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Digging deep behind the complexities of sustainable water supply in Nepal

Paper for the WASH systems symposium

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It has almost been five years since the report identifying high nonfunctionality of rural water supply schemes in Nepal (only 25% of systems are functional). It was found that the major factors of the nonfunctionality of rural water supply has been because of the institutional capacity, financing of rural water supply delivery, assets management, water resource management, and monitoring and regulation. However, an in depth contextualised analysis of the root causes of system failure, proper mechanisms to finance capital maintenance, decentralise technical capacity and solutions to existing inefficient financial and managerial models of the scheme, has not been done. We know the problems but are still struggling to identify evidence-based solutions. Therefore, this working paper explores the data behind the challenges presented. We look at three key areas i) financial challenges: what does financial challenges really mean, who is impacted and what are the financial consequences for the system, ii) how the governance of water supplies at the scheme and local level impact their sustainability, iii) how technical challenges impact the sustainability of the services. The research identified that schemes have some common technical problems around pipes, pumps, deep well and electrical systems which have increased operation and maintenance costs for rural water supply schemes. Collection of unscientifically calculated tariffs and unclear mechanisms to finance capital maintenance, and in many cases, with a slower adoption curve to household connections from shallow tube wells or community taps, have led to insufficient operation and maintenance funds causing scheme dysfunctional.

Introduction

The water sector in Nepal is looking for a solution to make the rural water supply scheme more sustainable. It is currently highly nonfunctional and obstructing regular access to safe water for the rural communities. Despite the relatively impressive coverage figures in water supply - 87% as of sector status report (SSR) 2016 which identified 'only 25.4% are functioning well , 36.1% are in need of minor repair within the capacity of the user's committee, 9.2 % are in need of major repair beyond the capacity of users committees, 19.8% are in need of rehabilitation to meet present demand, and the remaining 19.8% need construction while 0.9% cannot be recovered'. It is also imposing high financial loss/loads onto the Government of Nepal and WASH actors as they must spend heavily on reconstruction and repair. The World Bank 2017 report has identified and given an overview of the factors affecting the sustainability of the scheme. However, an in depth analysis of root causes of system failure, proper mechanisms to finance capital maintenance, decentralised technical capacity and solutions to existing inefficient financial and managerial models of the scheme are still unidentified. Oxfam in Nepal is investing heavily to identify these root causes of system failure and identify an alternate management model for water supply schemes as the trend of handing over everything to water user committees (WUCs) with little training did not prove to be sustainable. As it is, building and rehabilitating a significant number of water supply schemes in the Hills region (mountainous areas of Nepal) and two major deep boring schemes in Terai (southern flatland area of Nepal), Oxfam in Nepal is well placed to use this learning to invest in more targeted and effective systems strengthening initiatives to improve sustainability of water services.
The objective is to identify the major factors in technical, financial, institutional capacity and governance which can move the needle of sustainability, develop a prototype management model and test it through continuous monitoring of approach and then adopting the approach that works. Oxfam's research dives deeper into these factors to gain an in depth understanding of exactly what technical, financial and governance factors impact institutional capacity and financing to cause system failure for a rural water service .This operational research looks at three key areas i) how technical challenges impact the sustainability of the services, ii) financial challenges: what does financial challenges really mean, who is impacted and what are the financial consequences for the system, iii) how the governance of water supplies at the scheme and local level impact their sustainability. This study gives guidance to implementers and decision makers to identify the gears that need to be changed in technical, financial and governance aspects to make the water supply system sustainable. Oxfam works with donors, private sector, government, academia and institutional bodies to implement its findings. Oxfam's research has identified a few key levers that increase sustainability at scale: increasing the existing tariff itself; increasing the volume of tariff collected; reducing cash collection costs; reducing administration costs and optimising account management; reducing operation and maintenance; and reducing electricity costs for pumping systems (Oxfam, 2018). However, this paper investigates one of those levers in detail – the technical operation and maintenance

(O&M) costs affected by technical design and quality of construction. It does this by identifying the challenges that the rural water supply scheme is facing because of technical errors during and after construction and its corresponding annual financial burden to the water supply scheme which makes the system impossible to sustain because of complex repairs (operation and maintenance costs) resulting in its eventual collapse.

Literature review

The Brundtland report of 1987 defines sustainable development as 'the development that meets the needs of the present without compromising the ability of future generations to meet their own need'. Harvey and Reed (2003, p.1) defined sustainability of water supply as 'the water sources are not over-exploited but naturally replenished, facilities are maintained in a condition which ensures a reliable and adequate water supply, the benefits of the supply continue to be realised by all users over a prolonged period, and the service delivery process demonstrates a cost-effective use of resources that can be replicated'. This study, however, was more focused on shallow hand pumps. Several studies have been made on the sustainability of the water supply schemes to identify the factors that affect sustainability. Brikke (2001) prioritised financial management as a crucial part for sustainability. Brikke emphasised building on better knowledge of capital and recurrent costs in water supply and building reasonable and equitable tariffs for sustainability. Brikke and the business partner for development (2001) report that often projects do not involve the community in determining the service level e.g. upgrading from a community tap to household connection and therefore it becomes very challenging to collect revenue after construction. Research done by Bhandari and Grant (2007) in Nepal found that technical capacity and technical material availability was the factors affecting sustainability in rural water supply. They also prioritised user satisfaction as an important aspect to increase a willingness to pay. Community involvement in the planning of their own scheme rather than donor prioritisation has been regarded as an important factor to ensure sustainability in all the papers from Gleitsmann, Kroma and Steenhuis, (2007) and Barnes and Ashbolt, (2010). Another study found that the most crucial factor that moves the needle of sustainability is the financial component as the strong tariff system would generate savings for future operation and maintenance. (Mimrose et al, 2011). Smith (2011) concluded that there is a complex relationship between technical adequacy, community support and women's involvement to deliver a successful water supply project. This study prioritised technical design as the crucial factor, but remains silent about the importance of scientific tariff collection. Moreover, it speaks less on what these technical factors are and how deeply rooted the problems. On the other hand, the World Bank (2017) identified institutional capacity, financing for rural water service delivery, assets management for rural water supply, water resource management and security, and monitoring and regulation as crucial factors to sustainability in Nepal. This study gave a clear overview but doesn't explain how deeply rooted these problems are in the schemes in Nepal.

Methodology

The research is done in purposely sampled rural water supply schemes of Sarlahi and Rautahat districts in Terai and Nuwakot, and Gorkha and Dhading districts in the Hills region. In terms of administration, Nepal was initially divided into 14 zones and 77 districts. With new federal system, there are three tier structures (federal, provincial and local level). There are seven provinces under which there are 77 districts and 753 local levels. Each district has a different number of local levels depending on its area. The research only looked at the functional and non-functional schemes in Terai (flat lands) and Hills. This research looked at the schemes which were built prior to the earthquake in 2015. Some schemes were 16 years old while others were just five years old. The research looked at the three types of water schemes present in the study area. In the Hills, there are two types of water schemes which use water from rivers and springs - those with gravity flow (where water flows freely under the force of gravity) and those which utilise a combination of gravity flow and booster pumps. In Terai, deep aquifers (150m-300m) are accessed using submersible pumps to pump the water to tanks at a higher elevation, which is then distributed by gravity flow.

It is more of an exploratory research. The research has collected both qualitative as well as quantitative data from the field visit. Following 120 key informant interviews, 30 group discussions and 920 household (HH) interviews in the purposely selected schemes in five districts of Nepal, the list of problems was identified and finalised by listing only the common problems in all schemes. The key informants included government staff, government engineers, water user committee chiefs, mayors, plumbers, pump repair shops, pump operators, Federation of Water and Sanitation Users Nepal (FEDWASUN), telecommunication companies and private institutions. After listing these problems, we went back to the field to quantify the occurrence of these problems by visiting 28 different schemes. Out of the 28 schemes visited, 16 schemes were in Hills and 12 schemes were in Terai. By quantifying the existence of specific problems as 1 and non-existence of specific problems as 0, the occurrence trend of specific problems in Hills and Terai was separately counted. To ensure the information and data collected were area reliable, the technical problems were discussed with the local technicians. There were no cases where the problems reported in the focal group discussions were challenged by technicians. The financial data collected were all quantitative. Audit reports of ten different schemes were analysed to understand these problems and how costs were incurred under specific headings of pipes and pumps, personnel costs and electricity and tank cleaning throughout the operational period. The technical problems were verified through key informant interviews and audit reports which reflected the expenses.

This data was used to understand the most significant factors impacting sustainability of water systems, the financial implications of potential interventions to improve sustainability and where best to invest in systems strengthening to improve water service sustainability.

Findings and analysis

Technical factors affecting sustainability

The research identified that schemes have some common technical problems around intake, pipes, pumps, deep well and electrical systems which have not only increased operation and maintenance costs for rural water supply schemes but have also caused less willingness to pay directly. This impacts sustainability.

Frequent intake repairing in Hills and siltation in deep wells have caused an increase in operation and maintenance costs. The three most common problems in relation to pipes are i) external damage to pipe, ii) leakage and pipe burst and iii) distribution defects. External impact to pipes means damage to pipes due to external factors like landslides, flood, vandalism, road construction or heavy vehicular movement. In case of pipe outburst, the pipe cannot be re-used and should be replaced. Distribution defects means no proper design of pipe distribution which causes unequal flow of water at different joints; pipes sucking in more air because of not having an air valve chamber where required which hinders flows at some households. In some cases, air flows through a tap prior to water and increases the meter reading.

In the case of pumps, the major problem was around voltage fluctuation causing damage to pump motors and the wearing out of pumps because of siltation over a long period. Electromechanical components like control panels needed to be frequently repaired.

Out of the 16 schemes visited in Hills (including two pumping systems) 43.75% of the Hill schemes reported a problem with the intake. All of these schemes had a river as their water source and were constructed without a sedimentation chamber. 33% of the schemes visited in Hills reported cleaning of tanks at least every two months because of high silt. Out of 12 schemes visited in Terai, 58.34% of the schemes reported the problem of high siltation.

Upon technical consultation, it was identified that the prime reason for high siltation in Terai is the poor placement of the screen in the scheme during deep boring construction. Screens are the filters which are slotted vertically in the depth of the well along the fine strata of the earth to maintain a lower velocity of water entering in well and to check the inflow of silts or other fine particles. It was reported that the contractors generally do not place the screen in the right place because it requires high precision work and as it is not seen from the outside it can be easily ignored during monitoring visits.

The other major problems that were highlighted in Hills were around pipes. 87.5% of the schemes in Hills and 91.64% of schemes in Terai reported having problems with their distribution pipes. In Hills at least 26% of the schemes had external impact to pipes due to road construction, while 61.5% of the schemes were affected by disasters like landslides or animal attacks. Around 50% of schemes have not been embedded to the standard depth of 90 cm. While in Terai, 83.3% of the visited schemes had external damage to the pipes due to road construction and heavy vehicular movements - at least 44% of these schemes lie in the market area of Terai. It was identified that 70% of these schemes did not have their pipes embedded to

Table 1. Percentage of schemes reporting problems

Geographical area\ subject of problem	Intake structure/ cleaning	Pipe	Electro-mechanical	Water quality
Hills	43.75%	87.5%	100%	68.75%
Terai	58.34%	91.64%	91%	33%

the standard depth of 90 cm. In some cases, where the schemes had their pipes embedded to the standard depth, there were still cases of broken pipes due to external loads of vehicle. In some cases, after flooding, another heap of soil was added to the existing layer of road causing pipes to sink below the road level and creating excessive soil pressure. With the increased loading pattern and frequency of vehicle moment in Terai, it is important to re-test the standard depth for pipe laying in Terai.

A total of 20% of schemes in Hills reported pipe outburst while 80% of schemes reported leakages every year. Pipe leakage is often due to poor joints and improper laying depth. The cumulative impact is such that high vibration during water flow in Hills causes joints to loosen and leakage occurs. All the visited schemes had manual joints. On other hand, at least 83% of the scheme in Terai reported that they have experienced outburst or leakage of the pipe in their schemes almost every year. 100% of the schemes identifying pipe leakage as a problem reported that they have had problems with their pipe joints since they were manual joints. This is now changing with new mechanical pipe joining. Schemes in Terai have reported mechanical joints to be stronger with less leakage compared to manual joints. It is common for schemes in Terai to have experienced pipe leakage and outburst during the winter season. It is still unclear why leakage and outburst happen mostly during winter as the temperature in Terai does not freeze water to ice. This needs to be well researched as it has been causing frequent leakages.

Another common problem seen in the pumping schemes is the frequent breakdown of the pumps. 100% of the schemes with pumping systems in Hills and 91% of visited schemes in Terai reported having to repair pumps annually. In some cases, they must even repair pumps twice a year. The major problem is around voltage and siltation. This started in the first year of operation and is still a problem in many schemes. Discussions with the technical person at the local level and pump repair shops, identified that the pump is generally damaged because of highly fluctuating voltage. 85% of the pump repair cases are associated with voltage problems. Frequent repairing of control panels is also common in schemes. None of the visited schemes in Terai had stabilisers to control voltage. The remaining 15% of the problems associated with the pumps is related to siltation. This needs to be verified through separate research, but it is observed in two or three schemes and reported by pump technicians that pump burning increases rapidly after the transformer ages beyond seven years.

Frequent repairs because of poor workmanship, design or material quality required the system to bear higher costs. Also, frequent breakdowns of the system impact a willingness to pay for the system which is often unmeasurable but its impact to sustainability cannot be calculated. These technical factors cause systems to eventually collapse.

Financial factors affecting sustainability

For a system to run sustainably either the system must generate more income or minimise its ongoing operation and maintenance costs to keep sufficient savings for emergency repairs and replacement costs. However, the audit report of ten different schemes showed that schemes in Hills runs on breakeven and cannot bear emergency repairs or replacement costs (although gravity schemes in Hills do not require higher replacements). In Terai, schemes do have savings for some years until major replacements must be done and then the system's cash flow becomes negative (loss).

Personnel costs in both Terai and Hills include plumber, guard and meter reader, while in Terai, it also includes additional accountant and in some cases an extra pump operator. These costs use 39.83% and 33.11% of their overall expenditure figure in Hills and Terai respectively. Similarly, the technical recurrent faults mentioned above imposes higher financial loads on the system. Every year, 32.59% of total expenses of Hills and 25.74% of total expenses of Terai are booked under pipes, pump repairs and tank cleaning. A financial audit of these scheme reflects 9% and 4.5% of their annual expenditure on tank cleaning because of high siltation in Hills and Terai respectively. These high expenditures are gradually pushing the system towards negative cash flow (loss) eventually bankrupting it when the source of income is limited.

Table 2. Percentage of expenses annually

Geographical area	Total expenditure*	Personnel costs	Operation and maintenance replacement	Electricity	Office running costs
Hills (100HHS)	USD 1,310	39.83%	32.59%	24.93%	2.65%
Terai (800 HHs)	USD 22,800	33.11%	25.74%	32.74%	8.41%

*Conversion rate= USD 1 = NPR 113.6

Unless government subsidies are given, the major source of income in both Hills and Terai is tariff collection. It means the tariff amount should be enough and the volume of tariff collection should be sufficient. On average, a HH in Hills pay USD 5.28/annum while in Terai each pays USD 11/annum as a water tariff. Theoretically, the tariff set should be sufficient to bear the O&M expenses (OpEx) and capital replacement costs. However, none of the visited schemes practice setting the water tariff based upon actual running costs of the water scheme. However, some practices of scientific tariff collection are seen in the small-town water supply projects funded by the Asian Development Bank (ADB) which were not included in this research.

Bringing people to household connection is another big challenge i.e. volume of tariff collection is less. In Hills, households per scheme is very small and bringing them together in a single management bundling of schemes at a local level is difficult. On the other side, the adoption curve (the rate at which households buy private connection across years of operation) is an important factor of sustainability in the Terai water supply scheme as it increases volume of tariff collection. With the exception of one, none of the visited schemes in Terai have reached their full household coverage in their many years of operation.

Table 3: Adoption percentage for rural water supply scheme

Water supply scheme	Design year	Design pop	Connected % till 2018
Ganga pipara	2016	100	45%
Chandrapur	2011	2200	100%
Garuda	2012	1250	50%
Aurahi	2003	2000	30%
Dhungre	2014	2600	26%
Karmaiya	2003	3000	55%
Ishwarpur	2013	3000	38%
Ranigunj	2010	1200	73%
Hariwan	2015	4000	8%
Barahathawa	2008	4000	8%

The schemes with highlights are the failed or poorly operational schemes which are either currently in debt (from loans taken to cover electricity costs) or are not able to pay technical repair and electric costs. All these schemes have a common issue - poor adoption curve. The Aurahi scheme took 14 years to bring 30% of its design population. HHs to household connection, Hariwan took three years to bring just 8% of its customers to household connection and Barhathawa was unable to cross 8% in the last ten years and was closed in 2018. The community in these areas have shallow tube wells with iron content (and often arsenic) as an alternative to water supply. The fewer populations connecting to the water supply scheme means less HHs paying tariffs to the scheme i.e. less income to the scheme.

These regular yet high expenses on water supply schemes and fewer tariff collections have impacted upon the financial capacity of schemes. Strengthening the technical aspects in the water supply scheme to reduce the 50% of existing costs around tank cleaning would increase Hill scheme's profit by 15%. A 20% reduction in current expenditure on pipes and pumps would help increase the scheme's profit by 32%. In Terai, even by reducing the existing total pump and pipe repairs cost by 20%, the scheme gains a revenue equivalent to a yearly tariff paid by 46 HHs. Ensuring maximum HHs connection prior to construction therefore increases the schemes income making it financially strong.

To eradicate existing financial weakness, these schemes must reduce their O&M costs by reducing the above mentioned technical faults. On the other hand, the high office expenses should be controlled either by increasing automation or finding alternatives. Developing an approach to ensure maximum household coverage prior to the construction of water supply schemes can improve the adoption curve and increase regular income for scheme making it financially sustainable.

Factors of governance affecting sustainability

Rural water supply schemes in both Hills and Terai are handed over to water user committees (WUCs) after the construction of the scheme. The water supply and sanitation sub-division office (WSSDO) is responsible (not solely) to deliver the government projects. I/NGOs implement water supply projects through local communities in coordination with the WSSDO and local bodies. WUCs are legally registered bodies elected among water users every two years and have the authority to collect tariffs, manage schemes both financially and technically and are responsible for looking for additional funds to upgrade schemes. They are unpaid in most of the schemes. These WUCs are provided with a single training as a part of the project with almost no refreshers and are expected to manage the scheme. There is no proper mechanism of transferring knowledge from one WUC to newly elected WUCs. To operate the scheme, these WUCs hire a caretaker (guard) and a general technician within the community. The guard does the regular operation and the general technician takes control of any reported basic faults. Schemes with meters have additional meter readers. WUCs also hire accountants to manage the system. WUCs do not have expertise in tariff determination or financial management, and the technicians they hire are not able to deal with major repairs. In those situations, they must have support for complex repairs from their nearest headquarters which may increase the breakdown period and lead to a unwillingness to pay. If WUCs are not strong, it might take a while to receive a subsidy during which time the system remains nonfunctional. Some of the schemes are poorly accessible during the rainy season. WUCs do not see household connection as an increase in their income, and do not engage with increasing the adoption curve. Inefficiency of WUCs is not detrimental to WUCs as this is only a social contribution. Inefficient decisions by WUCs eventually hampers the scheme's sustainability. Technical backstopping is another problem. Even if WUCs want to hire a technically strong plumber, it is difficult to find them in their village and hiring them from their nearest headquarters is very expensive.

Attempts to strengthen WUCs have been done. The Federation of Water and Sanitation Users Nepal (FEDWASUN) is recognised to work with WUCs to strengthen their efficiency. Currently, the role of FEDWASUN is not as effective as it has to be. This has also affected the attempt to strengthen governance. As a result, the management of the schemes currently depends solely on the efficiency of WUCs which varies scheme by scheme provided that the scheme is built technically strong.

Although budget allocation for repair and maintenance of the rural water supply is available, it is often transferred to different areas before the end of the fiscal year if there are chances of it being underspent. The local bodies are not experienced in planning for preventive maintenance, and only dispatch money to the scheme, if allocated, when there is damage and the WUC request reimbursement. Had there been a pool fund where this repair and maintenance budget could be invested, these schemes could get funds for preventive maintenance when required.

Further, the coordination committee at village level known as village water and sanitation, hygiene coordination committee (V-WASHCC) and district water and sanitation, hygiene coordination committee (D-WASHCC) were more focused on the sanitation component in the last few years. Their role in sustainability of water supply were less seen. However, currently Nepal is moving to federal system with new structures in water supply which is yet to be final. The role of the WASH sector is expected to be more focused on sustainability with the new federal system and elected local bodies (Gaupalikas). Gaupalika will now have funds to invest in the sustainability of structures within their constituents. The role of gaupalikas will be important in strengthening schemes.

Overall, the capacity of WUCs and their supporting staffs, an inactive FEDWASUN, little focus by the coordination committees to water supply scheme sustainability, and with no elected body at local level, has affected the governance of the water supply schemes. With newly elected Gaupalikas and more decentralised authority at local level, and an evolving private sector there is a lot of opportunity to strengthen governance.

Conclusion

The outcomes of this research highlight the specific technical, financial and governance challenges in schemes of Nepal. Most water schemes in the study area can significantly reduce their running costs with improved technical design and installation of pipelines, water intake works (with appropriate water treatment/sedimentation measures), and improved installation of electromechanical pumping systems with voltage stabilisers, dry-run protections (for pumps), and appropriate installation of electrical control panels and wiring. Introducing solar/hybrid systems can be a huge cost saving. Reducing office expenses and personnel costs through bundling of schemes, centralised management system at gaupalika, provincial or federal level or use of information technology (IT) to reduce costs around cash collection and account management, can be an innovative approach. Exploring roles of the private sector in maintenance services - mostly around more complex repairs of pumps and distribution pipes - account management can be done more efficiently (as opposed to training local caretakers), through a type of structuring service agreements. WUCs and local government will be then more responsible to govern the service quality rather than manage the scheme. With the recent devolution of government in Nepal, the local government (gaupalika) now has an annual budget for the operation and maintenance of schemes within their area - though as yet there is no gaupalika level investment plan for these funds. Centralised accounts would give opportunity for gaupalika to fund these schemes annually which would make them stronger. Any scheme with a guaranteed higher number of private household water connections prior to construction (adoption curve with greater initial rates of uptake) and with an appropriately designed tariff collected from them based on consumption, is critical to bring sustainability to schemes by improving their source of revenue.

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