Livelihoods and Food Security Trust Fund

Community Survey on Water Access, Availability and Management Issues in the Dry Zone of Myanmar

Final Report for Component 2

Sonali Senaratna Sellamuttu[1], Olivier Joffre[2], Diana Suhardiman[1], Soumya Balasubramanya[3], Paul Pavelic[1], U Ye Thaung Htut[4], Matthew McCartney[1] and Robyn Johnston[3]

[1]IWMI, Vientiane, Lao PDR
[2]Independent Consultant
[3]IWMI, Colombo, Sri Lanka
[4]MMRD Research Services

International Water Management Institute

MMRD Research Services
Myanmar Marketing Research & Development Co., Ltd

CONTENTS

List of Figures

List of Tables

Summary

In our community level survey, we employed a stratified approach to select 24 villages that covered the three regions - Mandalay, Magway and Sagaing in the Dry Zone of Myanmar. We endeavored to gain a better understanding of the relationship, both direct and indirect between water related issues and local livelihood strategies, especially for the most vulnerable groups, i.e., the marginal and landless that make up a large proportion, approximately 79.5%[1] of the population in the Dry Zone. We ascertain at the village level, the availability of water for different uses and opportunities and constraints to access and manage water as perceived by local people. In addition, we also examined various institutional arrangements at village/community level in relation to farmers' farming strategies and water management practices as well as domestic water use.

Our assessment was essentially qualitative in nature. For the purpose of our analysis we categorize villages in our sample into: villages with irrigation all year around, villages with supplemental wet-season irrigation and rainfed villages (which do not have irrigation). We also identify three types of farmers: landed (those that own between 5-15 acres of farming land), marginal (those who own less than 5 acres and are not food secure for the entire year) and landless (farmers without farm land, who are not renting land for farming, and who are not food secure throughout the year).

We obtained an overview of water resources at the village level. As expected, our findings revealed that the sources of water, availability of water both in a temporal and spatial context, and access to water to utilize for different purposes varies across the villages in our sample. In general it appears that that in irrigated villages, the average number of water sources is greater than in rainfed villages. Water availability in surface water sources such as ponds and reservoirs vary a lot in a temporal context, from two months to perennial water bodies. Furthermore, there has been a rapid growth in the exploitation of groundwater in the last ten years. Irrigated villages show the highest increase over the last 10 years in groundwater use, with an increase in private motorized tube wells. Rainfed villages appeared to have a limited number of wells in comparison, often citing water quality issues. Overall, access to groundwater can be constrained by a number of different factors such as: water quality issues, as mentioned above, with non-drinkable groundwater (due to high salt content and other mineral contaminants); investment required for establishing tube wells in addition to maintenance and costs linked with pumping in the case of motorized tube wells; and overexploitation in areas where the local demand exceeds the natural supply. Our survey highlighted that the total investment cost needed to establish groundwater irrigation is highly conditional upon the local conditions and can vary by an order of magnitude. Therefore knowledge of the hydrogeological conditions is crucial to effective planning at the local level and to minimize poor investments.

With regard to rainfall in the Dry Zone, it was interesting to note that the weather hazards associated with drought, dry spells and temporal variability of the monsoon, described during the community survey, are in line with the key findings from Component 1 of our study which revealed that there had been a significant reduction in rainfall amounts in June in recent years, combined

[1] We calculate this figure based on our definition of marginal and landless farmers in our study. According to the LIFT baseline study (2012), p36, in the Dry Zone, 42.6% are considered landless, 2.5% own less than 1 acre, 12.8% own between 1-2 acres and 21.6% own between 2-5 acres. Therefore this makes up a total of 79.5% of farmers who are landless and own less than 5 acres.

with the very high variability in the onset date of the wet season, that is likely to impede agricultural production by increasing the risk of drought at the beginning of the rainfed crop cycle. Dry spells occurring usually during the early part of the monsoon period were reported as the most frequent weather hazard experienced during the last 10 years in our community survey. Rainfed villages experience on average a higher frequency of climate hazards, with a high sensitivity to dry spell within the monsoon season, early end of monsoon and flood. Irrigated village are less vulnerable to climate shocks compare to village with supplementary irrigation and rainfed villages. In addition to drought related events, our community survey also highlighted some “wet” weather events, such as floods and cyclones. Floods affect all types of villages and can seriously affect irrigated lowlands.

Depending on the different climatic conditions and weather hazards experienced, the relative proportions by which different livelihood incomes contribute to the overall income portfolio of a household changes in the case of both marginal and landless farmers in all three village types. To cope with a weather hazard, households may adopt a range of strategies from pawning gold jewelry to seeking alternate livelihood activities within the village or migrating.

In line with other studies (QSEM, 2012), farming and casual labor in the agriculture sector were the two key livelihood activities reported in our Dry Zone community survey. In the case of marginal farmers, irrigated agriculture makes up a significant proportion of their livelihood portfolio, and in a good year, accounts for 32.5% of their income in irrigated areas. For landless farmers, the household income proportion derived from casual labor in the local agriculture sector is relatively high in all three types of villages, with an income share ranging from between 38% to 58% for labor within the village. We therefore conclude that supporting irrigation whether it were wet season supplemental or the conjunctive use of groundwater, would indirectly benefit the landless and reduce migration. Another issue highlighted by marginal farmers was that they were usually required to borrow or rent pumping equipment for irrigated agriculture. The water fee and rights associated with irrigation may vary between different villages. Concerns were raised regarding the additional fees and pumping costs and these are considered a constraint by marginal farmers in accessing irrigation water. It was a similar trend with regard to the use of groundwater as an alternative source of water in irrigation schemes in periods of water scarcity or at the tail-end of the irrigation canal, as a result of the high costs associated with pumping, plus also water quality issues in some cases.

Livestock represent an important component of the livelihood portfolio for both marginal and landless farmers and in a good year, livestock accounts for approximately 10% to 14% of the household’s income in the case of landless and only 5% to 12% in the case of marginal farmers. For both groups, rainwater harvesting ponds and groundwater are important sources of watering for livestock in both irrigated and rainfed villages. A shortage of water for livestock is, as expected, more frequent and longer in rainfed villages than in irrigated villages. Usually during drought periods, villagers adopt the coping strategy of accessing an alternate source of watering within the village or traveling with their livestock to another neighboring village.

With regard to the allocation of water between different domestic uses from our community survey it was noted that approximately 15% to 20% of the volume of water collected was allocated for drinking purposes, about 50% towards other domestic uses and between 30% and 41% for watering livestock. The relative proportions allocated did not appear to change significantly between seasons and during a drought period for the different households groups (i.e., marginal and landless farmers).

In relation to domestic water, it was interesting to note that for approximately 50% of the sample, drinking water is collected by all members in the family, while young boy and girls (<12) are cited only in one case. Surprisingly, when the distance to collect water is greater, all members appear to be involved in the water collecting, as the task of water collection would be taken on by any family member who was available at that time. Moreover, the family member involved in water collection may also change depending on the season. Overall the main difference found between rainfed and irrigated villages, was that in the latter, the distance (calculated as minutes per trip) is shorter and the frequency of water collection is lower, compared to rainfed villages. Additionally, in both irrigated and rainfed villages, the distance to the water source in the dry season is about three times higher when access to groundwater is constrained by water quality issues. The price of purchasing domestic water varied according to village and different uses. Purchasing water from a neighboring village usually meant higher prices due to the distance. In some villages it was noted that in the event of high costs of transportation, though collective action, villagers support one another, where villagers without transportation can purchase water from the adjacent villages with the assistance of their neighbors.

Our analysis on local institutional arrangements with regard to farmer's farming strategies and water management practices highlighted how these could vary from one village to other, depending on how farmers and villagers shape and reshape their strategies to cope with challenges in acquiring access to water as well as in distributing it. It was interesting to note that where farmers had neither access to irrigation nor groundwater, water scarcity condition urged farmers and villagers to cope with the problem through collective action. In this particular case, the common problem identified was water scarcity for domestic water use and the villagers collectively come to an agreement regarding how to solve the problem, i.e., by pumping water from the nearby reservoir and convey it to the village pond, through existing canal networks. Based on insights gained from our case study, we identify one technical entry point for institutional strengthening, towards better water management in areas where farmers have access to irrigation which links the water delivery schedule to the farmers' cropping pattern and this is described in detail in Report 3 (see Johnston *et al.,* 2013).

In addition, through a preference voting exercise conducted in each of the FGDs, we also attempted to identify potential interventions that would reduce vulnerability to water stress, and that were of priority to the local communities Our overall analysis highlighted that the rehabilitation or construction of rainwater harvesting pond was a preferred option for all farmer-types, most likely as a result of increasing access to water for drinking, domestic use and livestock. The rehabilitation or extension of existing irrigation infrastructure was a preferred option among landed and marginal farmers in villages with irrigation all year round. But this may requires further investigation to determine how best to make these efforts cost-effective. Groundwater interventions are preferred over others by landed and marginal farmers in villages with supplemental wet season irrigation. Factors such as the quantity of groundwater available, installation costs, operation and maintenance costs and replacement costs are important considerations though prior to making an investment.

Overall, from our survey it is clear that in relation to the broader livelihood strategies found in the villages, water related interventions cover a range of different uses – agriculture, domestic water uses (including livestock and drinking water) and even protection against floods in some cases. Furthermore, different types of interventions are implemented in the same village with funding support from different sources. It is therefore important that a holistic approach is adopted with regard to investing in water related interventions at the village level – an approach that takes into consideration the full range of uses, shaped within each community based on their own specific priority needs, and ensures that all interventions are closely linked into the local level village development planning processes.

1. Introduction

This report relates to the challenge of managing water for inclusive and sustainable growth in the Dry Zone of Myanmar. Home to a population of approximately 10.12 million people (MIMU, 2013), the Dry Zone is the most water stressed regions of the country and also one of the most food insecure. Approximately 43% of households in the region live in poverty and 40-50% of the rural population is landless (JICA, 2010). The extreme variability of rainfall, high intensities, limited rainfall events in the growing season and poor spatial and temporal variability is believed to be a major constraint to rural livelihoods and hence an underlying contributor to the poverty of many households. It is believed that improving water availability and access, as well as water management, in the region would reduce risk, stabilize agricultural productivity, increase the resilience of households, improve food security and, contribute to poverty reduction.

Against this background, LIFT is developing a program for the Dry Zone that that will be implemented from 2013 to 2016. As water related concerns are known to have a strong bearing on food insecurity and low incomes in the Dry Zone, LIFT has decided to undertake a rapid review of access to and management of water resources. This review is expected to serve as one important input to the formulation of a LIFT program for the dry zone. In broad terms the review will identify:

- What the key issues are with regards to water availability, access and management in the Dry Zone;
- What is already being done in relation to these issues; and
- What the priority actions are to improve access and management of water for people living in the Dry Zone.

This report is the second of three derived from the IWMI review. It constitutes of a community level survey conducted in a small sample of villages in the Dry Zone to ascertain local water availability for different uses and opportunities and constraints to access and manage water as perceived by local people. We have also looked at various institutional arrangements at village/community level in relation to farmers' farming strategies and water management practices as well as domestic water use.

The overall objective of the community level study is to determine the present access and availability of water for agriculture, livestock and domestic use and to identify priority actions for improved access to and management of water resources which can improve food security and income of rural inhabitants in the Dry Zone of Myanmar.

The other components of the study consist of:

- Component 1: a water resources assessment to provide baseline information on water availability in the Dry Zone.
- Component 3: an evaluation of current investments and how successful they have been in improving livelihoods and food security, as well as a review of lessons learned from other IWMI work on agricultural water management solutions, in regions similar to the Dry Zone.

2. Methodology

Our assessment is essentially qualitative in nature. We proposed to understand the relationship, direct or indirect, between water related issues and livelihood strategies, especially for the most vulnerable. We place emphasis therefore on the marginal and landless.

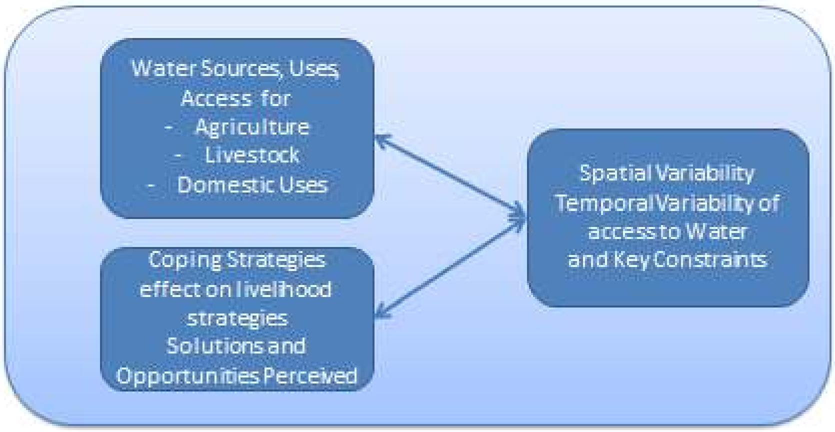

Figure 2.1. Vulnerability and opportunities of local livelihoods in relation to access and availability of water

2.1 Sampling framework

For our community level survey we employed a stratified approach to select sites suitable for our study; first selecting townships, and then selecting villages in chosen townships. Based on the short duration of this study and available budget, our sample consisted of 24 villages, with four villages each in six townships.

Selecting townships

Townships in the 3 Dry Zone regions of Mandalay, Magway and Sagaing were selected by using two indicators—the irrigable area per township, and the location of the township (whether west or east of the Irrawaddy River). [2]

To begin, we identified in each of the Mandalay, Magway and Sagaing Regions, the number of townships in the Dry Zone (18, 22 and 19 respectively), and then the number of Dry Zone townships in which LIFT has working partners (9,16 and 11 respectively) in order to obtain permission to conduct our fieldwork. Thus all the townships included in our study are ones where LIFT has funded projects in at least some villages. [3]

Our use of irrigable area per township was motivated by the purpose of the study, which seeks to examine the role of water in improving food-security and livelihoods in a predominantly agrarian system with limited irrigation. We calculated irrigable area per township for each of the LIFT Dry Zone townships using GIS data. The irrigable area was defined as the area with access to irrigation

[2] These indicators are available only at the township level, and not at the village level.
[3] LIFT has not funded projects in every village in any township, and we exploit this in selecting villages.

infrastructure, and was calculated using information on the location of government-built irrigation projects, which was provided by the Department of Irrigation of the Union of Myanmar. Additionally, Google Earth images were used to identify irrigated area to supplement the data from the Department of Irrigation. We normalized this indicator of irrigable area by using township area to address the likelihood of larger townships also having a higher likelihood of having greater areas with access to irrigation infrastructure.

The use of location as an indicator was motivated by the observation that areas to the east of the river are on average drier than those to the west of the river (LIFT, 2011). In the absence of town-level agro-climatic data, we used location as a proxy for capturing some variation in agro-climatic factors, which are likely to affect adaptation strategies.

We elected to sample more villages within fewer townships, rather than fewer villages with more townships. This decision was primarily based on the finding that variation in rainfall is highly localized (JICA, 2010; LIFT, 2011; LIFT, 2012). Rainfall data in Myanmar was found only at the district level[4], and this data did not reveal sufficient variation for selecting townships. Additionally, time and resource constraints prevented expansion of townships for the study. We thus decided to choose two townships per region, and four villages per township.

All Dry Zone townships in Mandalay Region lie to the east of the river, and all Dry Zone townships in the Sagaing Region lie to the west. In Magway Region, Dry Zone townships lie to the west and the east of the river. We randomly selected two townships in each of the three Regions, conditional on being a township with LIFT partners and whose area was above the mean township area in that Region. This was done to focus on townships with larger populations. [5]

In Mandalay and Magway Region, we randomly selected per Region, one township with irrigable area above the mean irrigable area of Dry Zone townships in that Region, and one below the mean. In Magway Region, we randomly selected one township to the east of the river, and one to the west.[6] The selected townships are summarized in the following Table 2.1.

[4] On average 3 townships make a district.

[5] The last census in Myanmar was conducted in 1983; thus updated official statistics were unavailable. The JICA study of the dry zone had collected population data in 2000. However, this study revealed a reasonably robust positive correlation between township area and population. The limited sample size of the study rendered the number of variables used for selection of townships to also be limited, to have adequate degrees of freedom. Thus township area was also used as a proxy for population size.

[6] The fact that both townships in Mandalay and both townships in Sagaing are in the same district is a happy coincidence. Though unlikely, this allows us to address concerns regarding differential district-level governance policies that may explain underlying differences in water management. In Magway, we deliberately chose both townships in the same district to accommodate the ability to study a township east and one west of the river.

Table 2.1. Townships selected for the community survey

REGION	DISTRICT	TOWNSHIP	LOCATION	IRRIGABLE AREA (PERCENT)
Mandalay	Myingyan	Kyaukpadaung	East	1*
Mandalay	Myingyan	Nyaung-Oo	East	5
Magway	Minbu	Minbu	West	0.3
Magway	Minbu	Taungdwingyi	East	5*
Sagaing	Shwebo	Sagaing	West	12*
Sagaing	Shwebo	Ta Sei	West	5

* The percent of township area that is irrigable was calculated as the ratio between the irrigable area in the township and township area. This normalization was done to account for the possibility that larger townships may have more irrigable area. Irrigable area is higher than the mean irrigable area for the corresponding region. On average, irrigable area constituted 3% of the township area in Mandalay, 3% in Magway, and 8.5% in Sagaing.

Selecting villages within selected townships
Villages were selected on the basis of four indicators—LIFT presence, population, rainfall shocks and irrigation source.

We wished to study both villages with LIFT-funded projects, and those without such projects, in order to understand how LIFT may impact food security issues. [7] We were able to obtain the information of villages with LIFT-funded interventions in the form of a consolidated list from LIFT.

We wished to study villages with populations representative of the township. From the data provided by LIFT on their intervention-villages, we inferred that a representative village in both Kyaukpadaung Township and Nyaung-Oo Township (Mandalay Region) has at least 200 households; those in Minbu Township and Taungdwingyi Township (Magway Region) had at least 150 households; and those in Sagaing Township and Ta Sei Township had at least 120 households.

Additionally, we also wished to study 'stressed' and 'non-stressed' villages, since localized weather patterns are likely to produce variance in water resource needs and adaptation strategies. We defined stressed villages as those that had experienced a loss of crop or livestock due to an extreme rainfall-related event in the past year (2012). Since consolidated data on such villages is unavailable, we relied on township officials at the Water Resources Utilization Department (WRUD) to help us identify such villages. Finally, we also relied on officials at WRUD to provide us with information to identify villages with irrigation, and those that are rainfed. For sources of irrigation water, we attempted to have some variance across villages in each region, and across the 24 villages in our study (see Table 2.2 and Figure 2.2)

[7] We note that villages may have projects that are funded by other donors, irrespective of whether they may have projects funded by LIFT.

Table 2.2. Sampling framework for the community survey and institutional study

REGION	TOWNSHIP	VILLAGE	LIFT	TYPE OF VILLAGE	SOURCE OF WATER
Mandalay	Nyaung Oo	Nwar Kyoe Aing	UNDP	Non Stressed	Pumping from Ayeyarwady river
		Kamma	UNDP	Stressed	Rain fed,
		Thea Pyin Taw	Non LIFT	Stressed	Rain fed,
		Ohn Hne Chaung	Non LIFT	Non Stressed	Pumping from Ayeyarwady river, groundwater
	Kyauk Pa Daung	In Taw	LIFT	Non Stressed	Surface (creek), groundwater (pump)
		Kyauk Sit Kan	LIFT	Stressed	Rain fed (Pump)
		Khway Tauk Kone	Non LIFT	Non Stressed	Surface (creek), groundwater (pump)
		Chaung Char	Non LIFT	Stressed	Rain fed
Magway	Minbu	Yae Twin Kone	OXFAM	Non Stressed	Supplementary irrigation, groundwater (pump)
		Kha Yu Kan	OXFAM	Stressed	Rain fed
		Kone Thar	Non LIFT	Stressed	Rain fed
		Kyauk Tan	Non LIFT	Non Stressed	Surface (creek), groundwater (pump)
	Taungdwingyi	Ma Hti San Pya	UNDP	Non Stressed	Surface (creek), groundwater (pump)
		Let Tet	UNDP	Stressed	Rain fed
		Taik Pwe	Non LIFT	Stressed	Rain fed
		Tha Hpan Kone	Non LIFT	Non Stressed	Surface (creek), groundwater (pump)
Sagaing	Sagaing	De Pa Yin Kwal*	Non LIFT	Non stressed	Groundwater
		Ta Ein Tel*	Non LIFT	Non stressed	Pumping from Ayeyarwady river
		Taung Yinn*	Non LIFT	Stressed	Rain fed
		Sarr Taung	Non LIFT	Stressed	Irrigated, surface irrigation (dam) and groundwater (pump)
	Taze/Ta Sei	Bay Yinn	Non LIFT	Non stressed	Groundwater (pump)
		Daung Gyi	Non LIFT	Non stressed	Irrigated, groundwater and surface irrigation (pond)
		Kan Du Ma	Non LIFT	Stressed	Rain fed
		Pa Kar	Non LIFT	Stressed	Groundwater (pump)

* Purposive sample of villages where the institutional study is being conducted.

We characterized our sample into two mains type of villages, 1) irrigated and 2) rainfed and within the later, two sub categories: rainfed and supplementary irrigation. For the purpose our study, we propose the following definitions:

- **Irrigated villages** are villages having access to water for irrigation all year round, for summer, monsoon and winter crops. The source of irrigation can be from an irrigation scheme, groundwater and/or reservoir (pond/sand dams). An irrigated village can have different sources of water to irrigate crops and those sources can varies spatially and temporally. Irrigated villages have in general a ratio of irrigated area/non irrigated above 0.5.

- Rainfed villages are divided in two sub categories: purely rainfed villages and villages with supplementary irrigation

  - **Village with supplementary irrigation** are villages with a spatially and temporally limited access to water for irrigation. The ratio of irrigated land to rainfed land is below 0.15 and not all villagers have access to irrigation. Source of water for irrigation are diverse and can include more than one source per village. It can be an irrigation scheme functioning only in the monsoon crop, groundwater or a rainwater storage pond. Irrigation is during the monsoon crop mostly and also limited area during the summer crop in few cases. Supplementary irrigation happens only in cases of dry spell or drought to limit the impact of water stress on yield during the main crop.

  - **Rainfed villages** are village without any irrigated area even supplementary. All agriculture relies on rainfall. Those villages are thus more vulnerable to dry spells during the monsoon season.

Based on the above criteria, our sample comprised of 5 irrigated villages, 8 villages with supplementary irrigation and 11 villages that were only rainfed (Table 2.3).

Table 2.3. Village categories based on irrigated and rainfed

	VILLAGES	REGION
Irrigated villages	5	Mandalay (2) ; Sagaing (3)
Rainfed villages		
- Supplementary irrigation	8	Magway (5) ; Sagaing (3)
- Rainfed Only	11	Magway (3); Mandalay (6); Sagaing (2)

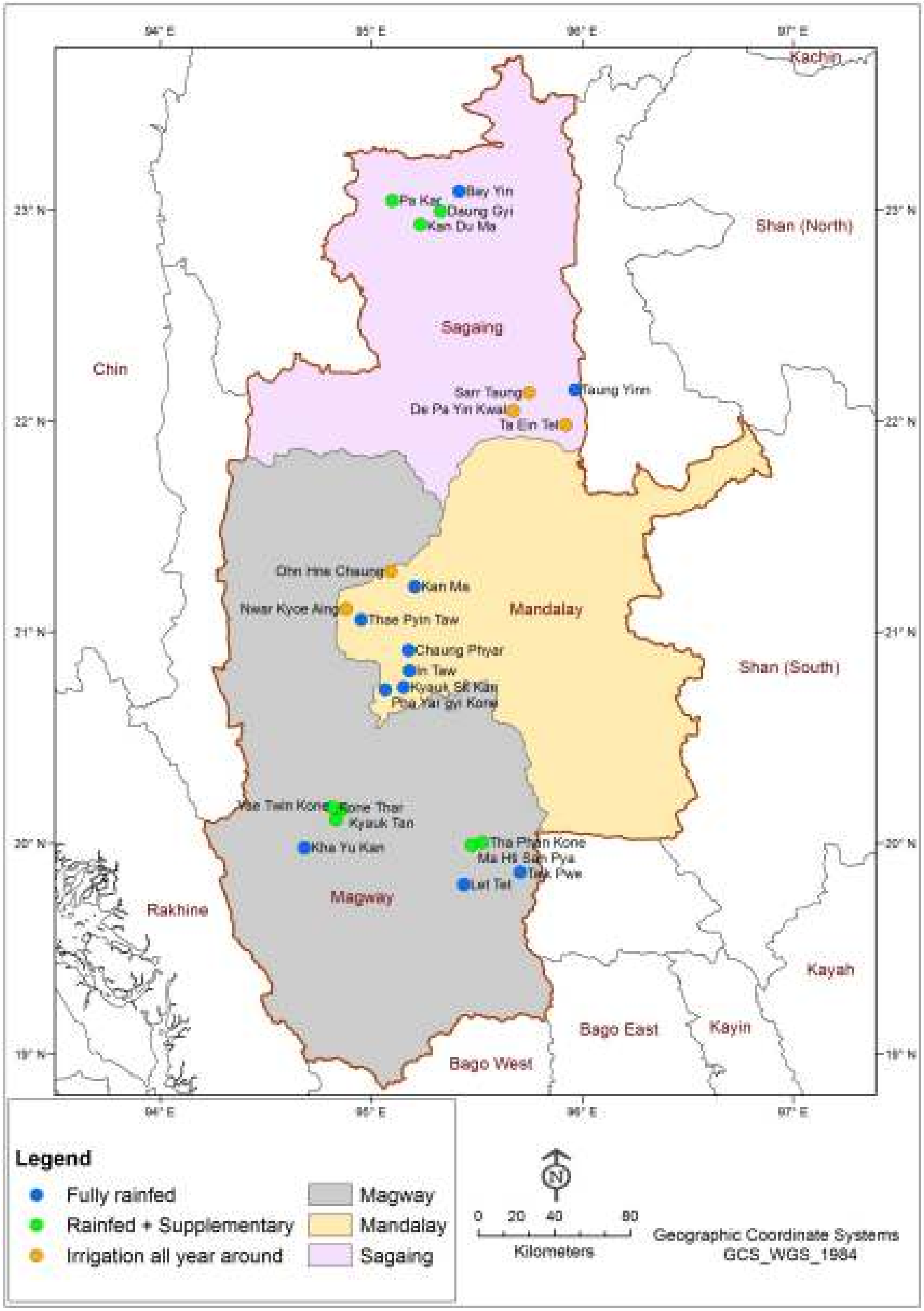

Figure 2.2. Villages in our sample for the community survey

2.2 Method and tools adopted in the community survey

For our survey, we conducted three Focus Group Discussions (FGDs) per village (i.e., 72 FGDs in total), categorizing farmers as landed, marginal or landless. In the FGDs we covered different thematic areas (as indicated in Table 2.4, and included the spatial and temporal variations in the sources of water available and water uses (including irrigation, livestock watering and domestic use); key constraints of availability and access and how this affects livelihoods strategies and food security; coping strategies adopted by households and communities in the event of shocks such as droughts; perceived solutions and opportunities; and interventions that have worked , lessons learned and finally perspectives from the community of regarding priority potential measures and investments.

We focused on marginal farmers and the landless because we understand that they are expected to be the two target groups of the LIFT Dry Zone program and we are interested in assessing how interventions proposed would affect these two groups differently. In our study we define marginal farmers as *farmers who own less than 5 acres and are not food secure for the entire year*[8] and landless as *farmers without farm land, who are not renting land for farming, and who are not food secure throughout the year.* According to the LIFT baseline study (2012), p36, in the Dry Zone, 42.6% are considered landless, 2.5% own less than 1 acre, 12.8% own between 1-2 acres and 21.6% own between 2-5 acres. Therefore this makes up a total of 79.5% of farmers who are landless and own less than 5 acres. Through our general FGD in our survey (FGD1), we also captured information from relatively better-off landed farmers (those that own between 5-15 acres of farming land) and represent approximately 16.2 % farmers in the Dry Zone according to the LIFT (2012).

[8] We purposively selected food insecure households to avoid the selection of landless or marginal farmers that may be better off and involved in nonfarm activities. Adding a food insecure criterion, allowed us to select more vulnerable households. Meanwhile, it should be noted that the access to land is in general correlated to the food security level of the household. Below 5 acres, the months of adequate household food provisioning (MAHFP) is below 10 (LIFT, 2012, pg 30).

Table 2.4. Selection criteria and topics covered under the FGDs held for the Community Survey

	FGD 1: WITH COMMUNITY LEADERS - GENERAL BACKGROUND AND WATER RESOURCES IN THE VILLAGE	FGD 2: WITH MARGINAL FARMERS ON WATER ACCESS, AVAILABILITY AND MANAGEMENT	FGD 3: WITH LANDLESS FARMERS ON WATER ACCESS, AVAILABILITY AND MANAGEMENT
Selection Criteria	Number of participants: 8-10 Village/community leaders (both those appointed by government and others; for example, elders, monks, members of WUA, representatives of local CBOs, at least 2 farmers who own between 5-15 acres of farm land) Equal representation of males and females	Number of participants: 8-10 Farmers that have less than 5 acres and are not food secure for the entire year If possible both tail farmers and head farmers Equal representation of males and females.	Number of participants: 8-10 Farmers without farm land and who are not renting land for farming. Also not food secure throughout the year. Equal representation of males and females.
FGD outline	1. Community structure and assets 2. Water sources at the village level 3. Institutional Arrangements associated with Water Use and Management 4. Land resources in the village (and links to irrigation and rainfed) 5. Cropping calendar 6. Timeline for climatic related events 7. Past and current interventions in the village 8. Potential interventions in the village	1. Climate related events 2. Agriculture and water related issues a) Rainfed System - No irrigation, even supplementary b) Irrigated Crops 3. Livestock 4. Past technical changes 5. Domestic use 6. Share of income 7. Potential interventions in the village	1. Climate related events 2. Livestock 3. Domestic use 4. Share of income[9] 5. Potential interventions in the village

[9] Marginal and landless farmers estimated the relative importance of each livelihood activity in the income portfolio for marginal and landless farmers as well as the average annual income of an average landless and marginal household. In a second step, the impact of climate hazard such as drought, dry spell or flood, was estimated by both marginal and landless farmers on their income portfolio and total annual income. For the relative importance of each livelihood activity and the total annual income we extrapolate the absolute income of each of the livelihood activities in a good year and in years with a clime hazard.

Groundwater questionnaire
Additionally, during the community survey, a semi-structured questionnaire was developed to derive a general understanding of the nature of groundwater irrigation technologies and the socio-economic factors that affect the household incomes and food security status of smallholder farmers across the DZ. This facet of the study seeks to provide a preliminary assessment of the livelihood and food security implications of smallholder farmers who establish and operate groundwater infrastructure to irrigate their fields.

We identified upfront investments and revenues and disaggregated by the season, the crops grown and sold in the market. An annual cycle was covered for the period from winter 2011 through to monsoon 2012. Additional information was sought to address other points of interest such as the major constraints facing implementing farmers. Levels of self-consumption of produce by the farming household was not directly examined and thus the revenue is considered to represent potential values rather than actual. The production value of rainfed systems was also not taken into account.

The survey tool was implemented in 6 villages distributed across the 6 Townships covered under our study: Nyaung Oo, Kyauk Pa Daung, Minbu, Taungdwingyi, Sagaing and Taze, in the three DZ Divisions. Two villages are categorized as 'rainfed', three are 'rainfed with supplemental irrigation' and one village (with 2surveys) as 'full irrigation' according to the protocols of the study. All of the villages are situated in an alluvial geological setting, which is one of the most prospective environments for groundwater development (McCartney et al, 2013).

In total of seven farmers who were well owners were interviewed. Those surveyed were the sole owners of the well, all male, who considered themselves as the head of the household. Four of the seven farmers were considered 'landed' and the remaining three 'marginal'. The limited sample size was all that could be achieved within the duration of the study, and whilst too low to provide statistically defensible data, it was considered sufficient to gain an initial appraisal of the general opportunities and constraints associated with groundwater use for agriculture.

2.3. Institutional Analysis

Our institutional analysis is derived from an in-depth case study analysis (Strauss and Corbin, 1990) using a purposive sample. It looks at how farmers perceive existing institutional arrangements in relation to their farming and water management practices. In cases where institutional arrangements were absent, the analysis sheds light on how farmers actually view the need for such arrangements.

Our purposive sample includes three villages in Sagaing township. These villages are: Ta Ein Tel, De Pa Yin Kwal, and Taung Yin. We selected these three villages based mainly on their access to water resources: irrigation, groundwater, and rainfed villages. We conducted a FGD in each of the three villages. Participants for this FGD were selected based on farmer's access to water (i.e. head and tail-end farmers in case of irrigated village), and access to land (wealthy farmers, marginal farmers, landless/laborer). The discussion was focused on identification of current challenges related to farmer's farming and water management practices, as well as farmer's strategies to cope with these challenges.

We conducted two key informant interviews in each of the three villages to follow up issues discussed in the FGD. We selected marginal and landless farmers as our key informants, as they form the majority of farmers in the Dry Zone. This selection is also based on the assumption that less powerful actors might decide not to tell their opinions openly in the presence of more powerful actors.

As an integral part of our in-depth case study analysis, we conducted key informant interviews with various actors and institutions at the township level across the three regions (Sagaing, Mandalay, and Magway). With this, we hoped to gain some insights on local institutional arrangements across the regions. A total of 11 key informant interviews were conducted in two townships in Sagaing region (Sagaing, Taze), two townships in Mandalay region (Nyaung-U, KyaukPaDaung), and two townships in Magway region (Minbu, Taungdwingyi). Actors interviewed included staff from the Water Resources Utilization Department (WRUD), Irrigation Department, Myanmar Agricultural Service (MAS), and Network Activity Group (NAG).

In addition to data gathered during the field research, we complemented our analysis with a literature review of various institutional approaches (Cleaver, 2012; Ostrom 1999), as well as secondary data analysis (various project reports) on local institutions in Myanmar in general and the Dry Zone in particular.

2.4 Implementation of the community survey, groundwater questionnaire and institutional study

We partnered with MMRD Research Services to support us in conducting the community survey, and implementing a short questionnaire on groundwater and another on the institutional component of our study. The survey instruments for the community consultation were finalized in early February by IWMI, taking into account key water related issues highlighted at the stakeholder consultation workshop and feedback received by MMRD.

Training of the MMRD staff in the institutional component was conducted by IWMI on the 7th February and training in the community survey instruments plus the short questionnaire on groundwater was undertaken by IWMI from the 11th – 14th February 2013. Thereafter two rounds of pilot-testing the survey instruments were conducted in Pyay, Bago West from the 15th – 18th February 2013. Feedback sessions were held between IWMI and the MMRD team after each pilot, to refine the survey instruments, taking into account the experiences and lessons learned from the pilot testing. A separate training to familiarize the MMRD team with the data entry template for the survey instruments was conducted by IWMI at the MMRD office on the 20th and 21st of February 2013.

The survey 'proper' was conducted in the Dry Zone by MMRD from the 11th to 30th March 2013. For our survey we covered six townships (4 villages in each township) and MMRD appointed one field team to work in each of the townships (therefore there were six teams and each covered four villages). In addition, MMRD administered the groundwater questionnaire to seven farmers who were a purposive sample of well owners. Members of the IWMI team responsible for the community and institutional survey made a visit to the Dry Zone during this period to observe and engage in the community survey and institutional study. We covered one township in Sagaing region and two townships in Mandalay region. In Sagaing Township, we visited Taung Yinn village. In our sampling framework, this is classified as a stressed, rain-fed village with no LIFT interventions. In Nyaung Oo Township, we visited Thea Pyin Taw village. This is classified as a stressed, rain-fed village with no LIFT interventions. In Kyauk Pa Daung Township we visited In Taw village. This is classified as a non-stressed village, using surface water/groundwater with LIFT interventions.

2. 5 Limitations of the Study

The short duration of the study meant that we could only work with a very small number of villages – our sample size was limited to 24 villages. In addition we were only able to conduct one round of field work. We were unable to carry out any follow-up field work to clarify certain results that emerged when undertaking our analyses. Moreover, when developing our sample framework, the lack of access to accurate information at the township level regarding water resources at the village level meant we had to revise our sample classification after visiting the villages that had been proposed by the township authorities. Additional time would have been useful to clarify some of these aspects before starting the community survey "proper".

3. Water Resources at the village level – an Overview

This chapter provides an overview of the different water resources used by the communities in our sample villages in the Dry Zone and availability and access to these resources. We will also briefly discuss some of the key water quality related issues that are found in the villages.

3.1 Diversity of water resources and uses at the village level

As expected, the sources of water, availability of water and access for different purposes varies across the villages in our sample. In general it appears that that in irrigated villages, the average number of water sources is greater than in rainfed villages. For example in our sample, irrigated villages have access on average to 137 individual sources of water, including a large number of motorized tube and dug wells, while rainfed villages have access to a much lower number of water sources (only 25 per village).

With regard to surface water sources, irrigated villages have better access to surface water sources such as rivers and ponds. However the large difference in number of ponds is due to one village Sarr Taung counting 36 ponds, otherwise the number of pond per village is not significantly different with other categories. Irrigated villages have access to perennial rivers in most of cases, and water is used for all purposes including irrigation (Table 3.1). In the case of natural springs, water use is restricted to domestic and livestock in all villages. The availability of water throughout the year varies, with a perennial water source in irrigated villages while it was reported that water availability in rainfed villages ranged from 7 to 12 months.

Water availability in ponds is extremely heterogeneous, from perennial water bodies to short duration seasonal ponds. Reservoirs are mostly used for domestic uses and livestock watering and less for supplementary irrigation purposes.

With regard to groundwater, only two villages, Kyaut Sit Kan and Kha Yu Kan in Mandalay and Magway regions respectively, did not have access. The ratio of well (hand dug or tube well) per household in our three village categories is: 0.15 in rainfed; 0.16 in irrigated; and 0.56 in supplementary irrigation. We can infer from this that the access to groundwater may be easier and better spread amongst the village population in the supplementary villages. However in villages with supplementary irrigation this is largely comprised of hand lift wells, compared to irrigated villages where more motorized wells are utilized (an outline of water resources and characteristics in each village is provided in Annex 1).

Access to groundwater is more restricted with respect to time for rainfed villages, with a more limited water availability (8 to 12 months a year compared to having access all year around in irrigated villages). The availability of water is limited in the dry season, when water is needed. In rainfed villages, groundwater from tube wells and dug wells is restricted mainly to domestic uses and livestock. In irrigated villages and supplementary irrigation villages motorized tube and dug wells are used for irrigation, while hand lifted wells are used mainly for domestic use and livestock.

In our community survey, we differentiate groundwater source by type of well – thus differentiating between tube well and dug well, and in addition distinguishing between the method of lifting water, i.e., motorized or manual, leading to 4 main types of wells: tube well manual and motorized, dug well manual and motorized. These 4 types of wells which we refer to in the Component 2 report correspond predominantly to Type 2 found in the Component 3 report, namely shallow tube wells and dug wells, operated privately or by the community.

Table 3.1. Different types of water sources per type of village

SOURCE OF WATER	IRRIGATED VILLAGE (N=5)	NON IRRIGATED VILLAGE (N=11)	VILLAGE WITH SUPPLEMENTARY IRRIGATION (N=8)
River	Only 1 village (Ta Ein Tel) does not have access to a river. All other villages use the river for livestock, irrigation and domestic needs all year long	No access (no source)	Kyuak Tan and Pa Kar villages have access to water from the river, during the entire year for Kyauk Tan (irrigation and livestock), while Pa Kar as water only during 4 months and use it for irrigation during monsoon
Spring	No access (no source)	3 villages have access to springs (1 to 3) but with a water availability varying from 7 to 12 months. Water is used for domestic purposes usually.	2 villages have access to a spring all year long, and used for irrigation (Pa Kar) and domestic use and livestock (Ma Hti San Pya village)
Pond and reservoir	3 villages have ponds or reservoirs. Approximately 36 ponds recorded in the case of Sarr Taung village, while only 1-2 units in the other two villages. Water is available between 4 to 12 months and used for domestic and livestock (Sarr Taung village) and in the case of 2 villages for multiple purposes.	8 villages have 1 to 11 ponds, with water availability for an average of 7 months (varying from 2 months to all year around). These ponds are used for livestock and domestic needs	6 villages have between 1 to 3 ponds, used from 2 to 12 months per year. Use of the pond varies, from single use (irrigation or livestock) to multiple use (livestock and domestic use or irrigation and livestock).
Tube well motorized	All villages have motorized tube wells. 1 to 15 in 3 villages, while De Pa Yin Kwal and Sarr Taung have 147 and 170 motorized tube wells respectively and these are used for multiple purposes.	5 villages have 1 to 5 tube wells, with perennial supply of water which is used for domestic needs and livestock.	All villages have motorized tube well (2 to 43 per village), with perennial supply of water and used for supplementary irrigation, domestic uses and livestock.
Tube well manual	3 villages have manual lift tube wells, 15and 50 in Sarr Taung and Ta Ein Tel villages respectively, while De Pa Yin Kwal has 241 tube wells. Water available all year and water is used for livestock and domestic uses or multiple purposes in the case of De Pa Yin Kwal village	5 villages have manual lift tube well, with wide variation: 1and 3 in In Taw and Thea Pyin Taw villages, and a range of 36 to 113 in other villages. Water is available all year and used for domestic uses or both domestic and livestock.	All villages have access to this type of groundwater, with 124 wells on average per village (34 to 308). Water is available all year and used for both domestic and livestock.
Dug well – manual and motorized	2 villages have 2 and 3 dug well in all case water is available all year and used for domestic and livestock	Only 3 villages have access to hand dug well (4 to 22), with water availability is between 8 to 12 months and used for livestock and domestic usage or only domestic uses. Bay In village has 10 motorized dug well, used for irrigation and domestic needs	4 villages have 7 to 100 dug wells, with water availability all year and used for domestic purposes and livestock. Kyauk Tan has also 300 motorized dug wells, used for all purpose.

3.2 Groundwater resources - trends

With respect to the trends in groundwater exploitation, according to our community survey, there is a rapid growth in the number of wells in the last ten years, especially in terms of private wells. Public wells[10] are less represented in our sample (seven public motorized tube wells reported for 2013 and two hand lifted tube wells in 2013) and no public dug wells were recorded. We note however that this increase in well numbers is not uniform across the villages in our sample, with the average increase in wells constructed per village that we observe, resulting from significant increases in number of wells in only a few of the villages.

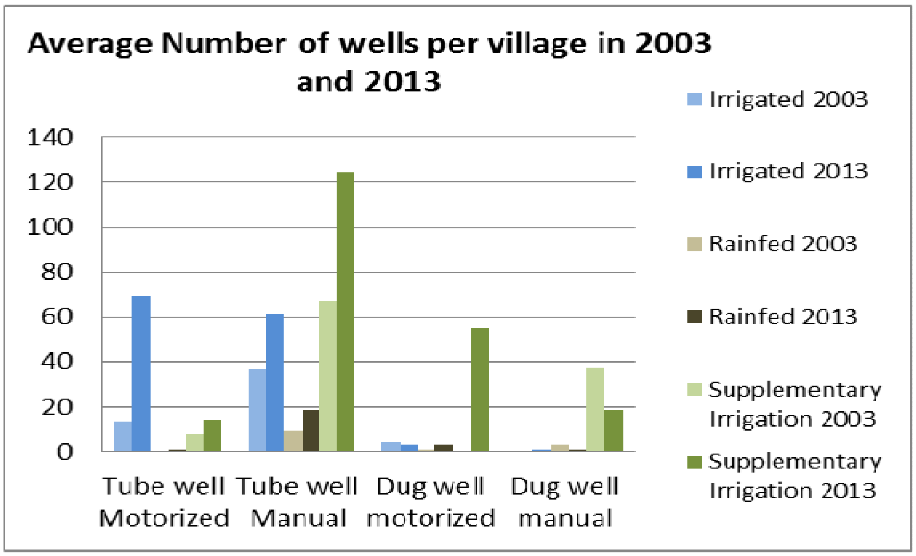

Figure 3.1. Average number of private well in village

The trend in access to groundwater per village is village-specific. The large increase of private motorized tube wells in irrigated villages reflect the large increase only in two irrigated villages (De Pa Yin Kwal and Sarr Taung in the Sagaing region) where the number of wells rose by more than 130 over the last 10 years. Currently, the irrigation system in De Pa Yin Kwal village is based exclusively on private motorized tube wells. A similar pattern in found for manual tube wells. For example, in De Pa Yin Kwal (Irrigated village) and the Daug Gyi and Kan Du Ma villages in the Sagain region (with supplementary irrigation), where between 2003 and 2013, the number of units increased up to 350. Similarly in certain villages with supplementary irrigation, the increase of number of tube and dug well is limited, with a maximum of 20 units during this period.

Diversity in development of groundwater uses between villages is great. Our limited sample shows a general trend with a higher number of motorized tubes well per households in irrigated village and villages with supplementary irrigation compared to rainfed villages. However, within these two categories a large variability can be observed. The following villages can be considered as villages with a significant increase of motorized tube well between 2003 and 2013 and a water supply strategy oriented toward groundwater exploitation. De Pa yin Kwal, Sarr Taung, Kone Thar and Kan Du Ma villages have in 2013 a percentage of motorized tube well per households higher than 10%. Another trend observed is

[10] The category 'public well' includes both government managed wells and wells managed by the community.

the conversion of manual dug wells into motorized wells in Kyauk Tan village (a supplementary irrigation village), where the number of wells increased by 400 units in the last 10 years, while we observe that the number hand lifted dug wells decreased during this time by 200 units.

> Key Observations on Groundwater trends
>
> - *Trends in groundwater exploitation are village specific, with large increases in some irrigated villages and villages with supplementary irrigation*
> - *Irrigated villages have invested more in private motorized tube wells, while villages with supplementary irrigation have increased their access to groundwater in the last 10 years, but mostly through hand lift wells which are primarily used for domestic purposes while their use in irrigation is of secondary importance.*
> - *Rainfed villages have a limited number of wells largely due to water quality issues.*

Groundwater associated constraints and benefits

Water quality Issues
One of the main issues associated with groundwater is the quality of the water which has implications not only for human consumption but also animal consumption and its use in irrigation. Water quality issues with high salt or iron content limit the uses to bathing and can sometimes be used for livestock. This issue is correlated with geological characteristic of the area and appears to be very specific and variable even at the highly localized scale, with wide variation within a single village territory such as in Ta Ein Tel village. Groundwater quality issue is found more frequently in rainfed villages than irrigated or villages with supplementary irrigation. In one village, water quality issues were found even with water from depths of up to 400 to 500 feet.

Furthermore, water quality issues may arise only some years after installation of tube wells. For example in the Nwar Kyoe Aing village, water quality issues occurred only three years after the installation of motorized tube wells, due to the lowering of the water table. Similar trend was observed in Thea Pyin Taw village.

Investment Cost
The second major problem related to groundwater access and use, is the investment required to establish the well (which was estimated to be approximately 0.15 million kyat to 2 million kyat[11]), in addition to the operation cost associated with pumping. Investment cost was described in all type of villages, with an increment of the cost in case of water quality issues, requiring deeper wells and higher operational cost.

[11] This important difference in investment cost is mostly due to the depth of the well.

Benefits
The major benefit accrued from the use of groundwater was time saving associated with water collection. Time saving enabled villagers to invest in other livelihood activities. Assured access to water was also a common answers mentioned, for both domestic use but also irrigation. Securing crops with supplementary irrigation is also mentioned as well as being independent to other village for water supply.

Benefit to support livelihood activities include, supplementary irrigation or for home gardening In addition, having an abundance of good quality groundwater enabled residents to sell this water to other villages, as mentioned in Kyauk Tan village. In another instance, in Tha Hpan Kone village groundwater was cited as beneficial in case of facing any fire hazard during the summer period when other sources of water were limited.

<u>Key constraints and benefits associated with Groundwater</u>

- *Access to groundwater can be constrained by different factors:*
  - *Water quality issues, with non-drinkable groundwater (salt and other mineral contaminants).*
  - *Investment required for establishing tube wells in addition to maintenance plus operational costs linked with pumping in the case of motorized tube wells.*
  - *Overexploitation in areas where the local demand exceeds the natural supply.*
- *Groundwater is used for supplementary irrigation in several villages, based on private motorized tube well.*
- *Use of groundwater for human consumption and irrigation depends on water quality.*
- *Access to groundwater saves time spent on water collection and allows engagement in other livelihood activities.*

With regard to water quality issues, according to our community survey, respondents did not in general perceive that the use of a common water source for both humans and livestock could lead to health issues, even in the case of open water sources such as ponds or a river. Only in one village, Kha Yu Kan, did respondents indicate that during the dry season when the water level was very low, a community pond had been contaminated by livestock. During this period the villagers, were compelled to travel to a neighboring village to collect water, with a cost of 500 Kyat per 50 gallons (10 Kyat per gallon). Fencing open water source was also described as a measure to limit contamination by livestock in period of water scarcity. In the case of groundwater in villages where open wells had been converted into a closed well system, improvement in water quality was perceived by community members. In addition, in our survey, respondents indicated that they used different containers to collect water for domestic use and for livestock watering and that therefore they had not experienced any water quality issues.

<u>Groundwater quality</u>

- *Having access to groundwater does not necessarily provide drinking water security.*
- *Correlation between water borne disease and livestock using similar open water source than human was not perceived by villagers.*
- *Some villages may take specific measure to limit pollution of the water source (fencing restricted access) especially during periods of water scarcity.*

4. Climatic Variations and Shocks

In this chapter we describe the main weather events that were experienced in our sample villages over the past 10 years (i.e., droughts, floods, shift in the monsoon season) and the impact these events/shocks had on the livelihood activities of different social groups (marginal farmers and landless) based on their own perceptions. We will also discuss the different coping strategies that were adopted by these different groups to deal with the impacts on their livelihoods.

4.1 Major weather hazards in last 10 years

In our village sample it appears that over the last 10 years the most frequent weather event reported was a dry spell occurring usually during the early part of the monsoon (around July). Dry spells were reported in 20 of the 24 villages in our sample (Table 4.1). Drought was less frequent, with only three villages affected in the last 10 years. Villages with access to irrigation described dry spells and drought as a shock confirming that even during the monsoon season, access and/or availability of water may be an issue in the Dry Zone. With regard to floods and severe floods, all categories of villages were affected. Cyclone Giri was also mentioned but only in two villages.

Table 4.1. Frequency of major weather hazard in the last 10 years

	IRRIGATED (N=5)	RAINFED (N=11)	SUPPLEMENTARY IRRIGATION (N=8)
Flood &Severe Flood	De Pa Yin Kwal – 2005 Aug. – 5 weeks	In Taw - August 2007 – 1 week Chaung Phyar – August 2010 – 1 week Taung Yinn - August 2006 – 7 weeks	Kyauk Tan – Oct. 2010 – 1 week Pa Kar – July 2011 – 1 week Daung Gyi – September 2010 – 2 weeks
Severe Rainfall &Cyclone Giri	Nwar Kyoe Aing: Oct 2010: 3 days	Kan Ma: Sept.2009: 3 weeks Thea Pyin Taw: Oct.2010: 1 day	
Drought Related Hazard: - **Drought** - **Dry Spell** - **Early end of Monsoon**	Ta Ein Tel : 2004 – May - 8 weeks (rainfed) Ta Ein Tel : 2012 – August - 8 weeks	Taung Yinn: Sept. 2012: 4 weeks Taung Yinn: May to August 2005 Pha Yar Gyi Kone July 2010 - 4 weeks Kyauk Sit Kan: June 2012 Pha Yar Gyi Kone : Sept. 2012- 24 weeks Chaung Phyar: July. 2012- 24 weeks Kha yu Kan: July 2012 – 9 weeks Let Tet: June 2012 – 12 weeks Taik Pwe: June 2012 – 12 weeks Bay yinn: 2012 June - 3 weeks	Kone Thar: 2008 – July - 16 weeks Yae Twin Kone -2003 and 2012 - 16 weeks Kyuak Tan: Sept. 2012– 28 weeks Tha Phan Kone: June 2012 – 2 months Kan Du Ma: May 2012 - 2 weeks Pa Kar: May 2012 2 weeks Ma Hti San Pya: June 2012 – 12 weeks Daung Gyi: June 2012 - 4 weeks
High temperature	Sarr Taung: April 2011: 8 weeks De Pa Yin Kwal: April 2010 – 5 weeks		

4.2 Definitions of weather hazards and type of impact

During our community survey, we obtained the views of respondents in terms of all the major weather hazards they had experienced over the last 10 years. They described these events and indicate how these impacted their major livelihood activities. An account of this is given below.

It was interesting to note that the weather hazards associated with drought, dry spells and temporal variability of the monsoon, described during the community survey, illustrated the key findings from Component 1 of our study (McCartney *et al.,* 2013) which revealed that there had been a significant reduction in rainfall amounts in June in recent years, combined with the very high variability in the onset date of the wet season, that is likely to impede agricultural production by increasing the risk of drought at the beginning of the rainfed crop cycle. In addition to drought related events, our community survey also highlighted some "wet" weather events, such as floods and cyclones

<u>Drought Related hazard</u>

<u>Drought</u>

A drought year was defined by farmers in Ta Ein Tel village as "a year with little rain during the monsoon" such as in 2004, when the monsoon was late (after May) and rainfall occurred only for a period of two months. Farmers could not cultivate rice paddy, wheat had a low yield and chick pea could not be harvested. All types of farmers were affected, and households were compelled to take loans with a 5%-10% interest rate, to invest in post monsoon (winter crop) or purchase seeds at credit. In some cases, land was sold and due to the lack of forage cattle had to be sold, especially in households owning more than two animals. Landless farmers described similar issues in terms of lack of access to forage areas for their livestock and no employment opportunities in the village due to absence of cultivation. Issues regarding access to drinking water were also mentioned by both landless and marginal farmers.

<u>Early retreat of monsoon</u>

In Taung Yinn village, respondents described the early end of the monsoon in September, at least four weeks prior to the usual end of the monsoon in late October. This affects mostly the winter crop (or post monsoon) crop due to the reduced water availability in the soil and high temperature. Lower production can lead to issues regarding repayment of the loan associated with the crop, and ultimately livestock or land has to be sold. For marginal farmers in rainfed villages, early end of the monsoon was related as an increase in farming cost due to increase in pest infestation, especially for groundnuts, leading to higher level of debts for farmers. In the meanwhile casual labour opportunities were less frequent and landless farmers are compelled to take out loans or migrate seasonally to find employment. According the findings from Component 1 of this study it was found that the onset of the wet season was more unpredictable than the retreat of the wet season and that within the Dry Zone, the monsoon period varies from 115 days to 175 days, with the shortest duration found in the central part of the Dry Zone.

<u>Dry spell and severe dry spell</u>

This climatic hazard (which is different than the end of the monsoon) occurs during the monsoon, with a period, usually around July without rain. This dry spell is normal, but can be detrimental if too long. Villagers differentiated between dry spell and severe dry spell according to the impact on crops and livelihoods. Sometime the distinction between dry spell and early end of the monsoon is not clear for farmers who sometimes consider the early retreat of the monsoon in August as a dry spell. According to McCartney et al., 2013, the drought period during the monsoon varies from 6 to 14 days, with longer drought in July and August, especially in the central part of the Dry Zone. The dry spell can affect various crops, differently depending on their cropping calendar.

In Kan Du Ma village, after the first two rains in 2012, rain stopped in May. Therefore crops needed to be delayed and there were crop losses in some case due to the lack of rain after sowing. Farmers invested in motorized tube wells to irrigate their crops (including rice paddy), and in addition, sold water to neighboring farmers (at 4,000 Kyats per hour). During a dry spell, access to domestic water can also be affected when groundwater resources are limited to shallow wells or rain water collection – such as in the case of Kha Ku Yan village. Domestic water and water for livestock was limited, and livestock faced high mortality in July 2012 according to villagers. However we were unable to gather further information to determine the reasons behind this.

Flood and Severe flood

Floods usually affect the main crop, i.e., the monsoon crops. Depending on the intensity of the flood all crops (both in dry land and lowland) can be damaged resulting in food insecurity and financial problems in the household. Villagers differentiate flood from severe flood, by the intensity an duration. In general severe flood has a higher intensity and /or a longer period (5-7 weeks) where the land is submerged. In Taung yinn, the land was submerged for a period of up to seven weeks during the monsoon season and farmers could not cultivate during the monsoon period. It affected especially the marginal farmers with limited access to other type of land. Landless farmers had to seek casual labour outside of the village.

Cyclone Giri

In Kan Ma village the cyclone damaged crops and placed at risk the main harvest of farmers in a village based on rainfed agriculture. Casual workers did not find any activity locally and needed to migrate. Farmers sold their assets or obtained loans to provide resources for their households. In addition, livestock was affected, especially goats. In Thea Pyin Taw village, the second monsoon crop was severely damaged by Cyclone Giri specially ground nuts, both in the field and in post- harvest drying process. It affected also the supply of forages for livestock. Households migrated to cities (Mandalay, Yangon) to find casual labour.

4.3 Frequency of weather events

Based on the recall of participants, we recorded the frequency of major weather events[12] that had occurred over the last 10 years in our sample villages. With respect to irrigated villages, only one village (Ohn Hne Chaung) did not record a major weather hazard in the last 10 years, while four villages recorded at least one event and five villages recorded two events, including events related to access to water such as dry spell or drought (Figure 4.1). In terms of the rainfed villages it was noted that the frequency of events is higher, with more villages recording one weather hazard (mostly severe dry spell), and three villages reporting over two climatic events in the last 10 years.

[12] We defined a major weather event as an event that is significantly different to one in an average year and that is re-called by the community members as remarkable and used as a milestone by community members to elaborate the village's timeline over the last 10 years.

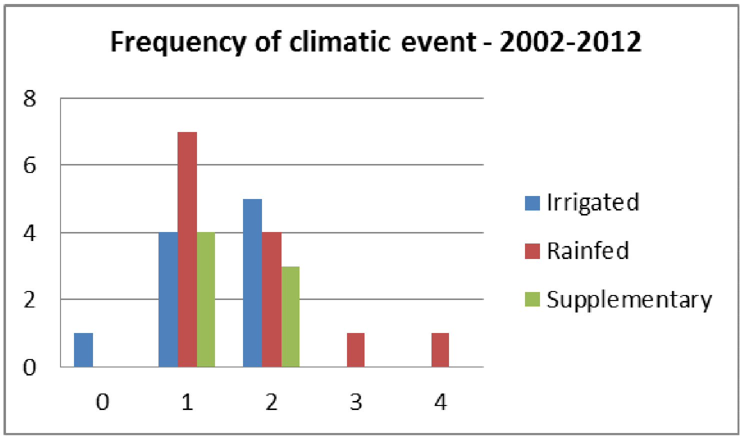

Figure 4.1. Frequency of weather hazard in rainfed (n=11), village with supplementary irrigation (n=7) and irrigated villages (n=5). One village with extreme value was removed from the sample.

4.4 Weather hazards and income portfolios

<u>Average income distribution within different groups</u>

In the case of marginal farmers, irrigated agriculture accounts for 32.5% of their income in irrigated areas, while this percentage drops to 12.5 % in villages with supplementary irrigation and accounts for only 2.5% in rainfed villages, where few acres or homestead garden can be irrigated. For landless farmers, agriculture income is null. However, the household income proportion derived from casual labour in the local agriculture sector is relatively high, with an income share between 38% to 58% for labour within the village and 15% to 22% for casual labor outside the village implying seasonal migration. These results are in line with the findings from other studies where it states "In the Dry Zone, the most common primary livelihoods are farming and casual labor" (QSEM, 2012, pg. 7).

Interestingly, livestock represent a higher share of income in the case of landless than marginal farmers in all three types of villages in our sample. In a good year, livestock accounts for approximately 10% to 14% of the household's income in the case of landless and only 5% to 12% in the case of marginal farmers. In irrigated villages, livestock have a highest share in the income portfolio than in other type of villages. However, in 9 villages within rainfed and supplementary irrigation categories, livestock do not count as a source of income for marginal farmers and livestock can be seen instead as an asset for investment and an asset for agriculture production.

With regard to salaried employment or remittances, there is no significant difference between type of villages and marginal and landless farmers. Landless farmers, appear to have a larger proportion of their income coming from 'other sources' of income such as petty trade (selling fish or tamarind) or handicraft making/selling (Figure 4.2).

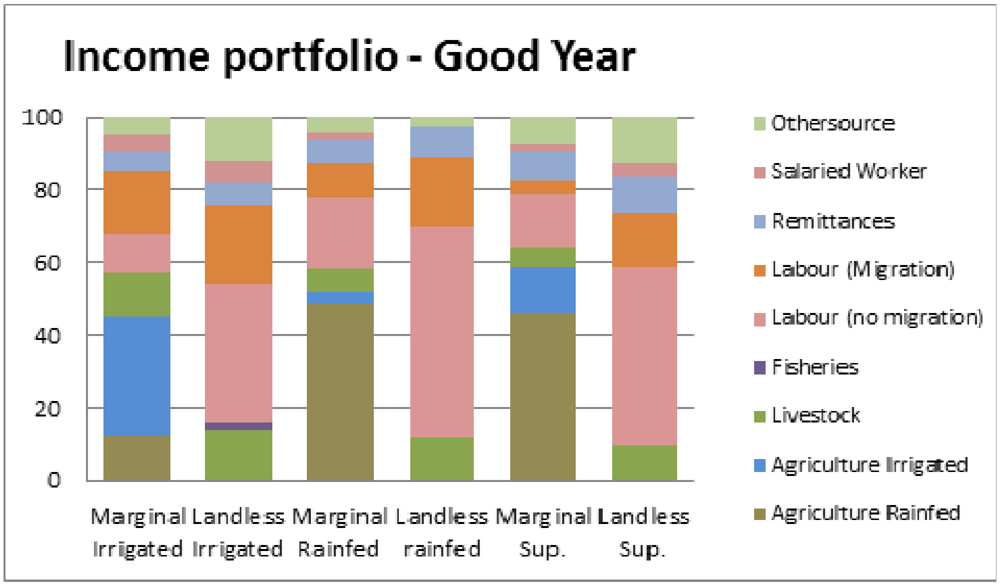

Figure 4.2. Income repartition during a good year for marginal and landless farmers in irrigated, rainfed and villages with supplementary irrigation

Key points related to income portfolios of the marginal and landless in a good year

- *For marginal farmers irrigated agriculture makes up the largest proportion on their income portfolio in irrigated areas.*
- *For the landless income proportion derived from casual labor in the agriculture sector is the largest in all three types of villages.*
- *Livestock represents a higher share of income in the case of landless than marginal farmers in all three types of villages.*

The relative proportions by which different livelihood incomes contribute to the overall income portfolio of a household changes in the case of both marginal and landless farmers in all three village types, depending on the different climatic conditions and weather hazards experienced. In our study the absolute value is an estimation based on the percentage of the total income of an average household of five members (Kyat per household per year).

For example in rainfed villages, the absolute income obtained from agriculture in a good year is much higher than in a year that a dry spell is experienced, where the latter could lead to a decrease in income from agriculture or no income obtained from agriculture that year. This was the case reported in Kha Yu Kan village, where during a good year the absolute income from agriculture is estimated as 600,000 Kyat per household per year, whereas when a dry spell was experienced there was apparently no income obtained from this livelihood activity. In another village Bay Yinn the absolute income in a good year from agriculture was reported as 1,050,000 Kyat per household per year and this decreased to only 210,000 Khat per household per year during a year that experienced a dry spell.

Table 4.2. Examples of rainfed villages illustrating how absolute income from rainfed agriculture changes between a good year and year with a weather hazard (dry spell)

RAINFED VILLAGES	AGRICULTURE RAINFED GOOD YEAR (KYAT/YEAR/ HH)	AGRICULTURE RAINFED DRYSPELL (KYAT/YEAR/ HH)	DROP IN INCOME (% COMPARE TO A GOOD YEAR)
Kha Yu Kan	600,000	0	100%
Taik Pwe	328,000	40,000	88%
Bay Yinn	1,050,000	210,000	80%
Thea Pyin Taw	360,000	0	100%

Where there is access to irrigation, only rainfed crops are affected by dry spells, reducing the income from rainfed crops. For example in Ta In Tel village after a severe dry spell of 8 weeks in August 2012 the income from rainfed crops decreased by 65%.

To cope with a weather hazard, households may have to engage in alternate livelihood activities, and this may also change the absolute incomes derived per year from a particular activity for both marginal and landless farmers. For instance in rainfed villages, in a good year, both marginal and landless farmers tend not to migrate and seek casual labour associated with the agricultural sector outside their village but they do so if they face a dry spell. For example, in Kha Yu Kan village during a good year no out-migration for agriculture related casual labor was recorded but in a year that experienced a dry spell, marginal farmers were estimated to earn 180,000 Kyat per household per year from casual agricultural labour outside their village and landless 80,000 Kyat per household per year (see Table 4.3). In line with earlier results, during a good year, the landless earned a bigger share of their income from casual agricultural labor within the village than marginal farmers did (300,000 Kyat per household per year for the landless compared to 100,000 Kyat per household per year for the marginal farmers). Similar trends were observed in other rainfed villages. Similar examples are found Ma Hti San Pya village, where villagers estimated that the proportion of income derived from casual agriculture related labor within the village dropped by 72% and 75% respectively for marginal and landless farmers in a year affected by dry spell compare to a good year.

Table 4.3. Example of a rainfed village illustrating how absolute income from casual labor both within the village and out-migration changes between a good year and year with a weather hazard (dry spell)

RAINFED VILLAGE	CASUAL LABOUR WITH MIGRATION GOOD YEAR (KYAT/YEAR/ HH)	CASUAL LABOUR WITH MIGRATION DRY SPELL (KYAT/YEAR/ HH)	CASUAL LABOUR WITHOUT MIGRATION GOOD YEAR (KYAT/YEAR/ HH)	CASUAL LABOUR WITHOUT MIGRATION DRY SPELL (KYAT/YEAR/ HH)
Kha Yu Kan				
Marginal	-	180,000	100,000	-
Landless	-	80,000	300,000	20,000

When floods affected De Pa Yin Kwal village, resulting in a decrease in income from rainfed crop and irrigated crops, of approximately 40%, and 60% respectively, marginal farmers compensate their income loss by adopting coping strategies such as selling livestock (+20% compare to a good year), while for landless farmer loss due to less casual labour opportunities at the village level (minus 50%) are compensate by migration (+20%).

During a drought or dry spell as livestock may have to be sold, the absolute income level could decrease, especially in the case of the landless (Table 4.4). For example in Taik Pwe village for the landless the absolute income derived from livestock decreased from 124,000 Kyats per household per year in a good year to 90,000 Kyats per household per year in a year that experienced a drought/dry spell. In addition, casual labor related to livestock is also reduced in period of dry spell, with less job opportunities for landless farmers in that sector.

Table 4.4. Example of rainfed villages illustrating how absolute income from livestock changes between a good year and year with a weather hazard (dry spell)

RAINFED VILLAGE	LIVESTOCK_GOODYEAR (KYAT/YEAR/ HH)	LIVESTOCK DRYSPELL (KYAT/YEAR/ HH)
Taik Pwe		
Marginal	82,000	80,000
Landless	124,000	90,000

With regard to less job opportunities being available at the village level, the landless farmers are the first group affected, as marginal farmers work in their own farm land, before contracting the landless as casual labor. Therefore landless are the first to seek employment outside the village. In Ta Ein Tel and Sarr Taung, the income from casual labour outside of the village increased by 16% and 33% respectively in a year with a dry spell.

<u>Weather hazards and income portfolios</u>

- *Villages with access to irrigation are less prone to drought related climate hazards but not exempt, especially in the case of supplementary irrigation.*
- *In our sample, dry spells within the monsoon were reported the most frequently.*
- *Income of landless farmers in all type of villages are highly dependent on casual labour in agriculture at the village level*
- *In years with climate events, landless farmers are affected by the loss of job opportunities in agriculture but also in the livestock sector at the village, thus triggering migrations.*
- *Irrigated villages are less vulnerable to climate shocks compared to village with supplementary irrigation and rainfed villages.*
- *Floods affect all types of villages and can seriously affect irrigated lowlands.*
- *Selling livestock is one coping strategy to obtain cash to cope with income shocks.*

5. Water Access, Availability and Management in terms of Agriculture, Livestock and Domestic Use

The following section looks at the use of water for agriculture, livestock and domestic purposes. We briefly describe the cropping calendar and impact of irrigation as well as farmer decision making regarding rainfall and crop types. There are three main cropping seasons: one monsoon crop from June to October, followed by a winter crop until January which can be based on residual soil moisture and a summer crop (February to May) that requires to be irrigated. The cropping calendar varies according to village and region and access to irrigation all year around allows for three crops per years, while rainfed village are limited to one or two crops per year. Besides rice paddy, agriculture in the Dry Zone includes oils seeds (groundnut, sunflower) pulses (sesame,) and beans in monoculture or intercropping. Cropping calendar and planting date is dependent on rainfall pattern and intensity. Farmer's decision to cultivate a crop also depends on rainfall and crop requirement.

We found that **rainfed agriculture** is a major source of income for marginal farmers in rainfed villages, and indirectly a major source of income for landless farmers hired as casual labor. Similar indirect benefit for landless farmers was found in the case of irrigated agriculture. Irrigation is mostly based on surface water irrigation, groundwater irrigation is found in several villages but cost of renting equipment and pumping cost are limiting the access to irrigation for marginal farmers. Use of groundwater for irrigation is found either for small scale horticulture, with a high return and generally implemented by wealthier households. However, rapid assessment of cost and benefit of groundwater irrigation (see Section 6.1.2) found that groundwater use for irrigation is highly profitable and can generate income for farmers while create job opportunities for landless farmers.

Livestock ownership is limited for both marginal and landless farmers. Groundwater was found as an important source of watering livestock in all villages. Meanwhile, the distance to the water source for livestock is longer in the case of public sources such as public ponds or wells, and in the case of rainfed villages it may take up to 30 minutes. During drought periods, villagers adopt the coping strategy of i) accessing another water source for watering their livestock or ii) taking the livestock to a neighboring village.

Regarding **domestic water use**, we found that in rainfed villages rainwater tanks and community ponds are used more in the rainy season, while public wells are used more in the dry season. This seasonal variation does not appear in irrigated villages. Distance to the main water source is longer in rainfed villages compared to irrigated villages. This difference increases in the dry season and in periods of water shortage with more time allocated to fetch water in rainfed villages.

In the case of water pricing, with a higher price being charged at the end of the dry season and prices found to be higher if the water was purchased from another village and included delivery. Landless farmers usually have less time to fetch water and therefore may have to purchase water. In a good year, the volume collected was recorded to be higher in the dry season, when water consumption is more important and rain water collection is not possible. During a drought period, water collection is reduced, with the higher difference in the case of marginal farmers in irrigated villages, where water collection drops from 100 gallons per day to an average of 68 gallons per day (32% drop). We also found that access to groundwater was perceived as one of the main positive changes for access to domestic water, reducing water collection time for villagers and improving water quality especially compared to other water sources. This last improvement was observed only in villages without groundwater quality issues.

5.1 Agriculture

Cropping calendar

The cropping pattern varies across regions and rainfall pattern, soil types, and access to irrigation which define different type of agro-ecological zones. We simplify the agro-ecological zones into 3 main categories, according to the type of land (*le, ya* and *Kaing –Kyung*) and the access to irrigation (JICA 2010). These zones include i) intensively farmed croplands (*le*) with access to irrigation all seasons; ii) croplands (*le*) with access to supplementary irrigation and river beds (*Kaing-kyung* lands), iii) rainfed crops lands which include both *le* and *ya* (dry land) lands and extensive rainfed upland agriculture.

Three main cropping season are distinguished: summer crop (dry season); monsoon crop and post monsoon crop (or winter crop).

Le land, flat terraces with heavy soil, is suitable for paddy cultivation in the wet season, from July to October followed by a second crops (pulses or oil seeds) during the winter crop (ground nuts, chick pea, sunflower) from November up to January, based on residual moisture, with or without supplementary irrigation (Figure 5.3).

With access to irrigation, the cropping calendar include summer crop of paddy, fully irrigated from mid-February to May. In some case a first irrigated crop can include a short term crop such as green gram or green pea (60 days) from early March –April to mid-May and June and followed by a monsoon rainfed crop, such as paddy until October and November.

Low land (le) with supplementary irrigation, includes a similar cropping calendar, but without summer crops. In comparison with a rainfed system, lowland with supplementary irrigation is less risky concerning dry spell and drought during the winter crop. Thus include a winter crop is more often found.

River beds are a specific agro-ecosystem and are cultivated only in the dry season, when the land is exposed. The irrigation source is either from a temporary hand dug well, or water collected directly from the river. This land is cultivated from December/January until the first rain, for horticulture production such as onion or water melon. In various cases, the last crop at the end of the dry season can be lost due to early rainfall and associated flood.

In rainfed systems on *le* and *ya* lands, land preparation occurs from February to May, with a start of the monsoon crop by mid-May -June, when soil moisture is considered sufficient (6 inches or 1 foot deep). Pulses (green gram, chick pea), oils seeds (sunflower) are cultivated until August-September and second crop can follow based on residual moisture, such as ground nuts, chick pea or cotton. Monsoon paddy starts usually later from transplanted in July until October to November. In some case only a single crop is cultivated on ya land – such as pulse or oilseeds like groundnut.

Another combination includes an early monsoon crop, like sesame (from mid-April to mid-July) followed by a second crop base on residual moisture, such as groundnut, maize or butter beans. Pigeon pea, cultivated in inter-cropping with sesame or cotton, has a longer cultivation period (225 days) is cultivated from mid-May until early January.

A similar cropping pattern is found in extensive rainfed agriculture, with mostly a single monsoon crop, from June/July to October.

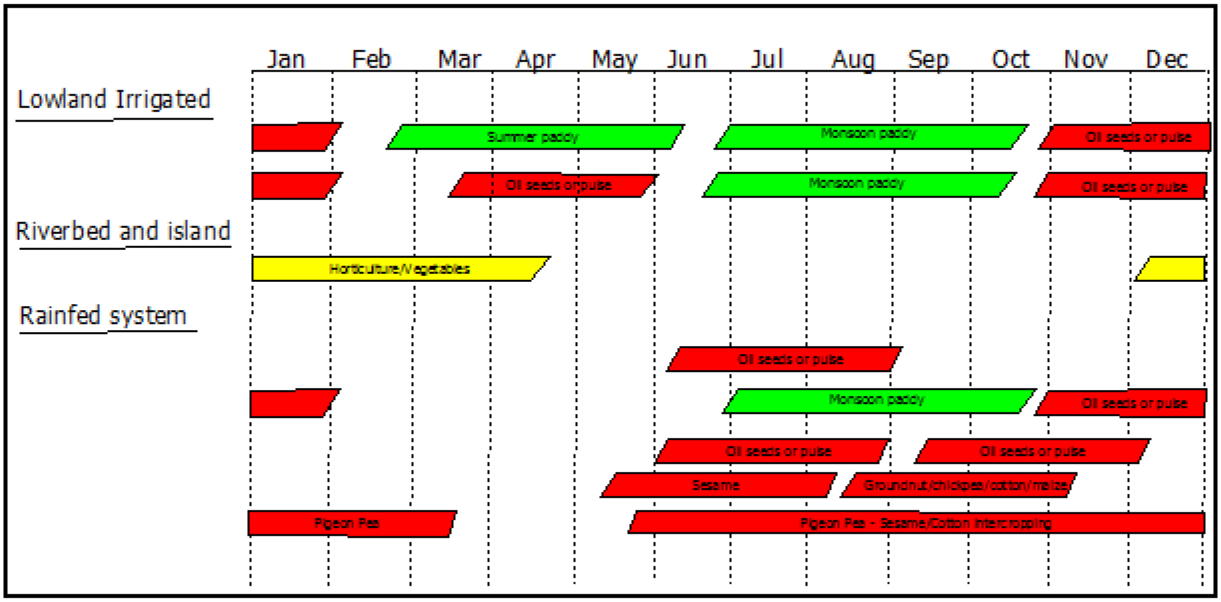

Figure 5.3. Examples of cropping calendar in the Dry Zone

Cropping calendar and decision making for planting crops is adaptable and varies every year. According to the marginal farmers, sesame and ground nut are mostly planted in May, as well as pigeon pea and green gram. Rice cultivation is spread from June to August, but large inter-annual variation in the planting date, from 2 to 12 weeks, while for other main crops like sesame or groundnut the variation in planting date is less frequent (less than 3 weeks difference in more than 60% and 80% of the villages surveyed for groundnut and sesame respectively). A dry spell in July, within the rainy season in July can have significant impact on pulses and oil seeds, taking into consideration planting dates in May and June and high vulnerability during the early step of the crop flowering and grain formation. This critical period in July also coincides with rice transplantation and could affect rainfed rice.

5.1.1. Irrigated Agriculture

In our community survey, marginal farmers from 10 villages (with irrigation all year around and supplementary irrigation) mentioned the cultivation of irrigated crops. The number of irrigated crops varies from one and more rarely two or three crops in rotation. The number of villages in our sample using groundwater for irrigation is limited (only four villages). Groundwater was used to cultivate oilseeds, pulses, wheat, and in one case, betel leaf. A specific village, De Pa Yin Kwal, irrigate 1,500 acre with groundwater, for pulses, oil seeds and wheat production.

Table 5.1. Irrigated crops type and source of irrigation

CROPS	NUMBER OF VILLAGES	SEASON AND WATER SOURCE
Oilseeds	6 villages	Pre-monsoon : Irrigation scheme (1) and motorized Tube well (2) Monsoon crop: motorized tube well (1) Post monsoon or winter crop: Irrigation scheme (2)
Pulses	4 villages	Pre-monsoon: Irrigation scheme (2) and motorized Tube well (2)
Rice	5 villages	Pre-monsoon crop: Irrigation scheme (1); Pumping canal – individual (1) Monsoon crop: Irrigation scheme (3);
Vegetables	1 village	Pre-monsoon: Manual Tube well (1)
Wheat or betel leaf	3 villages	Pre-monsoon: Motorized tube well

In general, marginal farmers do not hire out pumping equipment or irrigation rights to other farmers. but few cases were mentioned in Yae Twin Kone village, where marginal farmers indicated that they generally borrow equipment for pumping water in case of a dry spell during the monsoon crop. In Kan Du Ma village, marginal farmers cultivating betel leaf during the summer period can have access to irrigation from irrigated paddy fields for 4,000 Kyat per hour (including fuel charges). Overall, for marginal farmers, additional fees and pumping costs are a constraint to accessing irrigation water.

A rapid economic assessment of groundwater cost and return with seven farmers showed that the investment cost for motorized tube well was varied and between 0.11M to 1.36M Kyat and a pumping cost per acre and per crop averaging around 12,000 Kyat per acres, but with large variation between monsoon crop supplementary irrigation and summer crop irrigation. More details about groundwater opportunity and constraint are found in the next section.

<u>Key points on irrigated agriculture</u>

- *Marginal farmers are usually required to borrow or rent pumping equipment for irrigated agriculture.*
- *The water fee and rights associated with irrigation are variable according to villages.*
- *For marginal farmers, additional fees and pumping costs are a constraint to accessing irrigation water.*
- *In our sample, the number of villages using groundwater for irrigation is limited. Groundwater was used to cultivate oilseeds, pulses, wheat, and in one case, betel leaf.*

5.1.2 Opportunities and constraints of Groundwater Irrigation

Interviews were held with seven well owners during our community survey to determine the opportunities and constraints of groundwater irrigation in the Dry Zone. Six of the seven owned tube wells and only one owned a dug well. The wells were almost entirely self-funded, and only one of the owners received the support of a government subsidy to establish the groundwater irrigation infrastructure. Motorized pumps were used in each case with no reported cases of using manual lift methods. Pumps predominantly used diesel fuel with capacities ranging from 3 to 18 HP. The wells ranged in depth from 9 to 200 feet with a mean of 83.9 ft. The depth to standing water level in the wells ranged from 5 ft to 30 ft with an average of 18 ft during the monsoon, and in the summer the range was from 12 ft to 30 ft with an average of 21.5 ft. Pumping rates varied from 1020 to 4500 gallons per hour (gph) with and mean value of 2800 gph. The quality of the groundwater was described as being 'good' in all cases. According to the average days of pumping, the pumps are used most heavily and in 100% of cases during the wet season, whereas for 86% of cases in the winter and only 43% in the summer. The reduction in use over the course of the dry season would reflect the diminished water availability and water demand. In the wet season rice is most commonly grown whereas in the winter chickpea is most commonly grown (Table 5.2).

Table 5.2 Farming systems of the well-owner farmers

NO.	TOTAL FARM SIZE (ACRE)	TOTAL IRRIGATED AREA (ACRE)	NO OF CROPS/YEAR	WET SEASON CROP	WINTER CROP	SUMMER CROP	MONTHS OF CROPPING/YR	DAYS OF WET SEASON PUMPING/YR	DAYS OF WINTER PUMPING/YR	DAYS OF SUMMER PUMPING/YR
1	8	4	1	Rice	-	-	5	6	0	0
2	0.5	0.5	1	-	-	Ridged gourd	5	70	12	45
3	7	3	2	Rice	Chick pea	-	7	7	9	9
4	2.5	2.5	2	Rice	Chick pea	-	9	24	8	0
5	2.5	2.5	1	Betel leave	-	-	3	8	8	12
6	37	37	2	Ground nut	Chick pea	-	9	30	15	0
7	5.5	5.5	1	Rice	Wheat	-	8	6	16	0

Investment costs

The investment costs needed to construct the well and purchase the water pumps and distribution pipe varies by a factor of 12 across the cases surveyed, with value ranging from 0.11M to 1.36M kyat (Table 5.3). This large cost variation reflects the range of conditions encountered and the configurations of well type and depth and pumping capacity. On average, this investment is allocated as follows: drilling (31%), motor pump (49%) and provision of water pipe (20%).

Not surprisingly, the drilling costs, which account for almost one-third of the setup cost, are strongly correlated with the total drilled depth (R^2 = 0.65). Perhaps more surprising, the total setup costs are almost as strongly correlated with the drilling depth (R^2 = 0.58). Of the three components, drilling costs are most skewed by factor of 100 due to diverse range of hydrogeological conditions and the associated modes of installation. Substantial variations are also reported for pump costs (by a factor of 22) and for distribution pipes (by 43).

Thus savings in pump purchase costs would represent the single biggest opportunity to bring down the total investment costs. Higher upfront costs may need to be traded-off against higher maintenance and opportunity costs. Motor pumps are a relatively expensive investment for farmers (given the size of the typical household budget), but are highly valued due their high efficiency in lifting water.

Table 5.3. Farmer-wise costs to setup groundwater infrastructure

NO.	WELL TYPE	YEAR BUILT	TOTAL DEPTH (FT)	DRILLING COST (KYAT)	PUMP COST (KYAT)	PIPE COST (KYAT)	TOTAL SETUP COST (KYAT)
1	Tube	1997	60	80,000	460,000	118,000	658,000
2	Dug	2011	9	5,000	130,000	2,000	155,000
3	Tube	2008	55	300,000	250,000	600,000	1,150,000
4	Tube	1998	53	61,000	37,000	14,000	112,000
5	Tube	2009	90	465,000	443,500	85,000	993,500
6	Tube	2000	120	318,000	600,000	250,000	1,168,000
7	Tube	1997	200	500,000	800,000	55,000	1,355,000

Financial revenue and returns

Farm incomes and agricultural expenditures are highly variable on a crop-wise basis, even for farmers growing the same crop. In the wet season potential revenues range from -119,000 Kyat/acre for rice through to +237,000 Kyat/acre also for rice. In the dry seasons potential revenues were consistently positive and range from a low 9,000 Kyat/acre for chickpea through to 104,000 Kyat/acre for wheat in the winter and 796,000 Kyat/acre for ridge gourd. This reaffirms that irrigation is most profitable, on a per unit area basis, for those who can diversify into high valued cash crops. Net annual potential revenues range from -172,000 to +578,000 Kyat for the 7 cases in 2011-12. The area of land that can be irrigated under cash cropping is low compared to paddy due to the high labour requirement which needs to be considered in terms of household incomes. The input costs, on a seasonal basis can be partitioned as follows: additional labour (44%), pumping (24%), fertilizer (21%), pesticides and herbicides (11%).

The highest reported seasonal income comes from the dug well irrigating betel leaf, suggesting that the link between the type of water source and incomes is poor. Deeper tubewells are less prone to seasonal drying-out and thus can provide more reliable supplies. The high variability in profitability, and particularly the losses incurred in the wet season by some those farmers growing paddy can be attributed to the very dry year in 2012. A late start to monsoonal rains and the high water demand of the crop necessitated significantly more pumping than anticipated.

Payback time on investments

Comparing the investment costs along with net potential revenues reported earlier, enables an estimate of the payback time on original investment to be derived. This shows that for 4 of the cases packback anywhere from <1 year up to 8 years are required by farmers to generate the income to recoup the upfront investment. If maintenance costs are accounted for, then the average payback time is increased to a range of <1 to 17 years. These periods neglect the interest rate component that would need to be factored in if funds were sourced from lending institutions. In 3 of the cases negative net revenues precluded the calculation of a payback time.

Casual labour

Our data suggests that irrigation, even with motorized pumps, is still a labour intensive practice, with the cost of additional labor typically representing the highest single input cost. The survey results point to reasonably strong linkages and inter-dependencies between the land owning groundwater irrigators and the landless. In five of the seven cases, the landless play an important role in terms of casual labour, and only two cases where there was no requirement for casual labour. The tasks of those employed included the laying out of the pipe in the fields, running the engine, checking crop water needs and general supervision. In addition, those employed as casual labourers have access to their domestic water in all cases which offers an additional indirect benefit.

Informal water trading

In six of the seven cases there were reports of well owners providing water to approximately 2 to 30 other farmers. Thus informal water trading would appear to be commonly practiced. The net annual income generated from this practice has not been taken into account in the analysis. In 2 cases there is sharing of costs by the recipient farmers. Whilst small-scale groundwater irrigation is largely an individually owned practice, across the DZ its operation appears to often involve small collectives of local farmers cooperating together for mutual benefit.

Major challenges and constraints

The single greatest challenge reported by the well owning farmers concerning their GWI systems was largely related to the high fuel costs in general, and especially during the dry spells when groundwater levels were depressed and greater lift was needed (4 of the 7cases). In some instances this limited the area that could be irrigated. Mechanical problems or associated costs was either perceived as a problem (1 case) or simply reported but not considered problematic (1 case). Only one case reported no issues. Interestingly, access to capital to purchase inputs, maintain equipment or for system improvements was not reported to be the major issue by the well owners.

<u>Key points in relation to Groundwater Investments for Agriculture</u>

- *Irrigation with groundwater can be an important means for farmers to help improve their livelihoods, particularly during the dry season months. This is improved when high valued crops are grown (sometimes in addition to staple food crops such as rice), and household level cash flows are sufficient to meet the basic input needs.*
- *The total investment cost needed to establish groundwater irrigation is highly conditional upon the local conditions and can vary by an order of magnitude. Thus knowledge of the hydrogeological conditions are paramount to effective planning and to minimize poor investments.*
- *Job opportunities for landless workers in irrigation management emerge in around 70% of cases, along with more convenient access to domestic water supplies.*
- *The well owners have stressed the major issue affecting their use of motorized pumps is in relation to the high cost of fuel, and to a lesser extent to maintenance-related costs.*
- *Water from the wells is commonly used for domestic and livestock purposes. Therefore when making plans for irrigation or considering irrigation expansion one needs to consider the implications on these sectors along with the general sustainability of the technology.*

5.2 Livestock

In this section of our report for presenting the results from our community survey on livestock and water related issues, we have merged rainfed villages and villages with supplementary irrigation to present as a single group. This is as a result of the sources of water for livestock watering being similar between these two categories of villages. Thus the results are presented broadly focusing on two groups - rainfed and irrigated villages.

5.2.1 Type of livestock and water source and availability

In our sample, in both rainfed and irrigated villages, marginal farmers had a limited number of livestock per household and landless farmers even lower (own cattle, sheep and goats less frequently than marginal farmers and the average number of animals per household is also lower). For marginal farmers, each household owns approximately one or two cattle in over 80% of the villages in our sample (Table 5.4). The presence of other type of livestock such as goat, sheep and pigs is more specific to the villages and no real trends can be highlighted. The average number of animals per household is not significantly different between rainfed and irrigated villages.

Table 5.4. Frequency of presence of livestock and average number of animal per household in irrigated and rainfed villages

	IRRIGATED VILLAGES (N=5)		**RAINFED VILLAGES AND VILLAGES WITH SUPPLEMENTARY IRRIGATION (N=19)**	
	Marginal farmer	Landless	Marginal farmer	Landless
Frequency/Average number of Cattle per HH	80% -1.75	20% - 0.5	89% -1.8	22% - 1
Frequency/Average number of Goat per HH	40% - 1.5	20% - 2	26% - 1.6	11% -1
Frequency/Average number of Sheep per HH	20%- 1	0%	10% - 1.5	0%
Frequency/Average number of Pigs per HH	0%	20%- 2	57% - 1	55% - 1.1
Frequency/Average number of Poultry per HH	80% - 2.2	60% - 2	100% - 7	94% - 5.5

The main sources of watering for cattle, goat and sheep in irrigated villages are rivers and wells (both private and public in the case of landless while only private for the marginal). In the case of rainfed villages the main sources of water are public ponds, public wells and private wells for both marginal and landless farmers. Groundwater is therefore an important source of watering livestock in both irrigated and rainfed villages (Table 5.5).

The distance to the water source for livestock is longer in the case of public sources such as public ponds or wells, and in the case of rainfed villages it may take up to 30 minutes, while for private wells, this would take less time. In Irrigated villages, in the case of access to a river, this is recorded to be on average 15 minutes. Once again for private wells, the distance and time factor involved are much less.

A shortage of water for livestock is, as expected, more frequent and longer in rainfed villages than in irrigated villages. Rainfed village using public ponds are more vulnerable to drought. In several cases, a drought of 8 to 24 weeks could occur during the dry season, where this primary source of water is not available to livestock. Usually during such drought periods, villagers adopt the coping strategy of accessing another water source for watering their livestock. For example in the Yae Twin Kone village, other groundwater sources within the village are used as an alternate source of watering. Another strategy is to take the livestock to a neighboring village. This is what is adopted in Kha Yu Kan village, where the public pond usually dries up from March to May. These strategies are for cattle, goats and sheep, while water shortage is less problematic for pigs and poultry, requiring less quantity of water.

Table 5.5. Source of water, distance and period of drought for livestock in rainfed and irrigated villages

	IRRIGATED VILLAGES (5 VILLAGES)		**RAINFED VILLAGES AND VILLAGES WITH SUPPLEMENTARY IRRIGATION (19 VILLAGES)**	
	Marginal farmer	Landless	Marginal farmer	Landless
Source of Water	2nd River 1st Private well	1st River 1st Private well 2nd Public well	1st-Private well 3rd-Public pond 2nd-Public well	1st-Private well 2nd-Public pond 2nd-Public well
Average Distance (min)	River: 15 Private well : 4	River: 15 Private well: 4 Public well: 15	Public pond: 26 Public well: 17 Private well: 5	Public pond :35 Public well: 21 Private well: 5
Water shortage period and duration (weeks)	River in May – 2 weeks	River in May – 2 weeks	Public pond : March to June and Feb to May	Public pond : March to June and Feb to May

For households with access to private wells, in 95% of the cases water is usually collected from their private wells for their animals (cattle, sheep and goat). This proportion is more spread in the case of ponds and public wells where animal can be brought to the source of water, especially for public pond.

With respect to pigs and poultry, in more than 85% of the cases the animals remain in the household and water is brought to them from different sources (river or wells). In other cases, the water is both brought to the households or the animal walked to the source.

In our sample, in 81% of the cases, livestock are sharing the same source as for domestic uses. This proportion is reduced to 66% when we consider only animals that are brought to the water source and concerns only 16% of the case for river and public ponds (which may be an issue for public health and contamination by animal faeces

- *Both marginal and landless farmers have small herds.*
- *Groundwater is an important source of watering livestock in both irrigated and rainfed villages.*
- *The distance to the water source for livestock is longer in the case of public sources of water.*
- *In drought period villagers are looking for alternate water source for their livestock or organize the migration of the herd to another village.*

5.3 Domestic use

For presenting the results from our community survey on domestic water use, we have merged rainfed villages and villages with supplementary irrigation to present as a single group. This is as a result of the sources of water for domestic use not differing widely between these two categories of villages. Thus the results are presented broadly focusing on two groups - rainfed and irrigated villages.

Sources of domestic water and distance

In our study, under domestic uses of water we include drinking water, water used for bathing, cooking and watering livestock within the household.

In our sample villages, overall, similar sources of water are used for drinking purposes in both the rainy and dry seasons (Table 5.6). In rainfed villages, landless and marginal farmers have similar sources of drinking water. The only difference between seasons occurs in the rainy season for some villages, where villagers use rain water tanks and community ponds, while in dry season public wells are used. In irrigated villages, there appears to be no variation in the sources of water used for drinking purposes between marginal and landless farmers and also between seasons. In these villages, the proportion using river water in both the dry and rainy season is high, however it must be noted that our sample is small and includes only five villages.

It is interesting to note that rain water harvesting tanks were not considered an important source of drinking water in our sample. Only one village ranks it as the main source of water in rainy season, while this village does not have groundwater quality issues. In villages with major groundwater quality issues, for example, Taung Yinn and Kha Yu Khan (rainfed villages) and Sarr Taung (Irrigated village), they use mostly ponds, dams[13] and river as their key sources of water for drinking purposes and covered wells for other domestic water uses. In some cases, the water quality issues concern only one part of the village territory and therefore groundwater can be still used for drinking purposes.

[13] Ponds are defined as natural or man-made reservoirs, located in lowlands and filled by run-off water. Dams are man-made structures that block the water run off to create a reservoir. Rainwater harvesting tanks are built structures usually connected to a rooftop and gutter to collect rainwater in concrete tanks. This type of structure can be privately owned or collectively managed by the community.

Table 5.6. Main source of drinking water in irrigated and rainfed villages (%)

	ALL		IRRIGATED		RAINFED	
Source of drinking water	Dry season	Rainy Season	Marginal and landless Dry Season	Marginal and landless Rainy Season	Marginal and landless Dry Season	Marginal and landless Rainy Season
Covered well used individually (pump, hand well)	38%	38%	20	20	42	42
Covered well shared (pump, hand well)	8%	8%			15.5	11
Uncovered well used individually (pump, hand well)	13%	13%			16	16
Uncovered well and shared (pump, hand well)	17%	12.%	20	20	15.5	11
Rain water tank		4.%				5
Ponds, dams	13%	17%	20	20	12	16
River	8%	8%	40	40		

Distance to water resources

In regard to irrigated villages, overall the distance to domestic water sources does not differ in the rainy and dry seasons; the average distance varying from 3-5 minutes for private wells and around 15-20 minutes with respect to public sources of water such as public wells, rivers and ponds. In rainfed villages on the other hand, the distance to domestic water sources is on average longer in both dry and rainy seasons compared to distances noted in irrigated villages (Table 5.7).

Table 5.7. Average distance (in minutes) to domestic water source in rainfed village

	RAINY SEASON	DRY SEASON
Covered well used individually (pump, hand well)	5	5
Covered well shared (pump, hand well)	68	68
Uncovered well used individually (pump, hand well)	17	17
Uncovered well and shared (pump, hand well)	18	33
Public covered well		15
Rain water tank	20	
Ponds, dams	27	70

It was interesting to note that for approximately 50% of the sample, drinking water is collected by all members in the family, while young boy and girls (<12) are cited only in one case. Surprisingly, when the distance to collect water is greater, all members appear to be involved in the water collecting, such as in the case of Kam Ma and Thea Pyin Taw villages where the distance to collect water is recorded to be 45 and 120 minutes respectively. Respondents indicated that in these cases, the task of water collection would be taken on by any family member who was available at that time. Moreover, the family member involved may change depending on the season. For example, in In Taw village where the distance to collect domestic water is 45 minutes in the dry season, adults (both male and female) are engaged in water collection. In the rainy season, when water collection times are lower, teenagers are also involved in this activity.

Overall in dry season, the distance to collect water is on average greater in rainfed villages in comparison to irrigated villages, where in several rainfed villages, the water collection point for domestic use is more than 30 minutes away. In these villages groundwater sources are usually not used due to water quality issues.

In dry season, the average number of times that water is collected per week varies according to the village, and in our sample it varies from between 7 times per week to more than 105 times per week in the case of Kyauk Tan village, where households have access to individual wells.

To sum up, overall the main difference found between rainfed and irrigated villages, was that in the latter, the distance (calculated as minutes per trip) is shorter the frequency of water collection is lower, compare to rainfed villages. Additionally, in both irrigated and rainfed villages, the distance to the water source in the dry season is about three times higher when access to groundwater is constrained by water quality issues.

Water consumption

In our community survey, the price of purchasing domestic water varied according to village and uses. For example in Kyauk Sit Kan (rainfed village), landless farmers pay 250 Kyat per bucket (20 gallons) for drinking water and between 500 Kyat – 700 Kyat per drum (48 gallons) for water to use for other domestic purposes. In another rainfed village, Pha Yar Gyi Kone, the collective pond dried up during the dry season in 2013 and villagers were compelled to purchase water locally from owners of private motorized tube wells for 200 Kyat per 50 gallons.

In the case where water needs to be purchased from neighboring villages, the price is usually higher. For instance, at the end of the dry season villagers from Nwar Kyoe Aing, need to purchase drinking water from a neighboring village located some miles away. In that case, the cost is 1,500 Kyat per tank (50 gallons) including delivery charge. Without delivery, the tank of 50 gallons costs 300 kyats. In Taung Yinn village, landless farmers were purchasing water form a village located two miles away for approximately 3,500 Kyat per tank (50 gallons) and 200 kyat for 8 gallons. If the landless are unable to afford hiring transportation, they will walk, but due to the distance only one trip per day is possible. A round trip would take two hours carrying 5 gallons per trip for a female and 10 gallons per trip for a male. Due to the distance only one trip per day is usually possible. However in other villages it was noted that in the event that the cost of transportation is high, villagers support one another, such as in Taung Yinn where villagers without transportation can purchase water (200 kyat for 5 gallons) from the adjacent village with the assistance of their neighbors. In this specific village, respondents mentioned that to purchase drinking water, it needed to be ordered in advance.

Purchasing water from a source that is located elsewhere depends on labor availability. Landless farmers usually have less time to fetch water and therefore may have to purchase water from private tube well owners (25-50 Kyat for 8 gallons) such as is the case in In Taw village.

Water allocation for different uses

With respect to the distribution of the domestic water between different uses (i.e., drinking, other domestic uses and livestock), the relative proportion of water allocated between different uses did not appear to change significantly between seasons and during a drought period for the different households groups (i.e., marginal and landless farmers). From our community survey it was noted that approximately 15% to 20% of the volume of water collected was allocated for drinking purposes, about 50% towards other domestic uses and between 30% and 41% for watering livestock. Marginal farmers who own more livestock allocated more water to livestock watering in both rainfed and irrigated villages. Landless farmers on the other hand, allocate relatively more water for drinking in both dry and rainy seasons.

While the relative proportion of water allocated between different uses did not change significantly based on seasons, as expected, the volume of water collected per day was found to be different according to season and during period of drought (Figure 5.4).

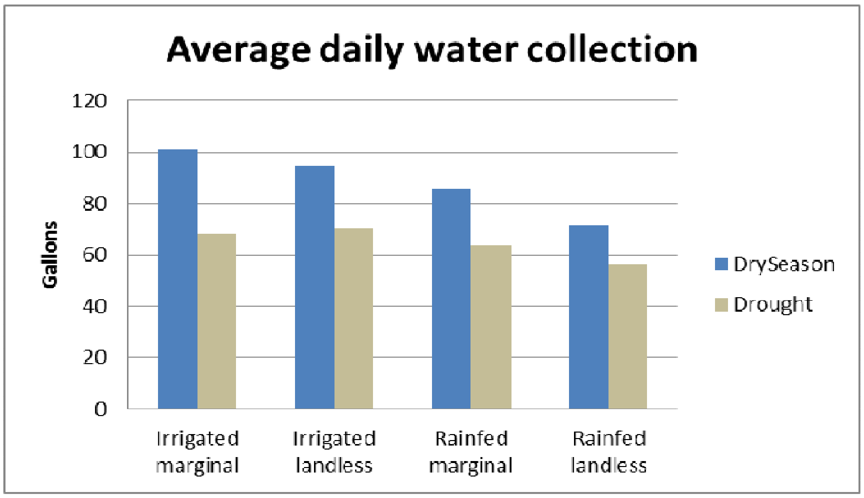

Figure 5.4. Average volume of water collected by a household in the dry season and drought period

In all cases the volume collected was recorded to be higher in dry season, when water consumption is more important and rain water collection is not possible. In the rainy season water collection was less important in terms of volume collected (50 to 70 gallons per day) as a result of the water demand for livestock and domestic use being replaced by rain water collection. During a drought period, water collection is reduced, with the higher difference in the case of marginal farmers in irrigated villages, where water collection drops from 100 gallons per day to an average of 68 gallons per day (32% drop).

Recent changes in access to domestic water: Importance of groundwater

As a result of some recent interventions associated with enhancing access to groundwater, such as increasing the number of manual tube wells or modifying open manual wells into motorized tube wells, 4 irrigated villages and 14 rainfed villages in our sample have been impacted positively. For example, in Kan Du Ma village, the increase in the number of manual tube wells enables time savings with regard to water collection, water is available all year around and the construction of the wells created employment opportunities for the local residents. When open wells were upgraded to closed well systems, improvements in water quality were also recorded in Pa Kar and Bay Yinn villages, especially regarding to water borne diseases.

- *In rainfed villages rainwater tank and community ponds are more used in rainy season, while public wells is more used in dry season.*
- *Distance in to the main water source is longer in rainfed villages compare to irrigated villages. This difference increases in the dry season and in period of water shortage.*
- *Price of water varied according to village, water source and uses. Water price also increased at the end of the dry season and prices were found higher if the water was purchased from another village and include delivery. Landless farmers usually have less time to fetch water and therefore may have to purchase water.*
- *During a drought period, water collection is reduced, with the higher difference in the case of marginal farmers in irrigated villages, where water collection drops from 100 gallons per day to an average of 68 gallons per day (32% drop).*
- *Access to groundwater was perceived as one of the main positive changes for access to domestic water, reducing time to fetch water, in the case where the hydrogeological characteristics enable a good quality of water.*

6. Institutional Arrangements associated with Water Use and Management

In this section of the report, we describe and analyze institutional arrangements at village level in relation to farmers' farming strategies and water management practices. It discusses the overall idea of institutional development looking specifically at the nature of institutions, their organizational origin, how they actually function and might evolve over time. Later, we also link this discussion with the notion of collective action, and how such action derives from actors' common understanding of problems and solution in relation to water availability, access and management.

The objectives of this institutional analysis are:

- To assess the role of local institutions, mechanisms, and arrangements in water management, looking specifically at farmers' farming strategy and water management practices
- To identify key constraints and opportunities to strengthen local community's role in water management practices
- To identify potential entry points for institutional interventions towards more effective and reliable water management
- To inform component 3 of our review on how the existing local institutional arrangements can support or hinder the uptake of the preferred intervention options.

6.1 Local institutions as the building blocks of 'good governance'

Institutions mediate relationships between people, natural resources, and society (Cleaver, 2012; Heikkila et al, 2011; Ostrom, 2010). Institutions play an important role in shaping natural resources management (Hardin, 1968; Ostrom, 1999). Community-based irrigation or so-called farmer managed irrigation systems (FMIS) gains its prominence in irrigation development literature in the early 1980s, with the introduction of organizational approach (Chambers, 1988; Cernea, 1991). The approach emphasizes the important role played by farmers in shaping the actual systems management. It focuses on farmers' capabilities in systems management and their potential role in improving the overall performance of government-managed irrigation systems. Here, community-based irrigation is advocated as the solution for better irrigation system management.

Current discourse on institutions in development policy seems to be focused on how to design the 'right' institutional arrangements to ensure good governance and effective policy implementation. As stated by Cleaver (2012: 2): *"'Getting institutions right' has become central to development policy"*. In water management literature, such tendency manifested in strong social engineering approaches, which view the overall idea of local institutions formation and organizational development as a linear step-by-step process that can be designed and anticipated beforehand (Mollinga and Bolding, 2004). The application of these social engineering approaches is most evident in the way major international donors (i.e. the World Bank, Asian Development Bank) promoted the formation and organizational development of Water Users Associations (WUAs) in developing countries worldwide (Jones, 1995; Subramanian et al., 1997).

Taking Ostrom's analysis on the 'design principles' of community-based irrigation as something that can easily be replicated, many but mostly international donor agencies assume that organizational property of farmer managed irrigation systems can be socially engineered to serve similar objectives in government-managed irrigation systems. The adoption of the idea was followed by widespread formation of Water Users Associations (WUAs).

Past and current research on community-based irrigation or farmer-managed irrigation system (FMIS) and WUA shows that WUA's organizational characteristics did not represent the organizational strength of community based irrigation. While there is a tendency to view community-based irrigation as a model for development, in practice, the translation of the farmer participation concept under FMIS into WUAs is problematic. Unlike in farmer-managed irrigation system where farmers have full authority to control water use, WUA depends on the irrigation agency for the operation of their water source (Hunt, 1989). This is not to mention the issue of technical characteristics and the scaling problem when WUA has to operate in highly technical, large-scale, government-managed irrigation systems. These problems in FMIS-WUA analogy, together with problems occurred during the policy implementation resulted in many dysfunctional WUAs.

In this component of our study, we look at local institutions and institutional arrangements mainly to understand how they function, the rationale behind such functioning, and how it benefits some people and excludes others. Highlighting the current gap in dominant institutional thinking, which assumes that better resources management can be gained simply through designing the right institutions (Varughese and Ostrom, 2001), this report highlights the prominent role of collective action in shaping and reshaping local institutional arrangements.

Moving beyond the social engineering approaches, we highlight the importance of collective action in shaping the overall relevance of institutions, how it emerges, being sustained, and identifies the institutions' organizational development path. We argue that one cannot force collective action to occur once local institutions are formed. Collective action derives from common understanding between actors and stakeholders about their common problems and how they can solve them.

In the next section, we start with a description of our case studies, based on data we gathered from three villages in Sagaing township. We describe and analyze local institutions and existing local arrangements in relation to farmer's farming strategy and water management practices in each of the three villages.

6.2 Local institutional arrangements: Case study description

Village with access to irrigation water (Ta Ein Tel)

Farmers in Ta Ein Tel village cultivated two paddy crops (rainy season and dry season paddy) and dry crops (cotton, sesame, green gram). They cultivated paddy mainly for subsistence farming. They have access to irrigation water through the Sintat River water pumping project. Water for irrigation is pumped from the river to a village lake and from the lake water is channeled through various 'irrigation canals' to farmers' fields. Farmers used pipes to convey water from the canals to their fields.

At present, farmers took irrigation water individually, without any institutional arrangements with other farmers in terms of irrigation turn, duration, and pumping request. When farmers needed water for their crops, they would inform the water management committee a week in advance. Water management committee is formed by the Water Resources and Utilization Department (WRUD) and is in charge to pump water from the river to irrigation canals during the entire cultivation periods (rainy season paddy, dry season paddy, dry crops). The committee is led by a village administrator as its chair, and comprised of a staff from WRUD as its secretary, and two farmer members whose tasks are to

distribute water within the irrigation canals. The village has 4 irrigation canals and 2 staff from the water management committee were in charge for water distribution practices, with each responsible for two irrigation canals. These staff's duties were to regularly check the condition of the irrigation canals (i.e. canals leakage) and ensure equal water distribution between head and tail-end farmers.
How the committee responded to farmers' water request, based on what criteria, remain obscured. Ideally, if water is available in the river, and electricity supply is sufficient, farmers would expect that the committee will pump water from the river to the irrigation canals, as requested by farmers, even when this means that they had to pump the water several times, especially when farmers submitted their request on individual basis. In practice, however, water was pumped to the village lake only at certain time period. Whether the committee held the final decision for water pumping remains unclear. Sometimes, water request need to be made in person to staff from Water Resources Utilization Department (WRUD).

Apart from these pumping requests, both farmers and the water management committee were not aware about any water delivery schedule applied in the irrigation system, at least not in practice. One farmer mentioned that some staff from the Department of Irrigation suggested that farmers take turn in their water taking activities. Similarly, tail-end farmers would propose to channel the pumped water to the entire irrigation canals first, before head farmers started to take water with their pipes. But in practice, farmers would put their pipes into the canal[14], to convey water to their fields, regardless of other farmers' water taking activities. The absence of water delivery schedule highlights not only the lack of institutional arrangements as regards farmer's water management practices, it also implies unequal water distribution between head and tail-end farmers. In time of water scarcity: 1) when there is not enough water in the river, or 2) when there is insufficient electricity supply to pump water from the river, water conflicts often occurred as head farmers would take water at the expense of tail-end farmers.

In general, farmers paid 6,000 kyat/acre for rainy season paddy, 9,000 kyat/acre for dry season paddy, and 4,500 kyat/acre for other crops. Referring to this irrigation service fee, farmers highlighted the need for systematic water pumping, when it could be done in such a way that it would increase water reliability for farmers.

At present, water management committee cannot ensure equal water distribution between head and tail-end farmers and are unable to solve water conflicts that occurred. Apart from their inability to design and implement water delivery schedule, their functioning is also hampered by erratic electricity supply to pump water from the river.

Village with access to groundwater (De Pa Yin Kwal)
Farmers in De Pa Yin Kwal village cultivated mainly vegetable crops and dry crops (i.e. tomato, sesame, chick peas) and fruit trees (i.e. mango, banana) the whole year round. Horticulture is the main farming activity. However, due to its high cost (for fertilizer, pesticides), farmers could only gain minimum profit from horticulture.

Farmers relied on groundwater use for their agriculture farming. Groundwater use has been applied in the village for the past 26 years. For farming lands, which are located near the Mu river, river water is

[14] The 'pipe' is made from a material that enables it to be inflatable. This provides flexibility for villagers to carry and move the 'pipe' anywhere without putting too much effort in installment procedures. The pipe is connected to a pump and serves as a support element for pumping water.

mainly used to irrigate the crops. For farming lands, which are located far from the river, farmers installed groundwater tube wells to ensure their crops water supply. As groundwater is almost readily available, farmers never experienced water scarcity problems in the village.

Nonetheless, farmers are burdened by high pumping cost (i.e. fuel charge and machine rental charge). Moreover, farmers also mentioned about poor water quality from the majority of tube wells. According to farmers, 75% of the total tube wells had high iron content in the water.

Water management committee or any other organizations responsible for ensuring farmers' water need are absent. In general, farmers arrange their irrigation water supply individually, using groundwater. Farmers cover the cost of pumping water, agriculture inputs by themselves. They harvested their agricultural produces, sell it in the nearby markets or through a broker that came to the village. Farmers knew about the latest price update for each agriculture produce. Big farmers who have high yields would often go to the city themselves to sell the produces there to get the highest profit. Other farmers who relied on brokers who came to the village receive lower price for their agriculture produces. Nevertheless, as they are well informed about the market price, they can use this information as their bargaining position in case the brokers came up with a very low price offers.

At present, informal farmers network do exists, in terms of spreading information about market price, access to new farming techniques (i.e. organic farming procedures, farm licensing). Such network is shaped mainly through direct interactions between farmers.

Rainfed village (Taung Yin)

Farmers in Taung Yin village had neither access to irrigation nor groundwater. They relied mainly on rainfall for their farming. In general, farmers cultivated groundnut, pigeon pea, and sesame in the rainy season, and chickpea, coriander, black cumin, onion, and others in dry season. Crop cultivation is limited in dry season, due to water scarcity issue.

During the dry season, water became very scarce, to the point that it affected villagers' access to drink water. Normally, villagers would take water from the village communal pond for their domestic use (i.e. bathing, cooking, washing, drink water). Water level in the village pond was very low, and villagers had to buy four diesel pumps machines to pump water from the nearby reservoir (6 km away from the village) and convey it through a PVC pipe before channeling the water to a stream that will convey the water to the village pond.

The villagers work together to ensure their drink water supply. They collected money from each household (i.e. wealthier households paid higher amount of 'fee' than poor households), and use this money to fund their pumping operation. This included purchasing the pumping machines, paying for the fuels, and assigning farmers and villagers to monitor and ensure that water is conveyed in most effective way. The villagers assigned 3 people in each of the diesel pumping 'station', including one at the reservoir, to ensure that each machine was working properly and that water was conveyed to the village pond in time. Villagers took turns in this monitoring activity.

With the money that they had collected, they can ensure pumping operation for up to 10 days or 2 weeks. At the time of pumping, villagers were already looking for alternative water source if water level in the reservoir dropped to a level where they could not pump it. In general, each year they have water scarcity problem. So, each year they will contact nearby villages in case these villages still have water reserve which they could share.

Efforts made by the villagers to cope with water scarcity issue especially with regard to ensuring their drink water supply, is coordinated through water management committee. Like the water management committee in Ta Ein Tel village, this committee was formed by Water Resources and Utilization Department (WRUD). It comprised of village head who acted as the chair, other staff from village administration unit who acted as secretary, vice chair, and treasurer. Unlike in Ta Ein Tel village where the water management committee is equipped with staff who are in charge in water distribution at irrigation canal level, in Taung Yin, the committee comprised mainly of village administrative staff.

6.3 Case study analysis: Institutional functioning and the role of collective action

Our case studies show how local institutions' actual functioning is shaped in part by contextual characteristics and actual water needs in each village. Table 7.1 gives an overview of local institutional arrangements in each of the three villages. In the following sub-sections, we analyzed how institutional arrangements are shaped at village level, and how this relates to the notion of collective action.

Table 6.1. Overview of local institutional arrangements

VILLAGE NAME	ACCESS TO WATER FROM	WATER MANAGEMENT COMMITTEE	ACTUAL ROLE AND FUNCTIONS	TYPE OF INSTITUTIONAL ARRANGEMENTS
Ta Ein Tel	Irrigation	Present	Water request	Canal hierarchy
De Pa Yin Kwal	Groundwater	Absent	NA	Informal networks
Taung Yin	Rain water	Present	Organize water pumping for domestic use	Collective action

Institutional arrangements according to canals hierarchy

In Ta Ein Tel village, for instance, where farmers have access to irrigation water whole year round, water management committee plays hardly any role in shaping the overall water distribution practices. Apart from its role in collecting or responding to water requests submitted by farmers, the committee lacks any authority to regulate farmers' water taking activities. Farmers' lack of awareness with regard to both formal and informal water delivery schedule highlights the need to fine tune formal water delivery schedule with actual water taking activities on the ground. It also brings to light the need for information dissemination from WRUD to water management committee with regard to their water delivery plan (i.e. pumping schedule and duration).

As farmers could arrange their irrigation water supply on individual basis (through water request to water management committee or the WRUD), they do not see the need for shaping certain institutional agreements based on common (water) needs. Moreover, we argue that while farmers need irrigation water for their crops, head and tail-end farmers might in fact have different, perhaps conflicting interests in time of water scarcity. Here, head farmers would perceive equal water distribution as something that might stay in the way of their individual water taking, and thus tended to sustain the current water distribution practices, as means to preserve the status quo. In contrast, tail-end farmers would view equal water distribution as a means to ensure the reliability of their water supply. Thus, while farmers might share common problem: water scarcity, this does not translate into collective action in water distribution and water management practices, mainly because head and tail-end farmers do not share common solution towards the problem.

In turn, the absence of local institutional arrangements to regulate farmer's water taking results in unequal water distribution between head and tail end farmers. In time of water scarcity, unequal water distribution results in water conflicts. Lacking any institutional arrangements in water distribution practices, farmer's access to reliable irrigation water supply depends mainly on the location of their farming lands, with head farmers have better access to irrigation water than tail-end farmers. Here, institutional arrangements are mainly embedded in the existing technical irrigation infrastructures (i.e. canal hierarchy and hydraulic levels).

Institutional arrangements by informal networks
In De Pa Yin Kwal village, where farmers have access to groundwater, farmers need neither local institutions nor local institutional arrangements for their water management practices. As farmers could arrange their water supply on individual basis, they hardly work together in their water taking activities.

Farmers formed informal networks to monitor their crops value at the markets, as well as to update each other on the latest agriculture techniques. While such networks are shaped mainly through direct interactions between farmers, we highlight their importance as the very basic foundation for institutional shaping. These informal networks resemble not only that farmers in the village share common problem: price uncertainty of their agriculture products, but also that they share common understanding on how they can partly solve this problem: through better access to available information (i.e. market price).

Thus, the shaping of farmer organization in De Pa Yin Kwal village would probably need to be focused on how to define institutional arrangements that can represent farmers' common interests to get better market price, to get higher benefits. Here, we highlight the role of farmers' agricultural products, rather than water as entry point and key factor to initiate collective action.

Institutional arrangements through collective action
In Taung Yin village, where farmers had neither access to irrigation nor groundwater, water scarcity condition urged farmers and villagers to cope with the problem through collective action. The enrolling of this collective action brings to light the notion of institutional emergence, where local actors identify their common problems: water scarcity, and come in agreement in how to solve these problems: pumping water from the nearby reservoir and convey it to the village pond, through existing canal networks.

The way local actors organized the overall pumping initiative, purchasing the pumps, defined the payment rules, ensured contributions from the villagers, divided the tasks between villagers, foresaw additional water sources shows how they can shape and reshape the actual functioning of water management committee to meet their actual water needs, even when this means to shift the context from agriculture to domestic water use. In other words, collective action exists in other types of water use activities, beyond agricultural use.

6.4 Water Users Associations, policy trends in irrigation development, and potential entry points for institutional strengthening

Current trends in irrigation development worldwide and in Myanmar in particular highlights the need to form and establish multi-layered farmer organizations in charge for water management and water distribution practices, from main canal systems down to farmers' fields, so-called Water Users Associations (WUAs) (Svendsen, 1993; Small, 1989; Anderson Engineering, 2012). Institutionally, these multi-layered farmer organizations (WUAs) would comprise of tertiary level farmer organizations (representing farmers within a tertiary unit), secondary level farmer organizations (representing tertiary level farmer organizations), and main level farmer organizations (representing secondary level farmer organizations). International policy makers believe that WUAs formation would improve the overall water management in government irrigation systems. As Hunt jested (1989: 79): *"If the farmers would only participate, the thinking goes, then the ditches would be constructed, the water would be allocated, and most important of all, the maintenance would be done".*

In practice, however, global experiences show some pitfalls in WUAs formation and establishment. Recent studies looking at the overall functioning of WUAs in Asia and the Middle East show, for instance, that the majority of WUAs were dysfunctional and exist only on paper (Mukherji et al., 2009; Ghazouani et al., 2012). Moreover, WUAs often function as government-induced and elite-driven farmer organizations, not necessarily representing farmers' actual development needs and aspirations (Ghazouani et al., 2012; Nikku, 2006).

We argue that while the idea of WUAs formation might fit with the technical characteristics of the irrigation system, unlike irrigation infrastructure, institutions cannot be designed and developed based on blue print model. Our case study analysis shows that institutions are not static entities. They are dynamic, prone to changes, and continuously evolving. The analysis highlights how local institutional arrangements with regard to farmer's farming strategies and water management practices can vary from one village to other, depending very much on how farmers and villagers shape and reshape their strategies to cope with challenges in acquiring access to water as well as in distributing it.

Institutional development and strengthening needs to be tailored cut to existing water characteristics in each village, based on farmers and villagers' view and development aspirations. As shown in our case study analysis, farmers in irrigated village have different (organizational) needs than farmers in respectively rainfed and village with access to groundwater. Referring to this variation, we suggest that the overall functioning of farmer organizations be made flexible, ranging from water distribution for agriculture, domestic water supply, to agricultural cooperatives, rather than focused on water alone. Furthermore, our case study analysis shows that water is only a factor, next to a series of other (perhaps more important) factors (i.e. labor, access to market, input costs, off farm opportunities) which shape farming households; decision. In this light, urging the formation and establishment of WUAs as uniform farmer organizations does not only impose its importance on the existing local institutions and arrangements, but it might also moves us further from our goals to empower farmers as key actors in agricultural and rural development in general.

7. Past and Current Interventions

In this section, we provide an overview of the past and current interventions in relation to water management that were described by the communities in the 24 villages we covered in our survey. For this purpose we extract and summarize information obtained on this topic from the 24 FGDs held with community leaders in our sample (i.e., one FGD per village) and determine the main trends and commonalities found in the interventions adopted in the three broad categories of villages in our sample –i.e., villages irrigation all year around, villages with supplemental wet-season irrigation and rainfed villages (which do not have irrigation). We look at water interventions associated with agriculture, domestic uses and flood control that were initiated by the Government, development agencies, individuals and collective groups. We also attempt to understand from the community's perceptive the reasons for success and failure for interventions and any common findings across the 24 villages.

Overall, as expected, past and current interventions linked with domestic water use (including livestock and drinking water), were reported in all three types of villages in our survey, while interventions associated with agriculture were recorded in only villages with access to irrigation and supplementary irrigation. Flood mitigation related interventions were reported in only two villages, one rainfed, and one with supplementary irrigation.

Key observations and inferences

From our survey it is clear that in relation to the broader livelihood strategies found in the villages, water related interventions cover a range of different uses – agriculture, domestic water uses (including livestock and drinking water) and even protection against floods in some cases. Furthermore, different types of interventions are design in the same village with funding support from different sources. It is therefore important that a holistic approach is adopted with regard to investing in water related interventions at the village level – an approach that takes into consideration the full range of uses and ensures that all interventions are closely linked into the overall village development planning processes.

It is also important to have a clear understanding of not just the range of different interventions operating in the village – both in the past and currently, but to also determine which were considered successful or not by the community and reasons for this. This would help inform decisions regarding potential interventions in the future. For example in terms of irrigation schemes, one problem discussed during our FGDs was the fact that sometimes tail-end farmers did not receive adequate water for their crop. Another issue mentioned was that while groundwater may be used for supplementary irrigation, fuel costs associated with mechanized pumping were of particular concern. These kinds of concerns would need to be taken into consideration and strategies of how these can be addressed thought through carefully before interventions are made.

With regard to groundwater exploitation, especially in the context of domestic water use, one of the main issues highlighted was related to water quality. In a number of villages it was reported that the water was too salty to be used for drinking purposes. Water quality was also reported to vary within close proximity – which meant that even within one village quality could differ depending on location. Thus knowledge of the hydrogeological conditions is paramount to effective planning at the local level to minimize poor investments in relation to groundwater.

Rainwater harvesting ponds were another key intervention in relation to domestic water use. However maintenance of the ponds was sometimes an issue due to siltation and poor infrastructure as well – and as a result a number of initiatives on pond rehabilitation and reconstruction appear to be also funded by various donors and agencies.

With regard to past and current interventions it appears that while some benefit the entire village, others appear to target specific groups. On other occasions, perhaps inadvertently some groups are unable to benefit at all or benefit less relative to others (for example tail-end farmers in an irrigation scheme, or households that are situated in part of a village where the groundwater quality is poor). With interventions therefore it is also important to be clear in the planning process as to who the beneficiaries or target groups will be, once again in the overall context of the village development planning process.

While there are a range of donors funding water related interventions, it appears that there are also collective action initiated among the farmers and villagers themselves to address water scarcity issues – so focusing on a common problem and coming to an agreement of how to solve the problem in a collective manner. For example in the case of pumping water into a village pond from a river through a four inch pipe using four pumps in Taung Yin village. Sometimes however the investments required are too large to be addressed by villagers alone – such as in the case of building a drainage canal in the event of a flood in the same village.

Finally, the past and current interventions found in the 24 villages and how these are perceived in terms of performance and their impact on improving the lives of the different farmer groups (landed, marginal and landless farmers), is likely to shape and influence community members in their preferences and priority setting for potential interventions in the future.

In Annex 2, we provide some examples of interventions that were captured in our community survey on agriculture, domestic use and flood prevention.

8. Potential Interventions

We attempted to identify potential interventions that would reduce vulnerability to water stress, and that were of priority to the local communities. To this end, we elicited in every FGD (i.e., a total of 72 FGDs), a few potential technical interventions from the respondents in that FGD. Participants were asked to discuss the potential impacts of the interventions they had proposed, the players who should be involved, the strengths and usefulness, and weaknesses and constraints, of each of the proposed interventions.

After this discussion, a list of potential interventions was provided to the respondents in the FGD. This list was developed based on the Dry Zone water linked interventions that were discussed during our Stakeholder Consultation Workshop[15] and also drawing on the literature. Each intervention on the list was explained, and farmers were asked to validate the list and add potential interventions if necessary. Each participant was then provided with five tokens, and they were asked to split the tokens across the listed intervention(s) they thought were most valuable, using all five tokens only once. The list of options is provided in Table 9.1.

Table 8.1. Potential intervention options discussed and voted on during community survey

Rehabilitation or extension of irrigation equipment (including canal rehabilitation and/or pumping station rehabilitation)
Collective well for irrigation including electric pumping station
Collective rainwater harvesting pond rehabilitation or new
Collective Groundwater for domestic use a and livestock
Sand dam/embankment for water storage
Watershed management program (e.g. reforestation, check dams etc.)
Embankment protection against flood
Rainwater harvesting tank for domestic use and garden watering
Tube well or Dug well (+diesel pump) in the fields for irrigation purpose
Other specify

The voting was conducted anonymously and participants were called aside to vote individually, one at a time. We present findings from the voting exercise, drawing on the qualitative discussions around potential interventions to substantiate the quantitative findings.

Two variables emerge as key for examining variation in stated preferences for alternative interventions at the village level: the availability of irrigation, and the type of farmer. As indicated in Chapter 2, Section 2.1, our study categorizes the availability of irrigation into the following: villages with irrigation all year around, villages with supplemental wet-season irrigation and rainfed villages (which do not have irrigation). As explained under Section 3.1 for our study we also identify three types of farmers: landed

[15] A Stakeholder Consultation Workshop on the *Sustainable Management of Water to Improve Food Security and Livelihoods in the Dry Zone of Myanmar* was held on the 4th and 5th February in Yangon. Forty people attended including Government line agencies and international and local NGOs working on water related issues in the Dry Zone. Presentations were made by stakeholders on water related investments in the Dry Zone.

(those that own between 5-15 acres of farming land), marginal (those who own less than 5 acres and are not food secure for the entire year) and landless (farmers without farm land, who are not renting land for farming, and who are not food secure throughout the year).

8.1 Results by village type – access to irrigation

Focusing on availability of irrigation alone, we find greater heterogeneity in preferences for water interventions in villages with supplemental irrigation and rainfed villages than in villages with irrigation all year round. This may be in part due to familiarity with existing interventions in villages with irrigation all year round—mostly government-funded canal irrigation investments in relation to agriculture. Additionally, our study found that landed farmers with access to canal irrigation also tended to privately access some groundwater. Therefore, it is likely that in villages with year round irrigation, farmers may be able to collectively develop other interventions, while rehabilitation of canals requires government action. At the same time, rainfed villages may be more flexible, due to not being locked into pre-existing investments. Moreover, the exercise we conducted listed interventions pertaining to not just irrigation but also to domestic water use, and water for livestock. It is also likely that rainfed village have fewer interventions in general, thus having more unmet needs.

In our study, 31% of respondents in rainfed villages voted for the rehabilitation or construction of a rainwater harvesting pond, and 13% voted for storage embankments, thus prioritizing investments pertaining to domestic water use and livestock. In villages with supplemental irrigation in the wet season, 24% of respondents voted for a tube-well with pump for irrigation, and 14% for a collective well with electric pumping station, thus prioritizing investments associated with enhancing irrigation. In villages with irrigation all year round, 36% of the respondents voted for the rehabilitation or extension of existing irrigation equipment, mostly canal irrigation, while 33% of respondents voted for the rehabilitation or construction of a rainwater harvesting pond, hence showing that priorities were focusing on irrigation and also domestic and livestock water uses.

8.2 Results by farmer type

Examining farmer types, we find preferences for investments to be fairly distributed across alternative options, likely indicating diversity in survival strategies. Landed, marginal and landless farmers tend to prefer rehabilitation or construction of a rainwater harvesting pond above other options, with 21% of landed farmers, 25% of marginal farmers, and 30% of landless farmers voting for this option. Since rainwater harvesting ponds are important water sources for the purpose of domestic water use – including for drinking water and livestock, it is reasonable that it should be considered a priority by all three farmer types. Livestock contribute to the livelihood portfolios in these areas, and according to our survey, in a good year, livestock account for about 10% to 14% of the household’s income in the case of landless and 5% to 12% in the case of marginal farmers. In this regard, the preference for a rainwater harvesting pond is likely reflective of the need for watering livestock.

8.3 Results by village and farmer type

We present our findings by irrigation and farmer type to better understand patterns of preferences. Cells shaded in dark green are the most popular option, while those in light green are the second most popular option. These results are summaries in Table 9.2 below.

Table 8.2. Preferences by farmer-type and access to irrigation

Preferred Interventions: Landed Farmers

Irrigation	Rehab. extn of irrigation equip.	Coll. well for irrigation + elec. pump	Coll. rainwater harvest. pond: rehab/ new	Coll. groundwater: dom/ livestock	Sand dam/ embank. for storage	Watershed mgmt. prog.	Embank. prot. against floods	Rainwater harvest. tank: dom dom/ gardens	Tube/dug well + dies. pump for irrig.	Other	Other
Rainfed	0.06	0.04	0.29	0.10	0.10	0.01	0.02	0.10	0.13	0.13	0.01
Supplement	0.12	0.19	0.09	0.02	0.00	0.01	0.07	0.03	0.36	0.12	0.00
All year	0.50	0.07	0.24	0.00	0.00	0.10	0.02	0.02	0.05	0.00	0.00

Preferred Interventions: Marginal Farmers

Irrigation	Rehab. extn of irrigation equip.	Coll. well for irrigation + elec. pump	Coll. rainwater harvest. pond: rehab/ new	Coll. groundwater: dom/ livestock	Sand dam/ embank. for storage	Watershed mgmt. prog.	Embank. prot. against floods	Rainwater harvest. tank: dom dom/ gardens	Tube/dug well + dies. pump for irrig.	Other	Other
Rainfed	0.07	0.07	0.30	0.11	0.18	0.01	0.03	0.08	0.07	0.09	0.00
Supplement	0.18	0.12	0.14	0.00	0.01	0.02	0.11	0.02	0.19	0.19	0.00
All year	0.28	0.07	0.31	0.05	0.01	0.02	0.02	0.05	0.18	0.00	0.00

Preferred Interventions: Landless Farmers

Irrigation	Rehab. extn of irrigation equip.	Coll. well for irrigation + elec. pump	Coll. rainwater harvest. pond: rehab/ new	Coll. groundwater: dom/ livestock	Sand dam/ embank. for storage	Watershed mgmt. prog.	Embank. prot. against floods	Rainwater harvest. tank: dom dom/ gardens	Tube/dug well + dies. pump for irrig.	Other	Other
Rainfed	0.05	0.05	0.34	0.08	0.10	0.02	0.02	0.08	0.13	0.13	0.00
Supplement	0.09	0.13	0.17	0.08	0.01	0.05	0.05	0.06	0.18	0.18	0.00
All year	0.28	0.04	0.46	0.09	0.01	0.03	0.02	0.07	0.03	0.00	0.00

In villages with all year irrigation, rehabilitation or extension of existing irrigation infrastructure is the most preferred option for the landed (50%) , but also the second most popular option for the marginal (28%) and landless (28%). This is reflected in the observation that irrigated agriculture contributes 32.5% of the income portfolio of marginal farmers in irrigated areas, while for the landless, casual labor in the local agriculture sector made up a significant proportion (between 38% to 58%) of their income. The marginal and landless in these villages most often voted for the rehabilitation or construction of a rainwater-harvesting pond (31% and 46% respectively). Again this is in line with the fact that rainwater harvesting ponds are important water sources for the purpose of domestic water use – including for drinking water and livestock (which is an important livelihood strategy and source of income for both the marginal and landless as explained above). In villages with supplemental wet season irrigation, all farmer types prefer groundwater interventions with a diesel pump (36% landed, 19% marginal and 18% landless). In rainfed villages, all farmer types prefer the rehabilitation or construction of a rainwater harvesting pond (29% landed, 30% marginal and 34% landless). Groundwater interventions were not preferred due to water quality issues (including salinity and turgidity), and the high costs involved in tapping groundwater.

Summing up, rehabilitation or extension of existing irrigation infrastructure is a preferred option among landed and marginal farmers in villages with irrigation all year round. In contrast, groundwater interventions are preferred over others by landed and marginal farmers in villages with supplemental wet season irrigation. Finally, rainwater harvesting ponds are an important option for all farmer-types in villages with dry season irrigation, and rainfed villages.

Rehabilitation and extension of irrigation infrastructure may be beneficial for farmers in villages with irrigation all year around. However, our interviews with the WRUD officials at the township levels, and FGDs with farmers in villages suggest a number of challenges in extending such investments. For one, regular and timely maintenance of irrigation infrastructure is a known challenge, thus requiring pre-mature rehabilitation. Additionally, improper construction of irrigation infrastructure may also require premature rehabilitation. This often forms a vicious cycle of build-neglect-rebuild, which is likely systemic for irrigation infrastructure. Additionally, water losses from evaporation and unlined canals are important considerations. WRUD finds it challenging to cover the costs of its operations, since water use is heavily subsidized. Collection of water fees from farmers is challenging, likely due to both the lack of capacity for collecting fees by WRUD and for paying fees by farmers and water user associations. Additionally, canal irrigation schemes require a pumping station that lifts and diverts water into irrigation canals. Electricity is in short supply in Myanmar, and with rising diesel prices, ensuring the running of pumping stations to deliver water to fields in a timely manner is challenging. Even though farmers may be willing to contribute labor, as indicated through the FGDs, further investigation is required to ensure how best to ensure that the benefits of this option would justify the costs.

Farmers in supplemental wet season irrigation areas are likely to benefit from groundwater investments with motorized pumps. Their preference for this option may be in part due to the reliability of groundwater interventions over canal irrigation, and also in part due to the economic challenges associated with extending canal irrigation to provide water the year around. Marginal farmers in areas with supplemental irrigation often rely on groundwater to supplement rainfall; however their responses suggest that the variable costs of this option, viz. fuel costs, are high. Moreover, interviews with WRUD suggest that digging wells is expensive, in part due to limited availability of drilling equipment. Also, due to limited exploitation of groundwater, information about the depth and quality is limited. As in the case of canal investment, short supply of electricity and increasing diesel prices makes pumping expensive. Villages are unlikely to be able to raise the money for financing these investments. Motorized tubewells may be challenging to implement effectively, given these constraints, especially for marginal farmers. However this potential intervention will require an assessment of water quality since groundwater quality was found an issues in several villages during this survey and affect several areas within the entire Dry Zone.

Rehabilitation or construction of a rainwater-harvesting pond is a preferred investment in almost all areas, especially in rainfed and all-year irrigation areas, by all farmer types. FGDs with villages indicate that the villages themselves can supply the labor and mechanical resources required for such investments. This intervention has the potential to reach many farmers, and may be income-neutral in its outreach. The focus group discussions suggest that this intervention is likely to be important for domestic water uses including drinking water and watering livestock, and thus has the potential to have an impact of livelihoods, and an important adaptation strategy. However evaporative losses in the dry zone are likely to be very high, and rainfall can be erratic.

Key inferences from preference voting exercise for potential interventions

- *Rehabilitation or construction of rainwater harvesting pond has the potential to have an impact in all areas for all farmer-types, by increasing access to water for drinking, domestic use and livestock.*
- *Rehabilitation and extension of canal irrigation may positively impact landed and marginal farmers in areas with year-round irrigation; but further research is required to understand whether these efforts would be cost-effective.*
- *When considering groundwater interventions, factors such as the quantity of groundwater available, installation costs, operation and maintenance costs and replacement costs are important considerations.*
- *Groundwater interventions with pumping are likely to impact landed and marginal farmers in areas with supplemental irrigation; however rising diesel prices and shortage of electricity challenge the efficacy of these interventions.*
- *Voting outcomes likely reflect familiarity with existing interventions, and in part preference for less risky options to increase the probability of accruing some benefits.*

It was interesting to note that some interventions were not considered of priority in the voting exercise: for example, the following interventions did not show high preference overall: watershed management programs and rainwater harvesting tank for domestic use and garden watering. Watershed management is very new concept to the community and many may not be aware of what exactly this involves. Another reason why watershed management did not get priority preference votes is that there is no quick impact and benefits will accrue more in the long-term – so communities opted for interventions that had impact in the short-term. Communities may have not shown preference for rainwater harvesting tanks for domestic use as a result of requiring tin roofing sheets and gutters and also the need for sufficient rainfall during the rainy season to make this intervention feasible. They may have also been focused on water for cultivation, as they could purchase water for domestic use.

9. Conclusions

As one part of our overall study, we conducted a community level survey in the Dry Zone to determine local water availability for different uses and opportunities and constraints to access and manage water as perceived by local people. We have also looked at various institutional arrangements at village/community level in relation to farmers' farming strategies and water management practices as well as domestic water use.

Overall, from our survey it is clear that in relation to the broader livelihood strategies found in the villages, water related interventions cover a range of different uses – agriculture, domestic water uses (including livestock and drinking water) and even protection against floods in some cases. There is great variation across villages in terms of water stress, resulting in significant differences in development opportunities and priorities between villages, even over small proximities. Therefore water-related interventions must be shaped within each community based on their own specific priority needs. For instance, in some of the more water stressed villages, obtaining better access to drinking water was of critical importance. In other villages, obtaining access to irrigation for cultivation was considered the major requirement. Our institutional case study analysis highlighted how farmer's farming strategies and water management practices could vary from one village to other, depending on how farmers and villagers shape and reshape their strategies to cope with challenges in acquiring access to water as well as in distributing it.

Moreover our community survey also provided a better understanding of how certain water related interventions in relation to agriculture and domestic use may impact different social groups (marginal and landless farmers) differently. This type of information is critical to be equipped with to ensure that appropriate targeting can take place if investments are being made. Preference prioritization in interventions between marginal and landless and those from different village types (irrigated, supplementary irrigation and rainfed) was also a useful exercise in gaining a broader understanding of what the main priority interventions are for different groups.

Based on our community survey, some of the key water related interventions that emerged as important to the DZ were:

Formal irrigation schemes:
The rehabilitation or extension of irrigation equipment (including canal rehabilitation and/or pumping station rehabilitation) appeared as a priority intervention for all farmers (including marginal and landless) with access to irrigation all year around. It was clear however that prior to initiating major rehabilitation programs, it is imperative that a set of assessments are conducted to determine how to address the technical, physical and institutional challenges that are at present inhibiting the effectiveness of these formal schemes. With regard to strengthening institutional aspects, a mechanism that enables farmers to link the water delivery schedule to the farmers' cropping pattern is one potential entry point to work more closely with government agencies (see Johnston *et al.,* 2013).

Groundwater interventions:
Small-scale irrigation through the use of groundwater is involving an increasing number of small farmers in the DZ. In our preference voting exercise, in villages with supplemental irrigation, all farmers showed preference for groundwater irrigation interventions. With regard to our interviews with well owners, the

first major finding is that irrigation with groundwater can be an important means for farmers to help improve their livelihoods, particularly during the dry season months. This is improved when high valued crops are grown (sometimes in addition to staple food crops such as rice), and household level cash flows are sufficient to meet the basic input needs. Job opportunities for landless workers in irrigation management emerge in around 70% of cases. Assured access to domestic water supplies is another indirect benefit.

The total investment costs needed to establish GWI are highly conditional upon the local conditions and can vary by an order of magnitude. Thus knowledge of the hydrogeological conditions are paramount to enable effective planning so as to minimize poor investments. Under optimal conditions, the payback times on initial investments can be very short. Well owners stressed that the major issue affecting their livelihoods is mostly in relation to the high cost of fuel, and to a lesser extent by maintenance-related costs in operating motorized pumps. The high upfront cost of setup can be a barrier to adoption which was not given adequate recognition in the design of the survey given that those farmers involved had already established their infrastructure.

Water from the wells is commonly used for domestic and livestock purposes. Therefore when considering irrigation expansion the implications on these sectors along with the general sustainability of the technology much also be firmly taken into account. Furthermore, the provision of drinking water must be the highest priority, and plans to expand irrigation development should not compromise current or future access to drinking water supplies (for people and livestock). If properly located, deep tube wells provide reliable, high quality water in all seasons for domestic use, with benefits for the entire community.

Rainwater harvesting and storage:
Rainwater harvesting (RWH) technologies, which include structures built to capture rainfall such as ponds, tanks, reservoirs and small dams are found in the Dry Zone. In our community survey, the preference voting exercise highlighted that rehabilitation or construction of rainwater harvesting structures was a preferred investment option for all farmer-types (including marginal and landless). Also, with regard to interventions adopted currently and in the past, rainwater harvesting ponds/reservoirs was an intervention mentioned several times in our survey. These technologies are therefore present in the DZ and NGOs such as ActionAID, IDE-Proximity in addition to the government (Irrigation Department) have considerable experience with construction and rehabilitation of village ponds. In our community survey, most rainwater harvesting ponds and reservoirs were used for domestic water purposes and livestock watering, and only few used for supplementary irrigation. Respondents report that the village would be able to provide the labor and mechanical resources needed for this intervention, and may require some expert knowledge from outside. Thus this intervention has the ability to affect livelihoods and adaptation strategies for everyone. However, evaporative losses in the Dry Zone can be large.

In conclusion, different types of interventions are implemented in the same village with funding support from different sources. It is therefore important that a holistic approach is adopted with regard to investing in water related interventions at the village level – an approach that takes into consideration both the priority needs in the local context and also the full range of uses and ensures that all interventions are closely linked into the overall local development planning processes.

References

Anderson engineering, 2012. Increasing the efficiency and effectiveness of pumped irrigation schemes in the Central Dry Zone of Myanmar. Working Paper 4 Management Operation and Maintenance and Water User Organizations. LIFT/UNOPS, Water Resources Utilization Department.

Cernea, M., 1991. Putting people first: Sociological variables in rural development. Oxford University Press, UK.

Chambers, R., 1988. Managing canal irrigation: Practical analysis from South Asia. Sage Publications, New Delhi.

Cleaver, F., 2012. Do institutions elude design? Institutional bricolage and natural resource management? Earthscan, London.

Ghazouani, W., F. Molle, E. Rap, 2012. Water users associations in the NEN region. IFAD interventions and overall dynamics. IWMI draft report submitted to IFAD. October 2012.

Gruyter, De P., 1933. Plant en water regelingen (plant and water control). De waterstaats ingenieur 1.

Hardin, T., 1968. The tragedy of the commons. Science 162: 1243-1248.

Heikkila, T., E. Schlager, M. W. Davis, 2011. The role of cross scale institutional linkages in common pool resource management: Assessing interstate river compacts. Policy Studies Journal 39(1): 121-145.

Hunt, R., 1989. Appropriate social organization? Water user associations in bureaucratic canal irrigation systems. Human Organization 48,

JICA (2010). The development study on sustainable agricultural and rural development for poverty reduction programme in the central dry zone of the Union of Myanmar. Report No. RDJR10-502, Japan International Cooperation Agency.

Johnston R., Ameer R., Balasubramanaya, S., Dousangsavanh S., Lacombe G., McCartney M., Pavelic P., Sellamuttu S.S., Sotoukee T., Suhardiman D., Joffre O. (2013) Identifying priority investments in water in Myanamr’s Dry Zone. Report to Livelihoods and Food Security Trust Fund /UNOPS for Component 3.

Jones, W. 1995. The World Bank and irrigation. Operational Evaluation Development of the World Bank. Washington DC.

LIFT Baseline Survey Results (2012). Livelihoods and Food Security Trust Fund. Yangon, Myanmar.

McCartney, M., Pavelic, P., Lacombe, G., Latt, G., Zan, A. K., Thein, K., Douangsavanh, S., Balasubramanya, S., Ameer, R., Myint, A., Cho, C., Johnston, R and T. Sotoukee (2013). Water

Resource Assessment of the Dry Zone of Myanmar. Report to Livelihoods and Food Security Trust Fund /UNOPS for Component 1.

Mollinga, P., A. Bolding, 2004. The politics of irrigation reform: Contested policy formulation and implementation in Asia, Africa and Latin America. Ashgate, London.

Mukherji, A.; Fuleki, B.; Shah, T.; Suhardiman, D.; Giordano, M. and Weligamage, P. 2009. Irrigation reform in Asia: A review of 198 cases of IMT. Final report submitted to the ADB. Colombo: International Water Management Institute.

Nikku, B., 2006. The politics of policy: Participatory irrigation management in Andhra Pradesh. Phd thesis. Wageningen University, The Netherlands.

Ostrom, E., 2010. Nested externalities and polycentric institutions: Must we wait for global solutions to climate change before taking actions at other scales? Economic Theory 1-17.

Ostrom, E., 1999. Institutional rational choice: An assessment of the institutional analysis and development framework, in: P. Sabatier (ed), Theories of the policy processes: Theoretical leases on public policy. Westview Press, Colorado, pp. 35-71.

Pasandaran, E., 2010. Historical perspective of irrigation management in Indonesia: Toward a new wave of development. Paper presented at ICID Seminar on History of Irrigation in Eastern Asia, 13 October 2010, Yogyakarta, Indonesia.

QSEM, 2012. Qualitative social and economic monitoring. Round one report, World Bank and Myanmar Development Research.

QSEM, 2011. A pilot qualitative social and economic monitoring. Livelihoods and Food Security Trust Fund.

Strauss, A., J. Corbin, 1990. Basics of qualitative research: Grounded theory procedures and techniques. Sage publications, New Delhi.

Subramanian, A., N. Vijay Jagannathan, R. Meinzen-Dick, 1997. Users organizations for sustainable water services. World Bank technical paper 354. The World Bank, Washington DC.

Suhardiman, D., 2008. Bureaucratic designs: The paradox of Irrigation Management Transfer in Indonesia. Phd thesis. Wageningen University, the Netherlands.

Van Maanen, Th. D., 1931. Irrigatie in Nederlandsch Indie (Irrigation in Indonesia). Visser and co.

Varughese, G., E. Ostrom, 2001. The contested role of heterogeneity in collective action: Some evidence form community forestry in Nepal. World Development 29(5): 747-765.

WFP (2011). Food Security Assessment in the Dry Zone Myanmar. World Food Program, Food and Agricultural Research Organization.

Annex 1: Water Sources and Characteristics for each Village

<u>Large irrigated area</u>

VILLAGE	NAME OF THE IRRIGATED SYSTEM	IRRIGATED AREA (ACRES)	TYPE OF LIFTING MECHANISM & SOURCE OF WATER	TYPE OF CANAL	MANAGEMENT	FUNDING AGENCY	START YEARS
Dry Season Irrigation							
Nwar Kyoe Aing	Ayeyarwady River water pumping project (Myit Yay Tin Project)	200	Diesel engine, River	Earthen canal and bricks	Irrigation Department and WRUD	Government's fund	2003 - 2006
Ohn Hne Chaung	Ayeyarwady River water pumping project (Myit Yay Tin Project)	539	Diesel engine, River	Earthen canal and bricks	Irrigation Department and WRUD	Government's fund)	2003
De Pa Yin Kwal	Groundwater pumping	1,500	Diesel engine Tube well motorized	Pipe	Private	Private	2001
Ta Ein Tel	Sintat river (Ayeyarwady river) pumping project	300	Pumping from Ayeyarwady river and irrigate by diesel engine	Earthen canal	Irrigation Department/WRUD	Irrigation Department/WRUD	2012
Sarr Taung	Two types from Magyiphyu Dam and from Groundwater	410	gravity dam irrigation by canal and collective Tube well motorized diesel	Earthen canal	Irrigation Department and City Development Committee	Irrigation Department and City Development Committee	2003
Supplementary irrigation							
Tha Hpan Kone	"Kandawgyi pond " to paddy lands as a water distribution program	1,300	Normally gravity flow, need to pump as low level due to dry spell	Earthen canal	Irrigation Department	Irrigation Department	Ancient water storage system

Surface and groundwater sources and uses per village

	TOTAL IRRIGATED AREA (ACRES)	MANAGEMENT TYPE	NUMBER OF MOTORIZED TUBE WELL PUBLIC - PRIVATE	USE OF MOTORIZED TUBE WELL*	NUMBER OF MANUAL TUBE WELL PUBLIC - PRIVATE	USE OF MANUAL TUBE WELL*	NUMBER OF MOTORIZED DUG WELL PUBLIC - PRIVATE	USE OF MOTORIZED DUG WELL*	NUMBER OF MANUAL DUG WELL PUBLIC - PRIVATE	USE OF MANUAL DUG WELL*
Dry Season Irrigation										
Nwar Kyoe Aing	200; Irrigation scheme	Government	2-1	4	0-0	-	0-0	-	0-0	-
De Pa Yin Kwal	1500; Tube well in dry season Pond in rainy season for few acres	Private	147-0	7	241-0	7	10-0	7	0-0	-
Ta Ein Tel	300 irrigation scheme	Government	15-0	4	50-0	4	4-0	4	3-0	4
Sarr Taung	410 Irrigation Scheme	Government	170-0	7	15-0	4	2-0	4	2-0	4
Ohn Hne Chaung	539 Irrigation scheme	Government	11-1	7	0-0	-	0-0	-	0-0	-
Supplementary irrigation										
Kyauk Tan	50, including 30 acres supplementary irrigation during monsoon (tube well)	Private	0-0	-	20-0	4	400-0	7	100-0	1
Ma Hti San Pya	20 1HH with tube well 15 acres from tube well 5 acres from rain water collection pond as supplementary irrigation	Private	7-1	2	70-0	4	0-0	-	0-0	-
Tha Phan Kone	1,300	Public	1-1	4	34-0	4	21-0	4	30-0	4

	TOTAL IRRIGATED AREA (ACRES)	MANAGEMENT TYPE	NUMBER OF MOTORIZED TUBE WELL PUBLIC - PRIVATE	USE OF MOTORIZED TUBE WELL*	NUMBER OF MANUAL TUBE WELL PUBLIC - PRIVATE	USE OF MANUAL TUBE WELL*	NUMBER OF MOTORIZED DUG WELL PUBLIC - PRIVATE	USE OF MOTORIZED DUG WELL*	NUMBER OF MANUAL DUG WELL PUBLIC - PRIVATE	USE OF MANUAL DUG WELL*
	Monsoon season									
Kone Thar	5 Few farmers use groundwater for supplementary irrigation cash crops –tube well	Private	40-0	2	83-0	1	0-0	-	0-0	-
Daung Gyi	5 Store water from stream in pond in monsoon and irrigated 5 acres – Few farmers use groundwater for supplementary irrigation cash crops	Private	10-0	5	350-0	4	10-0	4	10-0	4
Kan Du Ma	5 Few farmers use groundwater for supplementary irrigation with tube-well for betel leaf	Private	43-0	2	208-0	4	3-0	4	0-0	-
Yae Twin Kone	<5 Few farmers use groundwater for supplementary irrigation cash crops	Private	7-0	2	178-2	4	0-0	-	0-0	-

	TOTAL IRRIGATED AREA (ACRES)	MANAGEMENT TYPE	NUMBER OF MOTORIZED TUBE WELL PUBLIC - PRIVATE	USE OF MOTORIZED TUBE WELL*	NUMBER OF MANUAL TUBE WELL PUBLIC - PRIVATE	USE OF MANUAL TUBE WELL*	NUMBER OF MOTORIZED DUG WELL PUBLIC - PRIVATE	USE OF MOTORIZED DUG WELL*	NUMBER OF MANUAL DUG WELL PUBLIC - PRIVATE	USE OF MANUAL DUG WELL*
Pa Kar	3 Pumping from a canal	Private	5-0	4	52-0	4	7-0	4	7-0	4
Fully Rainfed										
Bay Yin	0	-	0-0	-	113-0	4	22-0	5	22-0	5
Kha Yu Kan	0	-	1-0	4	0-0	-	0-0	-	0-0	--
Let Tet	0	-	0-0	-	0-0	-	3-0	4	4-0	4
Taik Pwe	0	-	0-0	-	50-0	4	0-0	-	0-0	-
Taung Yinn	0	-	0-0	-	36-0	1	6-0	1	6-0	1
Kan Ma	0	-	0-1	4	0-0	-	0-0	-	0-0	-
Thea Pyin Taw	0	-	0-1	4	3-0	1	4-0	4	0-0	-
In Taw	0	-	3-0	4	0-0	-	0-0	-	0-0	--
Kyauk Sit Kan	0	-	0-0	-	0-0	-	0-0	-	0-0	-
Pha Yar Gyi Kone	0	-	0-1	4	0-0	-	0-0	-	0-0	-

*Groundwater uses: 1: Domestic only ; 2:Irrigation; 3: livestock; 4: domestic and livestock; 5: domestic and irrigation; 6: irrigation and livestock; 7: All

River, pond and spring uses per village

	RIVER	RIVER USE*	POND	POND USE*	SPRING	SPRING USE*
Dry Season Irrigation						
Nwar Kyoe Aing	1	7	0	-	0	-
De Pa Yin Kwal	1	7	2	7	0	-
Ta Ein Tel	0	-	1	7	0	-
Sarr Taung	1	7	36	4	0	-
Ohn Hne Chaung	1	7	0	-	0	-
Supplementary irrigation						
Kyauk Tan	1	6	0	-	0	-
Ma Hti San Pya	0	-	2	6	1	4
Tha Phan Kone	0	-	2	4	0	-
Kone Thar	0	-	3	4	0	-
Daung Gyi	0	-	1	2	0	-
Kan Du Ma	0	-	2	3	0	-
Yae Twin Kone	0	-	3	3	0	-
Pa Kar	2	2	0	-	1	4
Fully Rainfed						
Bay Yin	0	-	0	-	0	-
Kha Yu Kan	0	-	2	4	0	-
Let Tet	0	-	1	4	0	-
Taik Pwe	0	-	0	-	0	-
Taung Yinn	0	-	11	4	0	-
Kan Ma	0	-	1	4	0	-
Thea Pyin Taw	0	-	2	4	0	-
In Taw	0	-	1	4	3	1
Kyauk Sit Kan	0	-	2	4	2	1
Pha Yar Gyi Kone	0	-	3	4	0	-
Chaung Phyar	0	-	0	-	1	1

*Surface water uses: 1: Domestic only; 2:Irrigation; 3: livestock; 4: domestic and livestock; 5: domestic and irrigation; 6: irrigation and livetock; 7: All

Annex 2: Past and Current Interventions captured through the Community Survey

Water for Agriculture

In our village sample, interventions in relation to water for agriculture have included irrigation schemes from surface water sources that are managed by the Government, as well as the exploitation of groundwater resources (dug-wells manual lift and motorized and manual lift tube wells), that are funded through development agencies and also privately by individual farmers (see Table 8.1).

Two **Government irrigation schemes** were discussed during our community survey in the irrigated villages. In Nwar Kyoe Aing village (Mandalay region), it was recorded that **water was pumped from the river to irrigate agricultural land**. This was funded through the Irrigation Department. According to the farmers however, this was considered to have had mixed results in terms of success, at least until recently. This is because the farmers with irrigation, farmers were instructed to grow rice in replacement of groundnuts. However, limited knowledge of irrigation and cropping technique limited the yield at least in the first years. In the Sagaing region in the Ta Ein Tel village, the government developed an irrigation scheme based on a pumping station on the river and a pond allowing intensification of agriculture to three crops per year. However, in time of water scarcity tail end farmers suffer from drought and cannot irrigated their crops (for a more in-depth account, please refer to the institutional case study in Chapter 7).

With regard to interventions specifically focused on supplementary wet season irrigation, two were described under this village category in our sample during the community survey. For example, in Tha Phan Kone village in Magway, supplementary water for paddy is supplied since 2012 by the Irrigation Department **pumping water from Kandawgyi pond to paddy lands** as part of their water distribution program. This benefitted households in terms of paddy cultivation, especially farmers from the head canal area (167 households). However tail-end farmers did not benefit. To address this issue the Irrigation Department had pumped the water up into the canal to reach the tail end. The Irrigation Department covered the costs for diesel and farmers contributed their labor. Despite these efforts however, some tail-end farmers were unable to obtain water due to the very low rainfall and low water level in the canal.

Groundwater interventions were also used for agriculture. For example in Ma Hti San Pya village (in Magway), it was noted that in 2007 **three tube wells (depth approximately 50 feet)** were drilled for supplemental irrigation purposes by PC Myanmar. This intervention was specifically targeting marginal farmers and provided them with supplementary irrigation during the rice transplanting period in June. Groundwater interventions that are primarily for irrigation may also be used for other purposes too. For instance in the De Pa Yin Kwal village (in Sagaing), in 1997 WRUD constructed five **dug wells with manual lift for both irrigation and domestic use** which was considered a success. In addition, in this village there are a large number of private manual tube wells (241 units) and motorized tube wells (147 units) that are used for irrigation purposes. For additional details refer to the institutional case study in Chapter 7.

Water for Domestic use

In all three types of villages groundwater resources are utilized in relation to domestic water use. A number of past and current interventions associated with dug wells with manual lift, motorized and manual lift tube wells as well as combined tube wells (that included both a motorized and manual-lift tube well) were reported during our community survey (see Table 7.1). These investments had been funded through a range of different sources - Government agencies, private donors, development agencies, collective groups in the village and also through individual farmers in some cases.

Different types of interventions that exploit groundwater may be adopted within the same village with funding support from different sources. For example in the SarrTaung village an irrigated village in Sagaing, community members described five dug wells that were constructed in about 2003, with the support of the City Development Committee. There were however water quality issues (as reported in some other villages too), and in this case the water was too salty to be used for drinking or any other domestic uses, although a few households did use the water for bathing purposes. Another investment in this village was a combined motorized tube well (seven hole tube well) that was 65 feet deep and installed in 2002 with the funding support of a private Japanese donor. Water was pumped from that tube well to a holding tank and then distributed to households in eight wards. The pipe line was installed from the tank to the wards by the households at their own cost. There were altogether eight wards. Water can be distributed to 500 households living in 4 wards for one hour daily on an alternative basis.

Taking on board the range of different donors funding domestic water use initiatives in the Dry Zone, it was interesting to note that in one rainfed village, PhaYar Gyi Kone in Mandalay, in 2012 a **motorized tube well** was drilled in the village with the funding support of MOGE (Myanmar Oil and Gas Enterprise) and South East Asia Gas Pipeline Co. Ltd. The entire village benefited according to the community members as all households (both marginal and landless farmers) had easy access to domestic water and drinking water as well as could use the water for livestock. Water stress especially in the dry season was addressed by this intervention. There was a time saving mentioned in terms of water collection and the fact that farmers were able to use this time to devote to other income generating activities. The success of this intervention was also believed to be as a result of the good cooperation between the donor organization and the village community.

Ponds were another intervention reported in our survey with regard to water for domestic use. In some instances water is collected from surface water sources. For example, in Taung Yinn village, during a period of drought, to reduce water stress, **water is pumped from a reservoir** with a four inch water pipe and the water is successively driven by four pumps **into the north village pond** via the village creek. The pond is used for domestic purposes only. This is an example of collective action that was initiated within the village to find a solution to the problem of water scarcity. Private Donors and villagers fund this intervention. Fuel (diesel) costs for the pumps are funded by the Township elders as well as the villagers (money is collected from each household). As a result of this pond, drinking water is sufficient for villagers and also livestock. The landless were enabled to save time allocated for water collection as a result of this intervention and engage in other productive livelihood activities. For further details refer to the institutional case study in Chapter 7.

Ponds however need to be maintained and may fall into disuse for various reasons. Associated with this, pond renovations were another intervention that was reported in our community survey. For instance in Kan Ma rainfed village in Mandalay, a **pond renovation** was supported by UN Habitat and USAID in 2012. This was considered a success as it provided access to water for livestock, domestic use and drinking for the entire village over the past six months. In another rainfed village, Thea Pyin Taw, in

Mandalay, **the reconstruction of a rainwater storage pond with a higher embankment** in 2013 with Government funding (through the Irrigation Department) was reported. As a result of the existence of the old pond, the building costs were lower and reconstruction was also completed in a short period of time. According to our survey, the understanding was that all members of the village would benefit from this rainwater storage pond, where water could be accessible through the year.

Furthermore there were interventions that were focused specifically on drinking water. For instance with respect to improving the quality of drinking water, one intervention noted in Ta EinTel village in Sagaing was the **distribution of ceramic water filters** by an American organization and the provision of training on usage. This was beneficial in terms of health and there was also a saving made with respect to purchasing water containers. An intervention in Thea Pyin Taw village funded by BAJ in 2012 was **a concrete sand filter and 50 gallon concrete tanks**. This intervention was specifically targeting marginal and landless farmers in the village. This proved to be beneficial as it enabled them to store a larger volume of water due to the provision of water containers (the concrete tanks) and they could also have access to clean drinking water with the use of the concrete sand filters, thus helping to lower the incidence of water borne diseases.

Interventions to address flooding

As we see in Chapter 5, in addition to drought related events, the Dry Zone may also experience flooding events. With respect to interventions to address these, two were described during our community survey.

In TaungYinn village in Sagaing, as a result of floods, in 2006, the low land cultivation area in the village was flooded and needed to be drained off. Through a coordinated effort of the Township elders of Sagaing and the villagers, an attempt was made to **reduce the flood area by digging a drainage tunnel**. However not all the flood water could be drained off and therefore crops could not be grown. This flood mitigation intervention required a big investment and was beyond the scope of the village to address alone.

In the Thea Pyin Taw village in Mandalay, a **sand dam was constructed in 2012 to provide protection from floods**. This intervention had been proposed by the village community to UN-HABITAT and after a technical feasibility study had been conducted, the construction was funded by UN-HABITAT and USAID. The community contributed their labor during the construction. It was noted that the Min Kan Dam situated fairly close to the village had been damaged about 10 years ago and as a result no water could be contained in the creek near the village boundary, leading to water scarcity for the villagers. With the construction of the sand embankment, it is possible to contain some amount of water for hand dug wells. Therefore in addition to providing protection from potential flooding, the embankment enhanced groundwater recharge too. This is hence a useful intervention whereby the water problem in the village was resolved to a certain degree, in addition to playing a flood protection role.

Table A2.1. Past and Current Interventions in relation to water management reported during community survey

PAST AND CURRENT INTERVENTIONS	VILLAGES WITH IRRIGATION (N=5)	VILLAGES WITH NO IRRIGATION (RAINFED) (N=11)	VILLAGES WITH SUPPLEMENTARY IRRIGATION (N=8)
Agriculture related	**Irrigation schemes:** in NwarKyoeAing (Mandalay), water was pumped from the river to irrigate agricultural land. Funded through the Irrigation Department. In the Ta Ein Tel, Government irrigation scheme where water is transmitted to a pond from the Sintat river pumping project		**Pumping water from Kandawgyi pond to paddy lands** in ThaHpanKone (Magway), supplementary water for paddy supplied by **the Irrigation Department.** **Tube wells (depth approximately 50 feet)** for supplemental irrigation purposes in Ma Hti San Pya (Magway), by PC Myanmar.
Irrigation and domestic both	**Dug wells with manual lift**: in De Pa Yin Kwal (Sagaing) by WRUD using Government funds. **Private motorized and manual tube wells** in De Pa Yin Kwal (Sagaing) also used for irrigation and domestic purposes.		
Domestic use including livestock	**Motorized deep tube wells**: inOhnHneChaung (Mandalay) one with the funding from a private donor and the Township Development Department of Nyaung-U and one with funding from Japanese; in Ta Ein Tel (Sagaing) one funded by Japanese; in SarrTaung (Sagaing) also funded by Japanese. **Dug wells with manual lift:** in SarrTaung (Sagaing) with support of the City Development Committee.	**Motorized dug tube well** in Kan Ma (Mandalay) was financed by the Mandalay Region Development Council and Nyaung Oo City Development Council. In TheaPyin Taw (Mandalay) installed with funding from BAJ. And another being constructed for the village by the Government (City Development Committee). In PhaYar Gyi Kone (Mandalay) drilled in the village with funding from MOGE (Myanmar Oil and Gas Enterprise) and South East Gas Pipeline Co. Ltd. Also in ChaungPhyar (Mandalay) was funded by the Kyauk Pan Daung Township. One reported to be unsuccessful in Let Tet (Magway) which was funded by TaungDwinGyi City Development Committee. **Pond renovation** in Kan Ma (Mandalay) supportedby UN Habitat and USAID. Rehabilitation of collective ponds in Kyaut Sit Kan (Mandalay).	**Tube wells (approximate depth 100 feet)** in TaungYinn (Sagaing) and are self-funded by the villagers. **Dug private motorized and manual-lift tube well (combined tube wells**) in Kan Du Ma village (Sagaing,) and are self-funded by villagers **Ponds** in Kan Du Ma (Sagaing) two reserved only for livestock. **Water pumped from the Myittha Riverwith a four inch water pipe by 4 pumps into a village pond** in TaungYinn (Sagaing) funded by township elders and villagers.

		R**ainwater storage pond** with a higher embankmentin TheaPyin Taw (Mandalay) funded by the Government (Irrigation Department). Also in PhaYar Gyi Kone (Mandalay) with technical and funding support of IDE- proximity Design and LIFT. **A concrete sand filter and fifty gallon concrete tanks**in Kan Ma (Mandalay) also funded by UN Habitat and USAID. Also in TheaPyin Taw (Mandalay) funded by BAJ. **Sand filter for water purification in a pond** in Kan Ma (Mandalay) with AMDA funding.	
Drinking water only	**Motorize tube well:** in the NwarKyoeAing (Mandalay) with support of the BAJ organization. **Building of a reservoir (brick tank that stored water pumped from the river** in in NwarKyoeAing (Mandalay), by the Irrigation Department. **Rehabilitation of a silted pond** in SarrTaung (Sagaing)**,**through the cooperation of village members. **Distribution of ceramic water filters** in Ta Ein Tel (Sagaing) by an American organization.		
Flood mitigation		**Sand dam to provide protection from floods** in TheaPyin Taw (Mandalay), funded by UN-HABITAT and USAID.	**Digging a drainage tunnel to reduce the flood area** in TaungYinn (Sagaing) through a coordinated effort of the Township elders of Sagaing and the villagers.