CHAPTER 4

SENAPUK: MODERATE WATER

Photograph by Robert Yoder.

The village of Senapuk in Syangja District was chosen as a case study to represent a moderate water supply and the birthplace of the double-tank, two-line distribution system. The background information for this case study came from an earlier review of MUS called Nepal Process and Impact Study of the Multiple Use (Hybrid) Gravity Water Supply Schemes in Palpa and Syangja districts of West Nepal conducted by Eco-Tech Consult Ltd. in October 2004. A visit to Senapuk in September 2005 by international IDE staff and national-level SIMI staff included a physical-system inspection and group interviews. This was followed up by a visit in October 2006 where more formal interviews were conducted by IDE international staff and a consultant from the Monitoring and Evaluation Section of the Department of Agriculture. The local staff, who knew the population well, ranked all households into three categories—poor, middle-income, and wealthy. Two households were selected randomly out of each of the three income brackets for personal interviews. In March 2007 a visit of both international IDE staff and national SIMI staff included an interview with the whole community, a focus-group interview with all women users, a focus-group interview with three of the poorest households, and interviews with local-level SIMI staff.

SITUATION ANALYSIS

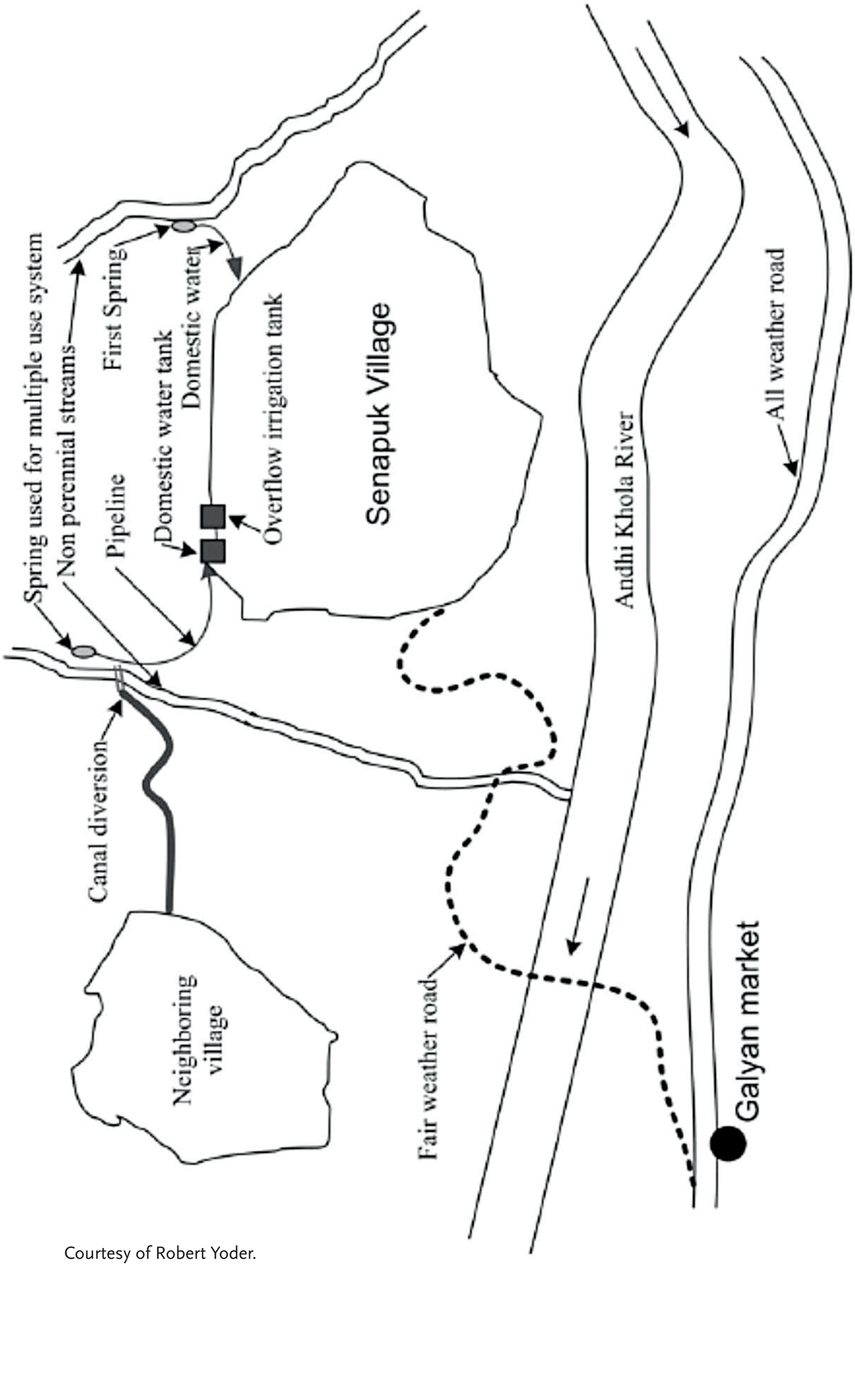
After the single-tank, one-line distribution system in Chhatiwan was completed with successful results (see chapter 3), SIMI engineers sought to design a system for an area with less water availability. Initially the village of Tori Danda was chosen, but when conflicts over use of the source arose, SIMI began construction in Senapuk instead. In Senapuk the idea of the double-tank, two-line distribution system was created and became the model after which many other MUS systems were built.

COMMUNITY SETTING

Location and Climate

Senapuk is situated in Pelakot VDC of Syangja District on a south-facing slope about 200 m above the Andhi Khola River at about 800 m elevation. It is located about 50 km southwest of Tansen, the Syangja municipality, by road and 2.4 km walking distance from Galyang market. There is a fair-weather road from Galyang village to Senapuk but only a foot suspension bridge across the Andhi Khola, so most travel to Galyang village is on foot via a pedestrian trail (see Figure 4.1). Senapuk has an annual rainfall of about 1,800 mm with a distribution similar to that of a nearby climate station in Tansen shown in Table 1.2. Due to the uneven nature of the rainfall, there is little available water in the dry season. The dry hilly landscape of Senapuk can be seen in Plate 8.

Figure 4.1 Schematic of Senapuk and surrounding area



Courtesy of Robert Yoder.

Population/Demographics

This community has been settled for many years. All the families are from the same caste (Brahman), and many are *pandits*[1] who have memorized a substantial portion of the *Vedas*.[2] The population of Senapuk has grown substantially since the 1980s, and there are now 36 households in the village, with a resident population of 235, making the average family size just under seven persons. Most men and many of the women are literate; one individual has a masters degree, four have bachelor's degrees, twelve have attained associate's degrees and fifteen have a high-school-level education.

Socioeconomic and Food-Security Situation

The only industry in the village is a small diesel-operated mill. It is a household-based enterprise that provides rice-hulling service to the community but no employment beyond the owner's household. Instead, "service" jobs are the primary cash-earning activity in Senapuk. In Nepal, it is common for Brahmins to have service jobs—employment as teachers, staff in government offices, and in the private sector mostly outside of the community. For example, in one interviewed household the husband worked for the India railways for 40 years and had a retirement pension. Another Brahmin livelihood and significant income-generating activity in the community is the pandit work, performing religious services for both public and private events. Agriculture, on the other hand, was not a large cash income-generating activity in Senapuk prior to the MUS project, and food production was primarily subsistence. Therefore, despite the income from service work, the households in Senapuk had cash income levels below the average of farmers in their district.

The average annual income of Senapuk residents was estimated to range from $285 to $2,000[3] prior to the project while the average annual family expenditure was estimated to be about $570 with roughly one-third spent on food, one-third on education, and the remainder on clothing, health care, and other necessities. Those on the lower end of the income spectrum were often forced to take out loans, borrow, or barter to make ends meet.

Landholdings of the villagers range from 0.25 to 1 ha with two-thirds of the population farming 0.25–0.5 ha and one-third of the population farming 0.5–1 ha. A few families have biogas plants and use the manure from their livestock mixed with about 20 liters of water per day to create energy for cooking. They then use the slurry waste from the biogas plant to fertilize their fields.

Prior to project implementation, only 12 households produced sufficient grain for their annual needs; the other two-thirds of the households produced less than half of their annual cereal requirements. Sale of goats, ghee, and what little vegetables they produced without irrigation, as well as money earned outside the community as day laborers, were all income sources used to purchase additional grain.

Pre-Project Agriculture

Before the MUS project Senapuk farmers had a traditional cropping pattern on their khet land as shown in Cropping Patterns in chapter 1 and used few, if any, external inputs. The khet fields are located a 20-minute walk below the village near the Andhi Khola River. In their bari fields near their homestead, they grew rain-fed crops of maize, mustard, and lentils. The only vegetables farmers were producing were traditional ones like beans and leafy greens grown near the house in a bari field for home consumption. Senapuk households typically grow some bananas (some of which are sold), guava, mango, and jackfruit. Except for a new variety of mango introduced by a farmer who had worked in Calcutta, all fruits found in this area are local varieties and used primarily for household consumption.

Most farmers in Senapuk have similar soil types and use as much composted manure as they have available. They also use small amounts of commercial fertilizer and pesticides as inputs for their crops. During the period of project intervention, farmers were trained in Integrated Pest Management practices, so now local pesticides and insecticides are also in use.

All households in Senapuk have some livestock, but because it is a fully Brahmin village, poultry and pigs are not raised. Each household has at least one milking buffalo, and some households raise goats both for consumption and sale. In general, livestock contribute meat and milk to local families' diets as well as cash income. The whole village collectively sells about 50 liters per day of milk and about 200 kg per year of goat meat.

Villagers traditionally made ghee and sold it in the Butwal market. But in 1984 a milk-chilling center was built in Galyang, making sale of all milk more viable for Senapuk farmers. In 2004 the plant was privatized and eventually closed, forcing the Senapuk households to stop selling milk and revert to their original practice of making ghee. Thus, sale of ghee has again become a good source of income.

As mentioned in Migration, Remittances, and Income Inequality in chapter 1, because agriculture on limited landholdings provides such low returns, many of the male population between the ages 20 to 40 leave the community for varying periods of employment. Numerous households in Senapuk have one or more members employed in India, and two households have members working in South East Asia and the Middle East. In total, 22 out of the 36 households have men working outside of the village (40 percent of the total male population). Consequently, in 70 percent of the households women are the primary vegetable cultivators. If all men stayed in the village, there would be underemployment. But for some households the work situation has shifted the balance toward a labor shortage during critical agriculture periods, causing some families to rent land out to balance labor availability. Traditional labor exchange (*parma*) is practiced for weeding and harvesting of cereal crops. And since Brahman households traditionally do not use bullocks for field work, they hire farmers from nearby villages to do their land preparation.

INITIATION OF THE MUS SCHEME IN SENAPUK

In 2001 a program supported by Helvetas prepared an area master plan for water-related resource development that included Senapuk village. The plan mapped available water resources and set priority water needs; then, DDC and VDC officials found projects to meet the needs. The SIMI project provided the perfect opportunity to address Senapuk's water requirements.

Through the SIMI search for villages to implement MUS projects, staff contacted the DDC officials for information on villages in need in the area. SIMI was put in contact with the Senapuk VDC chairman who was looking for a partner organization for domestic water development in the village. SIMI explained the concept of MUS to the VDC chairman, who became very interested in partnering with SIMI, realizing the double benefit of the system.

When SIMI approached the Senapuk villagers with the VDC chairman, they were mostly interested in an easily accessible domestic water supply. In order to explain MUS to the community, SIMI took some of the Senapuk villagers to see the Chhatiwan scheme. The villagers observed the system and saw that farmers in neighboring villages were gaining cash income from irrigated vegetable production. Despite little prior access to microirrigation technology, they were interested in a scheme that would provide them with both domestic water and water for irrigation of cash crops, and the training needed to grow the crops effectively.

WATER ACCESS PRIOR TO PROJECT IMPLEMENTATION

The previous drinking water scheme in Senapuk came about as part of a larger development project in the surrounding area in the mid-1980s called the Andhi Khola Project. The project components included a hydroelectric plant, a rural electrification program, irrigation, reforestation and erosion control, and the development of agriculture and employment opportunities. In the survey assessment of the area, it was determined that households did not have either a clean or year-round supply of drinking water , so a drinking water component was added to the program. For Senapuk, the Andhi Khola Project initially selected a spring called Chisapani to develop for domestic needs; however they soon realized that the elevation was too low to reach the village via gravity, and pumping was too expensive, so they decided to tap the nearby Dumkilla spring. The Andhi Khola Project implementers insisted that all households have a latrine prior to drinking water system construction, so 24 households built toilets. Once these were completed, a plastic pipe transmission line was built to deliver water to the village, where it was initially distributed through three public taps. Three more taps were added in 2000.

While the previous scheme had been a great improvement over walking to the spring for water, and output was sufficient in quantity and quality to meet daily domestic water needs at the time, the 0.2 lps flow rate that the Dumkilla spring provides became inadequate for the increase in demand by

2003. Since the upper settlement was the original village, they were using most of the water in the scheme before it reached the households in the lower settlement. So some villagers still needed to walk 30 minutes (about 700 m) each way to fetch water, and they faced an overall water shortage in the dry season.

Similarly to the domestic water system, Senapuk historically had access to irrigation canals for some of their khet land, but they had become unusable. In 1936 Mr. Laxmipati Patthak of Senapuk diverted water through earthen canals from the Dhap Pani Khola, a stream with steep banks located about 0.5 km west of the village, to a total of 1.5 ha of rice fields on both sides of the stream. Several years later a landslide destroyed some of the fields on the Senapuk side (the east side) of the stream and made it very difficult to maintain the canal leading to the undamaged fields. As a result, the formerly irrigated fields nearest Senapuk reverted to rain-fed cultivation.

Although Mr. Patthak did not have legal ownership over the springs or stream, his family had been using them for such a long time that they had prior customary rights. Therefore, when Mr. Patthak decided to sell the irrigated fields on the west side of Dhap Pani Khola to a farmer in the neighboring village to the west, the new owner attained the right to irrigate using the stream. The few households from Senapuk that have rice fields adjacent to the Andhi Khola River below the village and the few that have small rice fields below Senapuk village now use water from seasonal streams during the rainy season to irrigate.

PROJECT PLANNING AND IMPLEMENTATION

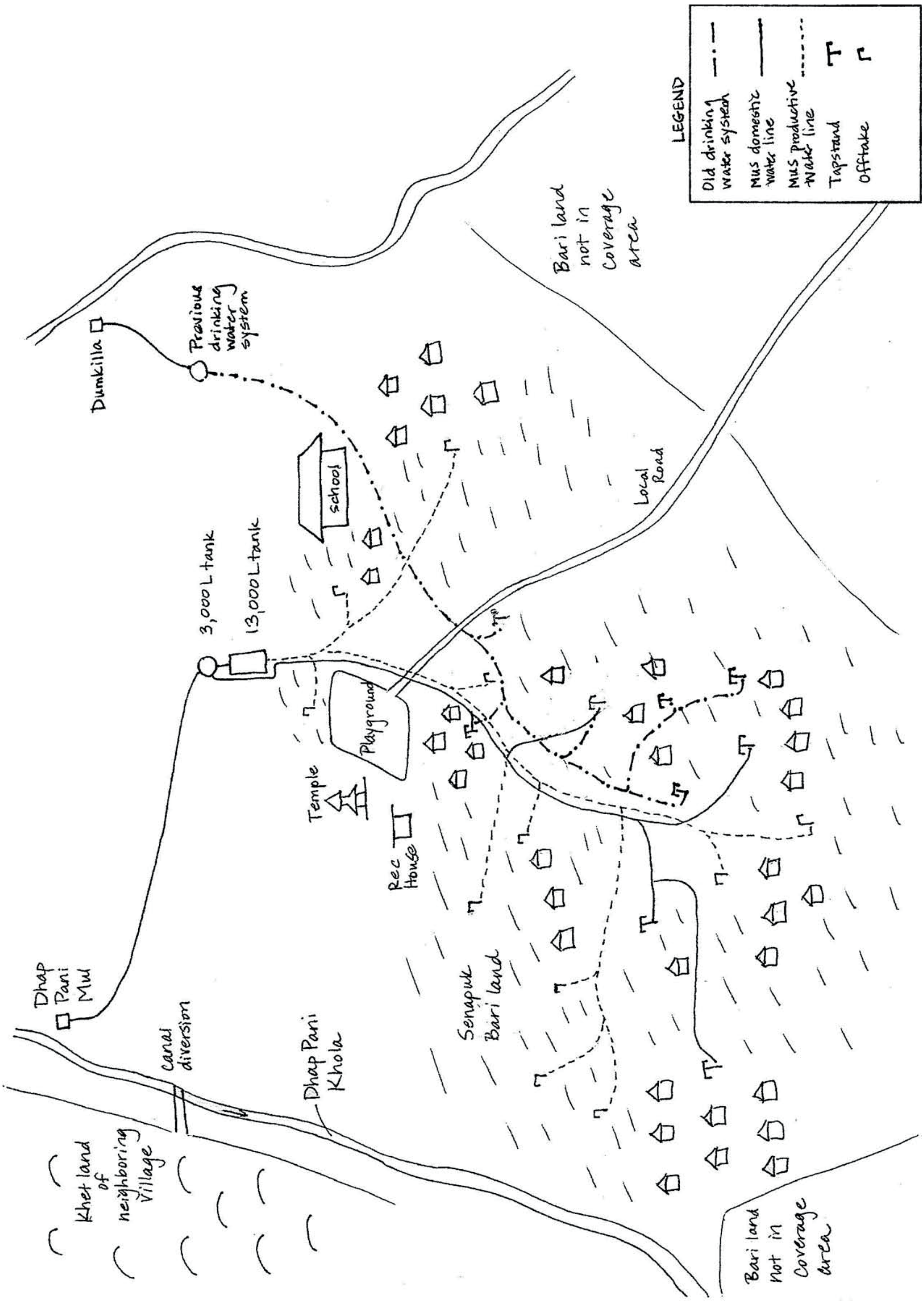
SYSTEM DESIGN

Projected Water Needs

After the first meeting with SIMI, the community organized a construction committee by holding a meeting with one representative from each household, at which they elected seven committee members, three of whom were women. The initial task of the construction committee was to find an appropriate water source. In order to choose the source, the projected water demand for both domestic and irrigation purposes needed to be determined. The SIMI irrigation technician conducted a feasibility study in conjunction with members of the committee to map out the village, nearby potential water resources, the capacity of the existing domestic system, and the projected demand.

Because the existing water supply from six village taps was still working, it was incorporated into the plan for the domestic side of the new water service. It was planned that the 13 households nearest to the existing taps would continue to use the old scheme for domestic water only,[4] and 23 households

Figure 4.2 Senapuk village schematic



Courtesy of Monique Mikhail.

would use the new scheme for domestic needs. It was assumed that the new domestic supply would need to serve a ten-year projected population of 183 people by 2013, resulting in an estimated domestic water demand of 8,235 liters per day.

For the productive portion of the MUS system, SIMI engineers estimated the irrigation need for Senapuk farmers at an average of 600 liters/household/day for all 36 households (see Project Implementation in chapter 2 for design parameters) totaling a productive-use demand of 21,600 liters per day. This allows all Senapuk farmers to use a medium-size drip kit of 250 m^2 and apply up to 2.4 mm/day/m^2 to their fields.[5] Combined, the projected productive and domestic needs for 2013 were estimated to be nearly 30,000 liters per day.

It was estimated during the feasibility study that a total of about ten ha of bari land in Senapuk was suitable for vegetable cultivation. The houses are located on the edges of the bari land, and the vegetable plots in most cases are very near to the homestead houses (see Figure 4.2). However, there are multiple limiting factors for cultivating the whole bari. In the monsoon and postmonsoon seasons, land in addition to the fixed area irrigated by the microirrigation system can be cultivated by direct water application. Yet in the dry season the 600 liter/day/household estimated productive-use supply limits the total area that can be irrigated with microirrigation to about one ha (less area would be covered if microirrigation kits were not being used). To drip irrigate the entire ten ha would require about 200,000 liter/day. Based on the agreement reached with the source owner, even with the enhanced water availability through the MUS system and improved efficiency of application with microirrigation, there is only enough water available in the Dhap Pani Mul in the dry season to irrigate about one tenth of the available land without development of yet another water source. But no additional water source is easily accessible. As development of a secondary resource for additional irrigation was not economically viable, the MUS scheme kept the estimated demand of 600 liters/household/day for productive use.

Water Resource Assessment

Using the estimated water needs and field information from the detailed engineering survey, the construction committee and SIMI team selected the appropriate source for their system, focusing on the perennial springs within the small Dhap Pani Khola catchment. At the beginning of the project the construction committee wanted to use a spring on the northeast side of the village because they believed its closer proximity would reduce cost. However, during the feasibility study the SIMI engineer found that the source on the northeast side was at an elevation below all but a few houses and would make the scheme infeasible without pumping, adding substantially to the cost. Alternatively, the Dhap Pani Mul spring on the northwest side of the village is the largest spring in the area and is 45 m above the village. Its minimum dry-season discharge of 0.4 liters per second (34,500 liters per day) is sufficient for the estimated 30,000 liters per day multiple-use demand. Therefore, although the Dhap Pani Mul spring was further away, it would provide the most reliable water source for Senapuk and allow for a gravity-fed system.

However, it was not easy to obtain the rights to use the Dhap Pani Mul. Several times in the past few years the villagers have approached the landowner who had access to the water rights acquired by Mr. Patthak to allow use of the Dhap Pani Khola stream for drinking water . The rights holder refused to give access even though Senapuk villagers still own the land on the east side of the stream and retain claim to water rights for irrigation.[6] Considering that the Dhap Pani Mul was the best option for the MUS system, representatives from the construction committee approached the rights holder again to discuss obtaining rights to the spring without jeopardizing his use of water from the stream. The negotiations were long and difficult, requiring many visits to the neighboring village. After each of the five negotiation meetings, the committee members reported back to the community and collectively planned for the next action. Although the process was grueling, it unified the construction committee and solidified the villagers' trust in their abilities. Ultimately, Senapuk offered to provide compensation to the landowner in order to reach an agreement. A written statement was prepared and signed by both the user committee and the landowner agreeing to the following:

- Senapuk would not disturb the rainy season irrigation needs of the farmer;
- Senapuk would allow a continuous flow of water all year in the farmer's canal for livestock needs;
- Senapuk would provide ten bags of cement to improve the diversion and canal for the existing irrigation scheme to the fields on the west side of Dhap Pani Khola originally irrigated by Mr. Patthak and now irrigated by the rights holder in the neighboring village;
- Senapuk could install a collecting tank with a one-inch orifice at the spring to control the discharge going to Senapuk village;
- All remaining water was to be available to the rights holder in the neighboring village.

Once the agreement was signed, the construction committee informed the VDC of their agreement with the source owner to legally ensure usage and prevent any future disputes.

Technical Design—Double-Tank, Two-Line Distribution System

After obtaining the right to use the spring, the construction committee focused their attention on effective system construction. Although SIMI already had the Chhatiwan experience of building a single-tank, one-line distribution system, they recognized that Senapuk had less water available than Chhatiwan,

Figure 4.3 Intake from Dhap Pani mul spring

Photograph by Monique Mikhail.

raising the potential for conflict and underscoring the importance of safeguarding the domestic supply. While a larger single storage tank would have been the more conventional and cheaper approach, it would not be able to ensure that productive-use demands did not exceed domestic-use needs. Instead, a two-tank system was envisioned such that only after the domestic tank is full does water get diverted into the irrigation tank. The uniqueness of this system lies in its dual function and the flexibility it gives the user committee: controlling the release in the domestic system determines how much overflows to the irrigation tank. This innovation became the first double-tank, two-line distribution system. With the new design, users would have separate control over distribution of water for domestic and productive purposes. Figure 2.2b in System Components section of chapter 2 shows a sketch of the double-tank, two-line distribution system that was ultimately designed. Despite the extra cost, the community appreciated the value of having full control over water distribution and protecting domestic water priority.

SYSTEM CONSTRUCTION

The total construction period was 34 days, and all 36 households contributed throughout that period of time. Although both men and women participated heavily in the scheme, their roles were somewhat different. While women gave suggestions on the needs and problems of the scheme, they were not as actively involved in the planning and decision making as the men. On the other hand, women provided the majority of the labor for construction (55 percent), possibly due to the large number of men working outside the village.

The construction committee developed rules for carrying out the construction — organizing labor, collecting sand and stone for construction, and transporting pipe, cement, and other materials from the Galyang market to the village. In consultation with all users, the committee established a fine for persons who did not fulfill their construction duties. The fine was approximately equal to the village rate for daily labor (roughly $1.00/day).

To begin construction, a collecting box (see Figure 4.3) was built to capture the seepage from the Dhap Pani Mul spring. A cover for the collecting box was not constructed even though the design called for one, because the community wanted to cut construction costs. As per the agreement with the rights holder in the neighboring village, a one-inch pipe was used as the outlet from the collecting box. A 32 mm-diameter high-density polyethylene pipe then transmits the water 570 m to the domestic water storage tank just above Senapuk village. With a 45 m elevation difference between the collecting box at the spring and the storage tank, the transmission system operates by gravity flow.

Figure 4.4 Two storage tanks for Senapuk MUS system – domestic with productive overflow
Photograph by Monique Mikhail.

Water from the transmission line fills a 3,000-liter Modified Thai Jar domestic water tank (Figure 4.4/Plate 9 jar-shaped tank), which overflows into a second 13,000-liter ferro-cement lined storage tank for productive use (Figure 4.4/Plate 9 rectangular tank). The domestic tank distributes water to three new hybrid tapstands (Figure 4.5a/Plate 10) built to complement the existing six taps from the old scheme. Two of the old taps were connected to the MUS system, while four of the old taps remain connected to the old system. Thus, there are now a total of nine tapstands servicing all 36 households. Location of the new taps was chosen by the construction committee to provide equal access to all new users with no more than 30 m walking distance from each home to the nearest tap. The productive tank distributes water to 11 irrigation offtakes near the farmers' bari land (Figure 4.5b) to which farmers directly connect their sprinklers or connect hoses to fill up their drip irrigation "header" tanks. Offtake locations were chosen by the user committee to minimize the distance to the users' fields. In addition to irrigation, these offtakes are used for livestock watering and often for all other household needs since they are closer to most houses than the domestic hybrid tapstands. The

Figure 4.5a Using the hybrid tapstand

Photograph by Robert Yoder.

amount of water each family is allowed to use from the irrigation system for domestic needs is determined by the users sharing the outlet. Although households are free to use their irrigation supply for domestic purposes, they do not use the domestic hybrid tapstands for irrigation because the tapstands are further from their bari land and it is too labor-intensive to carry all of the water necessary for irrigation from the tapstands to the fields.

As part of the agreement between the village and SIMI, at least 75 percent of the villagers had to indicate interest in purchasing microirrigation kits for cultivation of high-value vegetable crops (see Project Implementation in chapter 2). The SIMI team explained the purpose of the microirrigation kits: in the face of limited water availability, microirrigation technology enhances the area that can be irrigated. It can also decrease labor and fertilizer requirements and weed growth and increase yield and quality of produce. Seven different microirrigation kits were described to farmers and offered for sale by a vendor in the Galyang market (see Table 2.1 in System Components in chapter 2). It was up to each household to decide if it wanted to purchase the unsubsidized kits. Yet, despite access of all 36 households to irrigation off-

Figure 4.5b Irrigation offtake with hose attached to fill a drip header tank

Photograph by Robert Yoder.

takes through the MUS system, not all households purchased the kits. Twenty-two households purchased 125 m^2 drip kits, seven households purchased 250 m^2 drip kits, two households installed 250 m^2 minisprinkler systems, and the remaining five households opted out of purchasing microirrigation kits, citing a problem of inadequate labor for usage.

SYSTEM OPERATION

After the scheme was built, the villagers decided to convert the construction committee into a Water User Committee (WUC) to represent Senapuk village, but they kept the same members as the construction committee. They elected a chairperson, secretary, treasurer, and 12 additional members (of which two are female) to fully represent the village. The WUC continues to seek technical and financial support from NGOs and INGOs and long-term support from government organizations for all aspects of water resource usage in the village. They are also responsible for continued water distribution and all operation and maintenance activities.

A system operator was hired to manage the day-to-day water distribution. While the system was designed to provide all users with an equal water allotment, in practice the allotments are decided by the WUC according to the various needs and requests of the group members. The committee collectively decides the timing of distribution to each tap, and then the operator opens and closes the storage tank valves accordingly and monitors the system to ensure proper distribution. If disputes arise, the user committee and sometimes the whole village meets to resolve it.

Except in the dry months of the premonsoon season, the villagers have found that in addition to sufficient domestic water, they have enough supply to keep the irrigation distribution line open continuously as long as all taps are closed when not in use. This serves two much appreciated purposes. First, households closer to an irrigation offtake than a hybrid tapstand can draw their domestic water from those and save travel to the domestic tap. Since it is the overflow from the domestic tank that they are using, there is no danger that others' domestic needs are not being met. However, only the domestic tank has a tight cover so there is danger that water in the productive tank could become contaminated. Second, water close to the fields is available on demand for irrigation. In water-abundant months (October to February) farmers often use hose application for their vegetables.

In the dry season, system operation becomes less flexible. As mentioned above, 13 households still use the old domestic system, but in the dry season only three of the old domestic-system taps continue to function, forcing some households to use the MUS system for domestic purposes instead. Fortunately, even in the dry season the MUS system has enough water to keep the distribution valve on the domestic tank open continually. But the amount of water in the irrigation tank is insufficient to allow continuous distribution.

At this time an irrigation schedule of delivery twice per day (three hours in the morning and three hours in the evening) is instated and all households use their microirrigation equipment. Microirrigation allows them to maximize the use of limited water well above hose or flood irrigation application.

SYSTEM COST

Senapuk village contributed not only in the planning and labor for scheme construction but also with materials like stone, sands, gravel, bamboo, local wood, etc. that were needed for construction. In total, the community contribution including labor totaled 49 percent of the scheme cost. They also purchased their own drip or sprinkler irrigation systems in addition to the MUS system contribution. On the other hand, the SIMI project paid for the cement, steel, plastic distribution pipe, skilled labor, and flexible pipe for each offtake to connect to the microirrigation header tanks (total length of distribution pipe for the whole community was 180 m costing NPR 2,160/$31). The total MUS system cost NPR 250,000 ($3,475), not including the microirrigation kits.

Since the community owns the scheme and is fully responsible for maintaining it, the Water User Committee took up an initial collection of $0.70/household to create a maintenance fund for repairs upon completion of the scheme. They also collect a fee of $0.15/household per month to build the account, accumulating to about $65 annually. The maintenance fund is only used to pay for material or parts that are not available in the village. Labor for maintenance is mobilized from each household as required in addition to the water-use fee. The operation and maintenance fund is used as a revolving loan fund in the village at a low interest rate.

CAPACITY BUILDING

A major component of the MUS project is training villagers to care for the system, manage water distribution, grow high-value vegetable crops with microirrigation, and market the produce. Training sessions in Senapuk included all those listed in the Training section of chapter 2. On top of specific training provided to the villagers, community members gain skills through formation of the WUC, negotiation of water rights, and planning, construction, and maintenance of the system.

MARKETING

The final essential component of the MUS project in Senapuk was linkage of farmers to their local market for sale of the vegetables grown with their new microirrigation kits. A broader network of vegetable production groups had already been established by SIMI in many VDCs of Syangja District. A coalition marketing committee comprised of representatives from each of the groups had been organized by SIMI for selling produce in Galyang (see

Plate 11). The marketing committee is responsible for setting the price of different commodities and linking with traders coming to Galyang from the town of Tansen in the west and the larger city of Pokhara in the north (see Figure 4.1). The management subcommittee of this marketing committee is responsible for selling the vegetables in Galyang and transporting some of them to Pokhara and other area markets. Senapuk farmers take their produce to the collection center in Galyang, where the marketing committee collects and weighs the produce and pays the farmers according to the daily price of that commodity. Although farmers can get a higher price by taking their produce directly to Pokhara themselves, the time and expense of transportation make the nearby Galyang marketing committee option a good one. However, farmers did mention problems with marketing and bargaining power, claiming that they were sometimes unable to obtain what they felt was a good price for their vegetables. The marketing committee needs to review and address these issues within the larger district context, and perhaps in the future, the community could diversify by focusing some of their efforts on vegetable seed production in addition to fresh vegetables.

In order to create an alternative to the Galyang marketing committee, the Senapuk WUC built a marketing center with SIMI's help along the road from Senapuk to Galyang. This enables some of the farmers to sell the produce closer to Senapuk and catch the traders coming along the road before they reach the market.

Once the MUS system was constructed and running smoothly, the households had purchased and installed their microirrigation kits, SIMI had conducted all trainings, and the marketing linkages had been made, SIMI staff made follow-up visits to help the WUC with any problems that arose in system operation and to help farmers with production advice. In fact, SIMI staff continues to visit Senapuk periodically to get feedback and provide technical support. Moreover, SIMI conducts exposure visits where they bring farmers from other district communities, government officials, and NGO partners to see the MUS system and vegetable cultivation in Senapuk.

OUTCOMES

Village exposure visits are a great way for Senapuk farmers to share the story of their MUS system and the changes they have seen in their village since system construction. During the group interview in March 2007 the community was asked to rank the most important impacts of MUS. Their group conclusion was that increased drinking water availability was the most important improvement. Interestingly, the men in the village ranked nutrition and improved health as the second most important change, whereas the women thought that the increased income from vegetable production was the second most important outcome.

VEGETABLE PRODUCTION

One of the most important impacts of the MUS project is the rise in vegetable production of the participating households. The increase in both crop variety and intensity has enlarged their income which helps them mitigate risk. Prior to the MUS project very few farmers in Senapuk were raising vegetables for sale; instead, most were growing a few vegetables for home consumption. With the construction of the MUS system and introduction of vegetable production techniques, farmers are now growing new crops. And, with the purchase of microirrigation kits, 86 percent are now growing these vegetable crops both on- and off-season, with the off-season vegetables fetching a higher price at local markets than during the on-season. Table 4.1 shows the average household vegetable cultivation in two crop cycles during the first year after MUS system implementation in Senapuk.

Table 4.1: Average household vegetable cultivation in one year (two crop cycles) using MUS

Vegetable	Production (kg)
Tomato	217
Cauliflower	207
Cucumber	187
Cabbage	83
Bitter gourd	42
Bean	20

Source: Personal interviews conducted in the second visit in October 2006 with six households, two from each category—poor, middle-income, and wealthy. There was no opportunity to cross-check to verify their recall responses.

Because they have more disposable income and greater technological awareness, they are purchasing more inputs, which further affects their yield and income gains. Farmers have shifted to using about 60 percent hybrid seed varieties, although seeds for beans, greens, and radishes are still local varieties.

There is opportunity for increased cropping intensity in the future. With the MUS system and microirrigation it is possible to grow three vegetable crops per year, depending on the type of vegetable. As the Senapuk farmers become more adept at growing vegetable crops, there is potential for equal production in all seasons if the crop varieties are selected correctly.

HEALTH AND NUTRITION

Just as important to the villagers as income gains were the health improvements and abundance of vegetables in their diets. According to the villagers during the group interview in March 2007, additional domestic water has allowed them to practice regular personal hygiene. They claimed that because they are drinking more water on a regular basis, they are suffering fewer urinary-tract infections. And while 70 percent of the village households had toilets prior to MUS implementation, they did not have enough water to use the toilets at all times. Since MUS construction, the remaining 30 percent have built toilets, and all are using them regularly. All community members agreed that the incidence of illness had decreased since the MUS system was constructed.

Community members also claimed they felt healthier on the whole, and when asked why their health had improved, they directly linked it with consumption of fresh vegetables. Although data collected was not sufficient to prove enhanced health from vegetable consumption, the villagers' perception is that their health has improved because of the change in diet. With the increase in variety and quantity of vegetable production, consumption has also increased. The vegetables villagers were previously consuming were mainly beans and leafy greens which were added to their pulse curry, dry or pickled. After the project, they are consuming a larger variety of fresh vegetables per day. Household interviews indicated that roughly 20–26 percent of the total production is consumed at the household level.

The social value of vegetables has also changed due to the project. Prior to MUS system construction, the traditional gift that women gave to relatives during visits was homemade bread or bananas. Now, fresh vegetables are considered to be the most valuable gift they can give family members. This is likely due to the education they received about the health benefits of vegetable consumption.

However, one person indicated during the household interview that due to the increased production of vegetables, milk production in the village has decreased. She explained that the MUS system enables increased vegetable production, which makes it possible for her to do other work near to the house. Conversely, collecting fodder for her buffalo and cow requires going to the distant common land for several hours every day. With her husband working in India, it is easier for her to grow vegetables than take care of the livestock, so she has reduced the milking buffalo and increased work with vegetables. The vegetables can also be taken to the relatively nearby Galyang market for sale whereas in order to receive comparable prices for milk, it must first be made into ghee and then taken to farther-away Butwal for sale. Others during group interviews echoed her claim that there is less milk production in Senapuk than some years ago and much more vegetable production.

FINANCES

Even though a quarter of the vegetables are consumed, there is still plenty for the farmers to take to market, and off-season prices are much higher than they are used to receiving. Ultimately, the project has been a financial boon for Senapuk farmers. On average, the annual net benefit of vegetable production (what was consumed plus sold minus cost of production) was $243 per household. Considering that most households had no vegetables for sale prior to the project, the net annual cash income increase per household was $199 (what was sold minus cost of production).

For farmers with steady sources of outside income, such as remittances or other employment, vegetable production does not represent the majority of their total income. However, for some without external aid, vegetable sales represent a major portion of their current income, on average, 30–40 percent.[7] For example, for one poor farmer, vegetable sales in the first year after the MUS project represented 50 percent of household earnings. Fortunately for most farmers, it has only taken six months to one year to recover the cost of their investment in the project through their new income.

Obviously farmers who were already wealthier with more land and resources were able to purchase more inputs and farm more land, thereby obtaining a greater output from their investment. However, the MUS project has leveled the playing field for community farmers by providing equal access to water for their crops and knowledge of production techniques, which provides the potential to increase production value and yield for all farmers more or less equally. Moreover, the income received by the poorest households makes more of a difference for their families because it represents a higher percentage of their overall income.

Additionally, the dynamics between the wealthier and poorer households in the village created by the MUS project are financially beneficial to the poorer households. First of all, some of the wealthier families in Senapuk decided that they could not contribute labor for the construction of the project, possibly because they have more family members outside of the village earning money. Due to their lack of ability to contribute labor, they paid poorer households to provide their share of the labor contribution for construction. Secondly, although some of the wealthier families owned and farmed more land, other wealthy families said that they were accustomed to purchasing vegetables and did not want to grow their own. Nonetheless, instead of purchasing them from the market as before, they started purchasing them from the poorer households in the village. This provided a market for the poor households within the village and reduced the time and energy spent carrying that produce to the marketing center or roadside stand.

Not only did the MUS project create new revenue streams for the poorer households, it also changed the power dynamic between them and the wealthier households. When questioned separately from the rest of the community, some of the poorest families commented that prior to MUS implementation they had to frequently take large loans from the wealthiest families. Now due to the income they make from their vegetable sales, they still have to take occasional loans from the wealth families, but at a much lower amount. This, they said, makes them feel more independent and less beholden to the wealthy in their community.

One future cost consideration for all Senapuk farmers is the lifespan of the irrigation kits. Although the MUS scheme was designed to provide adequate water for a ten-year projected population, the irrigation kits last only around three to five years. This will mean that if farmers want to continue receiving the benefit of microirrigation, they will need to replace their kits two or three times in the next ten years.

TIME SAVINGS AND LABOR CONSTRAINTS

Another benefit from installation of the MUS system is the reduction of time spent collecting and carrying water each day for domestic needs. This has resulted in a decrease in school absenteeism, particularly among girls. As it is often women and young girls that are required to carry water, Senapuk villagers mentioned girls being able to fully attend school now that they no longer have to fetch water. According to the community group interview and observation by the SIMI irrigation technician and social mobilizer, about 20 percent of households were not sending their daughters to school prior to MUS construction, but now all girls in the village are attending school.

The benefit of time savings in domestic water collection is also an implicit financial benefit to the villagers. Each household is saving about 1.5 labor-hours per day because of the MUS system. Assuming that it is predominantly women's time being saved, this time savings equates to NPR 19 per day ($0.26),[8] about $100 per year.

The extra time women save on water collection is now being spent on vegetable cultivation, changing the nature of the domestic workload. And, since many men are working outside the village, vegetable production sometimes requires more time commitment than previous water collection, actually allowing women overall less free time. Although women in both the October, 2006 individual household interviews and the March, 2007 group interview said that they preferred to spend the time on cash-producing activity, they did reflect on their labor constraints because so many of the young men are employed outside the village. The women reported that since they are fully responsible for all aspects of household life, they are limited in the amount of production they can handle. So, the limiting factor in vegetable cultivation is lack of available manpower, not water shortage. Households with more available labor plant larger areas and the WUC has agreed to allow them use of as much water as needed, provided those that planted a smaller area do not suffer a water shortage. It is possible that as households continually see the financial benefits of vegetable cultivation, men may return to the village to cultivate increased area. However, it is too soon post-project for this sort of change to be observable.

CHANGE IN GENDER ROLES

Another significant impact of the project was the change in gender roles. Consultation and joint decision making between men and women on farm activities has increased. And, because the household tap is now nearer to their homes, men have begun cooperating with women to perform household chores, particularly fetching water and managing livestock. Likewise, although women had always participated in cultivation, with vegetable production their role has significantly increased. And, for some families, women are doing all of the vegetable cultivation. Women also have started marketing for the first time, and have been a key factor in the rise in household income, which they claimed has made them feel more independent and confident. Since they are the ones predominantly responsible for vegetable cultivation and sales, they are freer to spend some of their money while in Galyang market selling their produce. They buy the essential items like cooking oil, salt, and sugar, but also personal items for which they previously had to request money from their husbands.

CHANGE IN WATER-USE BEHAVIOR

An additional change for women was the abolition of a discriminatory cultural practice that existed around women's access to water. Due to the caste culture of the village, rules of "pollution" are very important, and when women are having their menstrual period, they are considered "unclean." They are not allowed to cook for their husbands during menstruation and after it ends they must bathe and wash their clothes before they are again considered "clean." They were not allowed to use the previous drinking water system taps for this purpose, but instead were required to go to the stream, which was a half-hour walk from the village. The project overseer refused to continue with the MUS project until this discriminatory practice was abolished which resulted in an animated community discussion. In due course, a decision was made that women would be allowed to collect water and bathe at the tapstands during menstruation so that project work could commence.

Yet, women's water use was not the only change for the village. The behavior of the entire community in regards to water conservation was also transformed. As the Senapuk community gained experience in operating both the domestic services and irrigation delivery of the MUS system they collectively modified the rules for water distribution. They found that there is usually sufficient water available for continuous water distribution in the domestic service line provided all taps are closed immediately after drawing water. It is common in the middle hills of Nepal to see domestic taps left open and running continuously. Closing taps after drawing water is an acquired habit that requires reminders and discipline. However, while visiting the village and observing the tap near the school where children gathered for a drink of water while playing, it was noted by international staff that they carefully closed the tap after each drink of water. After this observation, it was discovered that not a single tap was left open in the entire tour of domestic taps in the village. It is likely that the connection was made in the village that by shutting the domestic taps when not in use, more water would be available in both tanks. Therefore, they have been able to modify their own behavior to realize the full benefits of the MUS system and have a significant amount of water available in this moderate water supply region.

SYSTEM IMPROVEMENTS

While their behavior changed in regards to women's water access due to encouragement from SIMI staff, not all suggestions were received as conclusively. In several visits to Senapuk, SIMI staff noticed that the intake remained unprotected. Although the villagers were encouraged each time to collect the money necessary to provide a cover for the source intake, they have not yet taken the initiative. Partially due to this experience in Senapuk, source protection has become more advanced as the MUS projects have evolved in the past few years. For example, for the system in Lele village of Lalitpur District sand filtration tanks were built at the intake. Senapuk's lack of movement on this front indicates that the water quality information given through the trainings is not compelling enough for them to spend the extra cash on a cover.

On the other hand, there were other system improvements that the villagers did think would be useful along with problems they would like to solve. While meeting with the whole village community in 2007, there were a few suggestions for improvements to the system. Villagers mentioned that there was no provision to wash out the two water storage tanks. They also said that a problem with lime buildup in the tapstands was causing blockage, so regular cleaning of the pipeline was suggested as a low-cost solution. Furthermore, it was suggested that tapstands for future MUS systems be constructed with reinforcements to make them more durable. The community felt that they were somewhat weak because a drunk resident had been able to break one of the hybrid tapstands when he kicked it. In this instance, the man damaged the newly built structure when the concrete was still setting and not yet solidified. But, this created a perception within the community that the tapstand was weak.

CONCLUSIONS AND LESSONS

There is no doubt that the MUS system has brought positive change to Senapuk. The increased availability of domestic water has improved the health and hygiene of the villagers. The availability of irrigation water to make productive use of their bari land has enabled them to grow new vegetable crops, plant in the off-season, and receive higher levels of income. It has also increased their consumption of fresh vegetables and improved nutrition. And, although some reduction in milk production is expected with increased vegetable production, caution should be taken not to completely remove milk production from village activities. Both the existence of milk in their diets and the diversification of income sources from ghee production are important and must not be removed. Education given as part of future MUS projects should touch on the importance of these aspects of maintaining livestock.

Perhaps most strikingly in Senapuk was the emphatic declaration of women in the village that their sense of independence has improved dramatically from the system due to vegetable cultivation and marketing. Considering that the resident male population in many hill districts is decreasing, and the focus of development aid on improving the condition of women is strengthening, this change for Senapuk's women from their MUS system has dramatic implications. Furthermore, increased school attendance by girls only underscores the sustainability of MUS' positive impact for future generations of women. In order to fully actualize the benefits of MUS for women, more emphasis should be placed on their representation in WUCs and marketing committees and greater inclusion in the planning and decision-making phases of MUS projects. More care must be taken in training women heads of household in vegetable production, particularly if they are among the poorer households in the community. Additionally, since labor was cited as the limiting factor for increased production and as the reason for lack of purchase of microirrigation by some households, alternatives should be sought to this problem, such as loans for hire of additional labor. On the other hand, although water does not currently seem to be a limiting factor, if enough water were made available to irrigate all of their land, it could potentially make their farms financially viable to the point that the men would no longer need to work abroad and send home remittances. If this were the case, the labor shortage would no longer be an issue.

Despite a net annual cash income increase per household of $199, farmers felt that they were not always receiving the highest possible price for their produce. These marketing difficulties echo those of Chhatiwan Tole and are being mitigated in similar fashion. As mentioned above in the Chhatiwan case study, SIMI is now strengthening the dissemination of market information and creating apex marketing committees at the district level to help the smaller committees reach broader markets.

As for other communities in the hills with scarce to moderate water supply, the Senapuk case lends many lessons about source negotiation and equitable distribution. Negotiating for rights to water resources with surrounding communities and previous rights holders is critical for the success of MUS projects, and often takes patience, compromise and persistence. It also takes knowledge of the customary water rights and legal water rights in Nepal. In order for a MUS project to proceed, the community must obtain legal rights to the water source, which in turn requires them to be organized into a WUC. These formal steps are key to not only developing the ability of the community to organize themselves and negotiate as a unit, but also follow the formal legal steps to establishing their rights. As water resources come under increased demand in the future, these skills will be invaluable.

Yet, just the ability to use a source is not enough for all to have equal access. Ensuring the priority of domestic use over productive use through the system design and working together within the WUC to establish rules of operation for water allocation were essential in making maximum use of a moderate water supply and reducing the possibility of intra-community conflict. Ultimately, the double-tank, two-line distribution system was an innovation that was copied for areas with scarce-moderate water supply throughout the hills of Nepal.

Unlike the single tank model, those using the double tank model should be aware of the difference in water quality between the two. Because the productive-use tank does not have a cement cover, the water inside it is more susceptible to contamination. Although the system is designed to provide water for domestic use solely from the domestic tank and water for productive use solely from the productive tank, some families who are closer to the offtake than the hybrid tapstand use the offtake to get water for domestic use. The potential difference in the water quality in the two tanks should be made apparent to these households. And, if some households wish to use the offtakes for domestic purposes, the community should be able to decide during the design phase of the project if they wish to spend the extra cash for a cement cover on the productive tank. Alternatively, SIMI could work with the community to better site hybrid tapstands such that all households have closer access to their domestic tap than the irrigation offtake. Unfortunately, with the variance in location of bari land in relation to homes, this is difficult to ensure.

Although the future sustainability of the system has yet to be seen, there are many factors indicating that sustainability is likely. The community owns the MUS system from project initiation and makes all decisions collectively. They are raising the funds for operation and maintenance, are investing collected funds, and making all decisions upon their use. Additionally, for the first time, farmers are cultivating vegetables as a cash crop, which has increased their annual income. The income-generating nature of the system helps to ensure that households will put the time, effort, and finances into its future operation.

The development of the double-tank, two-line distribution system in Senapuk grew out of the need to ensure domestic supply in the dry season for this region of moderate water availability. As will be seen in the Krishnapur case study, an even more scarce water situation led to a different system innovation.