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Development, Current Status and Challenges of Multiple Use Water Systems in Nepal: A Review

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Abstract: Drinking water supply systems in Nepal, originally designed to meet domestic water needs, are currently being used to fulfill the multiple water needs beyond domestic use which created inefficiency, risking water shortage and even causing premature system failure and breakdown. International Development Enterprises (IDE) first implemented the scheme, which is referred, to as Multiple-Use Water Systems (MUWS) that addresses the productive as well as domestic water needs. The MUWS systems are implemented in middle hill districts of the western, mid-western and far-western development regions of Nepal. The onset point for MUWS is classified as domestic-plus in which users have access to water for productive uses but maintain the priority for domestic uses around homesteads; irrigation-plus in which, users can accommodate water for both productive and domestic uses but maintain the priority for irrigation uses; and community-driven in which communities and their existing water practices and priorities as a starting point for improvement, and offers technology choices designed for multiple uses. MUWS shows multiple benefits by ensuring water availability, enhanced economy and community involvement. However, the system faced challenges of water shortage during the lean period and unaffordable system connection fees and tariffs for the poor and marginalised. Properly planned, managed and regulated MUWS can be seen as one of the several potential adaptation options utilising scarce water for high-value and off-season crop production, more effectively and efficiently in the context of changing climate.

Key words: Domestic, productive, water use, MUWS benefits, adaptation options.

History and Development of MUWS

Humans have used water- one of the most crucial components of sustainability- for various purposes since time immemorial. The aqueducts and the water cisterns of the Bronze Age (Ortloff, 2009; Scarborough, 2003) were developed during urban center's development. A canal connected civilisation centers to the rivers and was used for water supply and navigation. The ancient Roman aqueducts and reservoirs were more common, bigger in size and capable of carrying a greater water volume; and provided water for public baths, and drinking water fountains and few provided water for industrial and irrigation purposes (Hodge, 2008; De Feo et al., 2010). The Ellagela system of Sri Lanka (Renwick, 2001) is evidence to multiple uses of water in the past. Similarly, the use of communal ponds, small reservoirs or tanks and streams all over the world for cropping, livestock and domestic purposes confirms multiple uses of water in modern times.

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The majority of conventional water systems are single use systems designed to meet either agricultural or domestic needs. However, most of the single use schemes fail because of de facto use for multiple purposes as communities invariably end up utilising these conventional systems in a manner other than intended (Hall et al., 2013). For instance, the usage of irrigation schemes for all water needs is mentioned in Kirindi Oya largest irrigation and settlement project in Sri Lanka (Bakker et al., 1999). In Sri Lanka, minor irrigation tanks, communal ponds, and small reservoirs were found to support domestic uses, agriculture and fishery (Harischandra, 2008; Ranganathan and Palanisami, 2004) and increased the productivity of rice-fish systems (Nagabhatla et al., 2012) thereby generating additional income. The 'Karez' system in Afghanistan (Qureshi, 2002) is an underground canal system for domestic and irrigation water needs. However, the lack of mechanisms to control or stop water flow when not needed in some irrigation systems further exacerbates the problem of water shortage.

People's water necessities in Nepal are integrated with multidimensional livelihoods. Therefore, a concrete, participatory and integrated approach that helps in meeting multiple water needs is required. With some modifications to conventional piped water systems in hilly areas, a new scheme was introduced in Nepal in 2003 with the aim of addressing water needs for domestic (drinking, washing and bathing) and productive (irrigation and livestock feeding) purposes. International Development Enterprises (IDE) through the SIMI (Smallholder Irrigation and Marketing Initiative) first implemented the scheme in Palpa, Nepal (Mikhail and Yoder, 2008). This scheme was referred to as multiple-use water schemes (MUS). MUS is defined as "water services planning and design of new systems or rehabilitations that start with people's multiple waters uses and reuses and needs at their preferred sites within communities" (van Koppen et al., 2008). It is a "participatory, integrated, and poverty reduction focussed approach that involves planning, finance and management of integrated water services for multiple domestic and productive uses" (van Koppen et al., 2009); a "strategy to move beyond sectoral barriers of the domestic and productive sectors" (Mikhail et al., 2008); "consumer-oriented approach" (Renwick et al., 2007). However, in this study, we refer to Multiple-Use Water Systems (MUWS) for the scheme that addresses the productive as well as domestic needs including drinking water.

MUWS Status in Nepal

Nepal, like many other countries, has a tradition where societies evolve their own multiple water sources such as ancient traditional canals, sacred ponds and waterspouts for multiple benefits. They constitute an essential part of culture, religion and well-being (Rautanen et al., 2014). However, the sustainability of such water infrastructure has to be taken seriously as it is linked to the functional status of the water supply. Although solutions for proper functionality have been proposed in various works of literature, empirical understandings of realistic implementation are still rare. In this context, MUWS has emerged that pursues to overcome the related sectoral divides by providing integrated services. Nepal is one of the pioneering countries for MUWS planning and implementation. While IDE Nepal initiated the MUWS concept in Nepal, a number of organisations such as Winrock International, Water Aid, Practical Action Nepal, NEWHA (Nepal Water for Health), BSP (Biogas Sector Partnership Nepal), RVWRMP (Rural Village Water Resource Management Project), NITP (Non-Conventional Irrigation Technology Project)/DOI (Department of Irrigation) and other organisations have promoted the MUWS approach in the country (Sharma et al., 2016). Most of these installed systems are found concentrated in middle hill districts of the western, mid-western and far-western development regions (Khawas and Mikhail, 2008; Sharma et al., 2016) possibly due to the applicability of such technologies to the middle hills of Nepal (Mikhail and Yoder, 2008).

The increasing trend of MUWS growth as shown in Figure 1, exhibited that the hill districts have adopted MUWS successfully as they benefitted from cost-effectiveness, flexibility, availability of water supply for

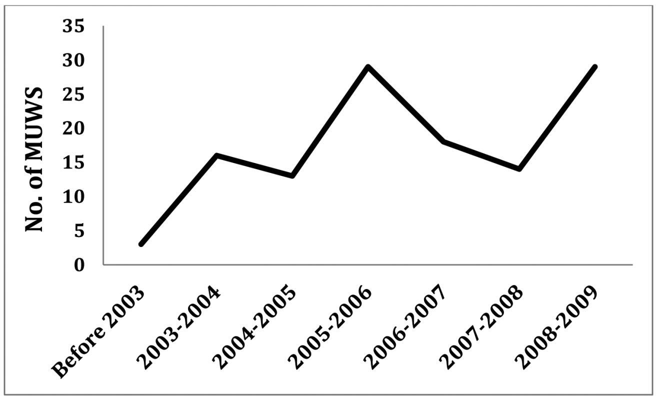

Figure 1: Trends of MUWS growth in Nepal hill districts (Source: Sharma et al., 2010).

Table 1: MUWS in South Asia

Type of MUWS	*Country*	*Uses*	*References*
Communal polls & small reservoirs	India/Sri Lanka	Paddy cultivation, livestock, domestic uses	Ranganathan and Palanisami, 2004
Stream water	Nepal	Domestic purposes, livestock and cropping	vanKoppen et al., 2006
“Karez” as underground canal system	Afghanistan	Domestic & irrigation	Qureshi, 2002
Ellegala system (reservoir based irrigation system with five small reservoirs) & small tank technology	Sri Lanka	Irrigation & domestic purposes	Renwick, 2001; Harischandra, 2008
“Ghatta”(traditional water mills)	Nepal	Irrigation, grinding grains	Shrestha et al., 2014

both household needs and micro-irrigation for homestead gardens, and low pay-back period with low household investments (Sharma et al., 2010). The success of MUWS is seen as an effective way of reducing water poverty, saving time and reducing drudgery, increasing household income, improving hygiene and sanitation, empowering women, ensuring community participation and thus improving the livelihoods of poor households not only in Nepal but also in India particularly in the north-eastern and other hill region states as well as elsewhere through improved use of the water and land resources of the region (Table 1).

MUWS Mechanisms

The simplest and the most economical MUWS configurations are gravity fed in which water from a higher elevated spring source is collected in storage tanks and conveyed by gravity through pipelines to the community located below the water source, which is then distributed to households through delivery structures (GC, 2010). However, electricity, liquid fuels (diesel or kerosene) and renewable energy powered pumps are usually used to lift water from a source, where gravity fed MUWS is not viable (McLoughlin et al., 2013). IDE Nepal pioneered the design and demonstration of solar lifting for MUWS for domestic and agricultural needs in 2012 in the Rupandehi district of Nepal (Sharma et al., 2016).

According to IDE guidelines for planning, design, construction and operation of MUWS (Sharma et al., 2016), consists of a single or double-chambered intake to capture water at the source that is then transferred to the reservoir tank near settlements through the transmission pipelines (Figures 2 and 3). The reservoir tank, also known as the storage tank, forms the main structural component of the MUWS. The distribution pipelines distribute water from the reservoir tank to the water outlets. Water outlets are designed to deliver water for end-use applications such as domestic use or water application technologies such as micro-irrigation. Flow regulating valves within the pipe network is

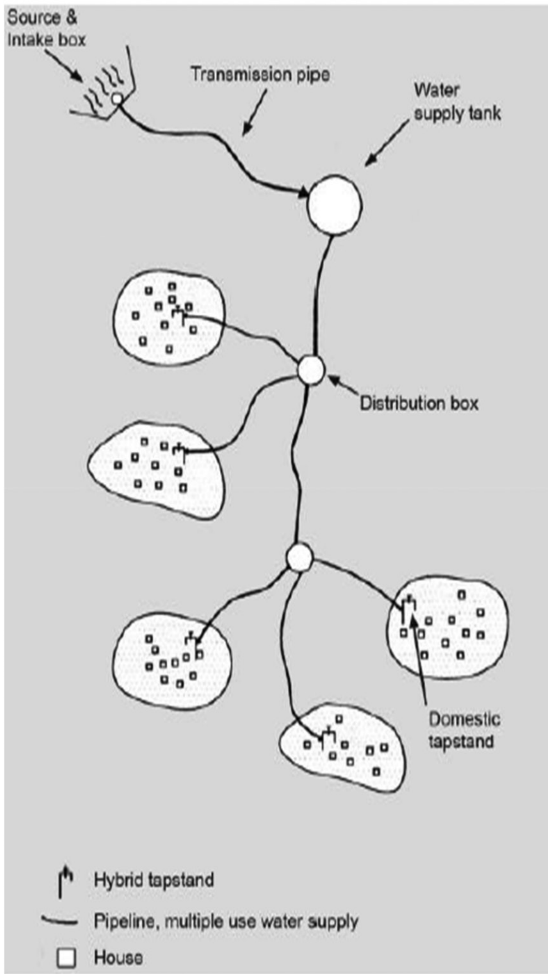

Figure 2: MUWS layout for single tank or intermittent flow system (Source: Sharma et al., 2016).

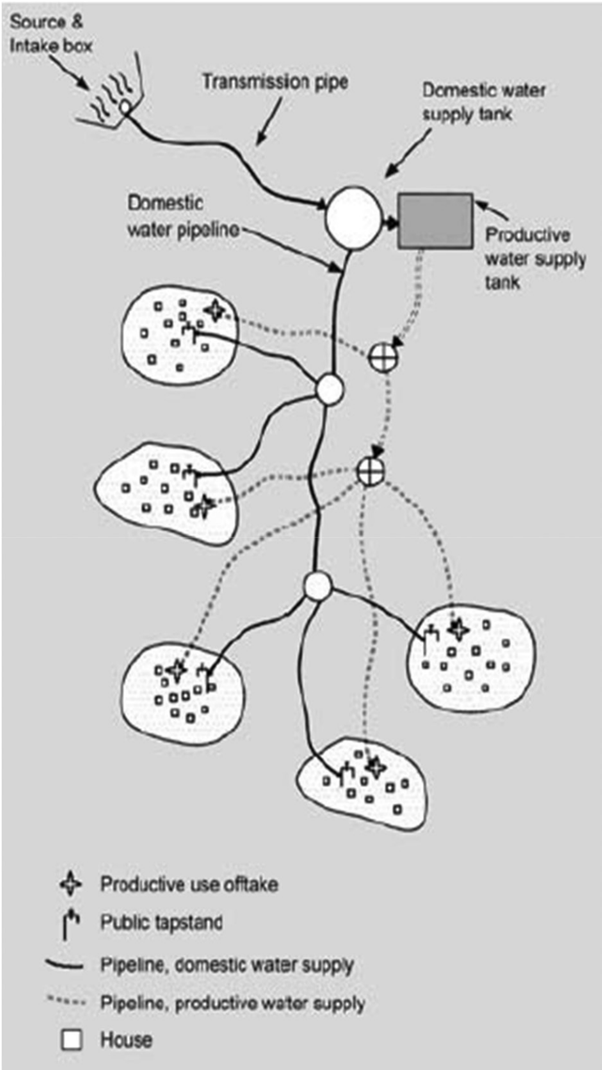

Figure 3: MUWS layout with double tank flow system (Source: Sharma et al., 2016).

used to control water in each tap to maintain uniform distribution. Low cost water tank technology such as Modified Thai jar and ferro-cement lined tank is also used as storage tanks for regulated MUWS systems which are used to collect spring water from upland sources (GC, 2010).

According to the guidelines by Adank et al. (2012), globally, the onset point for MUWS is classified into three categories as (Table 2): (i) Domestic-plus: Under this entry point, existing domestic water supply systems are modified in such a way that service is provided at a higher level than the minimum requirements to "climb the water ladder". (ii) Irrigation-plus: Under this entry point, existing irrigation systems are modified to enable access to relatively limited quantities of water for non-irrigation uses, both productive and domestic, can be accommodated but maintain the (implicit) priority for irrigation uses (van Koppen and Hussain, 2004). (iii) Community-driven MUWS by design: This entry point takes communities and their existing water practices and priorities as a starting point for improvement, and offers technology choices designed for multiple uses (Fontein et al., 2010).

Table 2: The principles identified to implement MUWS for livelihoods at different levels

Various level	*Principles identified to implement MUWS*
At community level	Appropriate technology
	Water resources for sustainable MUWS
	Adequate financing
	Inclusive institutions
At intermediate level	Participatory planning
	Coordination between sectors, actors & long term support
At national level	Decentralised long-term support
	Enabling policies and legislation

MUWS Benefits/Merits

MUWS benefits are multiple and ensure water availability, enhanced economy, improved well-being and community involvement/camaraderie.

Water Availability

MUWS implementation has increased water availability followed by an increase in water usage for all water needs (Khawas and Mikhail, 2008; Pant et al., 2006). The effective tapping of small sources in the hills, enabling irrigation with less water through micro irrigation technologies has effectively contributed to the small hill community's water supply (Mikhail and Yoder, 2008). MUWS users in Syangja, Surkhet and Palpa districts consider that MUWS have met their irrigation and domestic water needs better than previous water systems (GC, 2010; Pant et al., 2006). In those areas, MUWS have been shown to increase water use by approximately 50% for household use and 95% for irrigation (GC, 2010). Improvement in water availability due to MUWS was also noted in Bangladesh. The shift in water source from shallow tube-well to deep tube-well and the addition of a pipeline distribution network has increased the quantity of water in northwest Bangladesh (Fontein et al., 2010). The extent to which households carry out water-based activities primarily depends on their level of access to water. The better the access to larger quantities of water delivered closer to the homestead, the more that additional water is put to productive use once basic domestic needs have been met (Smits et al., 2008). Furthermore, the installation of additional technology, that can capture water or increase water storage or water lifting or water application technique, increases accessibility and reduces water collection efforts, especially for women and children (Mikhail and Yoder, 2008; GC, 2010).

MUWS approach has been proposed as the multiple-use water ladder, which expresses the relation between the extent of water use for livelihoods to the level of access to water; and categorise multiple-use service levels as basic domestic service, intermediate MUWS, and high-level MUWS as shown in Table 3 (van Koppen and Hussain, 2004). However, studies have shown that the quantity of water ranging from 40 to 100 lpcd or more, within less than 100 m from the point of use, is required to ensure that services meet people's livelihood needs at a significant scale (Smits et al., 2008).

Enhanced Economy and Well-being

Many empirical studies showed that MUWS systems have cumulative water uses that fulfill a broader range of water needs. The increase in the use of domestic water supplies for a wide range of productive activities represented an increase from 17 to 33% of the total income (Perez de Mendiguren Castresana, 2004). MUWS interventions through micro-irrigation kits have enabled households to grow high value crops for commercial purposes both on-season and off-season in Syangja, Surkhet and Palpa (Nepal) (GC, 2010; Khawas and Mikhail, 2008; Mikhail and Yoder, 2008; Pant et al., 2006). Crop yield is reported to increase from 30 to 60% as compared to crops grown prior to MUWS in Nepal (GC, 2010) with increased annual income by US$ 250 on average. MUWS combined with drip irrigation has increased farmers' annual average income by US$75 to US$300, depending on the size of the system in Nepal (Polak et al., 2004).

Water Quality

Water quality for drinking was primarily the single most significant concern. In many situations, the quality of water from surface streams and groundwater used for domestic purposes other than drinking is acceptable. While in specific cases, water quality is also acceptable for drinking uses (Yoder, 1983). Studies also suggested that the availability of additional quantities of water for cooking, and consumption, combined with improved hygienic behaviour reduced faecal-oral diseases (Van der Hoek et al., 2001, 2002).

MUWS Challenges/Drawbacks

Economic Barriers

MUWS incurs additional costs related to infrastructural construction, operation and maintenance and required engineering skills. There are also software costs such as costs for planning, institution building and skill development (van Koppen, 2006). The cost of operation and maintenance seemed serious. Few studies mentioned that the economic benefits from productive uses of water can be invested to maintain the system (Rautanen and GC, 2012; Smits et al., 2008). However, the economic benefits from MUWS are not enough for repair and maintenance. The pipeline connection fee and tariffs were unaffordable for the poor so they still have considerably lesser access to MUWS household supply (Fontein et al., 2010). Thus a pragmatic analysis of MUWS in its current form considers the reader to question the accurate effectiveness of the MUWS system for the actual poor and underprivileged population as

Table 3: Multiple-use water ladder

Service level	*Distance or roundtrip*	*Quantity in lpcd**	*Water needs met*
Maximal MUWS	Water at the homestead	>100	All domestic needs; livestock, gardens, trees and small enterprise
Intermediate level MUWS	Water at the homestead or within 5 min roundtrip	40-100	All domestic needs; livestock, garden, trees or small enterprise
Basic MUWS	Round-trip less than 15 min at distance between 150-500 m	25-40	Most domestic needs; some livestock, small garden or tree
Basic domestic service	Round-trip up to 30 min, or distance less than 1 km	10-25	Very few domestic needs, basic livestock

* Litre per capita per day

Source: (Renwick, 2007; Van Koppen and Hussain, 2007) economic barriers still pose a significant obstacle to effective implementation of such.

Water Shortage at Source

Though water usage increased after MUWS, water shortage still persists during the lean period due to the decrease in water availability at the source (Pant et al., 2006). A study of household preferences for the Water Storage Systems (WSSs) intervention in the mid hills of the Koshi river basin revealed that 78% have access to an improved water source (i.e. private tap, community tap, or protected well) even during the dry season, while the less privileged group lacked access to high quality water and obtained water from an uncapped spring source (Price et al., 2016). This displayed the need for even distribution of improved water sources for extending access to sufficient domestic water supply for the less privileged group.

Gender Equity

MUWS system benefits women in particular through domestic-plus approaches by adding productive activities. A newly installed domestic-cum-gardening water supply and drip irrigation kit in Nepal showed how women benefited (Upadhyay et al., 2005). Rural women and their roles in farm decision-making are better recognised, which has led to a more gender-balanced irrigation intervention. As women compared to men, tend to spend a higher proportion of their incomes generated from productive activities for overall family welfare, this benefited their family including children (van Koppen, 2002).

Despite being involved in generating income through farm activities, the women still have less control over their own earnings as they have to hand over their earnings to the male members of the family (Pant et al., 2006; Upadhyay, 2004) with men still controlling the decision-making on water provision (Upadhyay, 2004). Though women actively participated in the planning and decision making process in MUWS activities, they were reported to have been involved as leaders only because the male representatives were absent (Pant et al., 2006).

Towards Climate Adaptive Strategy and Sustainability

A significant portion of the world is still directly dependent upon the river flow for sustenance, seasonal fluctuations in river flow, aggravated by climate change have a direct impact upon the country and the lives and economy of its people. According to the International Panel on Climate Change, in its Third Assessment Report, there will be an increase in the South Asian monsoon by 8–24%, which will bring additional water and cause floods and damage to the infrastructure (Rasul et al., 2008). This changing climatic patterns aggravated situation calls for better water management that provides multiple use water services sustainably and equitably, to cope with projected climate change and its impact on the agricultural economy and environment. MUWS can be seen as an appropriate water supply and distribution system for utilising scarce water more effectively and efficiently as compared to conventional single use water supply systems. One of the several potential adaptation options to seasonal weather variability is the use of MUWS on high-value and off-season crop production (Gurung et al., 2016). MUWS provides surface storage while also increasing the recharge of groundwater. Water storage becomes increasingly important in situations where water availability is concentrated in shorter periods of time, and community or household water storage tanks and underground storage should all be considered as part of MUWS approach (Srinivasan et al., 2012).

MUWS provided benefits through increased income, time saving in water collections, and health improvements in terms of nutritious status through vegetable production (Mikhail and Yoder, 2008). Thus, increased economic returns provide incentives for communities to protect water sources. However, economic returns do not necessarily support sustainability. The system operation is misunderstood especially during system maintenance. As the economic benefits incurred from the system are not enough for repair and maintenance of the system, thus, sustainability is questionable. Furthermore, studies also recommended that sustainability will be increased if the planning stage allows evaluation of the needs of neighbouring communities which might affect the water flow available to the beneficiaries (Rautanen et al., 2014).

The institutional arrangements are the most critical condition for MUWS to work (Rautanen et al., 2014). The MUWS system needs to be institutionalised into the existing planning process at the lowest tier of local government such as at the ward/municipality level. This will ensure a sense of ownership and consequential use of the system.

Therefore, a properly planned, managed and regulated water management system, integrated with water efficient technologies and adequate water storage that allow adequate domestic commercial agricultural production, is needed for increased resilience to climate change and seasonal weather variability.

This review is based on the different case studies and narratives in the Nepalese context, these merits and drawbacks seem contextual. A rigorous review on a better understanding of MUWS challenges/upscaling in similar socio-economic contexts at a regional scale needs to be done.

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