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Irrigation Agriculture, Meaning, Types, Economic Importance and Management Strategies in Enugu Metropolis

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Abstract: This study looks into irrigation farming in Nigeria with particular reference to Enugu and Anambra States. It raised objectives from which the following hypotheses were formulated: There is correlation between under watering and the success of irrigation scheme, there is significant relationship between overwatering and the success of irrigation scheme. The design of the study was surveyed by using questionnaire to raise data. After testing the hypotheses and analyzing the responses to the questionnaire, it was discovered that: Under-Watering in Irrigation farming causes: Loss in market value through yield reduction and reduction in fruit size and quality; Over-Watering in Irrigations farming causes: Unwanted vegetation growth, Losses of valuable water to the water table, Irrigation water travelling over soil can cause erosion. In conclusion it was noted that water management is very necessary in the irrigation farming. It was therefore recommended that: Irrigation farmers should boost market value of their product by proper irrigation and quality crops, Irrigation farmers should ensure increase in size and quality of their product for better patronage, Irrigation farmers should constantly check undergrowth, Irrigation farmers should check underwater travelling that causes erosion, Irrigation farmers should use pesticides. Government should encourage irrigation farming through adequate funding.
Keywords: irrigation farming, scheme, overwatering, Watering.

INTRODUCTION

Water allocation and management are among the most challenging issues facing vast majority of the world populace today. The growing national, regional and seasonal water scarcities caused by the increased demand furthermore put severe pressure on international development and on the environment [1-4]. As water becomes scarce, competition between different uses (agriculture, industry, households, energy, and environment) has also increased. Moreover, the situation could become even more challenging given the trends of lower rainfall on the one hand. In developing countries this growing scarcity and competition for water threatens advances in poverty eradication, public health and food production [5]. In addition, as these economies develop, environmental and other in-stream demands are becoming more important.

In the face of growing water scarcity, increasing competition for water across different economic sectors, escalating costs of additional sources of water augmentation and increasing demand for water for other use makes adequate water allocation paramount need. While domestic water restrictions have occupied the focus of most people's attention, the reality is that about 40 per cent of the water is used by the irrigated agriculture sector. The use of irrigation system in farm production dated back to BC. Irrigation is the artificial application of water to land for the purpose of agricultural production.

Irrigation as artificial application of water to land for the purpose of agricultural production influences the entire growth process from seedbed preparation, germination, root growth, nutrient utilization, plant growth and regrowth, yield and quality in all agricultural production process. Currently the largest consumer of water in most developing countries is irrigation, with water demands often above 80% of total consumption. Irrigated agriculture consumes a high percentage of the total water global use, and contributes about 38 percent of the global food production. Globally, the irrigated agricultural lands have increased almost by 2.4 percent in the seventies to 1.4 percent during the eighties and late nineties. It is projected to increase further by 0.4 percent per annum for the next 34 years [6, 7]. This indicates that the irrigation sector uses a large share of global water. This illustrates the relevance of the irrigation sector as water user [8, 9]. It has therefore been suggested that the most readily available path to meet future demands is achieving water savings in agriculture [10, 8, 11].

Historically, irrigation system is accredited to the Ancient Nubians, which developed a form of irrigation by using a waterwheel-like device called a sakia, as such irrigation began in Nubia sometime between the third and second millennium BCE. It largely depended upon the flood waters that would flow through the Nile River and other rivers which is now the Sudan. In sub-Sahara Africa irrigation reached the Niger River region cultures and civilizations by the first or second millennium BCE and was based on wet season flooding and water harvesting.

Available studies reported the presence of irrigation system in developed and developing countries of the world. In Asia, the Middle East and North Africa. The system comprises a network of vertical wells and gently sloping tunnels driven into the sides of cliffs and steep hills to tap groundwater. The noria, a water wheel with clay pots around the rim powered by the flow of the stream (or by animals where the water source was still), was first brought into use at about this time, by Roman settlers in North Africa. By 150 BCE the pots were fitted with valves to allow smoother filling as they were forced into the water. It is reported that the Ancient Egyptians practiced Basin irrigation using the flooding of the Nile to inundate land plots which had been surrounded by dykes. Similar report was seen in pre-Columbian America, early Syria, India, and China. In the Zana Valley of the Andes Mountains in Peru, archaeologists found remains of three irrigation canals radiocarbon dated from the 4th millennium BCE, the 3rd millennium BCE and the 9th century CE. These canals are the earliest record of irrigation in the New World [12].

In the Americas, extensive irrigation systems were created by numerous groups in prehistoric times. One example says Allen *et al*. [7] is seen in the recent archaeological excavations near the Santa Cruz River in Tucson, Arizona. They have located a village site dating from 4,000 years ago. The floodplain of the Santa Cruz River was extensively farmed during the early agricultural period, circa 1200 BC to AD 150. These people constructed irrigation canals and grew corn, beans, and other crops while gathering wild plants and hunting animals.

Ammendment III [13] noted that irrigation works of ancient Sri Lanka, the earliest dating from about 300 BCE, in the reign of King Pandukabhaya and under continuous development for the next thousand years, were one of the most complex irrigation systems of the ancient world. Traces of a canal possibly dating from the 5th millennium BCE were found under the 4th millennium canal. This paper aim to highlight irrigation agriculture, meaning, types, economic importance and management strategies in Enugu and Anambra Metropolis.

Objectives of the Study

The study shall evaluate the following objectives:

- To examine the impact of under watering on the success of irrigation scheme.
- To survey the effect of overwatering on the success of irrigation scheme.

Research Hypotheses

The following research hypotheses are formulated for the study:

H_1: There is correlation between under watering and the success of irrigation scheme.

H_2: There is significant relationship between overwatering and the success of irrigation scheme.

REVIEW OF RELATED LITERATURE

Historical Development of Sophisticated Irrigation and Storage Systems

Sophisticated irrigation and storage systems were developed by the Indus Valley Civilization in present-day Pakistan and North India, including the reservoirs at Girnar in 3000 BCE and an early canal irrigation system from circa 2600 BCE. The largest contiguous areas of high irrigation density are found in North India and Pakistan along the rivers Ganges and Indus, in the Hai He, Huang He and Yangtze basins in China, along the Nile River in Egypt and Sudan, in the Mississippi-Missouri river basin and in parts of California.

In the center of the 20^{th} century says Jones [5] the advent of diesel and electric motors led for the first time to systems that could pump groundwater out of major aquifers slow than it was recharged. This can lead to permanent loss of aquifer capacity, decreased water quality, ground subsidence, and other problems. The future of food production in such areas as the North China Plain, the Punjab, and the Great plains of the US is threatened. Smaller irrigation areas are spread across almost all populated parts of the world. Large scale agriculture was practiced and an extensive network of canals was used for the purpose of irrigation.

The flood water was held until the fertile sediment had settled before the surplus was returned to the watercourse. In the Ancient Persia (modern day Iran) as far back as the 6^{th} millennium BCE, where barley was grown in areas where the natural rainfall was insufficient to support such a crop irrigation, Qantas note developed in ancient Persia in about 800 BCE, and are among the oldest known irrigation methods still in use today [14].

According to Mokhtar [15] the oldest known hydraulic engineers of China were Sunshu Ao (6^{th} century BCE) of the spring and Autumn Period and Ximen Bao (5^{th} century BCE) of the Warting States period, both of whom worked on large irrigation projects. In the Szechwan region belonging to the State of Qin of ancient China, the Dujiangyan Irrigation System was built in 256 BCE to irrigate an enormous area of farmland that today still supplies water. By the 2^{nd} century AD, during the Han Dynasty, the Chinese also used chain pumps that lifted water from lower elevation to higher elevation. These were powered by manual foot Peale, hydraulic waterwheels, or rotating mechanical wheels pulled by oxen. The water was used for public works of providing water for urban residential quarters and palace gardens, but mostly for irrigation of farmland canals and channels in the fields.

In the century Korea notes Richard [14] the world's first rain gauge, urgyanggye, was invented in 1441. The inventor was Jang Yeong-sil, a Korean engineer of the Joseon Dynasty, under the active direction of the king, Sejong the Great. It was installed in irrigation tanks as part of a nationwide system to measure and collect rainfall for agricultural applications. With this instrument, planners and farmers could make better use of the information gathered in the survey.

Research Design

The study adopted a Case Study Design. Both primary and secondary data was sourced by in study. The primary is the questionnaire, oral interview and interviews administered on irrigation farmers. The secondary are the information gleaned from textbooks, journals, magazines and newspapers.

Area of the Study

The study was carried out among selected irrigation schemes in Enugu and Anambra.

Population of the Study

The population of the study is unknown as there are innumerable irrigation farmers in the areas of the study.

Sample Size Determination and Distribution

The Sample Size is three hundred and sixty nine (369). It is taken from Zimund's Formula for unknown Population (1977:84)

$$n = \frac{Zc^2\, pq}{e^2}$$

Zc is the table value of 5% level of significance at two tailed test = 1.96

p = proportion of success in the population from Pilot Survey which is 0.60 from this study

q = 1-p = proportion of failure in the population from Pilot Survey which is 0.40 from this study

n = observable sample size from relevant questionnaire

$$n = \frac{1.96^2 \times 0.60 \times 0.40}{0.05^2} = 369$$

So questionnaire was distributed to 369 irrigation farmers in Enugu and Anambra States according to:

Enugu State	164
Anambra State	205
Total	369

The hypotheses shall be tested using sample proportion statistics:

$$\sqrt{\frac{Ps - p}{\frac{pq}{n}}}$$

Reliability and Validity of the Instrument

Method of Data Analysis

Hypotheses were analyzed using Sample Proportion Statistic:

$$Z = \frac{\bar{P}s - p}{\sqrt{\frac{pp.}{N}}}$$

Z = chosen statistic at 5% level of significance

Ps = Proportion of success in the sample of relevant questionnaire

P = Proportion of success in the population from pilot survey =

0.60
q= Proportion of failure in the population from pilot survey =
0.40
n= Observable sample size from relevant questionnaire =
240

DECISION

Do not reject Ho (Null hypotheses), if and only if, Table of value is greater than calculated value. Reject otherwise Table of value is taken from the normal table at 5% level of significance, at two —tailed test = 1.96.

The table of value is taken at 5% level of significance as shown in the table below:

Level of significance	One tail	Two tail
K = 0.05	1.65	1.96

After responses to the questionnaire where collated and analyzed, and hypotheses tested, it was discovered that: Under-watering in irrigation farming causes: Loss in market value through yield reduction and reduction in fruit size and quality.

Over-watering in irrigation farming causes: Unwanted vegetation growth, Losses of valuable water to the water table, Irrigation water travelling over soil can cause erosion. It was also discovered that the excessive displacement of the top soil also affects soil fertility (and hence crop yields), and so it also clogs drainage ditches and streams (silting), harms aquatic habitants, fouls water used for recreational activities, and increases the need for water treatments. It was also discovered that Irrigation farming causes: pesticides, pathogens and weeds to spread during irrigation, Cause runoff, Increase operational costs (labour, pumping, cost of water), Leaching of nutrients (e.g salt, phosphorus) may lead to algal growth, salinity and nitrate build ups (poisoning) elsewhere in the catchment, Downgraded product quality and reduced yield, Higher operational costs for the producer (hence, reduced profits), Pressure on water resources with the increasing demands for water use by urban dwellers.

Types of Irrigation Systems

Furrows Systems: This system comprises a series of small, shallow channels used to guide water down a slope across a paddock. Furrows notes Moha [16] are generally straight, but may also be curved to follow the contour of the land, especially on sleeply sloping land. Row crops are typically grown on the ridge or bed between the furrows, spaced from 1 meter apart.

Flood or Border Check Systems: These systems divide the padlock into bays separated by parallel ridges/borer checks. Water flows down the paddlock's slope as a sheet guided by ridges. On steeply sloping lands, ridges are more closely spaced and may be curved to follow the contour of the land. Border systems say Cohen [17] is suited to orchards and vineyards, and for pastures and grain crops.

Level Basin Systems: These systems offer from traditional border check or flood systems in that slope of the lands is level and area's ends are closed. Water is applied at high volumes to achieve an even, rapid ponding of the desired application depth within basins.

Center-Pivot Sprinkler Systems: A center-pivot sprinkler is a self-propelled system in which a single pipeline supported by a row of moble towers is suspended 2 to 4 meters above ground. Water observes Nmachi [18] is pumped into the central pipe and as the towers rotate slowly around the pivot point, a large circular area is irrigated. Sprinkler nozzles mounted on or suspended from the pipeline distribute water under pressure as the pipeline rotates. The nozzles are graduated small to large so that the faster moving outer circle receives the same amount of water as the slower moving inside.

Hand Move Sprinkler Systems: Hand move sprinkler systems are a series of lightweight pipeline sections that are moved manually for successive irrigations. Lateral pipelines are connected to a mainline, which may be portable or buried. Handmove systems are often used for small, irregular areas. Handmove systems notes Jones [5] are not suited to tall-growing field crops due to difficulty in repositioning laterals. Labour requirements are higher than all other sprinklers.

Solid Set/Fixed Sprinkler Systems: Solid set/fixed refers to a stationary sprinkler system. Water-system. Water-supply pipelines are generally fixed (usually below the soil surface) and sprinkler nozzles are elevated above the surface.

Solid-set systems are commonly used in orchards and vineyards for frost protection and crop cooling. Solid-set systems are also widely used on turf and in landscaping.

Travelling Gun Sprinkler Systems: Traveling gun systems use a large sprinkler mounted on a wheel or trailer, fed by a flexible rubber hose. The sprinkler is self-propelled while applying water, travelling in a lane guided by a cable. The system requires high operating pressures, with 100 psi not uncommon.

Side-roll Wheel-move Systems: Side-roll wheel-move systems have large-diameter wheels mounted on a pipeline, enabling the line to be rolled as a unit to successive positions across the field. Crop type observes Kemper *et al*. [14] is an important consideration for this system since the pipeline is roughly 1 meter above the ground.

Linear or Lateral-Move Systems: Linear or lateral-move systems are similar to center-pivot systems, except that the lateral line and towers move in a continuous straight path across a rectangular field. Water may be supplied by a flexible hose or pressurized from a concrete-lined ditch along the field's edge.

Low-flow Irrigation Systems (including Drip and Trickle): Love-flow irrigation systems (including drip and trickle) use small-diameter tubes placed above or below the soils surface. Frequent, slow applications of water are applied to the soil through small holes or emitters. The emitters observe ILRI [19] are supplied by a network of main, submain, and lateral lines. Water is dispensed directly to the root zone, avoiding runoff or deep percolation and minimizing evaporation. These systems are generally used in orchards, vineyards, or high-valued vegetable crops.

Water Resource Management

Water resource management Walling [20] is the activity of planting, developing, distributing and managing the optimum use of water resources. It is a sub-set of water cycle management. Ideally, water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands. As with other resource management, this is rarely possible in practice. Walling explains further that visualization of the distribution (by volume) of water on Earth. Each tiny cube (such as the one representing biological water) corresponds to approximately 1000 cubic km of water, with a mass of approximately 1 trillion tones (200000 times that of the Great Pyramid of Giza or 5 times that of Lake Kariba, arguably the heaviest man-made object).

The entire block comprises 1 million tiny cubes. Milliman *et al*. [21] notes water is an essential resource for all life on the planet. Of the water resources on earth only three percent of it is fresh and two-thirds of the freshwater is locked up in ice caps and glaciers. Of the remaining one percent, a fifth is in remote, inaccessible areas and much seasonal rainfall in monsoonal deluges and floods cannot easily be used. At present only about 0.08 percent of all the world's fresh water is exploited by mankind in ever increasing demand for sanitation, drinking, manufacturing, leisure and agriculture. Much effort in water resources management is directed at optimizing the use of water and in minimizing the environmental impact of water use on the natural environment.

Successful management of any resources requires accurate knowledge of the resource available, the uses to which it may be put, the competing demands for the resource, measures to and processes to evaluate the significance and worth of competing demands and mechanisms to translate policy decisions into action son the ground. Carter [22] states that for water as a resource this is particularly difficult since sources of water can cross many national boundaries and the uses of water include many that are difficult to assign financial value to and may also be difficult to manage in conventional terms. Examples include rare species or ecosystems or the very long term value of ancient ground water reserves.

Managing Water in Urban Settings

Zuo [16] states that half of the world's people now live in towns and cities, a figure expected to reach two-thirds by 2050. In the areas surrounding urban centers, agriculture must compete with industry and municipal users for safe water supplies, while traditional water sources are becoming polluted with urban wastewater. As cities offer the best opportunities for selling produce, farmers often have no alternative to using polluted water to irrigate their crops. Depending on how developed a city's wastewater treatment is, there can be significant health hazards related to the use of this water. Wastewater from cities can contain a mixture of pollutants. There is usually wastewater from kitchens and toilet along with rainwater runoff. This means that the water usually contains excessive levels of nutrients and salts, as well as a wide range of pathogens. Heavy metals may also be present, along with traces of antibiotics and endocrine disruptors, such as oestrogens. Blum & Roberts [12] note that developing world countries tend to have the lowest levels of wastewater treatment. Often, the water that farmers use for irrigating crops is contaminated with pathogens from sewage.

The pathogens of most concern are bacteria, viruses and parasitic worms, which directly affect farmer's health and indirectly affect consumers if they eat the contaminated crops. Common illnesses include diarrhea, which kills 1.1 million people annually and is the second most common cause of infant deaths. Many cholera outbreaks are also related to the reuse of poorly treated wastewater. Actions that reduce or remove contamination, therefore, have the potential to save a large number of lives and improve livelihoods. Scientists have been working to find ways to reduce contamination of food using a method called the 'multiple-barrier approach'.

According to Blum & Roberts [12] this involves analyzing the food production process from growing crops to selling them n markets and eating them, then considering where it might be possible to create a barrier against contamination. Barriers include: introducing safer irrigation practices, promoting on-farm wastewater treatment; taking actions that cause pathogens to die off; and effectively washing crops after harvest in markets and restaurants.

Agriculture: Water's Biggest Consumer

According to carter et al, agriculture is the largest user of the world's freshwater resources, consuming 70 percent. As the world's population rises and consumes more food (currently exceeding 6%, it is expected to reach 9% by 2050), industries and urban development's expand, and the emerging biofuel crops trade also demands a share of freshwater resources, water scarcity is becoming an important issue. An assessment of water resource management in agriculture was conducted in 2007 by the International Water Management Institute in Sri Lanka to see if the world has sufficient water to provide food for its growing population. It assessed the current availability of water for agriculture on a global scale and mapped out locations suffering from water scarcity. It found that a fifth of the world's people, more than 1.2 billion, live in areas of physical water scarcity, where there is insufficient water to meet all demands.

A further 1.6 billion people live in areas experiencing economic water scarcity, where the lack of investment in water or insufficient human capacity makes it impossible for authorities to satisfy the demand for water. As observes Chu *et al.* [16] the report found that it would be possible to produce the food required in future, but that continuation of today's food production and environmental trends would lead to crises in many parts of the world. Regarding food production, the World Bank targets agricultural food production and water resource management as an increasingly global issue that is fostering an important and growing debate. The authors of the book Out of Water: From abundance to Scarcity and How to Solve the World's Water Problems, published in 2011, laid down a six-point plan for solving the world's water problems.

These are: (1) improve data related tow water; (2) Treasure the environment; (3) Reform water governance; (4) Revitalize agricultural water use; (5) Manage urban and industrial demand; and (6) Empower the poor and women in water resource management. To avoid global water crises, farmers will have to strive to increase productivity to meet growing demands for food, while industry and cities find ways to use water more efficiently.

Future of Water Resources

Houben, Wunderlich & Schrott [23] explain that one of the biggest concerns for our water-based resources in the future is the sustainability of the current and even future water resource allocation. As water becomes scarcer the importance of how it is managed grows vastly. Finding a balance between what is needed by humans and what is needed in the environment is an important step in the sustainability of water resources. Attempts to create sustainable freshwater systems have been seen on a national level in countries such as Australia, and such commitment to the environment could set a model for the rest of the world. The field of water resources management will have to continue to adapt to the current and future issues facing the allocation of water. With the growing uncertainties of global climate change and the long term impacts of management actions, the decision-making will be even more difficult. It is likely that ongoing climate change will lead to situations that have not been encountered. As a result new management strategies will have to be implemented in order to avoid setbacks in the allocation of water resources.

Irrigation Management

Irrigation says Provenzano & Giuseppe [22] is the artificial exploitation and distribution of water at project level aiming at application of water at field level to agricultural crops in dry areas or in periods of scarce rainfall to assure or improve crop production. This article is about organizational forms and means of management of irrigation water at project level.

History

Scholars such as Julian H. Steward and Karl August Wittfogel have seen the management of irrigation as a crucial factor in the development of many early states (hydraulic empires).

Water Management

The most important physical elements of an irrigation project observe Nwala [18] are land and water. In accordance with the property relations of these elements, there may be different types of water management.

- The communal type
- The enterprise type
- The utility type

Communal Type

Until the end of the 19th century the development of irrigation projects occurred at a mild pace, reaching a total area of some 50 million ha worldwide, which is about 1/5 of the present area? The land was often private property or assigned by the village authorities to male or female farmers, but the water resources were in the hands of clans or communities who managed the water resources cooperatively.

Enterprise Type

The enterprise type of water management notes ILRI [24] occurred under large land owners or agricultural corporations, but also in centrally controlled societies. Both the land and water resources are in one hand. Large plantations were found in colonized countries in Asia, Africa, and Latin America, but also in countries employing slave labour. It concerned mostly the large scale cultivation of commercial crops such as bananas, sugarcane and cotton. As a result of land reforms, in many countries the estates were reformed into a cooperative, in which the previous employers became members and exercised a cooperative form of land and water management.

Water Pricing

According to Symon [25] irrigation water has a price by which the management costs must be covered. The following tariff (water charge) systems exist.

- No tariff, the government assumes the costs
- Tariff in labour hours, which holds mainly in communal types of management in traditional irrigation systems
- Yearly area tariff, a fixed price per ha per year
- Seasonal area tariff, a fixed price per ha per season with the higher price in the dry season
- Volumetric tariff, a fixed price per m3 of water; the consumption is measured by water meters
- Block or stepped-up pricing for water use per ha; the price increases as the water consumption per ha falls in a higher block.

The use of groundwater for irrigation is often licensed by government and the well owner may be permitted to withdraw only a maximum volume of water per year at a certain price.

Cost Recovery

The recovery of water charges may be below target, because Knikow & Leonard [26]:

- The revenues accrue to a (government) organization other than the one responsible for the management
- Farmers and water users have a say in the water management
- Lack of communication between farmers and project managers
- Poor farmers are unable to comply
- Farmers do not receive water according to need; for example insufficient quantity and/or inappropriate time
- Corruption at management level.

CONCLUSION

Irrigation is conducted in arid zones to make the dry land agrarian. Many schemes are being adopted as there are diversities of aridity and topography. In Nigeria, the typical arid zones are the sahelian states of the far North. In the Sudan Savanna and Guinea Savanna States, irrigation is conducted to make water round the year available. The problem usually noticed is water logging due to over watering which causes the soil to be acidic. The soil could be alkalinic which really is good. But under-watering can also deplete alkaline content of the soil, thus exposing it to poor nutrient accumulation.

In Nigeria, there is massive irrigation in the Northern States due to low rainfall. In the South, there is plethora of irrigation scheme along the river basin of Ajali. This scheme is sponsored by government as well as spirited individual businessmen. Sometimes World Bank via Food and Agricultural Organization (FAO) finances irrigation scheme in Nigeria especially in the North. Irrigation thus has been a veritable source of increasing agricultural productivity. However, the problems of under watering and overwatering pose a serious threat to the success of the scheme.

RECOMMENDATIONS

Following the findings of this study, the following are recommended:

- Irrigation farmers should boost market value of their product by proper irrigation and quality crops.
- Irrigation farmers should ensure increase in size and quality of their product for better patronage.
- Irrigation farmers should constantly check undergrowth.
- Irrigation farmers should check underwater travelling that causes erosion.
- Irrigation farmers should use pesticides.
- Government should encourage irrigation farming through adequate funding

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