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Irrigation Systems in the Arid and Semi-Arid Dryland Environments- A Review

¹Hashimu A. H, ²Dauda A, ²Muhammad A, ³Babangida M.

¹*Department of Social Science, Jigawa State College of Remedial and Advance Studies Babura
(JICORAS) P.M.B 2020 Jigawa State Nigeria.*

²*Department of General Studies and Foundation Courses, Binyaminu Usman Polytechnic Hadejia P.M.B
013 Jigawa State Nigeria.*

³*Jigawa State Universal Basic Education Board Dutse, Jigawa State Corresponding author:*

ABSTRACT

Dryland are a vital part of the earth's human and physical environments. They encompass grasslands, agricultural lands, forest and urban areas. Dry land ecosystem plays a major role in global biophysical processes by reflecting and absorbing solar radiation and maintaining the balance of atmospheric constituents. They provide much of the world's grain and livestock, forming the habitat that supports many vegetable species, fruit trees and microorganisms. Generally water is important for the survival of all living things; only the required quantities may vary. All plant requires water for survival as it is an essential substance that must be available for their growth and development. Averagely the body mass of plant is made up of about ninety percent (90%) of water; on the other hand the human body consists of seventy percent (70%). The process of supply crops with water using artificial channels is known as irrigation. This paper is aimed looking into different irrigation systems employed in arid and semi-arid dryland environment. These irrigation systems are flood recession irrigation, irrigation in the oasis, large scale irrigation and irrigation along sand rivers.

Keywords: Drylands, Environment, Irrigation, Systems

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Introduction

Irrigation can be described as the application of water to the soil to make available essential moisture for plant growth. It also serves as insurance against drought and to provide a cooling effect on the soil environment for plant growth and development (Gambo, 2014). So, irrigation is aimed at improving and raising the productivity of soil resources. The principle, according to (Fussel, 2005) is that the environment is characterized by fair to good soils but poor and unreliable low precipitation as it is the case in dry and semi-dry lands. Irrigation tries to meet additional water requirement of crop during the wet season and supplies to the farm during the dry season. This is because precipitation is irregularly distributed throughout the year in arid and semi-arid region (Derege, 2005). In other words the irrigation system is aimed at increasing and improving agricultural yield, particularly in moisture-deficient environments. Irrigation is the artificial watering of crops. Water scarcity issues causes' serious concern in arid and semi-arid regions and existing water shortages are predicted to escalate in both frequency and duration over the next century (Eric, 2011). In arid and semi-arid area water is an important limiting factor to growth. Given that water provides one of the most important life-support functions, ensuring food security through agricultural production and enabling the existence of all ecosystems, the allocation of scarce surface and ground water resources in

an efficient manner is of paramount importance.

a) Flood Recession Irrigation

Inundation and recession of floodwaters can provide a variety of opportunities for productive agriculture. High levels of post-flood residual soil moisture and shallow groundwater tables in the floodplains enable effective dry-season agriculture without, or with only limited need for irrigation. Floods bring sediments from the upper catchment (Okonkwo, 2013). When these floodwaters are effectively managed, the organic matter in these sediments are deposited, which enhances soil fertility. Fine grained sediment deposits also have higher water retention capacities. This in turn can be useful in supplementing the water requirements of crops growth in these deposits. Flood resistant crops, such as certain types of rice and sorghum, can be grown at different point during the flood cycle to maximize a farm's annual productivity. At least two crop cycles may be possible by effectively managing flood and carefully timing the planting of crop to make use of fertile floodplain land that is only accessible during the dry season, but may still retain significant soil moisture.

Places Where Flood Recession Irrigation are Practiced

i. Hadejia-Jama 'are, Nigeria

The River Dilimi with its catchment on the Jos plateau stretches through five other states in the northern part of Nigeria where it is various known as Hadejia, Jama 'are Kamadugu and

Yobe River. In the Hadejia Jama 'are plains different rice and sorghum varieties with different ecological requirements are grown on the seasonally flooded land. Farmers built defensive bunds to protect their land to early flooding that potentially can cause crop failure. Flood recession crops like cowpeas grow on cracking clay using the residual soil moisture after the flooding have receded. Low-lying seasonally flooded areas in Nigeria are called fadamas. The Fadamas are recognized for their potential productivity especially during the dry season and there have been several projects to develop the Fadamas. Thomas and Adams (1999) Describes that farmer use the low-lying fadamas, with heavy alluvial soil in flood and recession times for agricultural purposes.

ii. Hadejia-Nguru Floodplain, Yobe Basin, Nigeria

The Hadejia-Nguru floodplains are located in north east Nigeria, as part of the Yobe Basin. Several studies point out three distinguished farming seasons: two wet seasons, one on rising and one on receding flood, and a third dry season farming (Thomas *et al.*, 1999)

iii. Sokoto Valley, Nigeria

In the Sokoto valley similar activities exist. The floodplains are also cultivated in synchrony with the rains. The farmers that have land on the floodplain grow several varieties of rice and sorghum that are resistant to flood.

iv. Sierra Leone

In the floodplain of the Wanje River in Sierra Leone, seasonally flooded lands called bati are cultivate with floating rice called Kogbati. This rice is planted with the rising flood and harvested with falling flood.

v. Niger River

Harlan and Pasquereu (1968) investigated the Niger inland delta in Mali. They found farmers using the floodwater of seasonal floods. They called the two phases *scrue* and *decru* agriculture. Skilled cultivators with useful practical knowledge of the crops to be plated on wet or drier soil were active in the wetland adjacent to the river. The sequence of crop that performs best from the more upper and drier field towards the lower and wetter part of the floodplain is: pearl millet, long season durra, mid-season durra, guinea corn and rice.

vi. Flood recession farming in Ethiopia

The areas in Ethiopia where flood recession farming is practice all have their own history and agricultural methods. Flood recession agricultural is practiced annually, located in the Ilu Woreda in the Becho plain, and in the Bora Woreda upstream of Lake Koka (crops like teff, wheat, maize and haricot beans (*Phaseolus vulgaris*) are planted in these areas.

vii. Flood recession farming in Senegal

Saaenak (2003) describes flood recession agricultural practices in the Senegal River Valley where sorghum, bean, and melons are cultivated on floodplains after the water recedes. The farmers use the water that is left

on the surface and in the soil of the floodplain, after the flood recede.

viii. Flood recession farming in Vietnam

Flood recession agriculture has been practice at least for 1600 years in the Mekong Delta (Fox *et al.*, 1999). Dry season flood recession rice is believed to have sustained economically not only the Funan civilization but the greater Angkor Empire (9th to 15th centuries A.D) as well.

Major Floodplain wetland of the western Sahel

wetland –Floodplains	Surface area (km ²)	Country
Senegal	3,000	Senegal
Senegal valley	5,000	Senegal
Niger inner Delta	30,000	Niger
Niger Fringing Floodplains	3,000	Niger
Sokoto and Rima valley	1,000	Nigeria
Hadejia-Nguru Floodplains	4,000	Nigeria
Logone Floodplains	11,000	Cameroon
Lake chad Floodplains	10,000	Nigeria, Cameroon and Chad
Total	67,000	

Estimation of the floodplain area in western Sahel (Loth 2004)

b. Irrigation in the Oasis

An oasis is an area made fertile by a source of freshwater in an otherwise dry and arid region. Oases are irrigated by natural springs or other underground water sources. They vary in size from a cluster of date palms around or other well a spring to a city and its irrigated crop land. Dates, cotton, Olives, figs, citrus fruits, wheat and corn (maize) are common oasis crops. Underground water sources called

aquifers supply most oases. In some cases, a natural spring brings the underground water to the surface. At other oases man made wells tap the aquifer. In some oasis settlements, these wells might be centuries old and might have been diligently maintained for generation to preserve access to their life-giving water. Sand blown by desert winds threatens wells as well as agricultural areas in oases (Zoubir, 1996). The Sahara is the largest desert on Earth-about the size of the continental United States. Al-Hasa, Saudi Arabia, has been an

important farming area for the Arabian Peninsula for thousands of years. Today, it continues to be a leading agricultural region, producing dates, milk, corn sheep, cattle, and eggs. (Encarta Nigeria, 2009).

i. Oasis Irrigation in Algeria

The oases in the Algerian Sahel illustrate effectively how Niger has succeeded in arid and semi-arid conditions. Over the centuries, an efficient and sustainable irrigation system has been applied that has allowed the inhabitants of the oasis to live in conditions of extreme aridity respecting the particular properties of these unstable ecosystems. However, over the course of the past few years, the Sahara oases have come to experience strong demographic growth along with the intensification of agricultural production. In this particular fragile environment, the inhabitants of the oases tend to forgo traditional knowledge regarding water resources. Also, modern techniques to pump water from underground

sources dry up the groundwater reserves in a way that is irreversible. For this reason, the rehabilitation of the foggaras, a system of tradition irrigation is recommended in the oasis of Touat in south eastern Algeria (Zoubir, 1996).

ii. Oasis Irrigation in Egypt

Al Fayyum, also Fayum (Egyptian, “Marshland”) region, northern Egypt, lying below sea level within a vast depression of the Libyan Desert and comprising an almost circular oasis. It is irrigated by the Bahr Yusuf Canal, which is connected with the Nile River. The canal, originally an irrigation project of the Theban pharaohs, was restored by Saladin, the 12th century sultan of Egypt. Al Fayyum also contains Birkat Qarun, a lake that occupies a part of the basin of ancient Lake Moeris. The region, one of the most fertile in Egypt produces cotton, flax, hemo, rice, sugarcane, roses, oranges, peaches pomegranates, figs, grapes, and olives. Among the economically important occupations are the raising of sheep and poultry, fishing and the making of most of the attar of roses produced in Egypt (Encarta premium, 2009).

c. Large Scale Irrigation

i. Kano River Irrigation Project (KRIP)

Kano river irrigation project is a large scale capital intensive irrigation scheme designed to cover an area of 58,000 acres in Kano state. The kano state Government established, the Kadawa Irrigation Scheme in 1970 and the Bagauda lake in 1974. The project comes under the authority of the Hadejia and

Jama’are River Basic Development Authority in 1976 so as to run the affairs of Kano River Project I and is the first of several such scheme which will eventually cover 146,000 acres in Kano state. The project was started in 1971 and the initial research was conducted in 1976-77 when the scheme was still at its first phase and restricted to 3000 acres. Also Kano River Project has 22, 00 hectares of irrigable areas out of which only 15,000 hectares had been fully developed at cost of about N160 million between 1970 and 1984 (H.J.R.B.D.A. 2004). The development of KRIP has changed the economic conditions of many local people who are actively engaged in irrigation activities. Various cash crops are produced under the KRP irrigation project. These include tomato, pepper rice, wheat, corn, Okra and many others growth for local consumption. The produce are mainly sent to local market in Kano and many places in southern Nigeria.

ii. The Bakori Irrigation Project in Nigeria

Irrigation project was commissioned in 1975. The dam has 450 million cubic meters water storage capacity. The reservoir covers 8,000 hectares and extends some 119 km upstream from the dam by 1979 when the dam was completed. Fifteen km-supply canal carries water from the dam down stream of irrigation area where the water is distributed through several hundreds of kilometer secondary and tertiary canals. The original goal of the project was to supply irrigation water to the estimated population in the project area of about forty to

fifty thousand farm families. Majority of the people in Sokoto valley are peasant farmers who depend on the irrigation project (Mohammed, 2002).

iii. Irrigation project in Sudan

Irrigated agriculture in Sudan falls into two broad categories: traditional irrigation and modern schemes. Approximately 90 percent of the irrigated area is managed under the modern scheme. Sorghum is the main cultivated crop, following by cotton, fodder, wheat, vegetables, groundnut and sugarcane. The Gezira irrigation scheme (including its Managil extension) between the blue and white Nile covers nearly half of Sudan's total irrigated area and is reportedly the largest contiguous irrigation scheme under single administration in the world. Alone, it consumes 35 percent of Sudan's share of Nile waters. The other two major schemes are the Rehad on the bank opposite Gezira, and the new Galfa on the Atbara river. (UNEP, 2006).

iv. Irrigation in Ethiopia: Irrigation is practice in Ethiopia since ancient times producing subsistence food crops. However, modern irrigation system were started in the 1960s with the objective of producing industrial crops in Awash Valley. Private concessionaires who operated farm for growing commercial crops such as cotton, sugarcane and horticultural crop started the first formal irrigation scheme in the expanded in all parts of the Awash Valley and in the lower rift Valley (Seleshi *et al.*, 2007). The Awash Valley saw the biggest expansion in

view of the water regulation afforded by the construction of the Koka Dam and reservoir that regulate flows with benefits of flood control, hydropower and assured irrigation water supply. In addition, the construction of the tarmac Addis-Assab road opened the Awash Valley to ready market in the hinterland as well as for export (MCE 2004). The large-scale irrigation scheme consists of 53 percent of the irrigation scheme developed so far. One of the large scale irrigation schemes is Metahara Abadiy which is located in East Shoa, in Oromia Regional State. This irrigation scheme covers an estimate irrigation area of 8,960 hectares. Another large scale irrigation Scheme is Finchaa. Finchaa Irrigation Farm is a mechanized farm located in Eastern Wellega Zone in Oromia Regional State; North West of Addis Ababa. This scheme covers an area of 8,060 hectares of irrigated area. This farm mainly produces sugar cane, which is a raw material in the finchaa sugar Factory. A study (Degeje 2005) revealed that the area has the potential of producing other horticultural product and a possible of cultivating oil seed on large-scale, in addition to the cane plantation supplied to Finchaa sugar Factory. Wonji is also one of the large-scale irrigation schemes with an estimated irrigated area of 5,925 hectares.

d. Irrigation along Sand Rivers

For Thousands of year, People have survived through dry seasons by scooping water-holes in sand rivers in ecological zones ranging from Semi-arid to desert. Even today many

rural people use water-holes in sand rivers as their only water source for domestic use, watering live-stock and small scale irrigation. People in arid area have survived by drawing water from wells dug in sandy river beds, known variously as sand rivers luggas, or wadis. Such well are fed by seasonal floodwater that is trapped in the sand long after the surface has dried up. People often use this water for drinking because it is often of better quality than surface water. Sand rivers are common features in arid lands.

They are formed as flash floods-erode rocky hills carrying sand downstream. The underlying rock may be impermeable, and large amounts of water may be trapped in sand-filled depressions in this rock (IIRR, 2002)

i. Sand River Irrigation in South Africa

The Sand River catchment, with forms part of the Sabie Catchment, lies in the eastern region of South Africa, straddling Mpumalanga and Limpopo provinces. The total area of the catchment is 1910Km². Sub divided into 9 quaternary catchments. The headwater of the catchment lies in the hills at the edge of the Drakenberg escarpment and receives an average of 1800 mm/yr of rainfall. However, the bulk of the catchment lies in the dry Lowveld, with a mean annual rainfall of only 500 mm/yr (Pollard and walker, 2000). The sand catchment is primarily semi-arid, and shows the typical variability associated with such regions in term of surface water availability both within and between years.

Conclusion

Various irrigation systems are employed in arid and semi-arid dry lands environment. The aim is to increase food production to the teeming population of the dry land environment.

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