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Community pond rehabilitation to deal with climate variability: A case study in Nepal *Terai*

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ABSTRACT

A large number of small- to medium-sized community ponds exist in most parts of the *Terai* region in Nepal. Such ponds could be a viable alternative for other forms of surface irrigation. But, with the lack of efficient management, many of these ponds remain underutilized. An effort was made to facilitate the rehabilitation of such a pond in a selected village of Rupandehi District in Western *Terai* region of Nepal. This paper aims to evaluate the changed water availability situation in post-monsoon seasons after the pond rehabilitation. The paper also evaluates the feasibility of such interventions especially focusing on the potential to provide additional water and improve agricultural productivity. Results showed small increases in quantifiable indicators such as water availability, cropping intensity, productivity and income. The new institutional setup improved water allocation, improved operation and maintenance, and increased social awareness among the people about the importance of underutilized water resources. The intervention has the potential to be replicated in similar contexts.

1. Introduction

Nepal is endowed with natural resources, benefitting from a diverse topography, allowing a wide range of cropping patterns. By 2013/14, the agricultural contribution to Gross Domestic Product (GDP)

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was 32.6%, with 65% of the population involved in agriculture-related activities (MOAD, 2014). Despite heavy monsoonal rains and abundant groundwater resources, vast tracts of agricultural lands are unirrigated, resulting in low productivity and low income. Government statistics show that 1.33 million hectares (Mha) of total cultivable land is irrigated by both surface and groundwater sources. Canal irrigation remains predominant, which serves about 0.97 million hectares (MOAD, 2014). Furthermore, despite intermittent efforts by the government and development agencies, just about 0.36 Mha is irrigated with groundwater. Vast tracts of land, especially in the *Terai*, remain unirrigated during the dry season.

Small-scale water resources such as village ponds and tanks have played an important role in rural life, particularly in the agricultural practices in different parts of the world including Nepal (ADB, 2006; Bekele and Tilahun, 2006; Camnasio and Becciu, 2011; Huang et al., 2012; Kumar et al., 2013; Moges et al., 2011; Mushtaq et al., 2007b; Ngigi et al., 2005; Sukchan et al., 2014). Most often such ponds/tanks are found as stand-alone water resource, whereas in some areas a cascade of several tanks are common (Palanisami and Meinzen-Dick, 2001; Palanisami et al., 2010, 2012; Selvarajan et al., 2001). In some places, for example in Ethiopia (Bekele and Tilahun, 2006) and China (Cai et al., 2012; Roost et al., 2008), such ponds are built as in-system storage of canal irrigation system. Others report the conjunctive use of tank and groundwater as well (Ranganathan and Palanisami, 2004).

In general, tanks/ponds are common pool resources (Mushtaq et al., 2007b; Sakurai and Palanisami, 2001); however, they are operated under various management regimes. It ranges from individual pond/tank owned by individual/group, to the minor irrigation systems governed by local government (such as village development committee or Panchayat) or the part of irrigation system governed by state/national government. In the Nepal *Terai*, tanks are collectively known as *pokharis*, and they vary considerably in size. Larger tanks (more than 5 ha) are sometimes natural ponds that were converted for productive use, while smaller tanks were built by the local people. Some ponds were built by landlords, and many ponds remain under private ownership today. Others were built by public institutions such as temples, which continue to manage them today. Likewise, examples from India show that, generally, small irrigation tanks having command areas of up to 20 ha are owned by individuals or groups of farmers. The state governments construct and manage large tanks with command areas ranging from 20 to 2,000 ha. The tanks below 100 ha are now transferred to the Panchayats for management (Kumar et al., 2013; Pant and Verma, 2010).

Efforts have been made in the past to understand the management and various aspects of performance of ponds and tanks (Anbumozhi et al., 2001; Arnold and Stockle, 1991; Mosse, 1995, 1999; Palanisami and Flinn, 1988; Torii and Minami, 1985). Studies reveal that ponds and tanks have undergone tremendous changes over time and are facing serious problems (Jana et al., 2012; Moges et al., 2011; Palanisami, 2006; Palanisami and Meinzen-Dick, 2001; Palanisami et al., 2010, 2012; Selvarajan et al., 2001; Sikka, 2009). Despite potential, the large scale uptake of pond/tank irrigation is limited because of poor planning and implementation, poorly functioning inputs and output markets, lack of farmers' skill to use the ponds effectively and poor institutional arrangements including unclear property rights. Recent study shows that some technology-specific factors such as shortage of plastic-sheets may result into disadoption of rain water harvesting in the farm ponds (Wakeyo and Gardebroek, 2015).

In Nepal, most of the tanks/ponds are situated in the *Terai* region, with the largest concentration found in the Central and Eastern *Terai* Districts bordering Bihar. Tanks are more commonly used for irrigation in the *Terai*, where they represent 1.46% of the irrigated area, higher than the nationwide total of 1.19%. There are no data on public tanks, although the Nepal National Sample Census of Agriculture (NSCA) suggests that 3.51% of holdings in the *Terai* include private tanks, as opposed to the 2.14% at the national level (CBS, 2013). The tanks are mainly used for irrigation and fisheries, though the situation varies across the region. Both private and public tanks are also used by local people as a common resource for bathing livestock or washing clothes.

The Irrigation Policy of Nepal (first formulated in 1992 with subsequent revisions in 1997, 2003 and recently in 2013) has focused primarily on development of large and multipurpose surface irrigation and groundwater irrigation projects in the *Terai*. It is estimated that around 3,000 shallow tube well units are installed each year across the *Terai* (Bhandari and Pandey, 2006). However, as a part of Non-Conventional Irrigation Technology Project, limited tank rehabilitation work has been undertaken by the Department of Irrigation of Nepal. Nepal's new Irrigation Policy (2013) has continued the provision for promoting tank/pond irrigation in suitable areas of the country (Government of Nepal, 2013).

Rupandehi District of the *Terai* has high potential to produce priority crops such as paddy, wheat, legumes and oilseeds (Yadav and Peterson, 1993), but often constrained by inadequate irrigation in dry seasons. A number of groundwater development programs have been in place in Rupandehi since the 1980s under the support of the Groundwater Development Board. These include the Bhairawa–Lumbini Groundwater Project focusing on deep tube well irrigation, and the Nepal Irrigation Sector Project focusing on shallow as well as deep tube wells, both of which have been discontinued. In addition, many farmers have also benefitted from the Groundwater Irrigation Projects supported as part of Nepal Agriculture Perspective Plan (APP). Canal irrigation is limited in the villages of Rupandehi. There is some infrastructure although most of these canals are seasonal, and some are in a state of disrepair with poorly functioning user committees.

Several small- to medium-sized community ponds exist in Rupandehi District, but most are underutilized due to poor management. Facilitation of local efforts to rehabilitate such underutilized water resources could be an alternative to deal with water scarcity. In this context, CGIAR's Climate Change, Agriculture and Food Security (CCAFS) research program provided support to the community for the rehabilitation of such ponds in a selected village at Lumbini Village Development Committee (VDC) of Rupandehi District. This paper documents the process of community pond rehabilitation. The paper then evaluates the potential of such intervention by assessing changed water availability in post-monsoonal seasons, improvement in agricultural productivity, increase in income, and improvement in management structure.

2. Research methods

This paper is based on the process documentation of community pond rehabilitation efforts. In order to analyze "before"–"after" intervention situations, primary information was collected from the community and beneficiary households.

2.1. Description of the study area

The study site was Chhotka Mahuwari village of Lumbini VDC of Rupandehi District in western *Terai* region of Nepal. This village was selected by CGIAR's CCAFS research program as a representative village to study imminent impacts of climate change on agriculture and food security in South Asia (CEAPRED, 2013). This VDC is situated 35 km from the district headquarter Bhairahawa (Sidharthanagar) (Fig. 1). There is no infrastructure for canal irrigation. Some farmers have installed shallow tube wells (STWs) but the coverage is small. Agriculture is mostly rain-fed. This VDC has many small- to medium-sized community ponds, but they are underutilized due to poor maintenance.

Paddy cultivation in the rainy season is dependent on rainfall and natural flood events. In the rainy season, water availability is not an issue, but sometimes because of delayed onset of the monsoon, irrigation is necessary to establish the paddy crop. In some years supplementary irrigation is required during the later stages of paddy cultivation, especially during the milking stage, when farmers get water from a community pond. The pond is shallow and farmers can store only a limited volume of water, so that villagers can get water only for one irrigation event in the winter season resulting in crop water stress.

2.2. Rehabilitation of a community pond

The pond rehabilitation was planned and executed by the community, with guidance from the research team. During a focus group discussion, a common understanding of how the community pond is being used, the constraints and the need for rehabilitation were established. It was followed by the cost estimation for rehabilitation, and the mechanism to share costs between CCAFS and the community, the details of cost estimation and cost sharing are discussed in Section 4 of this paper.

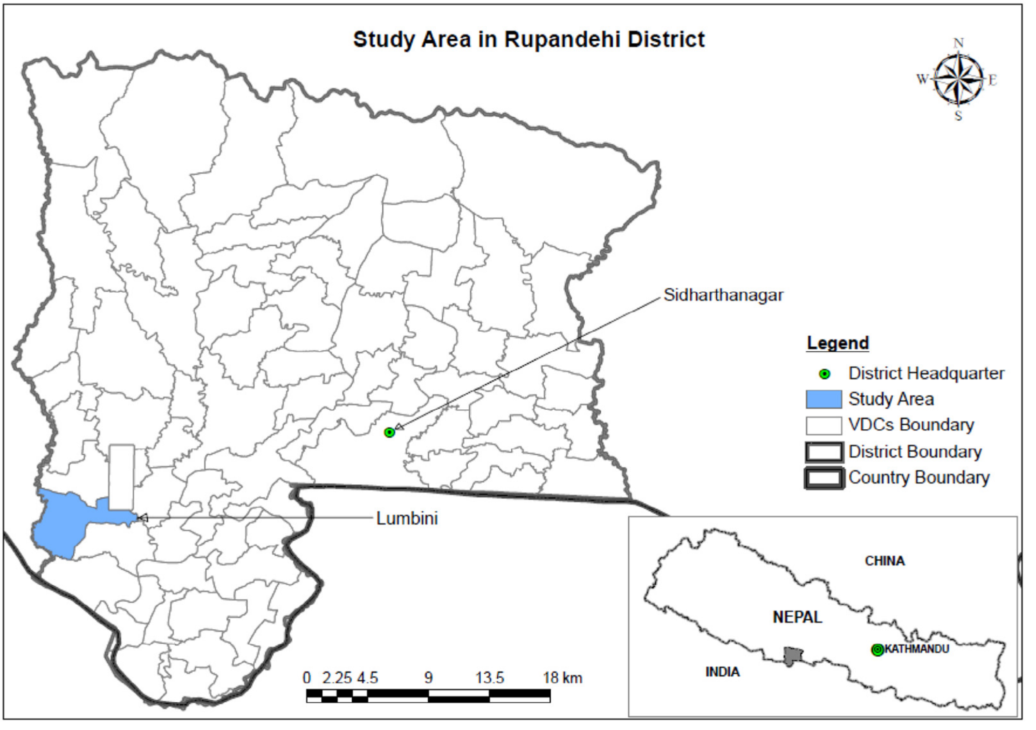

Fig. 1. Study area in Rupandehi District of Nepal.

Rehabilitation included hiring of a local contractor for mechanical excavation work and labor contribution of the community for soil leveling and dike improvement.

2.3. Data collection

Primary data were collected at community and household levels through Focus Group Discussions (FGD) and household survey. One FGD was done before pond rehabilitation and another after the intervention. Before rehabilitation, the FGD was conducted with a total of 18 beneficiaries, including 11 experienced farmers (farmers with more than 10 years of experience in farming), four progressive young farmers and three women farmers. The FGD after intervention included a total of 16 beneficiaries, including 10 experienced farmers, three progressive young farmers and three women farmers. A checklist was used for collecting information from the FGD.

Household surveys were carried out with all 30 beneficiary households of the community pond at two stages. First, the baseline information was collected before intervention; then a follow-up survey was done to assess the impact of the intervention situation. Both questionnaires were pre-tested and revised as necessary.

3. Before intervention: water availability and agricultural productivity situation

3.1. Socioeconomic features of community and sampled households

The Chhotka Mahuwari village of Lumbini VDC comprises 30 households. This is an agriculture-dominant community. Almost all the households in this village are dependent on agriculture as their main source of income (Table 1). Some of them are also involved in other income-generating

Table 1
Occupational status and annual income of the community (as some people are engaged in more than one occupation, the column total can be more than 100%).

Occupation	Male (%)	Female (%)	Average household income (NPRs)
Agriculture	97	93	67,833
Business	13	–	142,200
Service (employed)	7	3	46,667
Remittances	17	–	72,625
Off-farm wage earning	17	–	65,333
Annual gross income			131,300

Table 2
Socioeconomic characteristics of community.

Features	Average	Minimum	Maximum
Family size (no.)	8.6	3	18
Landholding size (ha)	1.2	0.3	2.2
% Distribution by landholding size			
<0.5 ha	17	–	–
0.5–1ha	27	–	–
>1ha	56	–	–
Number of land parcels	3	2	5
Membership in group (%)	77	–	–
Involvement in farming (years)	30	5	58
Cropping intensity (%)	180	100	276

activities such as off-farm laborers in the nearby brick factory, foreign employment, small business and service (employed). A gender-wise breakdown reveals that women are mainly involved in agriculture, not in other activities.

The average family size in the study area was about 8.6, with a range of 3–18 members (Table 2). The family size was significantly higher than the national average of 4.7 and the Rupandehi District average of 5 (District Development Profile of Nepal, 2012). Most of the farmers are smallholders, with an average landholding size of about 1.2 ha, but it ranged with a minimum holding of 0.3 ha to a maximum of 2.2 ha (Table 2). The land size distribution shows that each household of the majority has a landholding of about 1 ha or above. Farmers owned land in more than one parcel.

In the study village, the majority of farmers (77%) were affiliated to different local self-help groups as members. But there was no committee for management of the community pond. The average cropping intensity was 180%, which ranged from a minimum of 100% to a maximum 276%. The low cropping intensity was mainly because of the fallow period in summer season (Table 3).

3.2. Agriculture and water availability situation

The main crops grown in the case study village included paddy, wheat, oil-seed crops and legumes. Only a few farmers were involved in small-scale vegetable cultivation, but the potential exists for further scale-up because of good connectivity to the market centers. Table 3 shows the before intervention situation of major crops grown in different seasons.

The result shows that farmers mainly cultivate in monsoon and winter seasons. All the farmers cultivate paddy in the monsoon season, but the productivity (2.9 t/ha) was below the national average. Besides paddy, a few farmers grow vegetables and legume crops in the monsoonal season. During winter, wheat is grown by all the farmers, but the productivity (2.5 t/ha) was found to be below the national average. Other main crops in winter were legumes, mustard, potato and vegetable. The productivity of all crops was low.

Table 3
Before-intervention area and productivity of major crops grown in different seasons (for each season, the first column shows the percentage of farming households cultivating the crop in the monsoonal period, the second column shows the average area cropped in winter with minimum and maximum area in parentheses, and the third column shows area cropped in summer).

Crops	Monsoon			Winter			Summer		
	% hh	Area (ha)	Y(t/ha)	% hh	Area (ha)	Y(t/ha)	% hh	Area (ha)	Y(t/ha)
Paddy	100	1.3 (.3–2.4)	2.9	–	–	–	–	–	–
Wheat	–	–	–	100	1.0 (.1–2.2)	2.5	–	–	–
Mustard	–	–	–	57	.14 (.02–.33)	0.9	–	–	–
Vegetables	7	.13 (.10–.17)	4.1	23	.10 (.02–.17)	5.8	23	.06 (.02–.10)	10.5
Legumes	10	.09 (.03–.17)	0.7	60	.16 (.03–.33)	0.6	–	–	–
Potato	–	–	–	57	.04 (.02–.07)	10.0	–	–	–

Note: hh = households.

Table 4
Source of irrigation water.

Sources of irrigation (% area under particular source)	Percentage response
Groundwater (shallow tube wells)	45
Rivers/streams	22
Surface pond	17
Unirrigated	16

The village has no canal irrigation infrastructure for accessing surface water. Agricultural activities are primarily done in rain-fed conditions. About half of the respondents (45%) reported that they use groundwater as the source of irrigation (Table 4). Result showed that seven shallow tube wells (STW) have been installed in this village. Those STWs are installed by six farm households and they own pump also. The STWs are used mainly for irrigating the winter crops such as wheat and some vegetable crops. Farmers who do not own either STW or pump buy water from the STW owners. This village has a community pond, which can be used by any of the households in the village. But only few farmers (17%) have been using the water stored in the community pond. Since the pond can store only a limited volume of water, they cannot get enough water to irrigate the winter crops.

Paddy cultivation in the rainy season is dependent on rainfall and natural flood events. In the rainy season, water availability is not an issue; if the onset of the monsoon is delayed, farmers have to look for alternative options to irrigate the fields, especially for rice plantation or immediately after that period. In some years, supplementary irrigation is required during the later stages of rice cultivation, especially during the milking stage. In such a situation, farmers get water from a community pond.

3.3. Community pond as a source of supplementary irrigation: need for improvement

The village has a medium-sized community pond. The history of the community pond in this village goes back to more than two centuries. Over many years, people in this village have taken soil from public lands situated near the village as construction material for homes. Eventually, the pit turned into a pond, and the current size of the pond is 65 m × 50 m. People started using the accumulated water as a source of irrigation in winter and dry seasons. Currently, each of the 30 households in the village has the right to use the pond water as a source of irrigation. However, the actual use depends on water availability and distance of the farm from the pond.

The community pond is replenished during the floods in rainy season, but siltation and pond dike erosion every year have reduced the water storage capacity of the pond. The pond was shallow (average depth 1.5 m) and only a limited volume of water could be stored in it (4,875 m^3). Because of its low capacity, the villagers can get water only for one irrigation in winter season.

Table 5
Constraints in managing the community pond.

Constraints	Responses (%)
Poor maintenance of the pond	57
Low storage capacity	40
Ineffective coordination among users	33
No rule for water allocation and maintenance	37
Lack of funds for rehabilitation	40

3.4. Multiple use of community pond

For many years, fishing has been practiced in the pond. Earlier it was not done in an organized way, but recently, fishing was contracted out to one local resident who provided NPRs 8000 per year to the community. In order to maintain the growth of the fish, maintaining a certain water depth in the pond was necessary. This condition was mentioned in the contract.

Because of the shallow depth, the community had to stop irrigating the winter crop from the pond if it goes below a certain level. For the fish contractor, the shallow depth constrained the capacity to grow more fish, which otherwise could fetch higher return than the current level.

3.5. Major reasons for low capacity of the pond

The capacity of the pond was constrained by several factors (Table 5). Majority of the respondents (57%) consider that poor maintenance is the main factor. Because of poor maintenance, silt deposition, and erosion of pond bank, the storage capacity of the pond had declined over time (40%). The pond required rehabilitation but the community could not do it because of lack of funds (40%).

A third of the respondents reported that ineffective coordination among the users has affected the efficient management of the pond. Because of lack of coordination, there was no fixed rule for water allocation and maintenance of the community pond. During the post-monsoonal season if the farmers needed to irrigate their fields, they could bring a pump and then abstract water from the pond. The lack of a proper water allocation mechanism often resulted in disputes among the farmers.

4. Rehabilitation of the community pond

Based on the suggestions of the community and considering the potential, a decision was taken to rehabilitate the pond. The decision and facilitation thereafter were guided by CCAFS's aim to promote "Climate-Smart Villages" in South Asia. Climate-Smart Villages (CSVs) are the sites where researchers, policy makers, local partners, and farmers collaborate to evaluate and maximize synergies across a portfolio of climate-smart agricultural interventions. CSV is a community approach to sustainable agricultural development, which aim to improve farmers' income and resilience to climatic risks and boost their ability to adapt to climate change. In this approach, all the concerned stakeholders collaborate to select the most appropriate technological and institutional interventions based on global knowledge and local conditions to enhance productivity, increase incomes, achieve climate resilience and enable climate mitigation (Aggarwal et al., 2013).

The village has two community-based organizations (CBOs). One organization named '*Ishwar Samudayik Sanstha*' was established about 6 years ago, with assistance from the District Development Committee (DDC), Rupandehi. Twenty-five households are members of this CBO. The second CBO, 'Mahuwari Farmers' Group', was formed with the facilitation of the National Wheat Research Program (NWRP), Bhairahawa. The latter group is registered with the District Agriculture Development Office and has covered farmers of both Chhotka Mahuwari and Badka Mahuwari villages. The community proposed that these CBOs should be responsible for supervision of the rehabilitation work, and subsequently formalized water-sharing mechanisms.

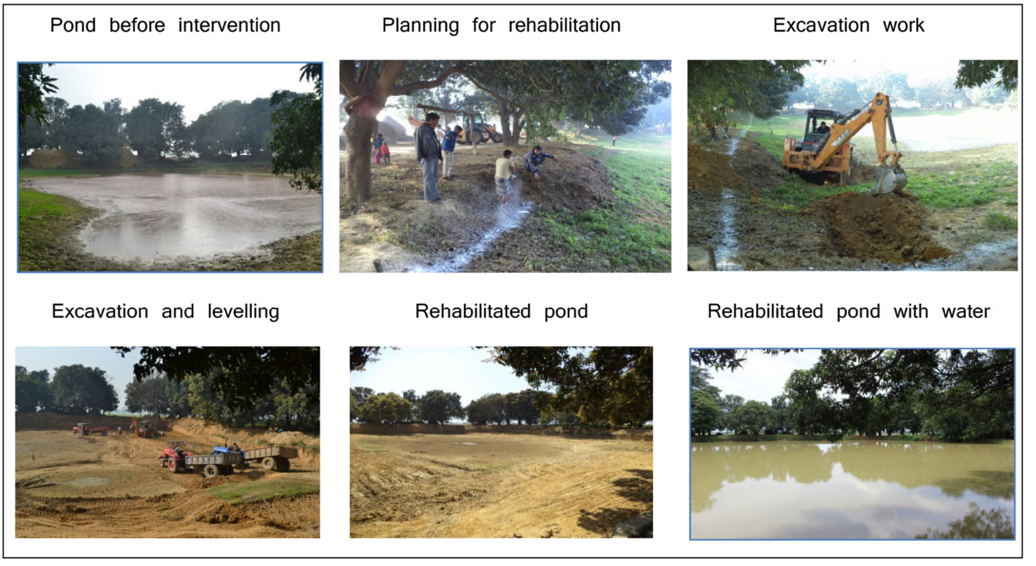

Fig. 2. Different stages of pond rehabilitation.

4.1. *Cost estimation for rehabilitation of the pond*

Even though the pond was fairly deep in the middle (1.75 m), the initial assessment suggested that a significant amount of earth excavation work is needed to deepen the dike areas. After detailed discussion with the community and a local contractor involved in excavation work, all agreed that, on average, the pond needs to be deepened by about 1 m. A local contractor would be hired for excavation work. At the same time, the pond intake would also need to be strengthened. After excavation of soil from the pond, leveling of soil outside the pond would also be required, mainly in the pond dikes.

The total cost required for this work was estimated as NPRs 200,000 (USD 2,353), which included machine hire of NPRs 140,000 (USD 1,647) and labor to level the soil and strengthen the dike that costs NPRs 60,000 (USD 706). The cost estimation was verified with a fishery pond management expert of the District Agriculture Development Office (DADO) Rupandehi. A cost sharing basis was discussed with the community. According to which, CCAFS/Water, Land and Ecosystem (WLE) provided the cost of the contractor (USD 1,647), which was 70% of the total cost. Beneficiaries contributed the remaining 30% of the total cost through labor contribution. Before commencement of work, the community received formal approval for rehabilitation from the VDC office, which has the property right to manage such ponds.

A local contractor was hired through a bidding process for the excavation work. The contractor completed the excavation work in about two weeks. The community leveled the soil and strengthened the dikes. Finally, the main intake of the pond was strengthened with concrete work. It was noted that the pond was filled during floods when water entered through the intake. As the flood receded, water in the pond was retained. Fig. 2 presents the different stages of pond rehabilitation.

Even though the increased amount of water stored in the pond (an estimated increase to 185% of the water volume before the rehabilitation) may not be sufficient for irrigating the winter crops, the villagers expect that the increased water availability in combination with improved water allocation mechanism could be able to provide at least one irrigation for about 15 ha of wheat crop at the crown root initiation (CRI) stage. This supplemental irrigation available could result in better wheat productivity. Farmers may cultivate different vegetable crops in the pond dike and surroundings, which would

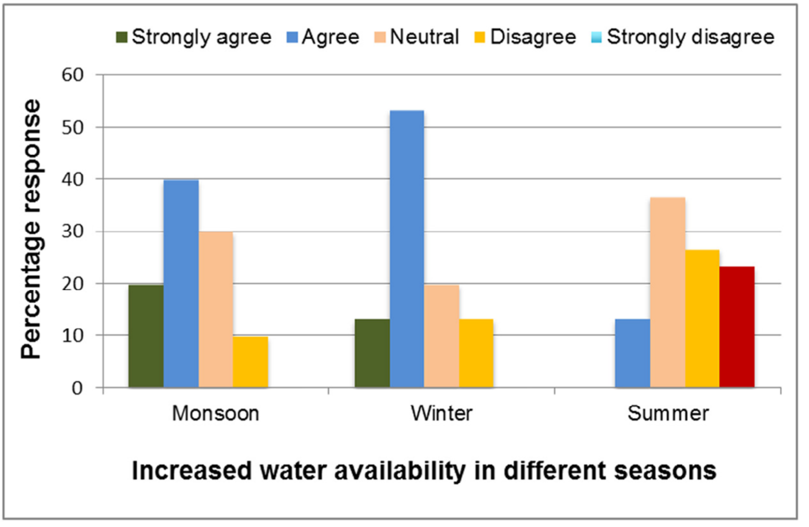

Fig. 3. Perception on increased water availability in different seasons due to pond rehabilitation.

generate additional income. In addition, fish farming in the pond may also improve due to increased water depth.

5. After intervention: changes in water availability and agricultural productivity

Increase in water storage and resultant socioeconomic benefits of rehabilitation effort was evaluated. Socioeconomic benefits were assessed based on added income as a result of this intervention. Both the change in household and community income and the increased multiple use of the community pond were also assessed. Many other studies have also reported that the realization of substantial socioeconomic benefits will facilitate the uptake of such interventions by smallholder farmers (Liang and van Dijk, 2011; Moges et al., 2011; Mushtaq et al., 2007a, 2009; Ngigi et al., 2005).

5.1. Changes in water availability and agricultural productivity

After rehabilitation, the pond's water storage capacity almost doubled and increased to 9,010 m^3 compared to 4,875 m^3 before rehabilitation. It included deepening of an additional 1 m (new depth being about 2.5 m) and some increase in surface area as well (68 m × 53 m). The result showed that 23% of the respondents reported an increase in availability of irrigation water.

The result revealed that 77% of the respondents had used pond water at least once to irrigate the winter crops. Among the beneficiaries, 67% reported increased access to pond water. The result showed some improvement in water availability from the community pond. Before the intervention 17% of area had some access to irrigation water from the pond, which has increased now to 21% of the area. Access of pond water showed some improvement in productivity for the wheat crop.

Respondents provided their view on increased availability of pond water in different seasons due to the intervention (Fig. 3). The majority of the respondents agreed that pond rehabilitation had increased water availability for both monsoon and winter crops. But the majority of them disagree regarding a likely increase in water availability for summer crops.

The results showed a minor improvement in cropping intensity after the pond rehabilitation. Post-intervention cropping intensity (CI) was 195% (minimum 93% to maximum 297%) compared to the "before" intervention cropping intensity of 180% (minimum 100% to maximum 276%). As the post-intervention survey was done immediately after the harvest of winter crops, information was collected

Table 6
Post-intervention area and productivity of major crops grown in different seasons (for each season, first column shows percentage of farming households cultivating the crop in a particular season; the second column shows average area under the particular crop with minimum and maximum areas in parentheses, and the third column shows the yield).

Crops	Monsoon			Winter		
	% hh	Area (ha)	Y(t/ha)	% hh	Area (ha)	Y(t/ha)
Paddy	100	1.2 (.1–2.2)	2.8	–	–	–
Wheat	–	–	–	100	1.0 (.1–2.0)	2.6
Mustard	–	–	–	60	.19 (.03–.67)	0.8
Vegetables	13	.08 (.03–.13)	5.0	27	.10 (.03–.17)	5.6
Legumes	13	.14 (.03–.27)	0.7	67	.21 (.07–.50)	0.6
Potato	–	–	–	63	.06 (.02–.33)	9.6

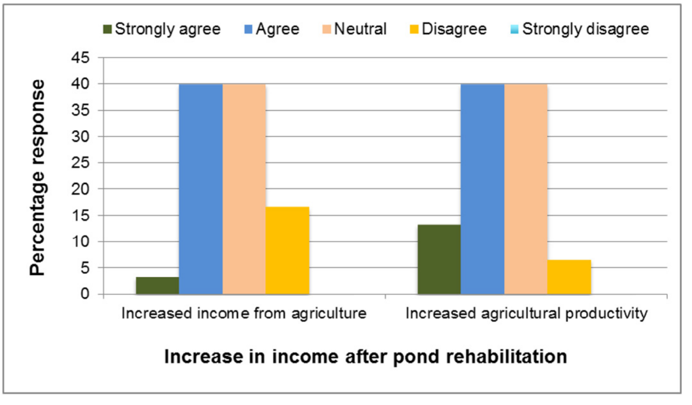

Fig. 4. Perception on increased household income due to pond rehabilitation.

only for monsoonal and winter crops. There were no major changes in the monsoonal crop area. The increase in CI was mainly a result of small changes in the cropping area during winter season. In terms of productivity (refer to Tables 3 and 6), because of flooding, there was a minor decline in paddy yield. But some increase was observed in the case of wheat yield. Likewise, vegetables and potato also showed minor increase in yield.

5.2. Changes in household income

About 30% of the respondent households noted the increase in household income after the intervention. The average annual household income from agriculture was NPRs 67,833 before intervention, which had marginally increased to NPRs 68,413. The change was due to some improvement in productivity of winter crop, especially the productivity of wheat. Respondents provided their views on the increase in household income because of increased income from agricultural sources and increased agricultural productivity after the intervention (Fig. 4). A majority of the respondents agreed that some increase in the income was because of increased agricultural productivity after intervention.

5.3. Multiple use of community pond

After rehabilitation, the community has become more aware about multiple uses of the pond. Almost all respondents (93%) know that the pond provides multiple services. Besides being a source of irrigation water, the pond can provide income from fishing (93%) and can be a place for recreation (30%).

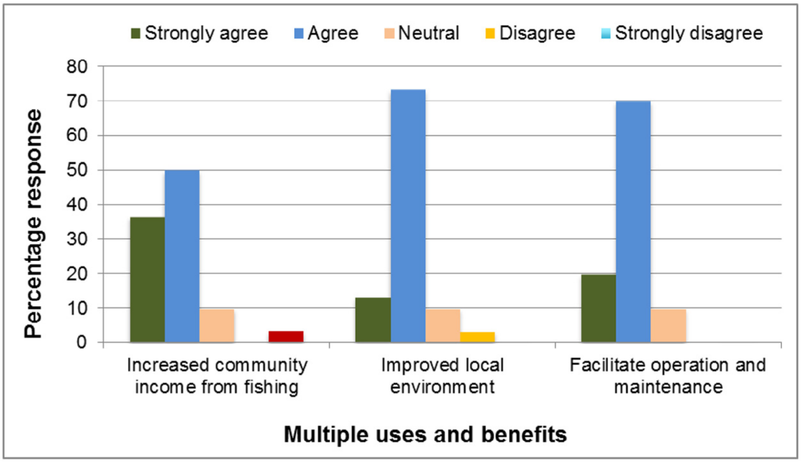

Fig. 5. Perception on improvement in multiple uses after the pond rehabilitation.

People can use water for domestic use (13%) and improve the microclimatic niche by helping in decreasing temperatures in summer (10%). The majority of the respondents (87%) reported an increase in total benefit from the community pond after rehabilitation. Respondents were asked to provide their view on multiple uses of the community pond after the intervention (Fig. 5).

One issue here is about the trade-offs between irrigation and fishing. During dry season both activities need water. However, considering the relatively higher income from fishing, farmers are happy to allocate water to maintain minimum water depth required for fishing. The majority of the respondents agreed that pond rehabilitation has resulted in increased community income from the fishing. The fishing activity was contracted to the same person after the intervention as well. With the increased water storage capacity, the pond can produce more fish compared to previous years. As a result, the local contractor agreed to provide a sum of NPRs 15,000 per year to the community. It was almost double the previous year's income from fishing (NPRs 8,000/year). The increased income from the fishing has been used to install shallow tube wells in the community. They also plan to use some funds to repair the local access road.

Likewise, a majority of the respondents agreed that pond rehabilitation has improved the local environment including sanitation of the community pond. Furthermore, they agree that multiple use of the pond would be helpful in realizing the importance of the pond and could, thereby, ensure continual operation and maintenance (O&M) of the pond. Other studies have also reported various multiple uses of the pond (Sukchan et al., 2014). For example, a pond not only serves as a source of irrigation water, it could also facilitate water-saving irrigation practices (Mushtaq et al., 2006). Likewise, small farm ponds could play a key role in sediment dynamics (increasing sediment trapping efficiency) in landscapes with considerable slope (Berg et al., 2015).

5.4. Improvement in management and water allocation mechanism

The development of local institutions has been considered as a key strategy in participatory rural development, including community management of water resources (Bastakoti et al., 2010; Mosse, 1995). Taking the case of tank irrigation in India, Mosse (1995, 1999) argued that management of local water resources is mediated by social institutions that are determined by changing configurations of power. In this case of pond rehabilitation through external resources, local institution played facilitating role in changing social relations and power politics. During the rehabilitation process, the community formed a users' committee for the management of the rehabilitated pond. The users' committee comprises 7 members. The newly formed committee is responsible for overseeing all the

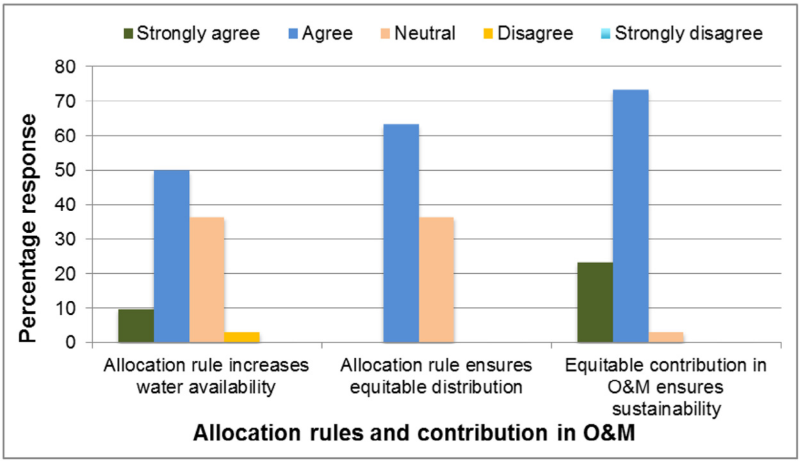

Fig. 6. Perception on the effect of the new rule on water allocation and equitable contribution to O&M.

management-related activities. The committee has formed some rules for water allocation, O&M of the pond, and use of additional benefit generated from the pond. Key rules formulated after formation of new committee were: (i) available water should be allocated on turn basis (farmers who need to pump the water from the pond should submit request to the committee and then the committee decides the turn on first come first basis, but any farmer cannot get second turn until the first turn is completed for all the farmers applied); (ii) pond will be used for both fishing as well as irrigation; (iii) minimum water level (of 1m depth) must be maintained while using the water for irrigation so that fish is not affected; (iv) all farmers should contribute in repair and maintenance of the pond; normal maintenance is scheduled for twice a year, whereas other repair should be done on need basis; (v) additional income generated from fishing should be used for community works; and (vi) all farmers should work together by following the principle of collective action for sustainable use of the pond as long-term resources.

It should be noted here that before rehabilitation, because of lack of coordination among the farmers, there was no fixed rule for water allocation and maintenance of this pond. As a result some of them (mainly the pump owners) were able to irrigate while others were not. Such situation created disputes among the farmers and lack of interest to contribute in O&M of the pond. The new rules formed by the new committee have been helpful in ensuring equitable water distribution and improved O&M of the pond. The new institutional set-up has changed the power relations among the farmers. It has resulted in improved access to pond water; both poor and relatively large farmers can access the water same way due to the formulation of water allocation rules.

Respondents were asked to provide their views on improvement in water allocation because of new rules and the effect of equitable contribution to O&M (Fig. 6). More than half of the respondents agreed that water allocation rule/mechanism had resulted in increased water availability. Likewise, the majority agreed that water allocation rule/mechanism had resulted in equitable water distribution. Furthermore, almost all agreed that equitable contribution in O&M will ensure the sustainability of the community pond.

Collective action among the users is crucial for pond management (Mosse, 1997; Mushtaq et al., 2007b). After the intervention, the involvement of the community in O&M has increased. When some damage to the pond occurred, the community came together for collective action and fixed the problem. Many of them consider that they are contributing in an equitable manner, which perhaps was because of the small size of the community and pond, as documented in other cases as well (Mushtaq et al., 2007b). The improved water allocation and O&M were facilitated by the new committee, as reflected by the views expressed by the respondents (Fig. 7). The result revealed that the new committee for

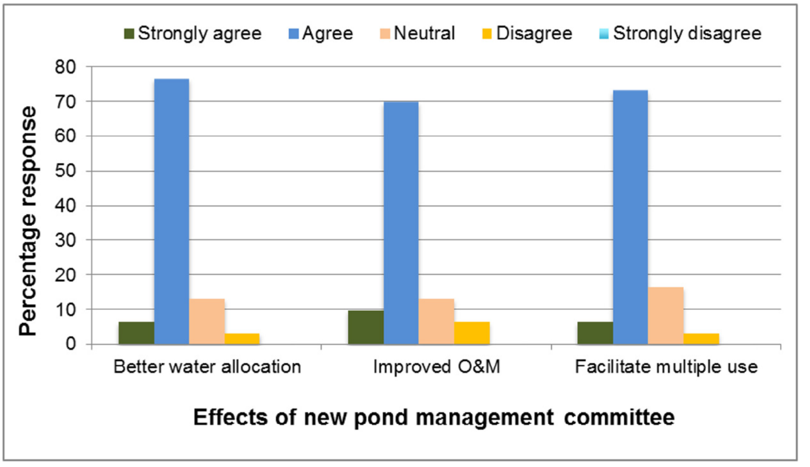

Fig. 7. Perception on effect of new committee on water allocation, O&M and multiple uses of the pond.

the management of the community pond has resulted in better water allocation and improved O&M. Likewise, the majority of the respondents consider that the new committee could also facilitate multiple uses of the pond.

5.5. Role of community pond to deal with climatic variability

Recent studies report increasing water stresses in Rupandehi District because of climatic variability, especially on key climatic parameters such as rainfall and temperature (Bhandari and Kayastha, 2010; CEAPRED, 2013). The respondents reported climate events such as delayed onset of rainfall, excess rainfall in the monsoon, and limited rainfall in other seasons. The main impact was the resulting water stress in winter and summer seasons, as well as floods in the monsoonal season.

The village is a rain-fed area without access to any surface irrigation facility. In addition, the groundwater has not been developed. In such a situation, the community pond could play a role in dealing with climatic variability. The majority of the respondents (60%) considered that the community pond could help cope with the impact of climatic variability. They provided their views on the possibility of reducing water stress in the dry season, reducing flood impact in the monsoon season, and the role in facilitating the adaptation (Fig. 8). The majority of the respondents agreed that community pond would help reduce water stress in the winter/dry season. When asked if the rehabilitated pond would reduce flood damage during the monsoon, most of the respondents disagreed.

The community pond could facilitate adaptation to impacts of climatic variability in different ways. First, the community pond will help in generating additional income for the community, through increased benefit from multiple uses. The majority agreed that the additional income could support new adaptation measures. For example, they have already installed shallow tube wells in a group, which they plan to continue in the future. Second, the community pond will help bring the community together. By doing so, it helps increase the collective action among the people. The majority agreed that such a process will enhance the adaptive capacity of the community and individual households. Our result regarding the role of pond to deal with the impacts of climatic variability is consistent with the findings of other studies (Anbumozhi et al., 2001; Ngigi et al., 2005; Palanisami et al., 2010). Palanisami et al. (2010) reported that increasing water storage in the irrigation tanks could be a key potential adaptation strategy to deal with climate change impacts in South Asia such as high-intensity floods and droughts, though there are many challenges to such adaptation response.

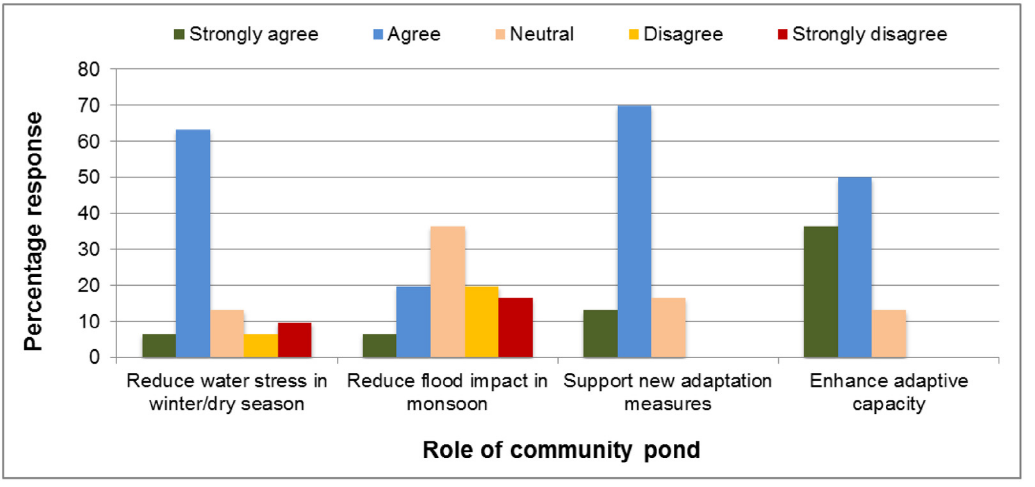

Fig. 8. Perception on the role of community pond to deal with climatic variability.

6. Conclusion and policy implications

Small-scale surface water systems, such as ponds/tanks, could be a viable alternative for other forms of surface irrigation in the Terai region of Nepal. But most of such ponds have remained underutilized due to lack of efficient management.

Community-led rehabilitation of the pond with the facilitation of external agencies showed some direct changes in quantitative indicators such as water availability, cropping intensity, crop productivity and income. Rehabilitation has increased the availability of pond water in the post-monsoonal season, mainly in the winter season. Cropping intensity has improved to some extent, mainly because of the small increase in cropping area during the winter season. There was a small increase in wheat yield as well. The increased agricultural productivity has resulted in a marginal improvement in annual household income. The community also generated more income with the increased fish stocking capacity of the rehabilitated pond.

Rehabilitation also resulted in establishment of new institutional setup and the increased ability of the community to manage communal resources. A new pond users' committee was formed during the rehabilitation process. The new committee formed new rules for water allocation and contribution to maintenance of the pond. New rules helped change the power relations in the community and ultimately resulted in improved water allocation in an equitable manner. The change in internal governance helped the poor farmers in accessing pond water. The new committee also facilitated equitable contribution in O&M of the pond through promoting collective action among the users. This effort has increased the social awareness among the people about the importance of underutilized water resources. The potential to generate benefit at village level has helped the community to work together.

Under rain-fed conditions with limited sources of irrigation water, community ponds could play an important role in dealing with the impact of climatic variability. This case study shows the potential to reduce water stress in the dry season and facilitate adaptation in different ways, such as by supporting new adaptation measures and enhancing adaptive capacity.

This effort was piloted in a small and relatively homogenous community. Similar initiatives could be replicated in other areas with similar biophysical contexts, but the size of the community and heterogeneity of the group should be considered.

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