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# RESEARCH PAPER

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# Analyzing Water Uses and Management for the Agriculture Sector in Myanmar's Dry Zone in the Face of Climate Change


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## 1. Introduction

Myanmar is a largely agrarian country located on the mainland of Southeast Asia. Agriculture contributes around 30 percent to the country's GDP with annual growth of about 3.2 percent in 2016.[1] About 61 percent of the total population is engaged in farming activities.[1] This implies that improvement in the agricultural sector will benefit the majority of the population. However, agricultural production in the country has been increasingly vulnerable to climate change. In 2017, Myanmar was rated as the second most vulnerable country in the world to climate change.[2] This is due to the fact that the country relies strongly on the agricultural sector, plus the limited adaptation and mitigation strategies.[2]

The dry zone (DZ), one of the major agricultural production areas, is more vulnerable to climate change than other agro-ecological zones in the country. In recent years, there have been changes in the climatic conditions of the DZ in terms of more erratic rainfall and a shorter rainy season, while the period of drought has been prolonged.[3] Such changes have had a negative impact on agricultural production. The government has made significant efforts to scale-up irrigation facilities and to improve water management in the agro-ecological zones. Water management, in this respect, means "organizing water resources and controlling water supplies in the best possible way in order to provide sufficient water''.[4]

A number of research papers have dealt with the issue of water resource utilization and management in the dry zone. This paper aims to present a synthesis of information based on those existing publications. The focus of the paper is on: (1) an overview of the current situation in respect of water resource utilization and management in the dry zone; (2) an assessment of the impact of climate change on agricultural production; and (3) a review of the policies and programs related to water resource management in the dry zone so as to identify options for improvement.

The paper begins with an overview of the agrarian characteristics of the dry zone and how the change in climatic conditions affects agricultural production in the area. The subsequent part looks exclusively at water resource utilization and management, leading to a discussion on the related programs and policies that have been implemented. The last section provides a conclusion.

## 2. Geographical conditions of the dry done

The dry zone (DZ) lies within Myanmar's central flat plains surrounded by mountains to the east and west, covering more than 75,000 $km^2$ (13 percent of the country area) (Figure 1). The southern part is parallel with the Bago Hills, gaining altitude towards the north and ending in southeast Mandalay.[5] The population of the DZ is approximately 10 million people (34 percent of the total population) and more than 80 percent are engaged in farming activities. The DZ has two main seasons: (1) the wet season with the southwest monsoon (May to October); and (2) the dry season (November to April).[3, 6] Annual rainfall is between 500 and 1000 mm.[3, 6] The DZ intersects with three major rivers - (1) the Irrawaddy, (2)the Chindwin and (3) the Mu - and these provide opportunities for the construction of large-scale formal irrigation systems near the area.[7]

Figure 1: Map of the dry zone


*Source: MIMU (Myanmar Information Management Unit) 2013*

## 3. Agriculture in the dry zone

Myanmar has three major agro-ecological zones: (1) the delta zone; (2) the dry zone, and (3) the hill zone.[3, 8, 9] The dry zone (DZ) is the region that is the most vulnerable to water-stress due to extreme weather events such as erratic rainfall and persistent dry spells in the growing season.[5, 7, 8, 9] The area is characterized by clay and sandy soils, exposing the zone to a high risk of water and wind erosion.[3, 6, 10] Farming in the DZ depends heavily on rainwater, and crop production is vulnerable to water stress and drought. The area consists of three regions: (1) Sagaing; Mandalay; and Magwe (Figure 1).[3]

Even though it is considered to be the driest part of the country, the DZ is capable of producing a considerable amount of agricultural products. The majority of farm households can grow multiple crops. [6] In 2010, the DZ contributed 22 percent of the total paddy produced in the country, 89 percent of sesame, 69 percent of groundnut, 70 percent of sunflower, 92 percent of pigeon pea, 97 percent of chickpea, 52 percent of green gram, and 95 percent of cotton, with 40-90 per cent of whole pulses and beans (Table 1).[5, 11]

Table 1: Types of agricultural production in the dry zone in 2010 (% to the total production of the country)

| No | Types of crops | Percentage |
|---|---|---|
| 1 | Paddy | 22% |
| 2 | Sesame | 89% |
| 3 | Groundnut | 69% |
| 4 | Sunflower | 70% |
| 5 | Pigeon pea | 92% |
| 6 | Chickpea | 97% |
| 7 | Green gram | 52% |
| 8 | Cotton | 95% |

*Source:* Water Resource Assessment of the Dry Zone of Myanmar Final Report for Component 1

### *3.1 Characteristics of the dry zone's agro-ecosystems*

The DZ's agricultural systems are complex and diverse with different crops and types of traditional land. The area has four kinds of traditional land: (1) Le – paddy land; (2) Ya – dry land; (3) – Kaing-kyung (alluvial land/island); and (4) Taung-ya – shifting cultivation (Figure 2). The characteristics of these agro-ecosystems are illustrated in Table 2.

Figure 2: The dry zone's agro-ecological systems

*Clockwise, from top left; Le (paddy land), Ya (dry land), Taung-ya (shifting cultivation), Kaing-kyung (alluvial land/island) – Source: Google*

- ***Le farming:*** located on flat land with impermeable heavy soils. The location is suitable for rice farming and other crops such as oilseeds and pulses.
- ***Ya (dry land)*** is a kind of lowland, not flood prone, and with no irrigation. Major crops are groundnuts, sesame, sunflower and pulses. Farmers on Le and Ya lands prepare their land between February and May then they grow their crops when the moisture in the soil is sufficient - during mid-May to mid-June.
- ***Taung-ya*** is a kind of shifting cultivation practiced by people over the hilly areas of the DZ. Farm production here is subsistence and rain-fed covering a wide variety of crops such as rice, maize, sesame, soybean, vegetables and orchards.
- ***Kaing-kyung land*** is found near rivers, including riverbed areas, and is cultivated in the dry season when the water has receded. The main crops are oilseeds, pulses, vegetables and tobacco.[3]

Table 2: Characteristics of the dry zone's agro-ecological systems

| Characteristics | Le (paddy land) | Ya (dry land) | Taung-ya (shifting cultivation) | Kaing-kyung (alluvial land/island) |
|---|---|---|---|---|
| Topography | Flat land suitable for paddy cultivation, impermeable heavy soils | Low land, not flood prone, no irrigation Cropland (not suitable for paddy cultivation) | Land in hilly areas | land near rivers, including riverbed areas |
| Cultivation Season | Rainy season | Rainy season | Rainy season | Dry season |
| Type of Crops | Paddy, rice, oilseeds and pulses | Groundnut, sesame, sunflower and pulses | Rice, maize, sesame, soybean, vegetables and orchards | Oilseeds, pulses, vegetables and tobacco |

*Source: Improving water management in Myanmar's dry zone for food security, livelihoods and health*

### *3.2 Impacts of climate change on agriculture in the dry zone*

By nature, the DZ is characterized by changing rainfall patterns, water scarcity and the risk of crop failure.[3, 6] Climate change has contributed to the changing climatic conditions - for example more prolonged drought and erratic rainfall.[12] All of these exacerbate the risks to agricultural production, threatening the livelihoods of farm households who depend on it. In 2010 and 2011, the dry spell adversely affected 129,811 acres of cultivated land, damaging 2,844 acres, and causing severe financial loss to approximately 41 percent of farming households. [3, 13]

In the center of the DZ, dry spells are generally long during the wet season, especially up to 14 days long in the longest dry periods, and take place in late July or early August.[3] The average temperature in the DZ has been steadily rising by about 0.8 °C per decade according to Myanmar's historical data on climate (over the past 60 years).[3] Though the literature does not clearly indicate this as a direct result of climate change, the rising temperature, heavier rainfall in some areas and prolonged drought can be expected to have a further negative impact on agricultural production in the area.[3] Furthermore, World Bank data also suggests that, while Myanmar tries to improve its agricultural sector, the country is increasingly facing the negative impacts of climate change from year to year.[14]

As the DZ plays an important role in the agricultural sector development of the country, and the area is increasingly vulnerable to the effects of climate change, there is need to scale-up the existing irrigation facilities and to improve the efficiency of water resource management. This will help to ensure sustainable crop production in the DZ. The section below discusses the issue of water management in the DZ, and highlights the relevant policy implementation.

## 4. The current situation of water management in the dry zone

Though most of the cultivated land in the DZ is rain-fed, the zone has three sources of water: (1) rainwater; (2) surface water from rivers and streams; and (3) groundwater. About 90 percent of the water is used for agricultural purposes.[3, 15]

### *4.1 Rainwater resources*

The DZ's rainfall has differed widely from year to year, while the changing climatic conditions have been posing additional risks for farmers who depend on rain water for their crops, especially those who are located in the central dry zone.[3, 5] The peripheral area of the DZ receives an annual rainfall of 1,000 mm, the central area receives, on average, less than 500 mm during the wet season and less than 600 mm per year.[7] The DZ farmers save the rainwater by constructing ponds and small-scale dams to improve water supplies for cultivation. The cost of building a pond varies depending on the size and type. Data from the International Water Management Institute (IWMI) indicates that the cost of building a small irrigation dam of around 10 ha is around USD 6,000. Rainwater can provide only a seasonal resource for seven to eight months per year then it dries up during the dry season.[3]

### *4.2 Surface water resources*

Another source of water used in DZ agriculture is surface water. The Irrawaddy River and its tributaries - (1) the Chindwin River (a major tributary), (2) the Mu River, (3) the Shweli River, and (4) the Myitnge River - are the major sources of surface water in the DZ. The surface water has not been extracted to its full potential. First, the extraction requires the establishment of a pumping irrigation system and the river flows are only adequate mainly during the rainy season especially in respect of the tributaries of the Irrawaddy River. Second, during the wet season, DZ farmers need to store rainwater for irrigation in the dry season. All these activities add to the cost of production, from digging the pond to purchasing the water storage facilities, and that might constitute a constraint for poor farmers.[3, 5]

Cultivation along the river banks and in the areas nearby are also at risk of crop failure as a result of early floods. To provide flood-warning alerts, water level measurements are made at key locations in the dry zone during the wet and dry seasons. To boost agricultural production in the areas where surface water is available, Myanmar's government has constructed more than 60 large reservoirs to collect surface water for irrigation and the total storage capacity is estimated to be 7,760 $mm^3$. In 2015, there were also about 2,000 small reservoirs with a total water storage capacity of 1,020 $mm^3$.[3, 5]

### *4.3 Groundwater resources*

Groundwater is also used for crop irrigation and domestic use.[7, 16] Around 50mm of it is recharged being annually by rain water and 63 percent of total extracted groundwater is used for agricultural purposes.[7] The utilization of groundwater in the DZ can be found in four forms (see Table 3):

- Deep tube wells: these represent the formal irrigation methods provided by international donors or with government support. The water is extracted using large electric pumps. Generally, this type of irrigation distributes water through a lined and unlined network of canals. The water is used for wet season rice and high-value crops in the dry season.[7]
- Shallow tube wells and permanent dug wells represent informal irrigation schemes established with funding from either NGOs or private sources. The shallow tube wells are popular among farming households in the rain-fed DZ. Shallow tube wells draw groundwater with small-scale motorized pumps. These offer a kind of informal irrigation method, owned and managed by farming households, and are mostly used to irrigate home gardens or small areas of crop production, mainly for vegetables.[7]
- Shallow dug wells are the third type of groundwater irrigation method in the DZ, and they are mainly established yearly along the river beds to extract the water once it has receded. This method uses human and animal power to operate the pump.[7]
- Indirect pumping is the fourth type of groundwater irrigation method. The water is drawn from an open pool near the canal using a small motorized pump. The water level in the pools that are used are generally consistent with the local groundwater table and have been re-infiltrated by surface water from the surrounding fields. Like the shallow tube wells, this type of irrigation is under the direct control of the farmers.[3, 7, 17]

Table 3: Four main types of groundwater irrigation methods used for agriculture in the dry zone

| Typology | Deep tube wells | Shallow tube wells and permanent dug wells | Shallow dug wells | Indirect Pumping |
|---|---|---|---|---|
| Characteristics | • Formal[i] irrigation<br>• International donors or government<br>• Large-scale electric pumps<br>• Collective-driven<br>• Market-oriented<br>• Highly subsidized | • Informal[ii] irrigation<br>• Private or NGO funding<br>• Small-scale motorized pumps<br>• Farmer-driven<br>• Unsubsidized | • Informal irrigation<br>• Private funding<br>• Small-scale motorized pumps<br>• Farmer-driven<br>• Unsubsidized | • Informal irrigation<br>• Private funding<br>• Small-scale motorized pumps<br>• Farmer-driven<br>• Unsubsidized |

*Source: (1) Improving water management in Myanmar's Dry Zone for food security, livelihoods and health and (2) Identifying priority investments in water in Myanmar's Dry Zone Final Report for Component 3 (3) Integrated Assessment of Groundwater Use for Improving Livelihoods in the Dry Zone of Myanmar*

## 5. Existing irrigation schemes in the dry zone

Irrigation is essential to safeguard crop production in the DZ, which faces rainfall scarcity and variability. Since 1988, Myanmar's government has been trying to improve water utilization for the DZ agriculture sector. In 2010, the aim was to provide irrigation across 25 percent of cultivated land. Up to 2015, less than 16 percent (1,272,593 acres or 515,000 ha) of the cultivated land in the DZ was irrigated, meaning that there was a huge on-going demand for irrigation facilities in the area.[3, 5] Details about the irrigated areas in the DZ are shown in Table 4. The irrigation area of the DZ in 2011 was estimated by the Irrigation Department (ID) to be 850,700 acres, with the use of the maximum number of canals/ pumps/ weirs that can provide adequate water with full capacity. The area delineated by the IWMI was 1,327,100 acres, consisting of some non-formal irrigation systems, and crops drawing on residual moisture. The irrigated area, according to IWMI estimates, is significantly larger than the ID estimate because it includes all types and sources of irrigation in its calculations. [5, 18]

Table 4: Irrigated area estimates by district in the dry zone (2011-2012)

| Division | District | Estimated irrigated area (acres) | |
|---|---|---|---|
| | | Irrigation Department | Delineated by IWMI |
| Sagaing | Shwebo | 133,000 | 228,000 |
| | Sagaing | 3,500 | 770,000 |
| | Monywa | 58,500 | 20,460 |

[i] Formal irrigation systems are mostly directed to agribusiness producers and are controlled by the government. A smaller proportion are used by smallholders.

[ii] Informal irrigation systems are directly managed by the farmers themselves without government control and without being reported in national statistics.

| | | | |
|---|---|---|---|
| Division Total | | 195,000 | 1,018,460 |
| Magwe | Pakokku | 33,500 | 30,390 |
| | Magwe | 87,900 | 27,100 |
| | Minbu | 177,000 | 107,400 |
| | Thayet | 31,000 | 14,200 |
| Division Total | | 329,400 | 179,090 |
| Mandalay | Kyauk Se | 211,700 | 15,000 |
| | Meiktila | 14,300 | 25,500 |
| | Myingyan | 38,300 | 73,700 |
| | Nyaung U | 200 | 15,350 |
| | Yamethin | 61,800 | - |
| Division Total | | 326,300 | 129,550 |
| Overall Total | | 850,700 | 1,327,100 |

*Source: (1) Water Resource Assessment of the Dry Zone of Myanmar Final Report for Component 1 and (2) Irrigation Development and Management*

### *5.1 Types of irrigation systems in the dry zone*

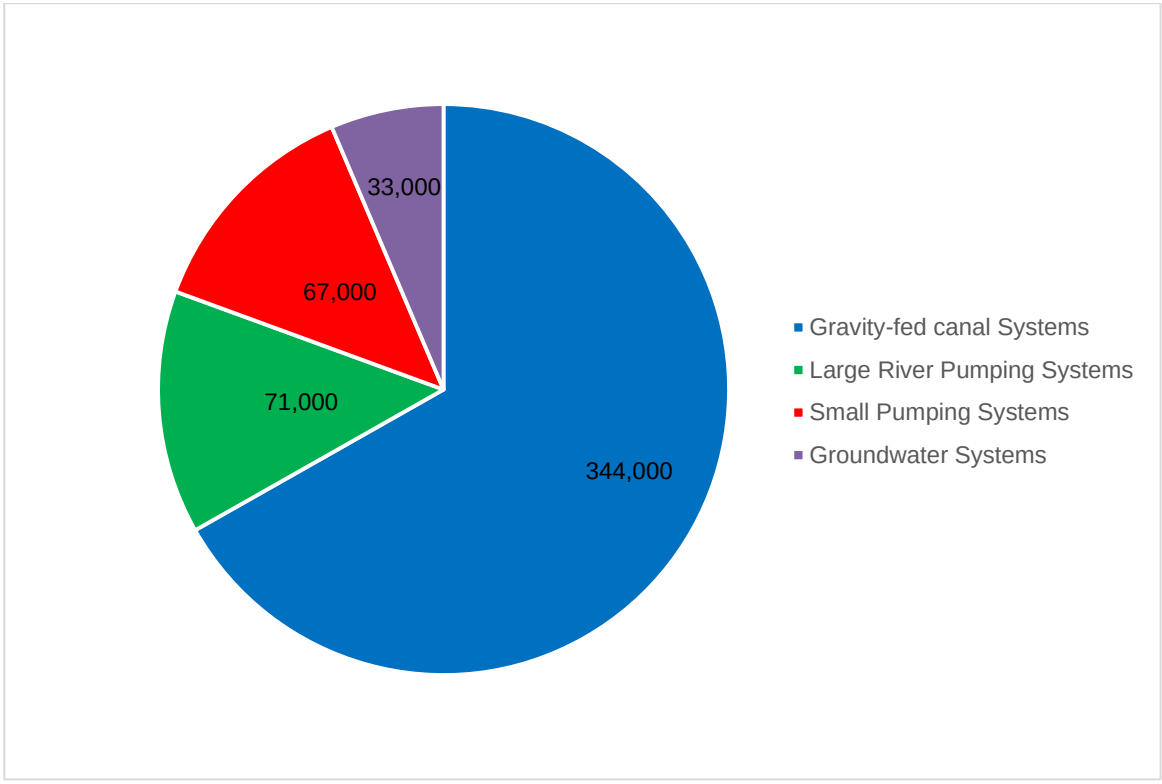
Irrigation in the DZ consists of four types (Figure 4) and Figure 3 shows estimations of the size of the irrigated areas served by the four types of irrigation schemes. The first system, gravity-fed canal systems, managed by the Irrigation Department (ID), are the major irrigation schemes, drawing from surface water, storage dams or weirs, especially designed for paddy fields. By 2013, the total area of this system was around 344,000 ha (850,043 acres).[3, 17]

Large river pumping systems are the second type of irrigation system, drawing water from rivers through the use of high-discharge pumps and there has been a focus on improving this system since 2000. The total area is more than 71,000 ha (175,445 acres) accommodating 18 schemes in the DZ under the management of the Water Resource Utilization Department (WRUD). [3, 17]

Some DZ farmers have overcome the farming constraints that have come from climate change (such as limited amounts of precipitation) by using small-scale, individual pumping systems for surface water and groundwater using motorized pumps from shallow wells or streams. This method is less costly, and is flexible and easy to manage and maintain. At the same time, it helps to reduce the risk climate change exerts on agricultural production.[17] In total, the irrigable area of the small-scale pumping systems is 67,000 ha (165,560 acres), with 165 completed smaller schemes.[3, 17]

According to an IWMI study in 2015, the least extensive irrigation method was groundwater systems covering about 33,000 ha (81,545 acres). Although the area accessed is only around 5 percent of that covered by formal irrigation from groundwater, use of this resource is increasing more quickly than is the case with the other sources.[3, 17]

Figure 3: Four types of irrigation systems in the dry zone in 2013 (ha)




*Source: Improving water management in Myanmar's Dry Zone for food security, livelihoods and health*

Figure 4: Four types of irrigation systems in the dry zone

*Source: IWMI (clockwise, from top left; gravity-fed canal system, large pumping system, small scale pumping system and groundwater system)*

### *5.2 Irrigation projects for the dry zone's agriculture sector*

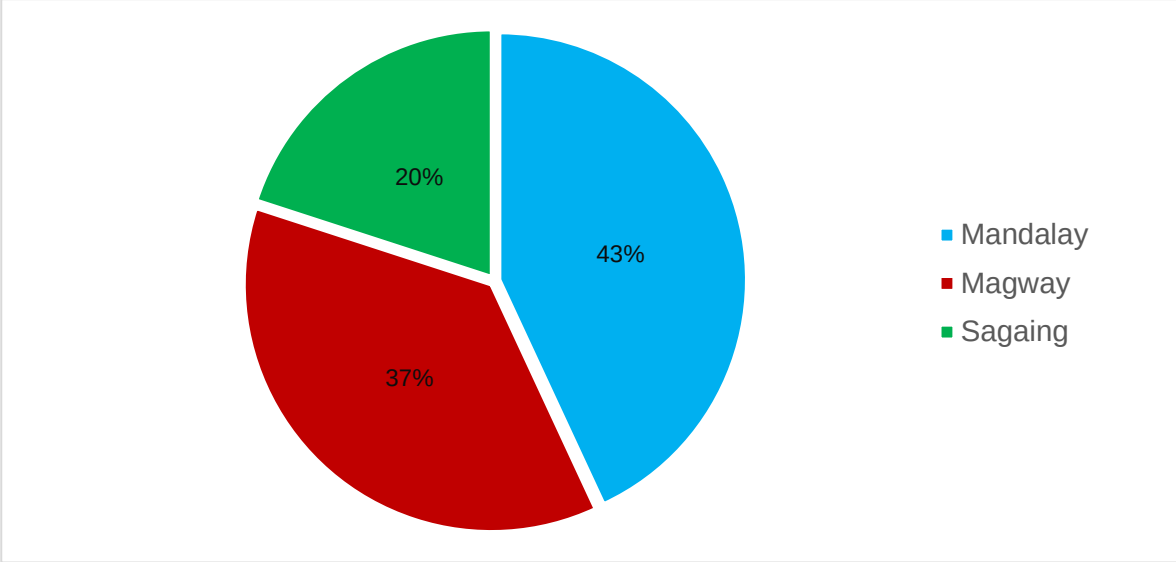
Since 1988, the government has focused on the implementation of new projects for irrigation, for border and rural area development and for the greening of the country. [10, 15, 18] Table 5 shows the irrigated area in the major agro-ecological zones including the DZ, where the extent of the irrigated areas reached 1,087,350 acres (about 2/3 of the total irrigated land in the delta zone but ten times that of the hill zone). The overall number of irrigation projects installed in the DZ was 130 of which Mandalay received the most (43 percent), followed by Magway (37 percent) leaving around 20 percent for Sagaing (see Figure 5).[10, 18]

Table 5: Government irrigation projects and the extent of the areas in Myanmar that benefited from them (1988-2014)

| Zone | State/Region | Number of Projects | Extent of Area benefiting(acres) |
|---|---|---|---|
| Delta Zone | Ayeyarwady | 10 | 322,420 |
| | Tanintharyi | 1 | N/A |
| | Mon | 11 | 113,800 |
| | Yangon | 20 | 304,690 |
| | Rakhine | 6 | 6,450 |
| | Bago | 51 | 900,470 |
| | Kayin | 1 | 100 |
| **Total** | | **100** | **1,647,930** |
| Dry Zone | Mandalay | 56 | 408,120 |
| | Magway | 48 | 301,485 |
| | Sagaing | 26 | 377,745 |
| **Total** | | **130** | **1,087,350** |
| Hill Zone | Kayah | 2 | 3150 |
| | Chin | 1 | 500 |
| | Shan | 7 | 114,675 |
| | Kachin | N/A | N/A |
| **Total** | | 10 | **118325** |
| **Overall Total** | | **240** | **2,853,605** |

*Source: (1)Overview of Irrigation Development and Government Policy in Myanmar, (2) Irrigation Development and Management*

Figure 5: Irrigation projects in Myanmar's Dry Zone




*Source: (1)Overview of Irrigation Development and Government Policy in Myanmar, (2) Irrigation Development and Management*

### *5.3 Challenges and constraints in respect of water management systems*

Apart from being vulnerable to climate change, agricultural production in the DZ has been hampered by a series of issues in relation to the management of water resources for crop production. The primary challenge revolves around how to improve the efficiency of current water management systems. Several cases of mismanagement have resulted from a lack of flexible water distribution and scheduling, limited technical capacity, and inadequate advice to farmers in the use of irrigation water. [3] The unequal distribution of water persists, stemming from the absence of clear and transparent institutional arrangements and guidance policy. [3, 9, 19]

There is also a need to address issues relating to the over-extraction of water resources from individual pumping systems through improving the regulations. Other factors include insufficient funding and high energy costs[iii]. A study revealed that the actual cost of operation for pumping projects, including maintenance, was estimated to be approximately MMK[iv] 40,000 to 45,000 per acre, according to WRUD[v].[3] To construct a well, farmers need to invest an average of USD 110 to USD 1,360; 31 percent covers drilling, 49 percent the motor pump and 20 percent water pipe provision. This cost constitutes a large amount for farmers and varies depending on the configuration and depth of the well, pumping capacity and the range of conditions encountered.[7]

## 6. Policies for water management in the dry zone

As mentioned above, water management is not only crucial for agricultural production in the dry zone, but also makes production more resilient to climate change. The small coverage of irrigated land in the dry zone indicates the need to scale-up the existing irrigation facilities and at the same time to improve the efficiency of water management. Improving irrigation facilities has long been on the development agenda of the Myanmar government.

[iii] Some 97 percent of the pump irrigated area is is served by diesel pumps
[iv] MMK 1 = USD 0.00089 (exchange rate as at June 2015)
[v] WRUD means that Water Resources Utilization Department.

The latest official document relating to water management was the Irrigation Law of 2017, formulated to regulate irrigation and drainage systems in the country as a whole.[20] In 2014, the Integrated National Water Policy relating to water resources was approved, and this was designed to act as a roadmap for the country to achieve the goal of sustainable water resource use by 2020. Established in 2013, the Myanmar Water Resource Committee (MWRC) is the sole institution in charge of the country's water resource management.[21] Apart from this policy, the country did not have a national water law until the one now being drafted .[22] Between 2014 and 2015, the Myanmar National Water Framework Directive (MNWFD) was drafted with public consultations held to pave the way for the National Water Law, which is being drafted by the Advisory Group of the National Water Resources Committee (NWRC) with the support of the World Bank and the International Finance Corporation (IFC).[23] The MNWFD seeks ways to earn revenue by utilizing water resources, to set up a water resources decision support system and a databank, and to promote international collaboration focusing on water sectors and the establishment of a water resources trust fund.[22]

## 7. Conclusion

This research has aimed to address issues surrounding water resource utilization and management in the dry zone in Myanmar, with a particular focus on the implications for agricultural development in the context of a changing global climate. The review has produced several key findings:

- Agriculture production in the DZ is fragile due to the mounting effects of climate change, particularly longer droughts and erratic rainfall. This exposes the livelihoods of farming households to increasingly higher risks of crop failure and financial difficulties.
- The statistics show that more irrigation facilities are required to overcome the issue of water shortage and to boost productivity as well as to increase the capacity of DZ agriculture to be resilient in response to climate change.
- The methods for extracting and collecting water remain quite conventional and thus rather insufficient. Some irrigation schemes are found to be less effective due to a lack of resources to operate and maintain them, along with poor management. This underlines the weakness of current water management in the DZ.
- The law relating to water resources has not been properly updated in response to changing agricultural development.
- With the absence of a policy on water resource management, the projects and programs in this sector have been carried out without a proper roadmap, hampering the coherence of sectorial development.

Based on these findings, the following policy options are suggested in order to improve water resource management for agriculture in the DZ:

The need to expand irrigation facilities in the DZ is pressing, but there is a lack of a comprehensive law covering the management of water resources. To ensure that development takes place with proper guidance from the law, there is an urgent need for a policy on water resource management to be finalized and implemented. At the same time, an improvement in the current water extraction technologies could be made available and distributed to farmers. Additional training to

build human capacity could be delivered to technical staff and those involved in the management and operation of irrigation facilities.

Lastly, a more decentralized approach to water resource management, such as water user groups, could be considered in the integrated national water law. This could bring power to the community to manage and address issues related to water utilization at the local level.

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