EVALUATING THE EFFECTS OF POOR SCHEDULING IN FORMAL IRRIGATED URBAN VEGETABLE PRODUCTION PROJECTS IN THE GREATER ACCRA REGION. A CASE STUDY OF WEIJA AND ASHIAMAN IRRIGATION SCHEMES.

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MASTER OF SCIENCE IN PROJECT MANAGEMENT

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DECLARATION

I, hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no materials previously published or written by another person nor material which to substantial extent has been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgement is made in the thesis.

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ABSTRACT

Irrigation which is the artificial application of water into the soil is a major factor in increasing the yield of produce, as compared to rain fed or weather dependent agriculture which is highly unpredictable and unreliable. Irrigation scheduling is receiving increasing attention in irrigation studies because of the need for adjustments in irrigation schemes that are scheduled poorly. As per the literature review of this research, the irrigation scheduling is broken down into duration of irrigation, timing of irrigation and frequency of irrigation.

The aim of this study was to evaluate the effects of poor scheduling in formal irrigated urban vegetable production in the Greater Accra region. The objectives of this study were, firstly, to identify the types of irrigation mostly used as well as identifying the perception of the farmers towards their current irrigation schedule (duration, timing and frequency of irrigation). Secondly, to determine the factors that cause the poor scheduling as well as identifying the mitigation factors to help control the situation. The third objective looked to determine and evaluate the effects of the poor scheduling on the farmers.

The simple random sampling technique was used in the study. Questionnaires were sent to the farmers under the Ghana Irrigation Development Authority (GIDA). Specifically the Weija irrigation scheme and the Ashiaman irrigation scheme. (10) Questionnaires each were sent to both Weija and Ashiaman summing up a sample size of (20). Results gathered were (19), which was used in conducting the research analysis. Data that was collected from the study was analyzed using Statistical Package for Social Scientists (IBM SPSS).

From the results obtained from the first objective, sprinkler irrigation systems was the most commonly used and a large majority of the farmers were not happy with the duration and frequency of their current irrigation schedule. While majority of the farmers were content with the timing of the irrigation schedule (mornings). For the second objective the results showed that according to the farmers, the main cause of the poor scheduling of irrigation was due to the frequent breakdown of pumps with 42.9% of the farmers in support of that. The results obtained for the final objective of this study showed that the major effect of the poor scheduling is the reduction of income of farmers. In conclusion, there is the need for proper irrigation scheduling in order to improve the productivity levels of the farmers.

Keywords; Irrigation, Irrigation Scheduling, Frequency, Duration, Timing

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

The current world population estimate shows that there are approximately 7,346,235,000 on earth. The introduction of agriculture and the gradual movement of humanity into settled communities saw the global population increase gradually. The total population of Ghana is estimated at 28.8 million people according to the latest census figures. The population of Ghana represents 0.36% of the world's total population which arguably means that one person in every 279 people on the planet is a resident of Ghana (Ghana Statistical Services, 2017). Accra is the capital of the Republic of Ghana. It is the most populous city in the country. The city is one of the most urban in the country and it has developed significantly since the 1990s with the addition of nightclubs, hotels, restaurants and other buildings. The most recent estimates show that the population of urbanized Accra is 2.27 million. Accra's urban area covers 225.67 square kilometers of land, while the entire metropolis has grown to nearly 900 square kilometers. In the metro area, the population density is approximately 1,300 people per square meter. Accra has seen its population grow throughout the years, particularly with immigration. Accra has grown by 185,647 since 2015, which represents 1.97% annual change. (UNFPA, 2012).

Urbanization is the movement of people from the rural areas to settle in the urban areas. The increasing rate of urbanization has caused the reduction of rural food supply to the urban areas due to the unavailability of farm hands. It is predicted that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized (The Economist, 2012). Urban agriculture is a dynamic sector characterized by proximity of production and consumption sites. Its performance is primarily hindered by the difficulty in assessing water to irrigate. At present and more so in the future, irrigated agriculture will take place under water scarcity, insufficient water supply for irrigation will be the norm rather than the exception and irrigation management will shift from emphasizing production per unit area towards maximizing the production per unit of water consumed, the water productivity (Fereres & Soriano, 2006).

The concept of formal irrigated urban vegetable farming is used to imply farming under well-organized system being manned by set up institution with technical men 1to assist farmers receive required levels of water from a dam and extension services for their farming activities.

Irrigation water is pumped through a well-constructed canal unto the farming plots. Weija and Ashiaman are locations for large or formal irrigated urban vegetable farms with sizes ranging between 0.8 to 2.5 acres which are dependent on nearby dams for irrigation. Under this study the form of irrigation practice in weija and ashiaman are regarded as formal irrigated farming. The kind of crops cultivated under this system of irrigation practice ranges from exotic vegetables such as cabbage, radish, lettuce, cauliflower etc., as well as the local ones such as garden eggs, tomatoes and okra. The exotic vegetables occupy more acreage as compared to the local one because there is high demand for the exotic produce by elite and foreigners. For many years, large scale irrigation across the world was based on state driven water management and on a planned innovation process and diffusionist extension services (Poncet et al. 2010).

Irrigation scheduling is the process used by irrigation system managers to determine the timing, correct frequency and duration of watering. Irrigation scheduling also takes into account; the distribution uniformity of the irrigation system, soil infiltration rate, topography of the land, rooting depth of plant and the soil available water capacity (McCready, 2009). The goal in irrigation scheduling is to apply enough water to fully wet the plant's root zone while minimizing over watering and then allow the soil to dry out in between watering, to allow air to enter the soil and encourage root development, but not so much that the plant is stressed beyond what is allowable and also applying the moisture along with the nutrients to meet the evapotranspiration and metabolic water requirements of the crop. Soil moisture deficit within the domain of the available water holding capacity of the effective root zone plays a crucial role in scheduling irrigation.

1.2 Problem statement

Due to urbanization, the population in the Greater Accra region has sky rocketed which has led to a very high demand for fresh vegetable produce for the urban farmers. This is also because of the shortage of hands in the rural farms. Irrigation has proven to be a very useful tool in enhancing all year round vegetable production for both the local and the foreign market. The scheduling of the irrigation however remains a problem. Poor timing, improper frequency, under/over watering etc. can have serious effects on the level of production of the vegetables which ultimately affects the capacity to meet the ever increasing market demand of the urban population. The purpose of this study is therefore to evaluate the effects of poor scheduling in formal irrigated urban vegetable production in the Greater Accra region.

1.3 Research Questions

The following questions were set to help answer the above stated objectives

- What are the forms of various irrigation used and the perception of the current irrigation schedule?
- What are the factors that cause poor irrigation scheduling?
- What are the effects of the poor scheduling of irrigation?
- What can be done to help control the poor scheduling of irrigation?

1.4 Aim of the Study

The aim of this study is to evaluate the effects of poor scheduling in formal irrigated urban vegetable production in the Greater Accra region.

1.5Objectives of the Study

1. To determine the forms of irrigation being used and the perception of the current irrigation schedule.

1. To determine the factors that cause the poor scheduling.
2. To determine the effects resulting from poor scheduling of irrigation.

1.6 Methodology

Data is going to be collected from the farmers involved under this irrigation scheme. The sampling method that will be adopted is the probability or representative sampling of which the simple random method will be used, such that each farmer has an equal chance of being selected. This data will be considered as primary data and it will be collected in the form of questionnaires. The research method that will therefore be adopted for this project is quantitative method.

All the data collected at this stage will be analyzed using statistical package for social sciences (SPSS).

1.7 Relevance of the study

This work is an attempt by the author to give greater insight into formal irrigated urban agriculture, the problems it faces and also its benefits. Another significance of this work is to provide knowledge on the dynamics of urban agriculture and how it improves the socio economic status of the people involved.

Lettuce, okra, tomatoes, cabbage, garden eggs, sweet pepper etc. are a few of the vegetables being cultivated in the urban areas, this study therefore seeks ways to ensure that these vegetables are available all year round to help supplement produce coming in from the rural areas and also those being produced through greenhouse technology. This study is also expected to find practical ways to mitigate the effects of poor scheduling in formal irrigated urban vegetable production.

1.8 Organization of the Study

This study is organized into five chapters. Chapter two presents a review of existing relevant literature on urbanization, urban agriculture, formal irrigation, irrigation scheduling, and the role of urban vegetable production and population growth.

The methodology, which outlines the theoretical framework and relevant model, is the subject of chapter three. The results of the study and discussion of results are presented in chapter four. Chapter five provides conclusions and policy recommendations, as well as limitations of the study.

CHAPTER TWO

LITERITURE REVIEW

2.1 INTRODUCTION

This chapter looks at related and relevant scientific literature regarding the study at hand and how some researchers have been able to apply them in attaining similar industrial and academic goals. It is intended to place the current study in its right perspective.

Agriculture is vital for the overall economic development of Ghana since it is the largest contributor to Gross Domestic Product (GDP) accounting for about 50 %. It also accounts for about 60 % of export earnings and directly or indirectly supports 80 % of the total population economically through farming, distribution of farm products and provision of other services to the agricultural sector (MOFA, 2011). A vital area necessary for the modernization of agriculture in Ghana is irrigation. Unfortunately, the total area under irrigation as at 1996 was estimated at 11,000 ha which formed only 0.44 % of the total land area (Hess,1996) or just 0.26 % of area under cultivation. According to Memuna and Cofie (2005), this has barely changed and this goes to buttress the fact that agriculture is mainly rain fed, subject to the vagaries of the weather despite the fact that yields are greater and cropping is twice yearly on some irrigated schemes.

The first scheme that the government conceived was in 1920 as part of the then Winneba Water Supply Project (Smith, 1969). According to (Abban, 2003), some forms of shallow tube well irrigation could also be identified in South-Eastern Ghana in the 1930's. The 1950's and early 1960's saw the development of some water schemes in the Guinea, Sudan and Coastal Savannah belts which accounted for about 240 earth dams and dug-outs in the north and about 66 in the Ho-Keta plains of the south purposely to provide water for domestic use, livestock and for dry season irrigated farming (Abban, 1994). It was soon after independence in 1959 that the first national irrigation project, Dawhenya, was started but available records indicate that Asutsuare Irrigation Project was the first to be completed in 1967. Even though the records date irrigation in the country to about a century ago, it is clear that serious irrigation is a more recent phenomenon.

African agricultural production systems and consumption patterns are vulnerable to weather, climate variability and change, global markets, and other shocks (African Union Commission, 2014; Challinor et al., 2014; Müller et al., 2011; Nhemachena et al., 2010; Niang et al., 2014). In addition, some of the priority issues facing the African agricultural sector include: addressing hunger and nutrition challenges; economic inequality and poverty particularly in rural areas; management of natural resources (especially land and water) and vulnerability to external shocks (African Union Commission, 2014; Nhemachena et al., 2018; Niang et al., 2014; SADC, 2016). The 2014 Malabo Declaration, adopted by the African Heads of State and Government, reaffirmed the importance of agriculture in achieving shared prosperity and improved livelihoods through accelerated agricultural growth and transformation (African Union Commission, 2014). Over 90% of agricultural activities are mainly under smallholder systems and rain fed. In addition, low agricultural productivity and food insecurity remain critical challenges for millions in Ghana.

The development and performance of the agricultural sector remains central to efforts focused on promoting socioeconomic development and reduction of poverty, food and nutrition insecurity in the region. One of the priority resolutions of the 2014 Malabo Declaration and the Africa Union Commission Joint Conference of Ministers of Agriculture, Rural Development, Fisheries and Aquaculture, to contribute to attaining accelerated growth of agricultural production and productivity, was to increase investments in efficient and effective water management systems (African Union Commission, 2014; African Union Commission, 2014). The Comprehensive Africa Agriculture Development Programme (CAADP) Pillar 1 on sustainable land and water management provides a continental resolve in Africa by African heads of state and respective ministries to increase investments in agricultural water management (AUC and NEPAD, 2009). The 2014 Malabo Declaration re-emphasized this commitment to support accelerated agriculture-led growth and development in Africa (African Union Commission, 2014).

2.2 IRRIGATION

Irrigation can be described as the application/addition of regulated amounts of water to crops at specific predetermined intervals. Irrigation helps in the growth of agricultural crops.

Irrigation helps preserves landscapes and re-vegetate disturbed soils in dry areas and during periods of relatively less than average rainfall. Irrigation also has other uses in crop production, including frost protection, suppressing weed growth in grain fields and preventing soil consolidation. (Ruma, 2011). In contrast, agriculture that relies only on direct rainfall is referred to as rain fed or dry land farming.

There are several methods of irrigation and their uses vary in how the water is supplied to the crops. The aim is to apply the water to the crops as uniformly as possible so that each plant has exactly enough water, neither too much nor too little. They are;

- Surface irrigation; It's the oldest form of irrigation and has been in use for so many years. It is also known as flood or level basin irrigation systems. Water moves across the surface (horizontal) of the agricultural land in order to wet it and infiltrate into the soil (vertical). The water application efficiency of surface irrigation is typically lower than other forms of irrigation. Surface irrigation can be further subdivided into furrow, border strip or basin irrigation
- Drip/ Micro irrigation; It can also be called localized irrigation, low volume irrigation or trickle irrigation. Here water is distributed under low pressure through a piped network and applied as a small discharge to each plant or adjacent to it. The field water efficiency of drip irrigation is typically in the range of 80 to 90 % when managed correctly.
- Sprinkler irrigation; It is also known as overhead irrigation, water is distributed by overhead high pressure sprinklers or guns and is piped to one or more central locations within the field.
- Irrigation by lateral movement
- Sub irrigation; It has been used for many years for areas with high water tables. It is a method of artificially raising the water table to allow the soil to be moistened from below the plants roots zone

2.3 FORMAL IRRIGATION

Formal irrigation may be defined as one that is reliant on some form of permanent irrigation infrastructure funded by the public sector. The development of formal irrigation schemes in Ghana dates back to 1960s. Under the First Republic (19571966), studies in existing water bodies that identified an estimated area of 500,000ha suitable for irrigation was undertaken. Some irrigation schemes, including those at Dawhenya and Ashaiman and sugar-cane cultivation under irrigation at Komenda and Asutsuare for sugar production were initiated and implemented.

During the era of the National Redemption Council, the Dawhenya Scheme was completed while others at Afife, Mankessim, Okyereko, Tono and Vea were initiated. The Afife and Bontanga Schemes were completed and commissioned under the Provisional National Defense Council (PNDC).

By 2003, GIDA had 22 irrigation schemes under its jurisdiction covering about 14,700 ha of which 60% were developed and about 9,000ha actually put under irrigation. In many schemes the rates of utilization are low due to poor operation and maintenance of the facilities. The Government plans to add a total irrigable area of 500,000ha or more (MOFA, 2011).

2.4 IRRIGATION WATER EFFICIENCY

Irrigation water can come from ground water (extracted from springs or by using wells), from surface water (withdrawn from rivers, lakes or reservoirs) or from non-conventional sources like treated waste water, desalinated water, drainage water or fog collection. Modern irrigation methods are efficient enough to supply the entire field uniformly with water so that each plant has the required amount of water it needs. Water use efficiency in the field can be determined as follows;

- Field Water Efficiency (%) = (Water Transpired by Crop ÷ Water Applied to Field) ×100

Today the competition for water resources is very intense because there are now more than 7 billion people on the planet. To avoid global water crises, farmers will have to strive to increase productivity to meet growing demands for food while industries and cities find ways to use water more efficiently. Successful agriculture is dependent upon farmers having sufficient access to water. However, water scarcity is already a critical constraint to farming in many parts of the world. With regards to agriculture, the World Bank targets food production and water management as an increasingly global issue that is fostering a global debate.. Physical water scarcity is include environmental degradation and declining ground water. Economic water scarcity however is caused by a lack of investment in water and insufficient human capacity to satisfy the demand for water.

2.5 Urbanization

Urbanization refers to the population shift from rural areas to urban areas, the gradual increase in the proportion of people living in urban areas, and the ways in which each society adapts to this change (Namara et al., 2010). It is predominantly the process by which towns and cities are formed and become larger as more people begin living and working in central areas. Although the two concepts are sometimes used interchangeably, urbanization should be distinguished from urban growth: urbanization is "the proportion of the total national population living in areas classed as urban", while urban growth refers to "the absolute number of people living in areas classed as urban"(Tacoli, 2015). The United Nations projected that half of the world's population would live in urban areas at the end of 2008. It is predicted that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized (The Economist, 2012). That is equivalent to approximately 3 billion urbanites by 2050, much of which will occur in Africa and Asia (UNFPA). Notably, the United Nations has also recently projected that nearly all global population growth from 2017 to 2030 will be by cities, about 1.1 billion new urbanites over the next 13 years (Barney & Cohen, 2015).

Urbanization is relevant to a range of disciplines, including urban planning, geography, sociology, architecture, economics, and public health. The phenomenon has been closely linked to modernization, industrialization, and the sociological process of rationalization. (Gries and Grundmann, 2018). Urbanization can be seen as a specific condition at a set time (e.g. the proportion of total population or area in cities or towns), or as an increase in that condition over time. So urbanization can be quantified either in terms of, say, the level of urban development relative to the overall population, or as the rate at which the urban proportion of the population is increasing. Urbanization creates enormous social, economic and environmental changes, which provide an opportunity for sustainability with the "potential to use resources more efficiently, to create more sustainable land use and to protect the biodiversity of natural ecosystems."(UNFPA). Urbanization is not merely a modern phenomenon, but a rapid and historic transformation of human social roots on a global scale, whereby predominantly rural culture is being rapidly replaced by predominantly urban culture. The first major change in settlement patterns was the accumulation of hunter-gatherers into villages many thousand years ago. Village culture is characterized by common bloodlines, intimate relationships, and communal behaviour, whereas urban culture is characterized by distant bloodlines, unfamiliar relations, and competitive behaviour. This unprecedented movement of people is forecast to continue and intensify during the next few decades, mushrooming cities to sizes unthinkable only a century ago. As a result, the world urban population growth curve has up till recently followed a quadratic-hyperbolic pattern (Kisekka et al., 2010).

Urbanization occurs either organically or planned as a result of individual, collective and state action. Living in a city can be culturally and economically beneficial since it can provide greater opportunities for access to the labour market, better education, housing and safety conditions, and reduce the time and expense of commuting and transportation. Conditions like density, proximity, diversity, and marketplace competition are elements of an urban environment that deemed positive. However, there are also negative social phenomena that arise, alienation, stress, increased cost of living, and mass marginalization that are connected to an urban way of living. Suburbanization, which is happening in the cities of the largest developing countries, may be regarded as an attempt to balance these negative aspects of urban life while still allowing access to the large extent of shared resources (Sisay and Fekadu, 2013)

In cities, money, services, wealth and opportunities are centralized. Many rural inhabitants come to the city to seek their fortune and alter their social position. Businesses, which provide jobs and exchange capital, are more concentrated in urban areas. Whether the source is trade or tourism, it is also through the ports or banking systems, commonly located in cities, that foreign money flows into a country (SADC, 2016).

Many people move into cities for the economic opportunities, but this does not fully explain the very high recent urbanization rates in places like China and India. Rural flight is a contributing factor to urbanization. In rural areas, often on small family farms or collective farms in villages, it has historically been difficult to access manufactured goods, though the relative overall quality of life is very subjective, and may certainly surpass that of the city. Farm living has always been susceptible to unpredictable environmental conditions, and in times of drought, flood or pestilence, survival may become extremely problematic (Naor, 2000).

Thai farmers are seen as poor, stupid, and unhealthy. As young people flee the farms, the values and knowledge of rice farming and the countryside are fading, including the tradition of long kek, helping neighbours plant, harvest, or build a house. We are losing what we call Thai-ness, the values of being kind, helping each other, having mercy and gratefulness (Fuller, 2012).

Particularly in the developing world, conflict over land rights due to the effects of globalization has led to less politically powerful groups, such as farmers, losing or forfeiting their land, resulting in obligatory migration into cities. In China, where land acquisition measures are forceful, there has been far more extensive and rapid urbanization (54%) than in India (36%), where peasants form militant groups (e.g. Naxalites) to oppose such efforts. Obligatory and unplanned migration often results in rapid growth of slums. This is also similar to areas of violent conflict, where people are driven off their land due to violence. Bogotá, Colombia, is one example of this (Johnson & Rozelle, 2016).

Cities offer a larger variety of services, including specialist services not found in rural areas. These services requires workers, resulting in more numerous and varied job opportunities. Elderly people may be forced to move to cities where there are doctors and hospitals that can cater for their health needs. Varied and high quality educational opportunities are another factor in urban migration, as well as the opportunity to join, develop, and seek out social communities.

Urbanization also creates opportunities for women that are not available in rural areas. This creates a gender-related transformation where women are engaged in paid employment and have access to education. This may cause fertility to decline. However, women are sometimes still at a disadvantage due to their unequal position in the labour market, their inability to secure assets independently from male relatives and exposure to violence (UNFPA, 2012).

People in cities are more productive than in rural areas. An important question is whether this is due to agglomeration effects or whether cities simply attract those who are more productive. Urban geographers have shown that there exists a large productivity gain due to locating in dense agglomerations (Borowiecki, 2013). It is thus possible that agents locate in cities in order to benefit from these agglomeration effects.

2.6 Urban Agriculture

2.6.1 The Role of Urban Agriculture

Urban agriculture refers, verges, balconies, vacant plots, gardens and containers within cities that are used for growing crops and raising small livestock or milk cows for own-consumption or sale.

Peri-urban agriculture on the other hand refers to farm lands/units not far from the cities that operate intensive semi/fully commercial farms to produce vegetables and other horticulture, raise livestock, and produce milk and eggs also for own-consumption or sale.

Urban agriculture can also be defined as an agricultural practice within and around the cities, which compete for resources (land, water, energy and labour) that could also serve other purposes to satisfy the requirements of urban population. (AUC & NEPAD,2009). Important sectors of urban and peri-urban agriculture include, fodder, milk production, aquaculture, forestry, horticulture and livestock.

The common perception that dominates much of the literature is the important role that urban and peri-urban agriculture plays in the huge cities in the world. For instance in the United States, it is estimated that 70% of fruits, vegetables and ornamental plants are grown on urban land (Rabinoritch and Schmetzer, 1997). The Asian experience also reveals similar trends where approximately 25% to 85% of vegetable demand can be satisfied by urban and peri-urban production respectively (Midmore, 1996).

Urban agriculture is practiced by an estimated 800 million people of the world, but until now was most prevalent in Asia (Smith et al 1996). In addition, intensive and livestock production systems for milk, meat and poultry or egg production are operational around and within city limits, with a trend to zero grazing.

Urbanized shifting cultivators cultivate wherever they can find vacant spaces and they usually cultivate vegetables mainly for the informal market in order to meet their basic needs. However, their rights to use the land are very limited; they do not seem to be the most recent migrants to town, but rather belong to the group, which has been residing there for a while, and who have resulted to farming as a source of stable income.

Household gardeners situate in towns and farm around their homes or elsewhere in the city. They raise small livestock and cultivate crops aiming at both subsistence and market production. Females in particular cultivate crops to supplement household food supply, while men concentrate on cash-crop production. Urban market producers are often specialized farmers on usually secure land around cities who tend to produce vegetables of higher values and some are done using sophisticated greenhouse technology (tomatoes, onions, cabbages, eggplants, and peppers)

Urban agriculture has become a permanent part of the landscape in many cities in Asia, Africa, Latin America and other parts of the world (Bardach, 1982; Nazario, 1984).

This is surprising and often embarrassing to many who had envisioned the evolution of modem, industrial cities as symbols of economic development and technological progress in the developing world (Bardach, 1982). Much to the dismay of these proponents of modernization, who range from city officials to international donors, many cities in the developing world currently show growing trends towards squatters' housing, street hawking and informal cultivation, none of which contribute to modernity, well-being or technological progress. Except for some attractive government building, a few office towers and at most one or two shopping centers, cities in the developing world, even the colonial capitals, seem to many to have regressed from earlier beautiful and orderly appearance (Sanyal, 1985).

Most authorities assume that urban cultivation is practiced by a small section of low income families, predominantly recent migrants from rural areas who have not been assimilated socially, culturally, or economically into the sophisticated social fabric of the monetized urban economy (Sanyal, 1985). Thus, urban cultivation is considered the manifestation of rural habits. Contrary to the official view that rejects urban cultivation as irrational activity by a small group of recent migrants who have yet to be integrated into the urban environment, urban agriculture is an innovative response by a majority of the urban poor, who are fully entrenched in an urban economy that currently lacks the capacity to provide them with sufficient real income. Despite the space limitations, the urban poor still put whatever land they can find to use in limited agriculture, producing a much smaller proportion of food they consume than do rural inhabitants (Yeung, 1987).

Urban agriculture can reduce the cost involving and problematic transportation of food produce from the rural areas because it produces the food locally. This means cost associated with roadways, truck, fuel, trains, boats and warehouse, as well as storage and refrigeration installations are saved.

Urban agriculture can optimize human resources. People who move into cities from rural areas often have social knowledge about land use that can be taken advantage of, for the proper management of green spaces in the cities. In addition, rapid urbanization normally makes it difficult for immigrants to adjust to the life in the large cities. Urban agriculture enables them to use their traditional attachment to the land to help them in the transition. Without resorting to highly artificial and expensive food production systems, the absolute output of urban agriculture is obviously limited.

Urban agriculture also has the capability to improve the socio-economic situation of the poor. A large number of rural residence in developing countries migrates to cities with the hope of finding a more promising future.

2.7 The Scope of Urban Agriculture

In the article, "improving urban agriculture in Africa: A social perspective," Stereiffelem (1987) indicates that urban agriculture plays an important role in any developing country and is of special significance in sub-Saharan Africa. The extent of urban agriculture varies according to time and place. For instance in Libreville in 1957, 80% of all women were reported to be engaged in urban agriculture. In a 1962 survey of Ouagadougou, 36.4% of those questioned called themselves urban cultivators; a similar percentage was found towards the end of the 1970's in Yaounde. In 1967, a study conducted in Dar es Salaam indicated that, 18.6% of the households were engaged in urban agriculture; during the last years of the Bokassa regime in Bangui, many of the prisoners and residents of Ngaragba survived only because of the gardening efforts of local women. In Zaire and Nigeria, aerial photographs showed that 66.2% of the urban area was cultivated.

The patterns of location may change over time as cultivated land is pushed outside the city by housing demands that out price the gardens as land use alternative. This was the case in both Dakar and Brazzaville. The latter described in 1963 as a garden city, has become a city in which economic factors decide where urban agriculture develops. In the ancient cities of Yoruba in Nigeria, cultural factors have determined that agricultural activities are traditionally located on the periphery. Streiffeler (1987), reports that the development of small scale agriculture on the urban fringes of Lome, Togo, has increased in the 1980s following economic crisis which developed in the second half of the 1970s, and the introduction of government policy promoting green revolution and food self-sufficiency.

Yeung (1987) also writes on examples of urban agriculture in Asia. Urban agriculture has been evolving rapidly in response to changing demand and supplies. Despite the lack of planning and government support in some Asian cities, many have produced food effectively within their spatial confines. Others have enjoyed a great deal of policy guidelines and capital injection to promote food production within the urban areas. Profile of six cities studied by Yeung, highlight different approaches and degrees of success in urban agriculture in Asia. Shanghai in China offer an example of highly articulated rural urban relationship leading to high level of self sufficiency in essential foods. Lae, Papua New Guinea, is noted for a comprehensive citywide food and fuel self-reliance programme. In George Town on the Penang Island, Malaysia, conflicting demands are posed by rightful landowners and entrenched farmers on the land that has been used to grow food. The city-states of Hong Kong and Singapore have vigorously pursued urban food production in an intensive and scientific manner. Kler (1987) also indicated that the history of small-scale food production in Polish towns and cities is already more than 100 years old. Generally speaking, one may identify two reasons for this phenomenon; it is a relatively cheap source of fruits and vegetables and equally important in providing recreation. Wade (1987), also says food production even in small spaces can be significant. He gives the example of surprisingly high yields obtained in model small-space home gardens developed in places like California (1976), Hawaii (1978) and Taiwan (1982) respectively.The above examples give an indication and emphasize the fact that urban agriculture is being practiced in most urban areas and cities of the world. As the urban areas become more densely populated, it has become necessary for the vegetable gardeners who have originally supplied a fairly stable market, to increase their output in order to keep pace with the growing demand. Shortage of animal protein often causes serious illness but these may be entirely prevented by judicious mixtures of different vegetable protein equal in quality to animal protein. Also, Tindall (1978) says vegetables are sources of fat as well as protein, carbohydrates, minerals and vitamins.

2.8 Characteristics of Urban Agriculture

Although there is a growing amount of literature on this topic, studies of urban farming systems in West Africa are scattered and scanty. A wide spectrum of production system can be found ranging from household subsistence to large-scale commercial farming. In general, there is a tendency towards more intensive production systems in the urban areas that better satisfy the increasing urban demand than in rural areas. Often, larger urban centres have conspicuous inner and outer zones where cultivation of food crops and market gardening are being pursued vigorously (Binns, 1994). In general, this confirms the model described by Von Thunen in 1826. He concluded that farm products would be grown in series of concentric zones outward from a central market city because readily accessible farmland would be in great demand and, therefore, quite expensive. Livestock production, potatoes and cereals would be raised farther away. Since transport cost to the city increases with distance, there comes a point beyond which it is uneconomical to grow food for the urban centres.

2.9. Vegetable Production

Vegetable farming basically can be referred to as the cultivation of vegetable crops for human consumption. The term vegetable refers to the fresh edible portion of an herbaceous plant consumed in either a raw state or a cooked state. The edible portion may be a root such as carrot and sweet potato, a tuber such as potato, the stem such as asparagus, a bud such as brussels sprouts, a bulb such as onions and garlic, a leaf such as cabbage and lettuce, an immature flower such as cauliflower and broccoli, a seed such as pea and lima bean, the immature fruit such as eggplant and cucumber or the mature fruit such as tomato and pepper (Green, 1996). Vegetable production operations range from small patches of crops producing a few vegetables for family use or marketing, to the great, highly organized and mechanized farms common in the most technologically advanced countries. These types of vegetable production are based on production of vegetables for the fresh market, for canning, freezing, dehydration and pickling and to obtain seeds for planting.

- Production for the fresh market;

Home gardening provides vegetables exclusively for family use. Market gardening produces assorted vegetables for a local market. Truck gardens produce specific vegetables in relatively large quantities for distant markets. Sometimes vegetables are produced out of their normal season of outdoor production in a method known as forcing usually done under greenhouses, cold frames and hot beds. These forcing structures admit light and induce favorable environmental conditions for plant growth. Hydroponics, also known as soilless culture, allows the grower to practice automatic watering and fertilizing thus reducing the cost of labor. To successfully compete with other fresh market producers, greenhouse vegetable producers must either produce crops when the outdoor supply is limited or produce quality products commanding premium price (Keraita et al., 2002).

- Production for processing;

Processed vegetables include pickled, frozen, dehydrated and canned products. The cost of production per unit of land is less for processing crops than for the same crops grown for market because raw material appearance is not a major quality factor in processing. This difference allows lower land value, less hand labour and lower handling cost (Fellows, 2004). Although many kinds of vegetables can be processed, there are marked varietal differences within each species in adaptability to a given method. Specifications for vegetables for canning and freezing usually include small size, high quality and uniformity. For many kinds of vegetables, a series of varieties having different dates of maturity is required to ensure a constant supply of raw material, thus enabling the factory to operate with an even flow of input over a long period. Acceptable processed vegetables should have a taste, odor and appearance comparable with the fresh product, retain nutritive values and have good storage stability.

- Vegetables raised for seed production;

This type of vegetable production requires special skills and techniques. The crop is not ready for harvest when the edible portion of the plant reaches the stage of maturity; it must be carried through further stages of growth. Production under isolated conditions ensures the purity of seed yield. Special techniques are applied during the stage of flowering and seed development and also in harvesting and threshing the seeds. (Adeoti, 2008).

For vegetable farming to be profitable, it requires attention to all production operations, including weed, insect and disease control and efficient marketing. The consumers demands mainly determines the kind of vegetables grown, which can be defined in terms of variety, size, tenderness, type of pack, freshness and flavor.

Effective management involves the usage of reliable techniques resulting in a study flow of the desired amount of produce over the whole of the natural growing season of the crop. Many vegetables can be produced all through the year in some particular climates, although yield per acre for a particular kind of vegetable differs according to the growing season and region where the crop is produced (Muller et al., 2011).

2.10 Scheduling In Formal Irrigation

Irrigation is a critical part of the management package for most crops. It reduces the danger of drought stress and allows for production in arid areas (Migliaccio et al., 2010). To specify when to initiate irrigation process and determine the amount of water to be applied, irrigation scheduling is needed. The amount of water applied to the field is dependent on the performance irrigation applied. However, traditional methods of irrigation scheduling usually result in over irrigation resulting in leaching nutrients, reduced yields, and higher energy and water costs. To schedule irrigation properly, crop water status, change in yield in response to water stress and irrigation method limitations must be known (Heermann, 1996). The employment of appropriate irrigation scheduling methods can lead to increased profit and water savings for farmers, reduced environmental impacts and sustainable agriculture (Smith et al., 1996). To date, research has offered a large number of agricultural water scheduling tools including procedures to compute crop water needs and to simulate the soil water balance (Pereira, 1999).

Development of technologies that apply the precise amount of water demanded by crops is necessary (Casadesus et al., 2012). Due to advances in irrigation science, new technologies have emerged in the context of agriculture (Wiedenfeld, 2004; Kallestad et al., 2006; Farahani et al., 2007). Weather-based and soil-based irrigation scheduling are examples of such technologies which by considering soil or weather information provide irrigation water to the crop based on actual water requirements (Vellidis et al., 2008; McCready et al., 2009; Migliaccio et al., 2010). A "Precision Irrigation" method, usually referred to as irrigation scheduling in the literature, determines the appropriate timing of irrigations (e.g. "when to irrigate" and/or "how much to irrigate"). Precision irrigation is a concept in the context of irrigation management which controls plant water stress at critical growth stages by applying the necessary amount of water to the crop (O'Shaughnessy & Evett, 2010). In precision irrigation soil and crop sensors are usually used to monitor soil and plant water status and schedule irrigation.

Irrigation scheduling methods are generally categorized into soil-based, and weather-based methods which are carried out by monitoring soil water status, sensing crop stress, and calculating soil water budget and reference evapotranspiration using weather data, respectively (Al-Kaisi et al., 1997; Orta et al., 2003; Jones, 2004; Ko & Piccinni, 2009). For soil water balance models, soil water in the root zone is the base to decide when to irrigate. Leaf water potential or canopy temperature is monitored as trigger point of irrigation for the methods based on crop status (Stegman et al., 1976; Turner, 1988; Jackson et al., 1977; Wanjura et al., 1995).

A reasonable number of scheduling techniques have been developed for formal irrigation. These methods have been widely used by irrigation researchers; however no user-friendly irrigation scheduling model that can be readily used by farmers for single and multiple field cases has been developed (Georgea et al., 2000). In a number of irrigation algorithms a combination of these methods have been used. A program was developed called WIF which used soil moisture signal to quantify the present soil moisture content. To predict the earliest irrigation replenishing the root zone to a desired level, it combined soil signal with an estimate of plant water use in the future.

Another irrigation scheduling program was developed called SCHED based on daily water balance calculations of the present soil moisture depletion and a future estimate of crop evapotranspiration. To foresee the earliest and latest dates to irrigate a particular field, these two were combined. The SCHED and WIF programs have been successfully used by irrigation consultants (Keraita et al.,2002). Hess (1996) described a real-time software package of irrigation scheduling. The package included almost all of the available algorithms including reference evapotranspiration, actual evapotranspiration, soil water balance and a model of irrigation forecast. Their evaluation of these models has shown the performance to be dependent on the accuracy of the input data measured in the field.

- Soil-based methods

In these methods, a "soil moisture" or "soil water potential" specifies when to initiate irrigation and when to stop irrigating. A wide range of measuring instruments is used for this purpose such as dielectric sensors (Time domain reflectometer, Frequency domain reflectometer etc), tensiometers, gypsum blocks, granular matrix sensors, etc. They range from very inexpensive gypsum blocks to fairly expensive time domain reflectometer sensors. Soil sensors have been used to automate irrigation in a number of plants including bell peppers, tomatoes, and onions (Thompson et al., 2007; Enciso et al., 2009; Zotarelli et al., 2009). In 2008 a prototype real-time, smart sensor array for scheduling irrigation of cotton which measured soil moisture and temperature as standard inputs was developed. The system was able to successfully monitor soil water status, soil temperature, and air temperature within the canopy during the entire growing season (Vellidis et al., 2008). There are disadvantages associated with use of soil sensors. Plant water stress responds to other factors such as atmospheric conditions, root-zone salinity, availability of nutrients etc. In addition, sampling in heterogeneous soils is difficult and it is difficult to know where the roots are located, thus the spot at which soil moisture is measured might not be a good representative of the entire field. In case of cheap gypsum blocks, they only provide information on when to irrigate but not on how much to irrigate (Fereres et al. 2012).

- Weather-based methods

These methods are based on a soil water balance and daily estimations of reference evapotranspiration from daily weather data and an ET model.

A complete set of weather parameters from a nearby weather station are required to calculate evapotranspiration. Using a feed-forward ET-based scheduling method can lead to over or under irrigation if the estimates of crop water use are incorrect, the soil water content at the beginning of the season is unknown, or the application efficiency of irrigation system is lower than expected. A method was proposed for automated irrigation scheduling by combining a compensating mechanism based on soil or plant sensors readings (feed-back control) and an estimation of water demand by water balance method (feed-forward control). (Casadesus et al., 2012). Their system was configurable by the user to support different irrigation strategies. The results suggested that the use of the water balance model allowed for a quick response to weather changes by predicting its effects, while at the same time the feedback mechanism could adapt the amount of water to the requirements of individual orchards by compensating for the bias of the model.

- Plant-based methods

Canopy temperature increases due to stomatal closure which most of the times is associated with water stress. Canopy temperature has shown to be an indicator of plant water stress and been used as an irrigation signal in many crops. Canopy temperature can be easily measured using infrared thermometers.

The use of infrared temperature of plant canopies along with a number of supplemental environmental measurements to standardize canopy temperature is an alternative approach to soil- or weather-based methods in irrigation scheduling of general crops (Cohen et al., 2005).

Plant-based methods of irrigation scheduling can be more advantageous in detecting plant water stress compared to soil-based methods of replacing water deficit. The tedious nature of soil water measurements using a neutron probe, the difficulty to determine tree root distribution and requirement of numerous field measurements make it inevitable to use plant water status indictors for irrigation scheduling (Naor, 2000). However, unlike the soil-based or water budget approaches, plant-based methods of irrigation scheduling lack any direct information on the quantity of water to be applied (Fereres et al. 2012). Thus, plant-based method should be used in combination with soil-based or weather-based methods to determine the required depth of irrigation water.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This chapter presents the study's methodology, which includes the description of the theoretical framework and methods of analysis that was adopted to address the study objectives. Some theoretical issues as well as the description of the data requirements, data collection, data sources and sampling techniques in this current study have been outlined.

3.2 Study Area

The study was carried out in the urban areas of the Greater Accra region. The Greater Accra region has the smallest area of Ghana’s 16 administrative regions, occupying a total land surface of 3,245 square kilometres. (Ghana Statistical Service, 2017). This is 1.4 percent of the total land area of Ghana.it is the second most populated region, after the Ashanti region with a population of 4,010,054 in 2010, accounting for 16.3 percent of Ghana’s total population (Ghana Statistical Service, 2017). The Greater Accra is the most urbanized region in the country with 87.4 percent of its total population living in the urban centres (Songsore, 2009). As shown in Figure 3.1 the region is made up of various districts, a few of them are, Accra (Accra Metropolitan Area), Ga, Tema, Asiaman municipal and Kpong municipal districts. Selected urban centres under a few of the districts mentioned, where formal irrigated vegetable production takes place were covered and these areas are Weija and its surrounding environs and Ashaiman. These farming areas in the urban centres of the Greater Accra Region were selected based on the recommendation of technical officers of the Food and Agriculture Organization of the United Nations. These farming areas are also among the major areas where vegetable farming activities are undertaken, in addition to the fact that they receive extension services and take part in farmer field schools organized by Ministry of Food and Agriculture (MOFA) and Food and Agriculture Organization of the United Nations (FAO-UN).

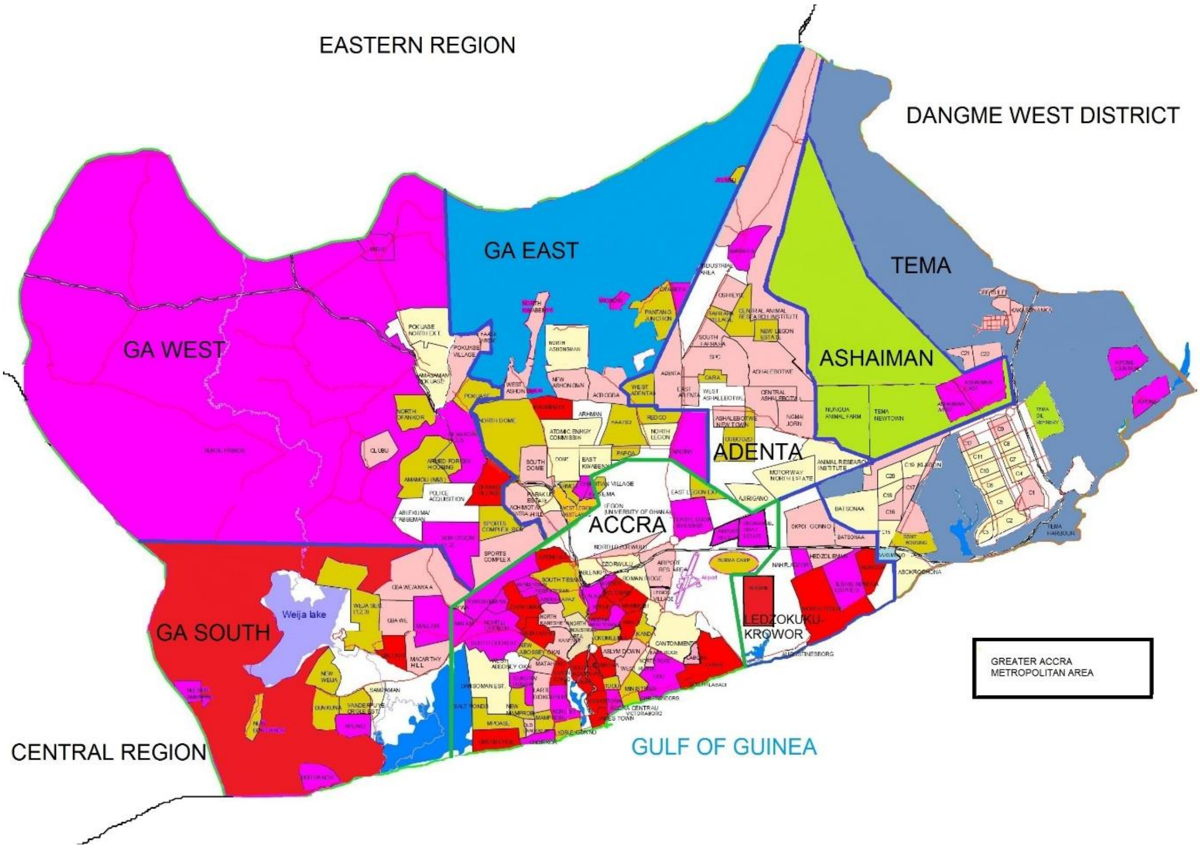

Figure 3.1 Map of the Greater Accra region

Figure 3.1 is a pictorial mapping of the Greater Accra region of Ghana.

3.3 Population

The total population of farmers for both the weija and ashiaman irrigation scheme is (40) farmers. In this case, the duration of which the farmers had been involved in this scheme is a huge factor. Only farmers who had been involved with the scheme for more than five years were considered for this study. This is because it was expected that they would have a lot more experience with the issue at hand as compared to those who hadn't been there that long. Therefore my population was reduced to (31) farmers.

3.3 Data Sources and Method of Collection

The data for this study was obtained from a cross-sectional survey of 20 randomly-selected urban vegetable producers out of the 31 from the selected districts of the Greater Accra Region with higher urban vegetable growers under the irrigation scheme. (10) Questionnaires each were sent to both weija and ashiaman summing up a sample size of (20). Results gathered were (19), which was used in conducting the research analysis. The questionnaire designed to collect data for the study were then pre-tested in some parts of the weija area. One type of questionnaire was used for the survey. The questionnaire was designed to gather information on, type of irrigation, timing of irrigation, reasons for poor timing of irrigation, effects of poor timing of irrigation as well as the duration of involvement under the scheme. In this study, farmers were questioned using individual contacts to obtain in-depth information on the research problems and issues involved.

3.4 Methods of Analysis

The first objective of this study was to find out the perception of the farmers towards the irrigation schedule; to find out what percentage of the farmers who were comfortable or happy with the timing of the irrigation (the time of day in which irrigation occurs, whether it occurs in the mornings, afternoons, or evenings). It also tried to find out the percentage that were comfortable with the duration of irrigation (whether it lasts for 1-2 hours, 2-4 hours, or 4-6 hours. Another thing this study tried to find was the percentage of farmers comfortable with the frequency of the irrigation schedule (the number of times it occurs during the week, once, twice or maybe trice in a week).

The questionnaire also sought to enquire about the types of irrigation practices undertaken to assist the farmers to dwell on which particular crops are most affected by the poor scheduling of irrigation. The following information gathered was then analysed using statistical package for social sciences (SPSS) and was represented using tables and graphical representations.

The second objective (determining the factors that cause poor scheduling), tried to engage the farmers to open up about factors or reasons that result in the poor scheduling of irrigation. The farmers were encouraged in the questionnaire to write down their opinions as to what causes the poor scheduling of irrigation and also what factors could help mitigate the poor scheduling. The following information gathered was then analysed using statistical package for social sciences (SPSS) and was represented using tables and graphical representations.

The third objective (determining the effects resulting from poor scheduling of irrigation), seeks to identify the end results of the poor scheduling of irrigation and the various ways in which it affects the farmers and their farming activities. The farmers were urged in the questionnaire to explicitly state the various ways in which the poor scheduling affected them. All the information gathered was then analysed and interpreted using statistical package for social sciences (SPSS) and was represented using tables and graphical representations.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

This section shows and discusses the results on the effects of poor scheduling in formal irrigated urban vegetable production projects in the Greater Accra region. The questionnaires that were sent out were used to address the three main objectives of this study.

The first objective looked at the type of irrigation being used and the perception of farmers towards the irrigation scheduling (duration, timing, and frequency). The second objective looked at the causes of poor scheduling and the mitigating factors. The third objective focused on the effects of poor scheduling on the farmers

4.1 DETERMING FORMS OF IRRIGATION BEING USED AND THE PERCEPTION OF THE FARMERS TOWARDS THE CURRENT IRRIGATION SCHEDULE.

The various types of irrigation that was being used by the farmers were estimated as indicated in figure 4.1. This was obtained by estimating the percentage of farmers and the various types of irrigation which they use on their respective fields.

Types of irrigation being used by the farmers

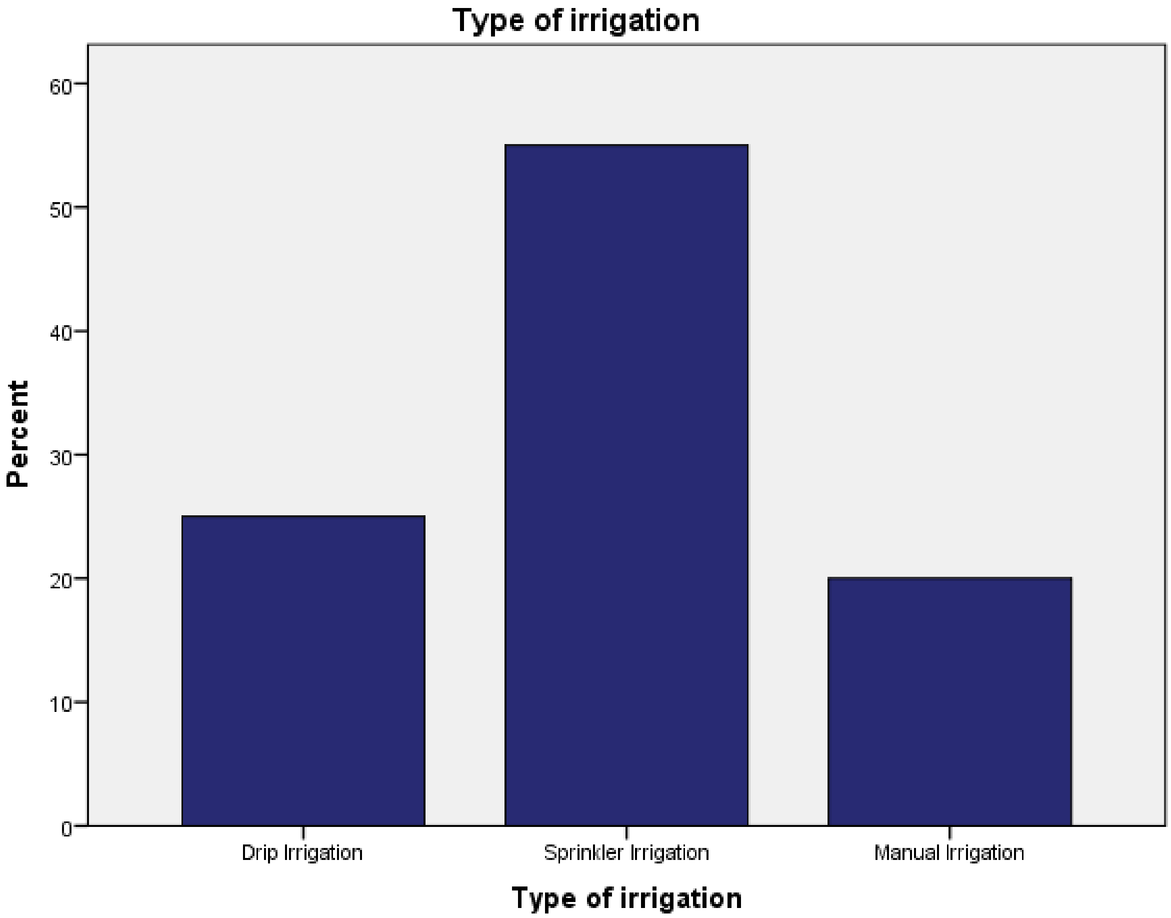

Figure 4.1.1: Graphical Representation of the Types of Irrigation

The graphical representation denotes the percentages on the y-axis and type of irrigation being untaken on the x-axis. The data obtained indicated that 23.8% of the farmers in question use the drip irrigation system which is the second highest percentage in this study. The reason for their choice of this method of irrigation is that it is the most economically efficient method as the percentage of water wastage is drastically reduced because the water is dropped directly to the root of the crops. This method also prevents moistness in the atmosphere which prevents / limits the spread of diseases. It is a slower method of irrigating.

It was also indicated that 52.4% of the farmers in question use the sprinkler irrigation system which is the highest percentage of this study. The majority of the farmers in question have chosen to use the sprinkler irrigation method because it is a relatively faster method. The rotary motor enables the sprinkler to evenly distribute the water over a large radius thereby covering more area within a shorter time. The sprinkler irrigation technique does however create a moist environment which facilitates the spread of diseases.

The data obtained also indicated that 19.0% of the farmers in question use the manual irrigation method. The reason for this was that, some parts of the field were located at areas where irrigation pipes hadn't been laid there. They therefore had no access to the regular irrigation systems being used by the rest of the farmers so they had to manually irrigate their farms as often as they could or depend on the rain.

Figure 4.1.2 A picture of sprinkler irrigation

Figure 4.1.2 is a picture of a farmer tending to this sprinkler irrigation as it irrigates a wide coverage area.

Figure 4.1.3 A picture of drip irrigation

Figure 4.1.3 is a picture of a drip irrigation system and how the wetted perimeter surrounds the root zone.

Another thing this objective of the study looked at was the perception of the farmers towards the current irrigation schedule. This aspect dwelt on the comfort level of the farmers towards the timing, duration and frequency of the current irrigation schedule

Table 4.1.2 Frequency of Irrigation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Two days	19	95.2	100.0	100.0
Missing	System	1	4.8		
Total		20	100.0		

Table 4.1.2 indicates that all the farmers who responded to the questionnaire indicated two days a week as the frequency of irrigation.

Table 4.1.3 Timing of Irrigation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Morning	19	95.2	100.0	100.0
Missing	System	1	4.8		
Total		20	100.0		

Table 4.1.3 indicated mornings as the usual timing of the irrigation schedule.

Table 4.1.4 Duration of Irrigation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2-4 hours	19	95.2	100.0	100.0
Missing	System	1	4.8		
Total		20	100.0		

Table 4.1.4 indicates 2-4 hours as the normal duration of irrigation schedule

As per the data collected, the average results of the current irrigation schedule are as follows;

- The regular frequency of the irrigation schedule was 2 days in a week.
- The regular timing was in the mornings.
- The regular duration was 2-4 hours per session.

The questionnaire also tried to obtain the perception of the farmers towards the irrigation schedule which is as follows;

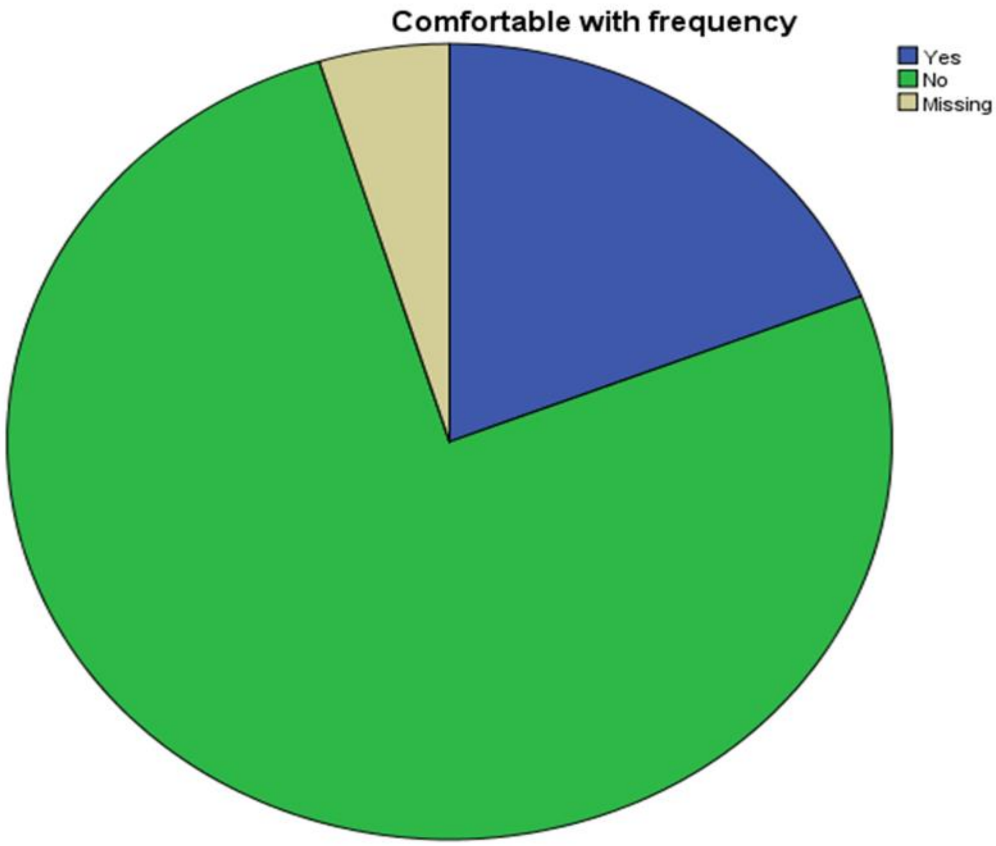

Figure 4.1.4 Graphical representation indicating the percentage of farmers comfortable with the current frequency

This data obtained indicates that only 19% of the farmers in question were happy with the current frequency of the irrigation which is scheduled at 2 days in a week. 76% of the farmers in question weren't happy with the current frequency. The farmers vocally indicated that 3 or 4 days of irrigation in a week would suit them better. Their emphasis was especially in the dry seasons where the moisture content in the soil is drastically depleted and the crops are affected by heat stroke.

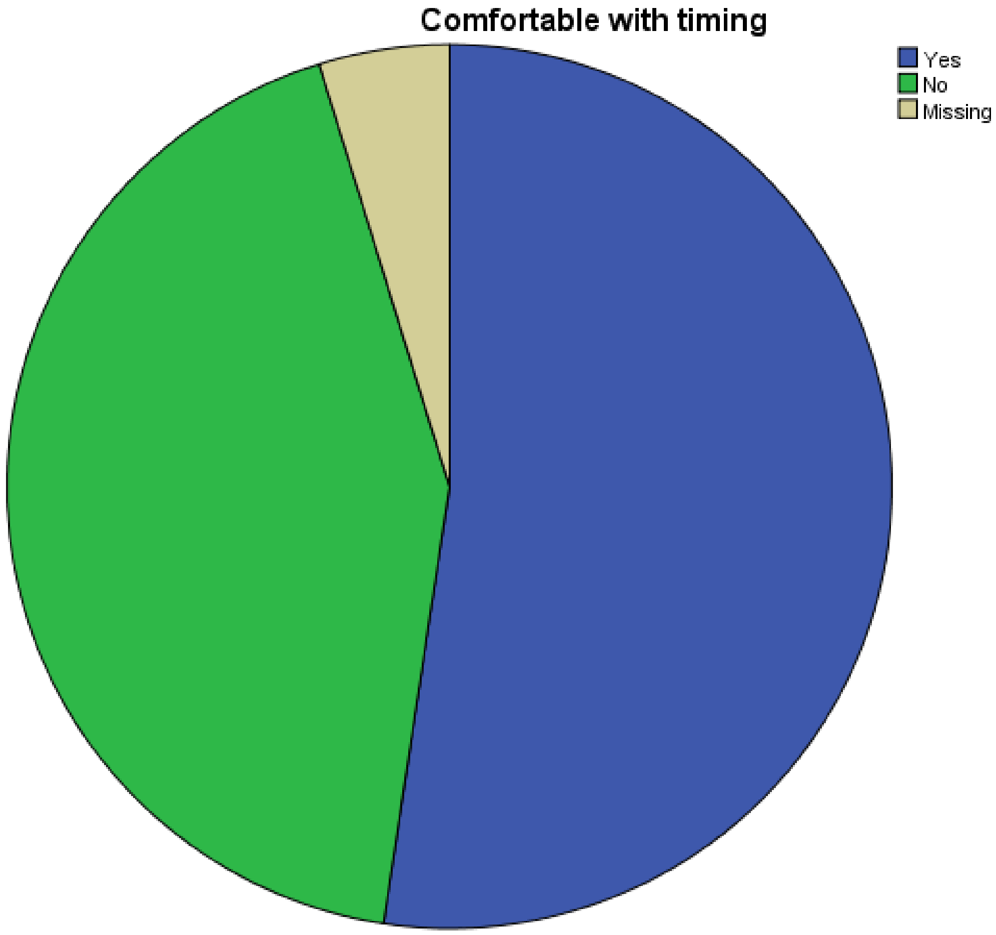

Figure 4.1.5 Graphical representation indicating farmers comfortable with the irrigation timing.

This data obtained indicates that 52.4% of the farmers in question were comfortable with the timing of their current irrigation schedule, which is in the mornings. On the other hand 42.9% of the famers were unhappy with the timing being in the mornings. The reason why the majority of the farmers were happy with it was because, they claimed that when the irrigation is done in the mornings before the sun comes out it gives them plenty of time to go about their other businesses.

The percentage of farmers in question that weren't happy with the morning irrigation preferred the irrigation to be done during the late afternoon / evening period. Their reason was that, when the irrigation is done in the evening, there is a longer period of darkness / no sunshine so that provides enough time for the water to properly infiltrate the soil hence providing a longer period of moistness of the soil which better promotes the growth of crops.

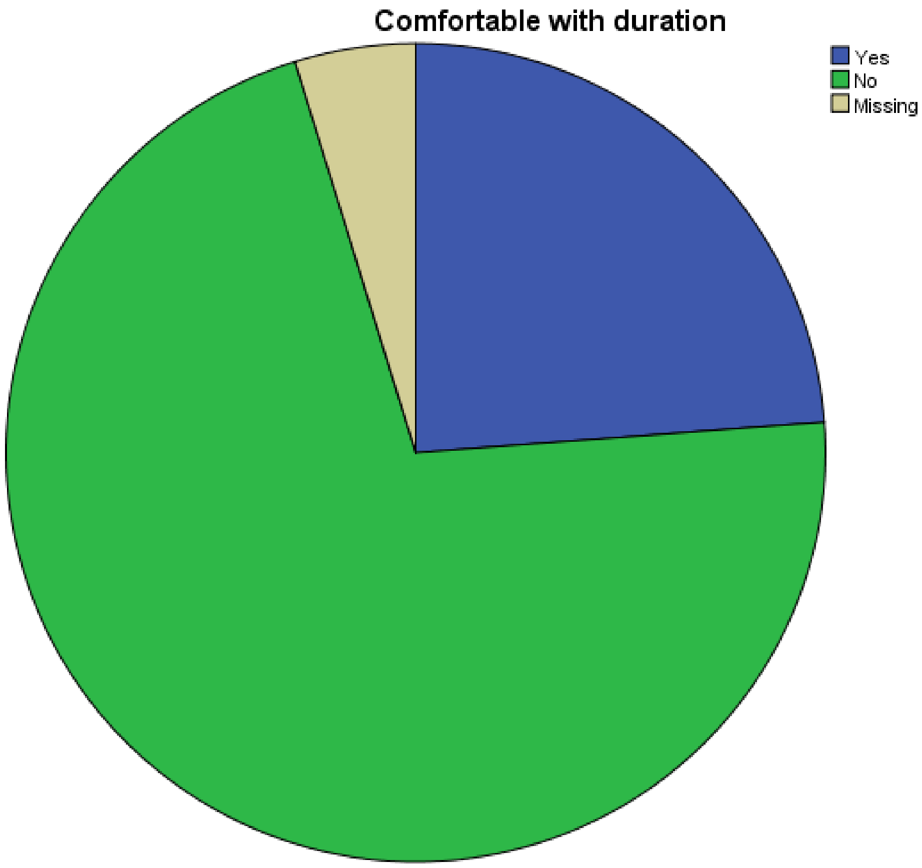

Figure 4.1.6 Graphical representation indicating the percentage of farmers happy with duration

The data obtained indicates that a huge majority of the farmers in question (71.4%) were not happy with the duration of the irrigation whilst 23.8% had no problem with it. The recorded duration was 2-4 hours. The main reason why the majority of the farmers in question weren't happy with the current duration was that, some have larger fields and not enough irrigation sprinklers therefore they needed more time in order to be able to evenly move around the sprinklers such that the entire cultivated field gets sufficient water supply. Another reason was that some of the farmers felt that some particular crops example tomato, required a lot more water as compared to some of the other vegetables being cultivated therefore a longer duration of irrigation would better help their course. An irrigation duration of 4-6 hours was the popular request.

These observations are similar to those obtained from (Memuna & Cofie, 2005). They discussed the effects of farming practices on the performance of rice in selected farms of Ashiaman irrigation project.

4.2 DETERMING THE FACTORS THAT CAUSE POOR SCHEDULING OF IRRIGATION

The poor scheduling of irrigation especially the timing, duration and frequency of the irrigation scheduling, has proved to be an obvious issue which is of high concern to the farmers. This particular objective of this study sought to find out the exact factors that lead to the poor scheduling of irrigation. The farmers were encouraged in the questionnaire to give their opinions in relation to this issue.

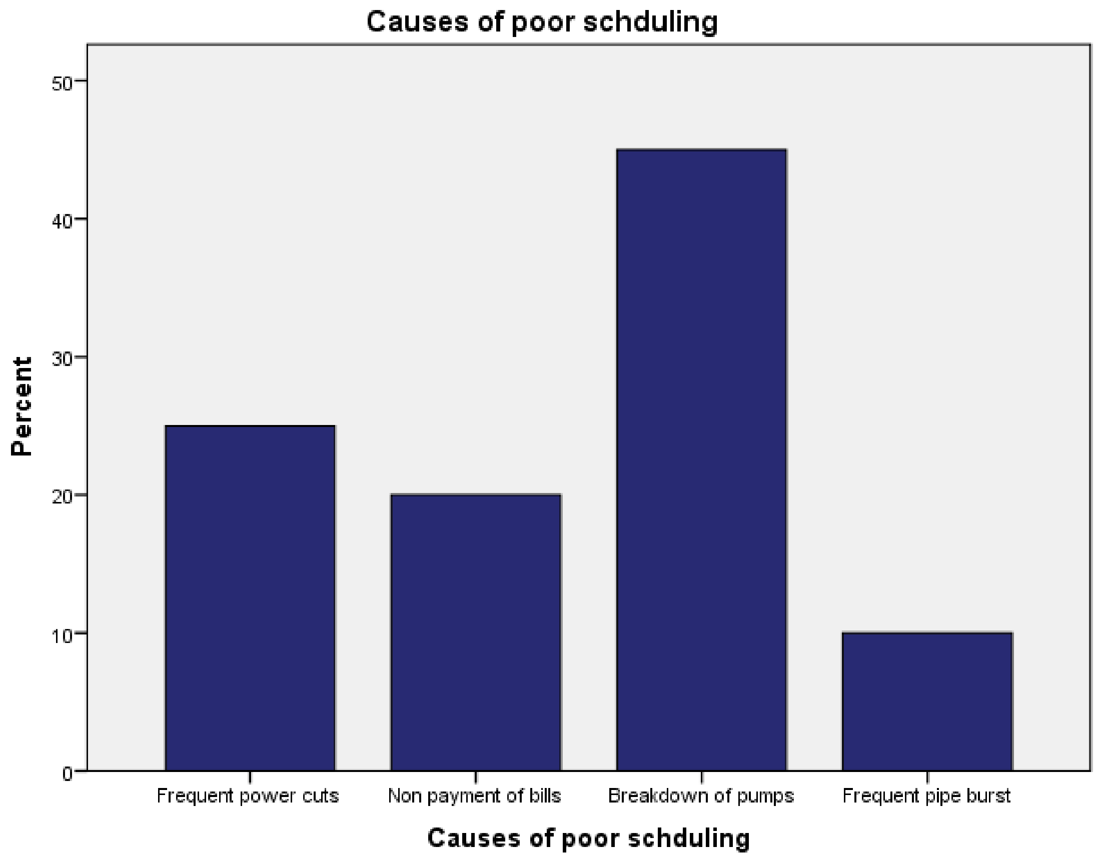

Figure 4.2.1 Graphical representation of the causes of poor scheduling

23.8% of the farmers in question pointed fingers at frequent power cuts as the major cause of the poor scheduling of irrigation. They explained that the power cuts sometimes affects the duration, timing and frequency of the irrigation scheduling.

In terms of duration, the power cuts sometimes reduce the amount of irrigation time scheduled per field which ultimately affects production. In terms of timing, if the power cut occurs in the morning, management might be forced to shift irrigation to the afternoon which according to the farmers isn't suitable for the crops because of the high evaporation rate. In terms of frequency the scheduled frequency is twice a week. According to the farmers, if the power cuts lasts an entire day which was scheduled for irrigation, they don't get it back. It therefore reduces the frequency of that particular week to once a week which ultimately affects production.

According to the farmers, sometimes although the power hasn't been cut, the electricity current maybe so low that it's unable to power the pump and this goes on to affect them.

19% of the farmers in question pointed fingers to non-payment of bills. According to the farmers, their irrigation bills are paid collectively. Meaning if for example 60% have paid their bills but the remaining 40% are owing, it tends to affect all of them. It results in the halting of irrigation supply which goes on to affect productivity. The farmers also admitted that the amount of money they are each supposed to pay for the irrigation keeps on increasing time after time making it difficult for them to always pay the bills on time.

42.9 % of the farmers (which was the highest percentage) pointed to the breakdown of pumps as the major cause of the poor scheduling. According to the farmers, the breakdown of the pumps is a relatively regular occurrence and it's a source of constant frustration. When the pumps develop faults, it sometimes takes a couple of days or even sometimes weeks before the engineers come and have a look at it. This delay greatly affects the irrigation scheduling thereby also affecting productivity and it sometimes requires the farmers paying a little extra money to try to get it fixed on time.

9.5% of the farmers in question (which was the lowest percentage) indicated the frequent pipe burst as the major cause of poor scheduling. This percentage is low because, it is an infrequent occurrence. According to the farmers, there are basically two forms of pipes involved. The first is the larger, immobile pipes which are buried underground connecting the field to the weigh lake, although those pipes are really old, they hardly ever have problems with them. The second kind of pipes are much smaller and mobile. These smaller pipes are moved around the fields to try and rotate the irrigation. The regular movements and mishandling sometimes lead to the bursting of pipes which takes a relatively long time to fix / replace thereby affecting productivity. According to the farmers, the frequent movement and mishandling isn't the only reason for the bursting of pipes. Another reason was that sometimes the pressure of the incoming water is too high and when that happens it sometimes leads to the bursting of the pipes. (Fereres & Soriano, 2006) did some work on deficit irrigation for reducing agricultural water use, which confirmed a few of these causes of poor scheduling of irrigation.

Figure 4.2.2 A picture showing the reservoir of water for irrigation as well as the pump house.

As part of this particular objective of the study, after evaluating the causes of the poor scheduling, we also had to look at some of the mitigation factors that help resolve these issues.

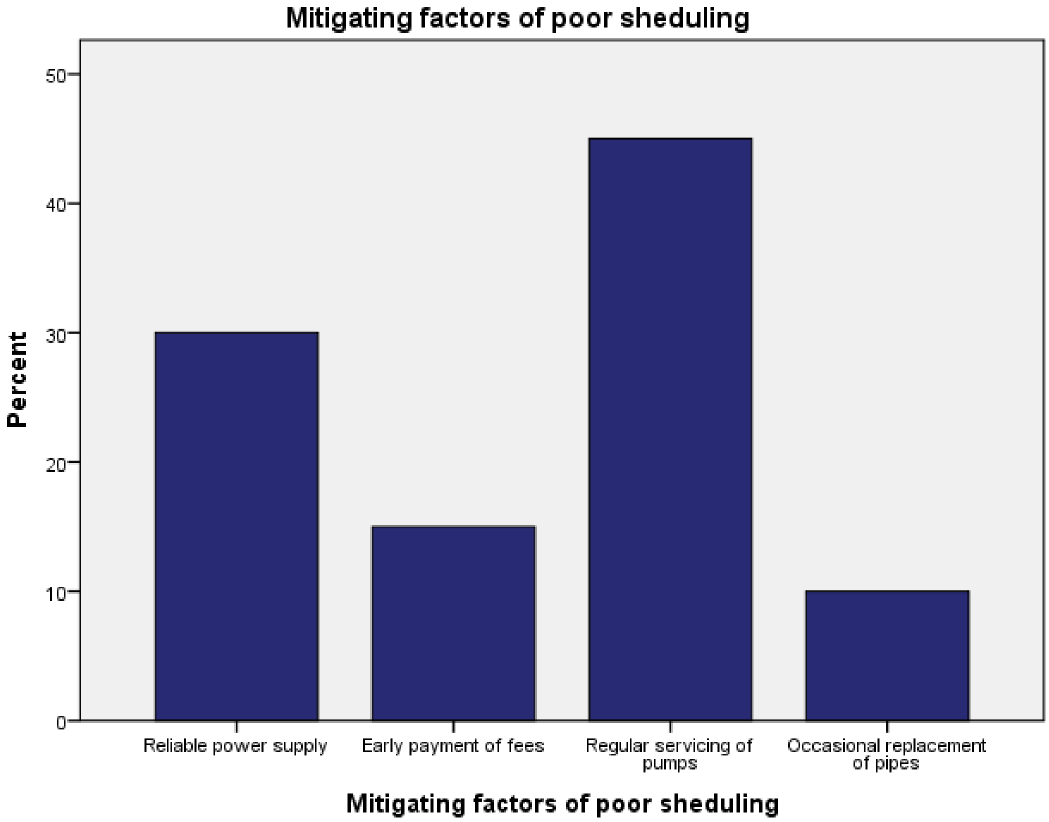

Figure 4.2.3 Graphical representation of the mitigating factors of poor scheduling

28.6% of the farmers in question felt a reliable power supply would be key to improving the poor scheduling of irrigation. 14.3% of the farmers acknowledged that early payment of irrigation fees would go a long way to help improve matters. The factor with the highest percentage (42.9%) indicated that regular servicing of pumps will best improve the scheduling of irrigation. The factor with the least percentage was the occasional replacement of pipes (9.5%).

4.3 DETERMINING THE EFFECTS OF POOR SCHEDULING OF IRRIGATION

This objective of the study focused on getting to know exactly how the poor scheduling of irrigation affects the farmers. The farmers were encouraged to explicitly elaborate on how the poor scheduling affects them.

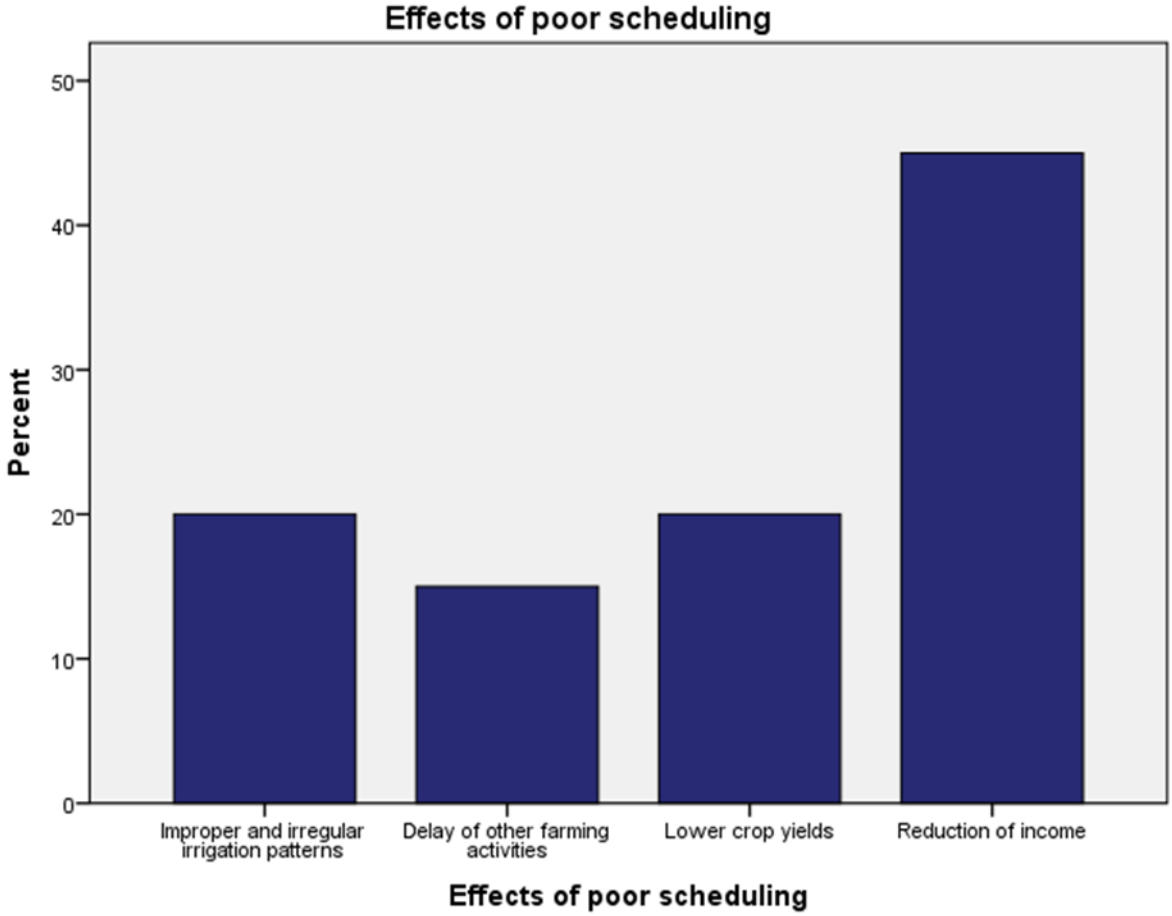

Figure 4.3.1 Graphical representation of the effects of poor scheduling

The first recorded effect was improper and irregular irrigation patterns of which 19% of the farmers pointed out to be the major effect of poor scheduling. According to the farmers, a regular irrigation pattern is essential for increased productivity. In terms of duration, since some of the farmers have to be moving their pipes around in order to irrigate their entire field, sometimes they are unable to move fast enough to cover the entire field. This leads to some parts of the field being irrigated while other parts are left dry which ultimately affects productivity. This vividly explains why the majority of the farmers were not happy with the scheduled duration of irrigation.

14.3% of the farmers in question indicated delay in other farm activities as the major effect of poor scheduling. According to the farmers, sometimes things do not always go according to plan in turns of timing. Irrigation can be scheduling for the morning but sometimes due to one reason or the other it gets shifted to afternoon. This therefore compels the farmers to shift their plans and it causes delays in other farm activities.

19% of the farmers indicated that lower crop yields is the major effect of poor scheduling of irrigation. In terms of duration, the farmers felt that if management was to increase the duration of the irrigation it will increase the yield of crops. In terms of timing, most of the farmers suggested that if the timing of irrigation is shifted to the late afternoon / evening, it increases the moisture content of the soil which in turns increases the yield of crops. In terms of frequency, the farmers indicated that if the frequency of the irrigation was to be increased to three or four times a week, it would drastically increase the yield of crops.

The highest effect recorded was the reduction of income (42.9%). This effect is directly proportional to the lower crop yield hence once the crop yield of the farmers are reduced, so does the income. All these effects of poor scheduling discussed can be linked to a few of them discussed by (Fereres et al., 2012) where he and his colleagues discussed the crop yield response to water of fruit trees and vines. (McCready et al., 2009) also confirmed a few of these with his work in water conservation potential of smart irrigation controllers on St Augustine grass and agricultural water management.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

This chapter shows the conclusions and recommendations on the project conducted.

5.1 SUMMARY OF FINDINGS

This study looked at three main objectives. The first objective looked at the type of irrigation being used and the perception of farmers towards the irrigation scheduling (duration, timing, and frequency). The second objective looked at the causes of poor scheduling and the mitigating factors. The third objective focused on the effects of poor scheduling on the farmers.

5.2 CONCLUSION

- For the first objective, this study showed that majority of the farmers preferred to used sprinkler irrigation as compared to drip irrigation and other types because although it isn't water efficient, it is relatively faster. They are able to cover more ground within a shorter period of time. This study also proves that majority of the farmers weren't happy with the frequency of the irrigation (2 days a week). The farmers felt an increased frequency of maybe 3 or 4 days a week would drastically increase productivity since the two days a week make it difficult for them to keep the soil moist enough to facilitate the growth of crops. Majority of the farmers in question were also not happy with the duration of the irrigation schedule (2-4 hours per session). They felt an increased duration of maybe 4-6 hours would better suit them since sometimes they aren't able to irrigate their entire field within that short period of time.

  Surprisingly a little more than half of the farmers involved in this study were happy with the current timing of the irrigation schedule (mornings). Some of the farmers preferred the morning session because they are able to irrigate their fields early in the day and then have enough time for other farming activities. Some of the farmers preferred the irrigation to be done in the evening because it provides a longer period of darkness such that the water is properly able to infiltrate the soil before the sun comes up the following morning. Therefore from the first objective it was concluded that the most commonly used irrigation type was the sprinkler and the majority of the farmers are not happy with the current irrigation schedule.

- The second objective managed to identify the causes of the poor scheduling in the opinion of the farmers as well as the mitigation factors. 23.8% of the farmers in question indicated frequent power cuts as the major cause of poor irrigation scheduling. The frequent power cuts affects the duration of irrigation by sometimes reducing the scheduled time allocated to the irrigation. The frequent power cuts affect the timing by sometimes shifting irrigation scheduled for morning to afternoon. It affects the frequency by sometimes reducing the number of days scheduled for irrigation per week. 19% of the farmers pointed fingers at non-payment of bills as the major cause of poor scheduling. The breakdown of pumps had the highest percentage with 42.9% of the farmers claiming it is was the major cause of poor scheduling of irrigation. Only a few farmers (9.5%) indicated pipe bursting as the major cause of poor scheduling of irrigation.

  In terms of the mitigation factors, 28.6% of the farmers opted for reliable power supply, 14.3% went for early payment of fees. Unsurprisingly a huge majority of 42.9% of the farmers went with regular servicing of the pumps. While very few of the farmers (9.5%) went for the occasional replacement of pipes. In conclusion to the second objective, the greatest cause of the poor scheduling of irrigation was the breakdown of pumps.

- The third objective took a look at the effects of poor scheduling, as to how the poor scheduling of irrigation affects the farmers. 19% of the farmers in question felt the greatest effect of the poor scheduling was improper and irregular irrigation patterns. Hence they are unable to properly irrigate such that the water is evenly distributed throughout the field. A few farmers (14.3%) felt delay of other farm activities was the greatest effect of the poor scheduling. 19% of the farmers indicated lower crop yield as the greatest effect of the poor scheduling while 42.9% of the farmers indicated that reduction of income as the greatest effect.

  Therefore in conclusion to the third objective, the greatest effect of the poor scheduling of irrigation was the reduction of income of the farmers.

5.3 Recommendations

This study proved that poor scheduling of irrigation is a major issue affecting farmers. It affects their farming activities, their productivity, and also their income obtained. It is therefore recommended to management to adjust the irrigation schedule by;

- Increasing duration of irrigation.
- Increasing frequency of irrigation.
- Adjusting timing of the irrigation.
- Regular servicing of pumps.
- Occasional replacement of pipes.

This then helps increase the productivity of the farmers.

REFERENCES

AFRICAN UNION COMMISSION (2014) Implementation strategy and roadmap to achieve the 2025 vision on CAADP.

AFRICAN UNION COMMISSION (2014) Resolutions of the AU Joint Conference of Ministers of Agriculture, Rural Development, Fisheries and Aquaculture.

Al-Kaisi, M.M., Berrada, A., Stack, M., 1997. Evaluation of irrigation scheduling program and spring wheat yield response in southwestern Colorado. Agricultural Water Management 34, 137–148.

AUC and NEPAD (2009) Sustainable land and water management. The CAADP Pillar I Framework. "Tool" for use by countries in mainstreaming and upscaling of sustainable land and water management in Africa's agriculture and rural development agenda. NEPAD, Midrand, South Africa.

Bardach J. E. (1982) Food and Energy, Problem of Third World Cities. Paper Prepared for Conference on Urbanization and National Development. East West Center Honolulu, Hawaii.

Cohen, B. (2015). "Urbanization, City Growth, and the New United Nations Development Agenda". **3** (2). Cornerstone, The Official Journal of the World Coal Industry. pp. 4–7.

Borowiecki, Karol J. (2013) Geographic Clustering and Productivity: An Instrumental Variable Approach for Classical Composers, Journal of Urban Economics, 73(1): 94–110.

Casadesus, J., Mata, M., Marsal, J., Girona, J., 2012. A general algorithm for automated scheduling of drip irrigation in tree crops. Computers and Electronics in Agriculture 83, 11–20.

Challinor, AJ., Watson, J., Lobell, D., Howdens S., Smith, D., Chhetri N (2014) A metaanalysis of crop yield under climate change and adaptation. Nat. Clim. Change 4 (4) 287.

Cohen, Y., V. Alchanatis, M. Meron, Y. Saranga, and J. Tsipris. (2005) Estimation of leaf water potential by thermal imagery and spatial analysis. J. Exp. Bot., 56(417): 1843–1852.

Enciso, J., Wiedenfeld, B., Jifon, J., Nelson, S., 2009. Onion yield and quality response to two irrigation scheduling strategies. Scientia Horticulturae 120, 301–305.

Farahani, H.J., Howell, T.A., Shuttleworth, W.J., Bausch, W.C., 2007. Evapotranspiration: progress in measurement and modeling in agriculture. Trans. ASABE 50, 1627–1638.

Fellows, P. (2004) ‘Small-scale Fruit and Vegetable Production methods , equipment Small-scale Fruit and Vegetable.

Fereres, E., Goldhamer, D., Sadras, V.O., 2012. In Crop yield response to water of fruit trees and vines: guidelines. Steduto, P., Hsiao, T.C., Fereres, E. and Raes, D. (eds.). Ch. 4, pp 246–295.

Fereras, E. and Soriano, M.A. (2006) Deficit irrigation for reducing agricultural water use. Journal of experimental botany 58 (2), 147-159.

Fuller, T. (2012). "Thai Youth Seek a Fortune Away From the Farm". New York Times. Retrieved 5 June 2012.

Georgea, B.A., Shendeb, S.A., Raghuwanshi, N.S., 2000. Development and testing of an irrigation scheduling model. Agricultural Water Management 46, 121–136.

Green, G. (1996) ‘Explaining Irrigation Technology Choices: A Microparameter Approach’, American Journal of Agricultural Economics, 78(4), p. 1064.

Gries, T. and Grundmann, R., 2018. Fertility and modernization: the role of urbanization in developing countries. Journal of International Development, 30(3), pp.493-506.

Heermann, D.F., 1996. Irrigation scheduling. In: Pereira, L.S., Feddes, R.A., Gilley, J.R., Lesaffre, B. (Eds.), Sustainability of Irrigated Agriculture. Kluwer Academic Publishers, Dordrecht, 233–249.

Hess, T., 1996. A microcomputer scheduling program for supplementary irrigation. Computers and Electronics in Agriculture 15, 233–243.

Jones, H., 2004. Irrigation scheduling: advantages and pitfalls of plant-based methods. J. Exp. Bot. 55, 2427–2436.

Johnson, N. and Rozelle, S. (2016) 'Irrigation investment in China : trends , correlates and impacts'. doi: 10.1108/CAER-09-2014-0084.

Kallestad, J.C., Sammis, T.W., Mexal, J.G., White, J., 2006. Monitoring and management of pecan orchard irrigation: a case study. HortTechnology 16, 667–673.

Keraita, B., Drechsel, P. and Africa, W. (2002) 'Wastewater Use in', *Urban Agriculture Magazine*, (December), pp. 11–13.

Kisekka, I., Migliaccio, K.W., Dukes, M.D., Schaffer, B., Crane, J.H., 2010. Real-time evapotranspiration-based irrigation scheduling and physiological response in a carambola (Averhoha carambola) orchard. Applied Engineering in Agriculture 26, 373–380.

Ko, J., Piccinni, G. (2009) Corn yield responses under crop evapotranspiration-based irrigation management. Agricultural Water Management 96, 799–808.

McCready, M.S., Dukes, M.D., Miller, G.L. (2009). Water conservation potential of smart irrigation controllers on St. Augustine grass. Agricultural Water Management 96, 1623–1632.

Memuna, M. M. and Cofie, O, O. (2005).Effects of farming practices on the performance of rice (Oryza sativa) in selected farms of Ashaiman Irrigation Project. In Hunger without Frontiers. (Eds. Bobobee, E. H. Y. and BartPlange, A.). GSAE/WASAE, Kumasi, Ghana p.244-254.

Midmore D.J. (1996) Sustainable and Ecologically Sound Vegetable in Peri-urban Farming. Agriculture and Rural development, 3(1), 50-52.

Migliaccio, K.W., Schaffer, B., Crane, J.H., Davies, F.S., 2010. Plant response to evapotranspiration and soil water sensor irrigation scheduling methods for papaya production in south Florida. Agricultural Water Management 97, 1452–1460.

MOFA,(2011) National Irrigation Policy, Strategies and Regulatory Measures Ministry of Food and Agriculture Ghana Irrigation Development Authority.

Muller, C., Cramer, W., Hare, W., and Lotze-Campen,H (2011) Climate change risks for African agriculture. Proc. Natl Acad. Sci. 108 (11) 4313–4315.

Namara, R. (2010) Typology of Irrigation Systems in Ghana, IWMI working Paper.

Naor, A., 2000. Solar noon stem water potential as a plant water stress indicator for irrigation scheduling in fruit trees. Acta Horticulturae 537:447–454.

Nazario M, de L (1984) The Unofficial Economy and the Crisis'. A Brazilian Debate: Ecodevelopment News, pp33-35.

Nhemachena, C., Hassan, R., Kuruku (2010) Measuring the economic impact of climate change on African agricultural production systems. Clim. Change Econ. 1 (1) 33–55.

Nhemachena, C., Matchaya, G., Karui, S., Muchara, B., (2018) Measuring baseline agriculture-related sustainable development goals index for Southern Africa. Sustainability 10 (3) 849.

Niang I, Ruppel O., Essel A., LENNARD, C., Padgham, J (2014) Africa. In: Barros V, Field C, Dokken D, Mastrandrea M, Mach K, Bilir T, Chatterjee M, Ebi K, Estrada Y, Genova R, Girma B, Kissel E, Levy A, MacCracken S, Mastrandrea P and White LL (eds), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge and New York. 1199–1265.

Orta, A.H., Erdem, Y., Erdem, T., 2003. Crop water stress index for watermelon. Scientia Horticulturae 98, 121–130.

O'Shaughnessy, S.A., Evett, S.R., 2010. Canopy temperature based system effectively schedules and controls center pivot irrigation of cotton. Agricultural Water Management 97, 1310–1316.

Pereira, L.S., 1999. Higher performance through combined improvements in irrigation methods and scheduling: a discussion. Agricultural Water Management 40, 153–169.

Poncet, J, Kuper, M, Chiche, J. (2010) Wandering off the path of planned innovation: The role of formal and informal intermediaries in a large scale irrigation scheme in Morocco. Agricultural systems 103 (4), 171-179.

Rabinovitch, J., and Schmetzer, H., (1997) cited in Drenchsel at al (1999) Urban Agriculture: Food, Job and Sustainable Cities. Agriculture and Rural Agriculture Development, 4(2), 44-45. In: Drechsel.P, Quansah, C.

Ruma, M. (2011) 'An analysis of urban irrigation farming and its urban planning imiplication: case study of Katsina Urban area, Nigeria', Bayero Journal of Pure and Applied Sciences, 2(2), pp. 116–120.

Sanyal B. (1985) Urban Agriculture: Who Cultivates and Why? A Case Study of Lusaka, Zambia: Food and Nutrition Bulletin. Vol, 3, ppl5-24.

SADC (Southern African Development Community) (2016) Outcomes of the ministerial workshop on food security and poverty reduction: towards a poverty free and food secure future. SADC Secretariat, Gaborone.

Sisay, B. and Fekadu, B. (2013) 'Small-scale irrigation and household income linkage: Evidence from Deder district, Ethiopia', African Journal of Agricultural Research, 8(34), pp. 4441–4451. doi: 10.5897/ajar12.1793.

Smith, M. (1969). A historical sketch of water resources development in Ghana.

Smith, M., Pereira, L.S., Beregena, J., Itier, B., Goussard, J., Ragab, R., Tollefson, L. Van Hoffwegen, P. (Eds.), 1996. Irrigation Scheduling: From Theory to Practice. FAO Water Report 8, ICID and FAO, Rome.

Smith, Nasr J., and Annu R. (1996) Urban Agriculture: A Neglected Resource for Food, Jobs and Sustainable Cities. New York: UNDP.

Songsore, J. (2009) 'The Urban Transition in Ghana: Urbanization, National Development and Poverty Reduction', Stegman, E.C., Schiele, L.H., Bauer, A., 1976. Plant water stress criteria for irrigation scheduling. Trans. ASAE 19, 850–855.

Tacoli, Cecilia (2015). Urbanisation, rural-urban migration and urban poverty. McGranahan, Gordon, Satterthwaite, David. London: International Institute for Environment and Development.

Thompson, R.B., Gallardo, M., Valdez, L.C., Fernandez, M.D., 2007. Using plant water status to define threshold values for irrigation management of vegetable crops using soil moisture sensors. Agricultural Water Management 88, 147–158.

Turner, N.C., 1988. Measurement of plant water status by the pressure chamber technique. Irrigation Science 9, 289–308.

UNFPA (2012). "Urbanization, gender and urban poverty:Paid work and unpaid carework in the city". The Economist, "Urban life: Open-air computers". 27 October 2012. Retrieved 20 March 2013.

Vellidis, G., Tucker, M., Perry, C., Kvien, C. Bednarz, C., 2008. A real-time wireless smart sensor array for scheduling irrigation. Computers and Electronics in Agriculture 61, 44–50.

Wanjura, D.F., Upchurch, D.R., Mahan, J.R., 1995. Control irrigation scheduling using temperature-time thresholds. Trans. ASAE 38, 403–409.

Wiedenfeld, B., 2004. Scheduling water application on drip irrigated sugarcane. Agricultural Water Management 64, 169–181.

Yeung, Yue-Man (1987). Examples of Urban Agriculture in Asia, Food and Nutrition Bulletin 9(2), 14-23.

Zotarelli, L., Scholberg, J.M., Dukes, M.D., Mu˜noz-Carpena, R., 2009. Tomato yield, biomass accumulation, root distribution and irrigation water use efficiency on a sandy soil, as affected by nitrogen rate and irrigatioscheduling. Agricultural Water Management 96, 23–34.

APPENDIX

QUESTIONNAIRE

EVALUATING THE EFFECTS OF POOR SCHEDULING IN FORMAL IRRIGATED URBAN VEGETABLE PRODUCTION IN THE GREATER ACCRA REGION.

My name is Eric Asare-Boafo and I am currently studying for a masters in Project management at the Kwame Nkrumah University of Science and Technology (Accra campus). I am conducting research into **EVALUATING THE EFFECTS OF POOR SCHEDULING IN FORMAL IRRIGATED URBAN VEGETABLE PRODUCTION IN THE GREATER ACCRA REGION**. This questionnaire consists of 11 questions and will take no longer than 10 minutes to complete. All responses will be kept anonymous and no one will be identifiable in the research.

1. What is your role within this scheme?

………………………………………………………………..

2. How long have you worked under this irrigation scheme?

☐ Less than a year ☐ 1-5 years ☐ 5-10 years ☐ 10 years +

3. What is the usual frequency of irrigation under this scheme?

☐ Once a week ☐ Twice a week ☐ Three times a week

4. What time during the day does the irrigation usually occur?

☐ Mornings ☐ Mid-day ☐ Evenings

5. How long does the irrigation usually last in a day?

☐ 1-2 hours ☐ 2-4 hours ☐ 4-6 hours

6. Are u comfortable with the frequency of the irrigation?

☐ Yes ☐ No If No, please explain and suggest

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7. Are u comfortable with the timing of irrigation?

☐ Yes ☐ No If No, please explain and suggest

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8. Are u comfortable with the duration of irrigation?

☐ Yes ☐ No If No, please explain and suggest

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9. What is your view on the following potential causes of poor scheduling?

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Frequent power cuts					
Non-payment of bills					
Breakdown of pumps					
Frequent pipe burst					

10. What is your view on the following potential effects of poor scheduling?

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Improper and irregular irrigation pattern					
Delay of other farming activities					
Lower crop yields					
Reduction of income					

11. What is your view on the following potential mitigation factors of poor scheduling?

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Reliable power supply					
Early payment of bills					
Regular servicing of pumps					