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Rural water supply system debugging, servicing and refurbishing

Rajeeb Ghimire

National Water Supply and Sanitation Training Centre, Bhaktapur, Nepal

E-mail: rajeebghimire@gmail.com

Abstract

Many community water supply systems in Nepal are suffering from non-functionality. For various reasons, the communities responsible are unable to manage their water assets. External support is needed to improve water asset management. The required external supports were analyzed based on the life cycle curve. Subsequently a new management concept of debugging, servicing and refurbishing of the rural water supply system has been proposed. Debugging decreases the duration of the burn in period, servicing increases the useful life period and refurbishment revitalizes the system at the end of its design life.

Key words: community managed, debugging, functionality, refurbishing, servicing, sustainability, water supply

COMMUNITY MANAGEMENT AS A KEY CONCEPT

Over the last two decades, responsibility for the Rural Water Supply and Sanitation sector in Nepal gradually moved from national government to local community. Community management became a prominent concept in this sector. All Water Supply Sanitation and Hygiene (WASH) sector agencies recognized this as a key concept. The transition started with community contribution, which gradually developed into community involvement, then to community participation, and ultimately to community management. Nepal's National Policy on Rural Drinking Water Supply and Sanitation (RDWSS) (2004) provides guidance on water and sanitation service provision in rural areas using demand driven community led participatory approaches. The policy has recognized community management as a key concept. The Nepalese RDWSS policy provided favorable policy environment for:

1. Demand-driven community management, based on empowerment of the community to ensure their full participation in all stages of the project cycle.
2. Community ownership of the assets through Water Users and Sanitation Committee (WUSC).
3. Full responsibility for operation and maintenance (O&M) by the community.

SUCCESS OF COMMUNITY MANAGEMENT

The community management approach significantly reduced the burden on the national government's over-stretched resources. This provided the government an opportunity to invest resources in other important sector. It is widely recognized that the community participation concept is able to replace a large portion of the state's implementation capacity. The RDWSS policy provided an environment which enabled the number of community managed water supply projects to increase significantly. The demand for community managed water projects has continued to increase. Key successes of the Nepal WASH sector's community management approach are as follows:

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1. **Increased coverage:** The rural water supply and sanitation coverage has increased considerably due to the adaptation of community management as fundamental approach. This is because new resources were mobilized in this sector including community's labor, motivation and management skills. Table 1 shows the increase in coverage of the water supply and sanitation.

Table 1 | Millennium Development Goal Progress in Nepal for Water Supply and Sanitation, 2013

Indicator	1990	2000[a]	2005[b]	2010[c]	2012/2013[d]	2015 (MDG)	2017 National Target
Proportion of population using an improved drinking-water source	46%	73%	81%	80.4%	85%	73%	100%
Proportion of population using an improved sanitation facility	6%	30%	39%	43%	62%	80%	100%

(Source: National Planning Commission 2013).
[a]National Planning Commission (NPC) & United Nations Country Team (UNCT) (2005).
[b]Central Bureau of Statistics (CBS) (2004).
[c]NPC & UNCT (2010).
[d]NPC (2013).

2. **Increased community cohesion:** Water supply projects in Nepal are implemented through community managed committees. The community expresses their desire and aspiration for water infrastructure through their representative institution, WUSC. The WUSC is 9–11 member committee whose members are elected by 'one house one vote' concept. Their tenure remains for 3–4 years depending on the constitution of the WUSC. Though the government or other agencies can partly fund projects, the WUSC accepts full responsibility for service delivery.
   WUSCs have extraordinary management authority. Its acts as owner, financer, service provider and regulator. Key responsibilities of the WUSC include:

- Regular office administration
- O&M of the system
- Establish and collect water tariffs
- Generate and mobilize resources
- Regulate service quality

The concept of community management introduced social changes in the community which created strong positive relationships. This brought more communication and interaction within the community. This enhanced an understanding and appreciation of people's beliefs and practices. It was a catalyst for the development of a common vision and the sense of belonging.

FAILURE OF COMMUNITY MANAGEMENT

In early stages, stakeholders were optimistic regarding the success of community management in light of the benefits to the community and government treasury. WASH professionals initially believed community management would solve all WASH problems. With a very optimistic assessment of community capacity, the government responsibility was gradually transferred to the community (to the WUSC). The WASH professionals failed to appreciate the limitations of the WUSC for the provision of water and sanitation services. Key problems with community management include:

1. **Poor Functionality**: In 2014 a survey of community managed water supply projects was conducted by the National Management Information Project (NMIP) from the Department of Water Supply and Sewerage (DWSS). It surveyed 38,000 community managed projects. The survey showed that only 25.4% of the projects are fully functional Table 2. All others have some degree of poor functionality.

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Table 2 | Functionality status of Water Supply Systems in Nepal, 2014

S.N.	Functional Status	Percentage
1	Fully Functional	25.4
2	Requiring Minor Repairs	36.1
3	Requiring Major Repairs	9.2
4	Requiring Improvement and Extension	19.8
5	Requiring Rehabilitation	8.6
6	Dead Projects	0.9

(Source: DWSS/NMIP 2014).

2. **Substandard service delivery:** Overreliance of policymakers on the capacity of the community is reflected in the poor quality of the services provided by WUSC. Whilst a separate study has not been conducted, it is widely observed that rural water supplies are frequently interrupted, unreliable and have low user satisfaction. The primary causes of these problems include:

(a) Low revenue due to inadequate tariffs, weak billing procedures, and low tariff collection rates
(b) Absence of internal 'controls and quality' documents
(c) Lack of funds for system O&M leading to a backlog of maintenance works
(d) Lack of equitable distribution to customers
(e) Frequent system failure, with a lack of technical and financial capacity to rectify problems

UNDERSTANDING NON-FUNCTIONALITY

The cause of poor functionality had drawn very little attention from Nepalese WASH professionals. Despite the promotion of community management successes, WASH professionals fail to recognize current problems. Questions which should be addressed include:

- What does the high rate of non-functionality indicate?
- Is a strengthening of the community management concept required?
- What interventions can strengthen community management?
- What are the areas of intervention required?
- Are communities capable to strengthen themselves?

Is strengthening the community is sufficient or external support is necessary? To find suitable answers to these questions we first need to understand at which stage of the project's lifetime the system becomes defunct. We can analyze the nature of failure of RWSS based on the Bathtub Hazard Rate Curve (Figure 1). The Bathtub Curve is not typically used in a rural water supply perspective. However for this case we can consider the water supply system as a single entity – a 'product', which consists of several parts. The water supply system can be considered a 'product' of the project construction process. This curve does not show the failure rate of a single part of the water supply system, rather it describes the relative failure rate of the entire 'product' over time.

Table 3 shows possible reasons for the failure of a water supply system and proposes suitable interventions at various stages in the bathtub hazard curve.

IMPROVING FUNCTIONALITY

The NMIP report, which is collated annually, shows that there has been a small increase on number of functional projects in last three years. In 2011 17.91% of projects were fully functional. This

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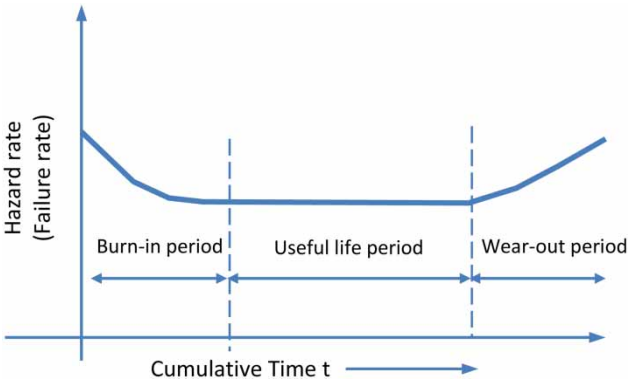

Figure 1 | Bathtub Hazard Rate Curve.

Table 3 | External support required for community managed water supply systems

Regions	Possible Reasons for Failure	External support types
I: Decreasing hazard rate region (**Burn-in period**)	Poor construction methods, poor processes and handling techniques, poor quality control, human error, incorrect startup, substandard parts and materials, substandard workmanship, incomplete final test, substandard calibration process	Diminishing support (how: system debugging)
II: Constant hazard rate region (**Useful life period**)	Low safety factors, undetected defects, human errors, system misuse, higher random stress than expected, natural failures	Periodic support (how: system servicing)
III: Increasing hazard rate region (**Wear-out period**)	High wear due to incorrect operation, insufficient or improper maintenance, incorrect overhaul practices, corrosion, material or design not suitable for application, limited design life of components, material degradation.	Increasing support (how: system refurbishing)

(Adapted from: Birolini 2007).

increased to 25.4% by 2014. Therefore in these three years 7.49% of all water supply projects were returned to fully functional status. The remaining 74.6% of projects have some degree of non-functionality. Each year about 150 new community managed water supply projects are constructed. The increase of the functionality figure during this three years period was partly due to a large number of these newly constructed projects. This shows the actual improvement in functionality of existing systems, is quite low.

The low level of functionality indicates that the community is not able to manage their water systems properly and that the community requires external support.

Support for increasing water system functionality should consider all periods in the project lifecycle (Figure 2). The useful life period of a given project should be increased by decreasing the burn-in-period and wear-out-periods.

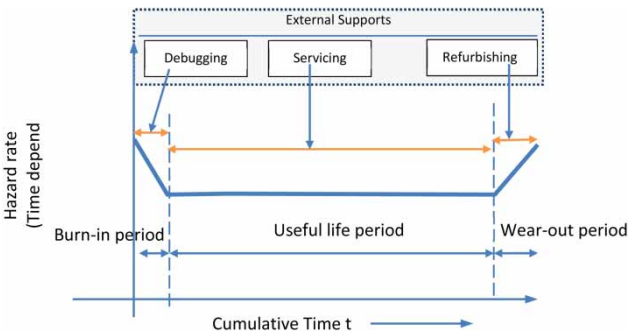

Figure 2 | Types of external supports.

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External support I: debugging

Studies have found that 30 to 50% of rural water projects, whether water systems or wells, fail three to five years after construction (Walters & Javernick-Will 2015). This period is also called 'infant mortality period', where project fails without achieving its objectives. This high rate of failure during the burn in period is not acceptable. The community's optimism and confidence in the benefits of a water supply project can be undermined if the supply is frequently disrupted and has limited functionality.

Possible reasons: The decrease in system functionality at this stage is generally caused by design or construction defects. The causes of these initial defects need to be clearly understood. In Nepal the projects are constructed through the active participation of WUSC, specially formed for construction. Most projects have a construction period of 3 years. Community forms WUSC for the construction. This WUSC when completes the construction, handovers the project to new WUSC for O&M. The WUSC for construction always want to complete the project as early as possible, this is simply to get the due recognition that they have completed the project in their tenure. The WUSC's members are elected based on the voting by users, this recognition helps them either for next tenure or to make the favorable background for the political carrier. In such situation the premature and hasty handover-takeover takes place without due attention to fix these 'bugs':

(a) Poor design of network, causing inadequate flow, low pressure head and low velocity in the pipe network.
(b) Insufficient quantity of water for the population
(c) Insufficient water storage causing unreliable water supply
(d) Leaking or cracked water storages
(e) Leaking or broken pipes, fittings and joints

The water supply system is operated and maintained by the Village Maintenance Worker (VMW). The VMW is appointed by the WUSC. Training provide to the VMW is often limited nature, just sufficient to operate the system. VMWs do not have the knowledge, resources or capacity to fix complex technical problems in the water system.

Diminishing support: Debugging is required to find and resolve defects that prevent correct operation of the water supply system. This needs to be conducted by trained technicians. VMW, do not normally have the required technical proficiency.

To maintain community good will and confidence the debugging phase should be concluded within one year, and no longer than two years. This period should be supported by qualified technicians. The experts should provide their services periodically and on an on-call basis. The support should be gradually withdrawn so that knowledge and technology are transferred to the VMW. During the intensive support period, the VMW gradually builds their capacity so that they can fix minor problems after the team leaves.

Network performance testing: Testing is performed to verify that a water supply system performs and functions correctly, according to design specifications. This is done by operating the system at the design limits. For example, operating the water supply system with (i) all valves closed and (ii) all valves open for an extended period. Any defects, such as insufficient flow or leaks, can then be identified. During the period of intensive support, water users can report problems with the system which can be fixed by the expert team.

External support II: servicing

During the useful life period, the water supply system is expected to operate with minimal disruptions. The required external interventions should be limited to increasing functionality or extending the useful life of water supply system. The useful life is the normal operation period when the system is operating normally, and the cost of ongoing maintenance is less than the cost of system replacement.

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Possible reasons: The possible reasons of failure during this period are relatively difficult to determine. They are often caused by improper operation or insufficient maintenance. In rural water supply system, the common failure types are cause by:

(a) Overloaded pipe network due to unexpected population growth.
(b) Blockage, cavitation, water main burst, airlock
(c) Insufficient pressure, or water leakage
(d) Improper operation by VMW's due to limited knowledge, skill and capacity

Servicing the system: The water supply system should be regularly serviced after construction is completed. Regular preventative maintenance is required to ensure the system continues to operate properly. It prevents small problems from causing greater damage throughout the system.

Whenever systems fail, the VMW's priority is to reinstate supply as quickly as possible. They will be under community pressure to reinstate the system. This pressure can result in unconventional 'band-aid' techniques being used which can be harmful to system's long term functionality. This can be due to a lack of resources or a lack of knowledge. Over time, these improper repairs accumulate, limiting the functionality of the system, ultimately causing complete failure. To avoid this, regular servicing is required. The servicing is done by an expert at regular intervals. This will considerably increase the useful life of the asset. Examples of servicing tasks include:

(a) Rectifying faults not repaired by VMW
(b) Identify components of the system close to failure, but not known to VMW.
(c) Refine the operation of the system.

Due to the VMW's limited capacity, the servicing should be conducted by a qualified technician. The WUSC may independently hire an expert for servicing. Alternatively, if WUSC do not have sufficient fund for outsourcing, a local Government agency responsible for water supply and sanitation can form a team of experts which periodically visits the community managed water supply systems to provide servicing. The experts should have sufficient engineering knowledge to understand and repair a variety of water supply systems. They should have strong diagnostic, problem solving, engineering and technical skills.

External support III: refurbishing

Near the end of the product life, failures become more frequent. This final stage of the product's service lifetime failures occur due to wear, material degradation and fatigue. WASH professional in Nepal have historically not given much consideration to this phase. The designed period of typical rural water supply projects is currently 20 years. The WUSC requires additional support at the end of the system's life, because the community alone could not manage the increased maintenance technically or financially. The VMW is generally not capable to provide the required maintenance in this period.

Possible reasons: In rural water supply systems, most components wear out due to aging. Some common examples of this failure are:

(a) Brittle, cracked, corroded or leaking pipes, fittings and valves
(b) Leaks, and sedimentation in water storage structures
(c) Pump wear and tear

Refurbishment generally involves undertaking significant repairs or replacement of components which are no longer functioning correctly. Although refurbishment does not always bring the water supply system back to its original state, the system can continue to operate at its designed capacity.

The wear-out period is not same for all components in a water supply system. The least robust component will determine the wear-out time of that product. Refurbishment is undertaken when the

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system reaches the fatigue state. This stage is characterized by frequent breakdowns of components in the system. In rural water supply systems typical types of failure include breakdown of valves, ruptures in pipeline, large decrease in pump capacity or complete failure etc.

The refurbishing process typically involves the following steps:

(a) Assess network for non-functional components
(b) Replace non-functional components
(c) Upgrade parts if necessary
(d) Thorough system check, clean and disinfection

Due to their limited knowledge and capacity, VMW would not be able to fully understand the process of refurbishing. WUSC may wish to hire expert or contact local Government agency responsible for water supply and sanitation for the technical assistance.

CONCLUSION

In Nepal, the proportion of functional community managed water supply system is very low. The low rate of improvement in this figure (17.91% in 2011 and 25.4% in 2014 i.e. only 2.49% increase in a year) indicates that communities are not capable manage their own water supply system. This is primarily due to insufficient resources and knowledge. These communities require external support throughout the life cycle of the water supply system. The type of support required can be categorized as debugging during burn in period, servicing during useful life period and refurbishing during wear out period.

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