,222
	Kapilbastu	3,967	46	49	244	293
Midwestern	Dang	1,510	40	461	10	471
	Banke	1,788	19	–	718	718
	Bardia	3,798	141	–	836	836
Farwestern	Kailali	4,860	79	497	1,160	1,657
	Kanchanpur	2,392	79	603	831	1,434
						22,632

Notes: STW = Shallow tubewell. DTW = Deep tubewell.
DOI = Department of Irrigation.

MANAGEMENT AND PERFORMANCE

Farmer-Managed Groundwater Schemes

During the last two decades very heavy public expenditures have been incurred to motivate farmers in installing private STWs and pumpsets. Sample surveys of their performance and management have revealed that utilization of water and areas actually irrigated are much less than their potentialities. Generally, pumps have operated for 100-200 hours and irrigated only 2-3 ha varying considerably between locations. Therefore, the social returns do not commensurate with the government's expenses in supporting STWs. Also, benefits from the support do not reach the poorer rural communities equitably as they have small landholdings or are even the landless.

Condition of the Systems

The STW units are mostly located at higher elevations of the service area in order to facilitate distribution mostly through earthen field channels. Some farmers have permanent channels whereas others dig temporary ones to irrigate winter and dry season crops. During the rice season field-to-field irrigation which is definitely inefficient, is practiced . Even the sandy channels are not lined. Generally pumps are not installed permanently in sheds and do not have fixed foundations. They are brought to the STWs at the time of pumping. However, some farmers have constructed pump houses and division boxes. The discharge available from most of the wells is between 6 to 25 lps. In some areas the discharge decreases during the dry season. But within the monsoon season the static water table rises by 1.5 to 2 m enabling a higher discharge from a well. It is observed that an STW giving a discharge of 10 lps can irrigate 6.0 ha of farm lands if it is operated on an average of 12 hours per day during peak demand of the rice growing period.

Irrigation Practice

In most cases it is found that the STW operators use water to irrigate winter and spring crops (wheat, maize, vegetables, etc.,) and rice seedbed. They use STWs when monsoon fails or when rains do not occur for a long time. In localities where supplementary gravity canals are not able to serve the full command or do not supply water during the lean period, farmers are motivated to use STWs for conjunctive use. This explains the low total annual hours of operation of an STW. The sample survey of 1988 has shown that the average STW operation was 120 hours whereas survey of 1991 shows an operation of 168 hours annually. In the former case the cropping intensity had increased by 19 percent while in the latter the increase is 54 percent mainly due to the expansion of area during the dry season to grow crops such as wheat, maize and vegetables. The average irrigation per unit STW was 2.18 and 1.85 ha, respectively, during the two surveys.

Operation and Maintenance

Operation and maintenance of the systems are carried by the individual owners including general maintenance of the pumpsets. Where the STWs are installed with ADB/N assistance, some owners have taken maintenance training. However, for major defects in pumps, they have to go to mechanics. In most systems the water use efficiency can be increased by making permanent field channels, controlling leakage by lining, etc.

Agency-Managed Groundwater Irrigation Systems

Government agencies operate and manage two types of DTW irrigation schemes, i.e., DTWs on large-project scale and DTWs on small scale. The former provides a more structured approach to groundwater development for irrigation. The experience of this type with BLGWP indicates that it can generate relatively high benefits because of specific agricultural support programs and water management activities. They have also been successful in achieving the targeted production and effecting the full utilization of the command area. Also the operating costs are minimized by use of electricity. However, high per hectare cost prohibits widespread adoption of this approach. The second type, DTWs on small-scale model, comprises localized single DTW units. Such units serve 60 to 120 ha and are equipped with permanent pump houses and distribution systems. These can also generate benefits comparable to large-project scale DTWs. However, the major difficulty here is the very low level of utilization of the command area as the farmers are not willing to bear the operating costs.

Agency-operated and -maintained DTWs are scattered in different districts of the Terai. The O&M of these DTWs are being carried out by different agencies in different ways. DTWs of some larger projects are fully operated and maintained by the concerned agency whereas some DTWs are operated jointly by users and the agency. DTWs of most of the small projects are operated by the beneficiaries but maintained by the agency. Taking into account these factors, management and performance of some of the DTW projects are indicated below:

Performance and Management of the Systems

The performance of the systems are summarized in terms of actual irrigated area by seasons, annual operating hours and irrigation intensities.

i) The 28 DTWs under Birganj GWP is being fully managed and operated by the Narayani Irrigation Development Board (NIDB). Earlier the water service charge was levied on the basis of time of pumping demanded by a farmer. But a few years ago a flat rate of Rs 400 per ha per year was fixed. A farmer may use pumped water at any time and in any quantity; he has got only to request the operator to supply water. Still the cropping intensities have not increased as anticipated. The total command area is never irrigated. The net irrigation has been nearly 70 percent in the case of old (but improved) DTWs and 75 percent in the case of new ones. Corresponding per unit operation of DTWs averaged 600 and 450 hours. It is to be noted that average discharge of old wells is between 50 to 80 lps whereas in new wells it is 80 lps. The payment of water charge is below 50 percent and the O&M costs are subsidized.

ii) All the DTWs under BLGWP Stage I (64 units) and Stage II (16 units) are fully operated and managed by the project itself. Here also a flat water charge of Rs 400 per ha per year is levied. Up to last year it was only Rs 200. The performance evaluation of BLGWP Stage I has shown that 89 percent of the holdings in the command area is getting water for partial/full irrigation, while the remaining 11 percent is still kept under rain-fed conditions. The percentage of irrigated area is slightly higher in larger farms. Efficient and controllable water management with effective agricultural support built directly into the project has made the Stage I area achieve full development within four years. The cropping intensity, yields and extent of crop diversification into high value crops have exceeded the appraisal estimates. Appraisal estimated that cropping intensity would increase from 118 percent to 165 percent and yield of rice from 2.0 tons per ha to 3.5 tons per ha. However, the real achievements from the project recorded 190 percent cropping intensity and a yield level of 4.0 tons per ha. In the Stage II area the

38 DTWs are being provided with polyvinyl chloride (PVC) buried pipe distribution system to overcome shortcomings in the open-channel system. At present all WUGs are actively involved in the distribution and allocation of water while the O&M is the responsibility of the project.

The payment of water charge last year was negligible due to the rise of the rate to Rs 400 per ha per year although this amount is only a fraction of the actual O&M cost. The government cannot go on bearing the full O&M cost for ever and therefore it is the policy of the agency to turnover the O&M of all the DTWs to WUGs. In the beginning, it is planned that users should pay only the electricity bill and the government will provide operators and the maintenance cost.

iii) The JADP DTW systems are being managed jointly with the beneficiaries. The very approach to provide a DTW system to a community was to organize farmers to take the responsibility of managing it after completion. But the community was not consulted in introducing the system into the area. Politicians took the lead and WUGs could not be evolved to take up O&M of the systems which have been turned over to them after commissioning. WUGs are told to manage water distribution and, conflict resolution, adopt cropping patterns, provide diesel and lubricants, hire operators and watchmen and do minor maintenance work. However, it is not effective because the implementation process did not embrace any norms to promote WUGs as institutions of the farmers in creating feelings of belonging right from the beginning.

JADP has equipped the DTW systems with Japanese diesel-driven engines EBAR and FIAT. They consume 10 and 6 liters of diesel per hour, respectively. This cost cannot be borne by all farmers in all seasons. Hence, there is very poor utilization of the wells. They use it only for supplementary irrigation during critical times. On an average, about 30 percent of the users of a system irrigate once in the wheat season and once at the time of rice seedbed preparation. The WUGs feel that they would be able to operate the system in full when the DTWs are run by electricity.

The operation of DTWs together with their management is accomplished by the project which levies the water charge in two ways. Under the first system the user is required to pay Rs 16—only a fraction of the fuel cost—prior to pumping. Under the second, Rs 10 is payable for lubricants and the required quantity of diesel should be supplied by the user.

iv) The SIRDP and Kailali-Kanchanpur DTWs are now operated jointly but maintained by the groundwater project of the DOI. The development approach of these DTWs was not participatory. Except for site selections, the farmers were not involved in nor were they informed of any matters during implementation. The project did not ask for any help or contribution, nor did the farmers do anything for the project. This was so because of the tradition of DOI of doing irrigation work unilaterally. The officials did not know that the O&M of these DTWs would be transferred to the users; similarly, the users were unaware of it. Now, the project has organized WUGs in each unit and asked them to operate it by themselves. Farmers are getting organized and developing norms to operate the systems. At some places users have generated funds to hire operators. All the wells are equipped with diesel-driven and battery-operated engines which are either of Japanese or Indian origin. Japanese engines consume 6 to 8 liters per hour (l/hr) whereas Indian ones consume 4 to 6 l/hr. The average discharge of the DTW is 30 to 60 lps. The record of utilization is not kept systematically. The method of operation is to bring diesel and give a nominal charge for lubricants (up to Rs 5 per hour) and get water. Farmers feel it to be very costly and they restrict irrigation as indicated earlier.

On an average, only 30 to 40 percent of the command area is irrigated. The field officers have nothing at their disposal to promote and facilitate utilization.

v) There is a successful example of jointly developed DTWs but operated and maintained by the users alone. Dang Tubewell Project is a case in point. Three DTWs have been installed on the request of the farmers who undertook the full responsibility for O&M. The WUGs were actively involved in all the activities of implementation and during this process a feeling of ownership developed in them. They have now electrified DTW units with nice pump houses. However, their main distribution canal is still unlined for which task they are prepared to contribute 25 percent of the cost. They have approached the DOI to get the lining done. The DTWs are fully operated and maintained by the WUG of each unit and all the beneficiaries are assured of water to their satisfaction. Last year, the winter crop (mustard) yielded 4 times more with just one irrigation. During the rice growing period they pumped water as and when needed mostly at the peak season. They hire their own operators and pay electric bills which they raise on a pro-rata basis.

NEW APPROACH FOR SUSTAINABLE GROUNDWATER IRRIGATION

The performance of agency-managed DTWs based on large projects is better than DTWs of small projects. However, the recurrent cost recovery is so meager that their sustainability is endangered. The government cannot solely go on providing funds indefinitely for the O&M of these systems. Also, it would be an injustice to a large number of farmers who are operating their STWs after having shared a part of the capital cost of construction. Hence, the new policy of irrigation development specifies to transfer the O&M of the DTWs to the WUGs which have to be organized and registered under the prevalent rules. The transfer of this responsibility will occur gradually in stages. Initially the electricity bill or fuel cost shall be borne by the users. With the capacity build up, the full responsibility of O&M will be turned over to these WUGs. At present, the BLGWP is working on this policy where increasing roles are entrusted to the WUAs for water management, distribution and adoption of cropping patterns, whereas primary responsibility of O&M remains with the project. A full program is launched to promote institutions and capabilities associated with WUAs in order to convert all the DTWs to farmer management. However, there is great reluctance on the part of the farmers to take over the systems as they have had the privilege of being free riders from the beginning.

Sectoral Approach for Groundwater Irrigation Development

In retrospect, irrigation activities have now changed the main focus toward the issue of utilization and sustainability. Presently, all TW schemes are taken up on the basis of locally felt needs and demands as against the traditional supply-oriented systems. In the present context, the users are deeply involved, right from the initiation of the scheme, in contributing partly to the capital cost of construction of TWs and related structures and there is also a firm commitment of taking the responsibility of management and O&M. Since the last three years, STWs, medium tubewells (MTWs) and DTWs are making headway in the western Terai under Irrigation Line of Credit (ILC) Program assisted by the World Bank. Here, a cluster of TWs are initiated based on the genuine demand of the farmers in areas where rich groundwater aquifers exist. Farmers have to form a WUG for each unit. For a group or a cluster of TWs a farmer irrigation association (FIA)

would have to be established and registered to get legal status. Through an agreement between the DOI and the FIA, the responsibility and obligations of each party are clearly spelt out and fixed. The users mostly contribute toward the construction cost of the well and to the water distribution system. The share amount is fixed so as to ensure their commitment to construction and ownership responsibility and afterwards to the O&M of the completed TWs. Under this program users of an STW have to provide the pump and construct the distribution channels with materials provided by DOI while the TW is installed by the DOI under the subsidy scheme. In case of MTWs and DTWs contribution consists of an "outright" cash deposit (usually 5 percent) of the cost together with labor and land required for the distribution system. If an access road is desired for the cluster of wells, then the land for the purpose is provided by the FIA free of cost. The latter pays compensation if a land belonging to a non-beneficiary is acquired.

In the case of STWs, which require machine drilling, e.g., deeper than 20 m, it will be taken up under this program. Shallower STWs which can be installed by hand drilling will be normally handled by the ADB/N-STW Program.

In the coming years, quite a large development of conjunctive use of groundwater with surface water is anticipated owing to the longer gestation periods associated with larger surface schemes since their inception.

DISCUSSION

Historically, irrigation in Nepal was confined to gravity canal systems. People do not have much knowledge and experience of lifting groundwater for irrigation. One of the reasons for the slow progress of the exploitation of groundwater is the expectation of the farmers that the TWs will replace surface water use for irrigation. In fact, there is a vast difference between irrigation practices used by farmers utilizing surface water and those who use TWs for irrigation. Hence, awareness should be created not to conjoin TW irrigation with gravity canal water which is less costly and abundantly used. In general, TW irrigation development has greater chance of success if it is based on real locally felt needs and demands. That is why all the STWs that are installed at the initiation of individual farmers are working well. MTWs installed on group demand and on a cost-sharing basis have an in-built element of a sense of ownership as well. All the TWs of this type are farmer-managed and hence better utilized to grow diversified crops including vegetables and cash crops.

The DTWs on large- and small-project scales generally came to an area in the form of a top-down process. The agency personnel in these projects always worked with irrigation development targets in view. Hence, the engineering component was the decisive factor in planning and implementation and the sustainability aspect has been overshadowed. Beneficiaries were not involved from the beginning as WUAs could not be evolved *pari passu* as a body to operate and utilize the system created.

STWs are preferred and would perform better where shallow and rich aquifers are available up to a 20 m depth and also with a shallow static water table which enables farmers to pump the required discharge by a suction lift pump only. Generally, an individual farmer should initiate to own and operate an STW. If his landholding is not large, then a few farmers need to form a group to own an STW. Such STWs are encouraged where farmers are growing cash crops, vegetables and multiple croppings and where a market is available. They are also promoted where the gravity canals are inadequate to fulfil the irrigation functions or where entrepreneur farmers want to grow crops in nonmonsoon seasons. Factors such as the relative management burden, ease of implementation and cost effectiveness and availability of rich aquifers, motivated farmers of Terai Nepal into widespread use of STW irrigation. STW is attractive even for a farmer having 1.0 ha

of landholding. However, group ownership is needed to expand the per unit service area in order to permit small holdings to be benefitted from STW irrigation, thereby, promoting its wider adoption.

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