



## EVALUATION OF ON-FARM DRAINAGE SYSTEM IN NIGERIA: A REVIEW

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### ABSTRACT

Drainage involves the removal of the excess water on the farm to improve the aeration and trafficability of soils in regions characterized by seasonal high-water tables. There is no doubt that drainage is intrinsically linked to crop yield. A well-drained soil reduces water stress on crops and improves root development, which is required to increase crop yields and food production quality. Nigeria is committed to a national policy that ensures sustainable development based on proper management of the environment to meet the needs of the present and future generations. This demands positive and realistic planning that balances human needs against the potential that the environment has for meeting them. Management strategies must be implemented to achieve effective and efficient drainage systems. The existing on-farm drainage systems were evaluated and found ineffective and inefficient; thus, modifications are required to improve the conditions at various locations in Nigeria.

### 1.0 Introduction

Natural and artificial rainfall (irrigation) apply water to crops for growth and development (Mushombe *et al.*, 2016). Pore spaces fill with water applied through rainfall or irrigation and are absorbed by the plant's roots. When the pore spaces are saturated, water overflows the soil's surface and runs off into more extended drains in the field.

Drainage involves the removal of the excess water on the farm to improve the aeration and trafficability of soils in regions characterized by seasonally high-water tables (Alfred *et al.* 2016). Drainage systems help to increase crop yield of poorly drained soils by providing a better environment for plant growth, especially during wet periods, and improving field conditions for timely tillage, planting, and harvesting. When drainable water is removed from the soil profile, infiltration can occur. This is due to the available soil pore space, which allows water that would otherwise be stored in the surface depressions to infiltrate and have a direct pathway to downstream flow via the subsurface drains. Although agricultural production has benefited from agricultural drainage in many regions and countries, there are concerns about potential environmental impacts. The most dramatic hydrological changes in a landscape occur when the latter is converted from native vegetation to intensive cropping systems (Mushombe *et al.*, 2016).

Nigeria is committed to a national policy that ensures sustainable development based on proper management of the environment to meet the needs of the present and future generations. This

demands positive and realistic planning that balances human needs against the potential that the environment has for meeting them. Although disasters such as floods and erosion are nationwide challenges in Nigeria, the intensity varies in different places. The problem, however, is most prominent in Eastern and Northern Nigeria. As a result, arable lands, agricultural produce, and landed and household properties have all been damaged by gullies created right in the middle of roads, and many farmlands, markets, and communities have been cut off from one another. It is a fact that floods and erosion are natural occurrences (Alfred *et al.*, 2016).

## 1.1 Drainage Pattern

According to the configuration of the channels, drainage systems can fall into one of several categories known as drainage patterns. Drainage patterns depend upon the topography and geology of the land. The following are the types of drainage patterns (i.e. natural drainage) stated by Ling *et al.* (2012) and Valipour *et al.* (2020).

**1.1.1 Dendritic Drainage System:** They are not straight and are the most common drainage system. In a dendritic system, there are many contributing streams, which are then joined together into the tributaries of the main river. They develop where the river channel follows the slope of the terrain. Dendritic systems form in V-shaped valleys. As a result, the rock types must be impervious and non-porous.

**1.1.2 Parallel Drainage System:** A parallel drainage system is a pattern of rivers caused by steep slopes with some relief. Because of the steep slopes, the streams are swift and straight, with very few tributaries, and all flow in the same direction. This system forms on uniformly sloping surfaces. A parallel pattern also develops in regions of parallel, elongated landforms like outcropping-resistant rock bands. Tributary streams tend to stretch out in a parallel-like fashion following the slope of the surface.

**1.1.3 Trellis Drainage System:** The geometry of a trellis drainage system is similar to that of a standard garden trellis along a strike valley. Smaller tributaries feed into the steep slopes on the sides of mountains. These tributaries enter the main river at approximately 90-degree angles, causing a trellises-like appearance of the drainage system.

**1.1.4 Rectangular Drainage System:** Rectangular drainage develops on rocks that are of approximately uniform resistance to erosion but have two directions of joining at approximately right angles or 90 degrees. The joints are usually less resistant to erosion than the bulk rock, so erosion tends to open the joints preferentially, and streams eventually develop along the joints.

**1.1.5 Radial Drainage System:** The streams radiate from a central high point in a radial drainage system. Volcanos usually display excellent radial drainage. They can sometimes also be found on top of mountains. Other geological features on which radial drainage commonly develops are domes and laccoliths. The drainage may exhibit a combination of radial patterns on these features. The radial pattern develops when streams flow from a central peak or dome-like structure in various directions.

**1.1.6 Centripetal Drainage System:** The centripetal drainage system is similar to the radial drainage system, with the only exception that radial drainage flows out versus centripetal drainage flows in

**1.1.7 Deranged Drainage System:** A deranged drainage system is a drainage system in drainage basins with no coherent pattern to the rivers and lakes. It happens in areas where there has been much geological disruption.

**1.1.8 Annular Drainage System:** In an annular drainage system, streams follow a roughly circular or concentric path along a belt of weak rock, resembling a ring-like pattern. It is best displayed by streams draining a maturely dissected structural dome or basin where erosion has exposed rimming sedimentary strata of wildly varying degrees of hardness, as in the Red Valley.

## 1.2 Reason for Artificial Drainage

Wetlands soil, especially those found on farmlands, is drained with open ditches and trenches, primarily used for high-value crops such as vegetables (Valipour *et al.*, 2020). Wetland soils usually need drainage to be used for agricultural purposes. People are confident that combining drainage and wetlands is the key to economic and environmental concerns, but there is no proof either way yet. The invention of wind-powered pumping engines in the 15th century gave room for some of the marginal land drainage. Still, the final drainage of the lake had to await the design of large, steam-powered pumps and agreements between regional authorities. The lake was eliminated between 1849 and 1852, creating thousands of km<sup>2</sup> of new land in the Netherlands (Valipour *et al.*, 2020).

## 1.3 Classification of On-Farm Drainage System

There are two major types of on-farm drainage systems. These are surface drainage and sub-surface or underground drainage. Drainage can also be categorized into a gravity system (surface and sub-surface) and a pump system (wells and sumps).

### 1. Surface Drainage

This is the removal of the excess water from the surface of the farmland using constructed open ditches, field drains, and land grading and lateral ditches. The regular surface drainage systems, which start functioning as soon as an excess of rainfall or irrigation is applied, operate entirely by gravity (Valipour *et al.*, 2020). They consist of reshaped or reformed land surfaces and can be divided into Bedded systems, used in flat lands for crops other than rice;

- Bedded systems, used in flat lands for crops other than rice
- Graded systems, used in sloping land for crops other than rice

### 2. Sub-Surface or Underground Drainage

When subsurface drains are in place, the drainable water fraction of the soil profile is converted to short-term (detention) storage over a few hours, days, or weeks, depending on several variables (Barnes *et al.* 2018). These include subsurface drain size, depth and spacing, soil type, outlet size/condition, and whether or not under continuous rainfall or snowmelt conditions. This is an orderly of excess water from the farmland artificially using different materials like pipes, tiles, moles and plastic tubes. The common type is the tile drains (Sharma & Kumar, 2023). This consists of pipes connected to a continuous line and laid in a narrow trench. These pipes have holes (openings) drilled around them to drain excess water toward the outlet. Usually, filter materials are laid around the pipes to prevent holes from clogging. Concrete and clay pipes are the most common tiles used in irrigated areas. Bamboo sticks are extensively used in Asia. They have been tested in many regions in Nigeria and found to be suitable.

## 2.0 Nigeria Situations of On-Farm Drainage Systems

In this section, the situation of drainage in Nigeria was looked into. The first of which is the Zauro Polder Project (ZPP). The scheme was designed for the Sokoto River Basin Development Authority to be used as a model for the farmers on the northern part of Birnin

Kebbi next to the southern bank of Sokoto Rima valley. It was designed to irrigate above 11,000 ha and managed by 7,790 farmers (Idah *et al.*, 2009).

The scheme was operational with a 2.65km flood safety dyke, 3.5m high, and a temporary pumping station with a generator. This central canal is connected to a compensation reservoir, four lateral canals, and a collector drain. These facilities are anticipated to improve water circulation and management to successfully operate the surface irrigation that is essentially practised in the area. At the end of the research by Idah *et al.* (2009), it was discovered that four areas were waterlogged, caused mainly by lack of surface outflow, lack of effective drainage, lack of adequate percolation, an excessive inflow of water and increase in the underground water table height, these affected various farmers and their output because the farmland available for cultivation was reduced. The presence of excess water on the farmland reduced the crop yield of the farmers.

The second publication that was looked into was the study undertaken at Offa local government of Nigeria by Musa *et al.* (2010). Research on the Effect of surface runoff on Nigeria's rural roads (A Case study of Offa LGA) was undertaken, which looked into the following highways and farmlands in Offa LGA of Nigeria, the roads were Erin-Offa Road, Oyun-Offa Road Maikka-Offa Road, Ojoku-Offa Road, Wara-Ilorin Road and Ogbomoshon-Ilorin Road and the farmlands in the area.

The study asserted that the influence of surface runoff on the rural roads and farmlands in Offa Local Government Area cannot be overemphasized as most farmers lose their produce during transportation due to potholes caused by surface runoff and reduction in the size of land suitable for cultivation thereby hindering farmers activities and resulting to decrease in their produce during the peak rainy seasons (Musa *et al.* 2010).

### **3.0 Discussion of Drainage Systems**

In geomorphology, a drainage system is the pattern formed by the streams, rivers, and lakes in a particular drainage basin. The land's topography governs them, whether a specific region is dominated by hard or soft rocks, and the gradient of the land. Drainage basins are divided from each other by topographic barriers called watersheds. A watershed represents all of the stream tributaries that flow to some location along the stream channel (Oweis, 2018). The number, size, and shape of the drainage basins found in an area vary, and the topographic map is larger (Bogale, 2021). On-farm drainage criteria can be defined as criteria specifying the highest permissible levels of the water table, on or in the soil, thereby reducing or eradicating the problems of water logging for agricultural benefits (Singh & Lal, 2018; Kamra *et al.* 2019). When the actual water levels are higher than specified by the criteria, an on-farm drainage system may have to be installed, or an already installed system may have to be improved to eliminate the water logging. However, if a drainage system has lowered water levels to a depth greater than specified by the criteria, then an over-designed system needs to be modified (Du Preez & Van Huyssteen, 2020). Other criteria like the technical drainage criteria (to minimize the costs of installing and operating the system while maintaining the agricultural criteria), environmental drainage criteria (to reduce the environmental damage), and economic drainage criteria (to maximize the net benefits) are also taken into consideration when designing a drainage system. Drain is intrinsically linked to crop yield; well-drained soil reduces water stress on crops and improves root development, which is required to increase crop yields and quality of production (Ullah *et al.*, 2019).

### 3.1 Analysis of On-Farm Drainage Systems

The Effect of on-farm drainage is strongly influenced by the features of an individual location, which includes: topography (slope), soil type (hydraulic conductivity) as well as drainage system design (spacing, depth and size of drains) (Tuohy *et al.* 2018, Kamra *et al.* 2019). The purposes of on-farm drainage systems are to reclaim and conserve land for agriculture, increase crop yields, permit the cultivation of more valuable crops, allow the cultivation of more than one crop a year, and reduce crop production costs in otherwise waterlogged land. Such objectives are met through two direct effects and many indirect effects. The direct impact of installing a drainage system in waterlogged land that was given by Barnes *et al.* (2018) and Manik *et al.* (2019) as follows:

- A reduction in the average amount of water stored on or in the soil, inducing drier soil conditions and reducing waterlogging;
- A discharge of water through the system.

It was also mentioned that assessing the indirect effects is more complex, but not less important, than evaluating the direct effects. The indirect effects, which can be physical, chemical, biological, and/or hydrological, can be either positive or negative, some of which were given as;

- Negative effects owing to the drier soil conditions: decomposition of organic matter; soil subsidence; acidification of potential acid sulphate soils; increased risk of drought; ecological damage;
- The indirect effects of drier soil conditions on weeds, pests, and plant diseases: these can be both positive and negative; the net result depends on the ecological conditions;
- Positive effects owing to the discharge: removal of salts or other harmful substances from the soil; availability of drainage water for various purposes;
- Negative effects of the discharge include downstream environmental damage by salty or otherwise polluted drainage water, as well as the presence of ditches, canals, and structures impeding accessibility and interfering with other infrastructural elements of the land.

### 4.0 Conclusion

Undoubtedly, drainage is intrinsically linked to crop yield, ensuring food security for the ever-growing population in developing nations like Nigeria. This implies that well-drained soil reduces water stress on crops and improves root development, which is required to increase crop yields and production quality in poorly drained soil. The existing on-farm drainage systems were assessed and found ineffective and inefficient; thus, modification is required to improve the on-farm conditions at various locations in Nigeria.

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