Review Article

The bio-geosystem strategy for sustainable irrigated agriculture in Africa.

Abstract

The concentration of the soil solution is ideal for plant nutrition, and the stomatal apparatus of the plant is in a mode of regulation where there is no excessive transpiration, evaporation, or percolation of water from the soil root zone. By incorporating nutrients and soil-structuring materials such as dispersed industrial, agricultural, and biological waste, biochar, waste from the gasification of biological products, etc. into the soil, waste recycling is provided during the milling processing of the soil's illuvial horizon and intra-soil pulse continuous-discrete watering of plants. The bio-geosystem strategy is promising for agriculture, horticulture, viticulture, forestry, the spread and stability of the biosphere, the production of food, raw materials, and renewable biofuels. It also provides long-term stable high productive soil evolution, freshwater conservation, environmentally safe waste recycling, and expanded high-rate biological carbon phase in the biosphere. This review examines the adoption of the bio-geosystem strategy how effective it can be adopted to improve irrigated agriculture in Africa.

Keywords: *intra-soil milling processing, soil-structuring, bio-silicification, irrigation, plant nutrition.*

INTRODUCTION

The biosphere is contracting due to faulty biogeochemical cycle maintenance. The majority of carbon is found in lithosphere deposits, making the crude method of removing carbon from the biosphere hazardous to both the biosphere and the climate. The destruction of life takes the form of an avalanche as the carbon content of the biosphere and atmosphere continues to decline. It is suggested to reject the current industrial approach to land utilization. Correcting the biogeochemical cycle drivers will increase the biogeochemical cycle's abundance, the biosphere's stability, and the climate's predictability, which will improve the conditions for life (Kato, 2013).

The bio-geosystem is made up of the following elements: pedosphere, water, waste disposal, and plant growth transcendental technique (“HGF: ‘Bio-geosystems: Dynamics, Adaptation and Adjustment’ – Programme 4 Within the Helmholtz Research Field ‘Earth and Environment,” 2004). The negative outcome of both soil evolution and industrial agrarian technology, soil compaction, can be addressed by milling the soil illuvial horizon (the layer of 20-50 (30-70 cm). With the use of new technology, soil can be improved over a long period of time (more than 40 years after a single intra-soil milling procedure), dead-end porosity can be reduced, and good soil structure may be achieved for plant growth (Pott, 2014).

REVIEWS

2.2 Empirical studies

2.2.1 Alternatives for Sustainable Irrigated Agriculture in Ghana

Ghana's management of irrigated agriculture is still ineffective. The government of Ghana has implemented plans and strategies to support new advancements and technology to promote sustainable irrigated agriculture in response to the increased awareness of irrigation challenges and their effects on the economy and environment (Loiskandl & Nolz, 2021). The project aims to find viable strategies for developing irrigated agriculture in Ghana

The Ministry of Food and Agriculture (MoFA) and the Ghana Irrigation Development Authority (GIDA) handled the institutional framework for national irrigation policy implementation. GIDA supported organizations and groups to work together to efficiently manage irrigation, including regulatory bodies, local governments, and NGOs. Ghana's irrigation management was under GIDA, a division of MoFA that was in charge of promoting irrigation on both public and private levels (Shvets, 2022). Ghana's GIDA has built 22 public irrigation projects totalling roughly 14,700 acres, 60% established in 2003 (MOFA, 2011). Recently, GIDA and farmers have been in charge of 56 irrigation schemes. Most of the programs were first run by GIDA and Irrigation Company of Upper East Area (ICOUR) in Ghana's northern region s(Jonas & Romanus, 2017). The entire country uses irrigation schemes and various small-scale irrigation techniques. About 500,000 farmers actively participate in the estimated 1,850,000 ha of privately owned small-scale irrigation systems. Private and limited Farmers work on tiny farms and employ straightforward methods (Sarpong et al., 2011).

According to the findings of this paper, good WUA management, a robust irrigation system, efficient farmer training, improved extension service delivery, sustainable irrigation techniques, and efficient teamwork helps achieve sustainability. Irrigation sectors should, in conclusion, make the most of Ghana's plentiful water resources and make sure that irrigation gets managed in a way that preserves the environment for the current generation without compromising the advantages for future generations (Sarpong et al., 2011).

2.2.2 West African agriculture's changes and the function of family farms

Economic growth is impacted by agricultural transformation because households engaged in agriculture consume more as their earnings rise. Thus, it increases demand in non-agricultural industries, further increasing demand across the board and supporting economic growth**.** According to Snodgrass (2014), at least three factors can impact economic growth due to agricultural transformation. First, the potential for agricultural development to support economic growth through a multiplying effect on local industries connected to agriculture. Increased need for modern inputs (such as fertilizer, improved seeds, and other agrochemicals), transportation, and fuel will partly arise from agricultural industry growth (Wahab et al.s, 2020).

This research got created as a preliminary scoping study for the Sahel and West Africa Club (SWAC) Secretariat to lay the groundwork for creating a longer-term work program to examine the changes in West African agriculture and the difficulties smallholder production systems are facing. Such was motivated mainly by the following query: Because of the significant changes in agriculture over the past 20 years and the probable future developments, what is the family farm's future in West Africa? The overall initiative's broad goals were to: Raise debate about agricultural policy and the future of family farming in West Africa at national, regional, and international levels; highlight key issues and trade-offs between policy objectives; develop partnerships with West African organizations and support their strategies for participating in policy debate nationally, regionally, and internationally; identify and document impacts from OECD policies (Issaka et al., 2016).

For this preliminary scoping research, background information, groups in West Africa, and the OECD's consultation feedback guide crafting this document. The study contributed to SWAC debates on follow-up and proposals for future studies (Ikerd, 2014). The Sahel and West Africa Club have worked on several different projects, including those in the following areas, which are closely related to this work on the transformation of West African agriculture and the importance of family farms (Plana & Gallizo, 2021).

*2.2.3 **Kenyan SME Agricultural Businesses' Sustainability and Strategic Management***

This study's primary goal was to determine how strategic management methods affected the viability of agribusiness for small-scale farmers in the Githunguri Sub-County (Gachuhi & Awuor 2019).

In most developing nations, like Kenya, agriculture is a pillar and the backbone of the economy. It offers work opportunities for the populace, supporting the expansion of rural development. The agricultural industry continues to perform poorly, and the bulk of those working in agriculture remain in poverty despite the expanding populations in emerging countries. According to Awuor *et al.* (2019), creating new strategies to holistically address the issues limiting growth to build a sustainable agriculture sector was necessary. With a general focus on Githunguri Sub-County, the overarching goal of this study was to determine the impact of strategic management on the sustainability of agribusiness by small-scale farmers in Kenya. In particular, the study determined the effects of strategic supply chain management practices on the performance of the agribusiness in Githunguri, established the impact of using technology strategies on the performance of the agribusiness, and also established the impact of financial management on the performance of the agribusiness in Githunguri (Abusalma, 2021).

In Githunguri Sub-County, 12,170 SME farmers were the study's target population. The study used a descriptive research approach to examine the variables, stratified random sampling, and Fisher's scientific technique to calculate the sample size. The correlation analysis determined the degree and kind of association between the variables. The report suggested enhancing human resource strategies through developing farmers' capacities, applying technology to current farming practices, enhancing the supply chain for maximum value addition, and sound financial management planning and controls. To maintain the sustainability of agriculture, both the national government and county governments must pass laws and develop more robust agricultural policies (Gachuhi, 2019)

2.3 Theoretical framework

Humans engage with nature by using skewed and partial perceptions of its dynamics, linkages, and organizational principles. According to Jones (2011), the opinions are subjective, based on personal experience, and location-specific. They impact the issues taken into consideration, how those issues are perceived, and potential solutions to those issues (Lynam *et al.*, 2004). Thinking about the following issues with bio-geosystem dynamics and level of stability, does bio-geosystem recovery after disturbance have any limits? Which management practices have the best chance of preserving desirable biogeosystem? A significant change in how we view nature significantly alters the answers to these issues and how we engage with nature to support sustainable ecosystem management and human well-being. Resilience theory and non-equilibrium ecology represent a shift in how people view nature.

2.3.1 Non-equilibrium

Non-equilibrium ecology questions the notion of ecosystem stability and quick, linear recovery from natural or human disruptions. The "balance of nature" metaphor reflects equilibrium ecology, illustrated by the contentious Gaia hypothesis, which contends that the Earth system is partially self-regulatory to preserve favourable circumstances for life. Folke (2006) viewed that theoretical evidence of nonlinear system dynamics that emerged in the middle of the 20th century questioned equilibria ecology at first. Then inconsistent results of natural resource management followed.

In addition to internal biotic regulation, non-equilibrium ecology considers the contributions of disturbance, geographical heterogeneity, and numerous stable states. This perspective on ecosystem dynamics is more dynamic and less predictable (Wu and Loucks 1995). It raises more issues with the prevailing steady-state approach of natural resource management, which depends on equilibrium ecology.

2.3.2 Equilibrium theory.

The concept of ecological stability, which had previously prevailed, was found to be an unrealistic interpretation of the dynamics of observable bio-geosystem, leading to the emergence of resilience theory. Biogeosystems, for instance, can experience significant changes in ecosystem composition while being remarkably resilient (Curtain & Parker, 2014). The concept of resilience also acknowledges the presence of threshold circumstances that help establish alternate stable states. The transformation of grasslands into woodlands and perennial shrub steppes into annual grasslands are two well-known instances of non-reversible dynamics that lead to the emergence of different ecosystems on the same site (Wilcox & Huang, 2010).

Additionally, resilience-based management offers an alternative to steady-state management that encourages managers to foresee change and guide it in the right direction rather than trying to stop it (Chapin *et al*., 2010). This allows bio-geosystem to continue to sustainably provide ecosystem services to society. To give ecosystem management and policy a "humans-in-nature" perspective, resilience theory has recently expanded to social systems. Social learning—the ability of groups of people to accomplish goals—and adaptive management—learning through experience—have emerged as crucial elements of robust human-dominated systems. By embracing uncertainty, fluctuation, and the acknowledgment of partial information, these resilience-based approaches—collectively called "resilience thinking"—seek to pave the way for increased sustainability (Parker ,2014).

2.4 Conceptual framework

2.4.1 Equilibrium and non-equilibrium Biogeosystems

Although the equilibrium biogeosystem and the metaphor "the balance of nature" is connected with our old concepts in human thought, the modern base got created in the 1960s from systems theory. It anchors on the idea that biotic activities occurring within ecosystems, such as intra- and interspecific competition and interactions between plants and animals, significantly govern ecosystem dynamics and limit them to a single stable state (Yang & Zaman, 2009).

The equilibrium theory came under increasing scrutiny due to various factors, such as a lack of solid evidence for ecological equilibrium conditions. Again, it came under evaluation of an inability to explain the existence of alternative stable states in some ecosystems and slow or non-existent return to alternative forms after they have been established (Briske et al., 2003). The exploration of theoretical competition models in the middle of the 1950s gave rise to non-equilibrium theory, and the initial mention of the possibility of several biogeosystem states occurred about 15 years later (Petraitis, 2013). But it wasn't until the next decade, when several non-equilibria systems, such as rangelands, were reported, that this hypothesis became widely accepted in ecological circles.

2.4.2 Mechanisms for Feedback, Controlling Variables, and Drivers

According to Walker et al. (2012), resilience is affected by interactions among several variables. As was previously stated, events both internal to the system and external can change how these interactions play out. Drivers, governing factors, and feedback systems, of the most crucial elements of resilience, in addition to the state factors previously mentioned. Walker *et al.*, 2012 suggested that drivers are external to the system because feedback mechanisms do not connect them (e.g., climatic regimes and extreme weather events).

Resilience is greatly influenced by controlling variables, and most systems get controlled by a minimal number of these variables (Chapin *et al.*, 2010). The primary way that resilience is changed is by drivers changing the regulating variables either directly or indirectly through feedback mechanisms (Beisner *et al.*, 2003). Ecological processes called feedback mechanisms to affect how quickly system variables change. More specifically, they are side effects of interactions between variables that either speed up or slow down the originating variable's rate of change. Stabilizing (negative) feedback slows the starting variable's pace of change (Gunderson, 2000).

2.4.3 Threshold Indicators

The challenge of threshold identification has drawn attention to the need for prompt warning indicators. The changes in state variables (structural characteristics), controlling factors, and, to a lesser extent, the signs represent feedback mechanisms that affect a state's ecological resilience.

Indicators help a management perspective to determine the trajectory of systems toward impending thresholds so that management strategies can be implemented or changed to avoid thresholds being crossed (Briske et al., 2008).

2.5 Conclusion

A strong and competitive African agricultural industry and a smooth transition from subsistence agriculture to agribusiness depend on increasing agricultural production.

In fact, it is challenging to imagine how the agricultural sector might develop without significant gains in farm production. At almost all temporal and spatial scales, environmental variability is present and is influenced by both natural and human influences. Over the course of a person's lifetime, we can see environmental change in our neighbourhood, deduce it from stories our grandparents have told us, and identify it in historical documents and bio-geosystems record data. By understanding the patterns, processes, and principles controlling biological systems' participation in environmental change—as well as how those systems react—is of the utmost importance to science and society in today's rapidly changing world.

2.6 Recommendations

This paper suggests that a substantial new research effort be focused on the three research objectives listed below in order to encourage considerable and timely progress in understanding the geologic record of ecological processes; greater comprehension of the fundamental dynamics and structures of bio-geosystem, improving the capacity to foresee how bio-geosystem will react to climate change in particular, present a method to discern between changes in bio-geosystem produced by anthropogenic and natural causes. These issues are very relevant to society and are ripe for scientific investigation. In order for the bio geosciences field as a whole to succeed, infrastructure support for research integration, collaboration, and coordination between earth scientists and biologists is also necessary

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