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Chapter

The Implications of Conservation Agriculture in Forests Management against Soil Erosion and Degradation

Moses Z. Sithole, Azikiwe I. Agholor and Shalia M. Ndlovu

Abstract

Ecosystems play a huge role in support of human life, this is evident through their provision of food, fiber, water and fuel. However, these potentials are reduced through human activities, which comes with the lack of conservation of our forests. Deforestation is one of the major issues as far as sustainable development is concerned. Deforestation contributes towards soil erosion, particularly, in forests across the world. Soil erosion deprives human beings of the opportunity to enjoy the benefits of harvesting the forests' potential towards supporting human life, which includes the release of oxygen and the uptake of carbon dioxide. Thus, the concept of conservation agriculture becomes of paramount importance. Hence, this paper explored the implications of Conservation Agriculture in Forest management and evaluated policies in place to promote the adoption and use of conservation agriculture across the globe.

Keywords: soil degradation, soil erosion, conservation agriculture (CA), Forest management, deforestation and sustainable agriculture

1. Introduction

The ecosystem plays a very paramount role in support of human life. This is manifested in the four forms established by the 2005 Millennial Assessment of Ecosystems (TMAE), namely: 1. Provision of habitat, food, fiber and water; 2. Regulation of climatic conditions, water and air quality; 3. Support system for the formation of soils, recycling of soil nutrients, as well as soil health and quality and preservation of biodiversity; and 4. Cultural support involves cultural beliefs, tourism and recreation as well as herbal benefits [1, 2]. It is moreover, emphasized by [2] that ecosystems are essential for human life, with which without, there is no life. It can further be argued that an ecosystem is an anchor to human life. Ecosystem refers to the community of living organisms, their diverse physical environment, and their interrelationships within a unit space [3]. It is that environment that supports the flow of energy. As per [4], ecosystems aid in carbon sequestration as well as

the preservation of both biotic and abiotic organisms. This, therefore, is evidence enough to argue that forests support human life and their management is a policy matter.

However, growing scientific concerns point to the fact that the support and services humanity receives from the world's ecosystems are on a rapid decline due to forest degradation [1, 2, 5]. Forest refers to a complex ecological system with interdepended, interrelated and interconnected elements of both the biotic and abiotic organisms largely dominated by trees [1]. Furthermore, this may not be limited to the only current dominance of trees, as geographers argue that forests exist in the past, the now and the future. However, 31% of the worldwide land is under threat of degradation and this has negative implications for human life [6]. Therefore, this threat calls for proper forest management so that future generations will benefit from the diverse services and support of the same forest and ecosystems we benefit from now. Moreover, the degradation of our global forests is a result of factors such as climate change, veld fires, pests and diseases, air pollution, land pollution, forest fragmentation, and soil erosion and degradation [1–3].

Forest management is the practical application of efforts in controlling the use and exploitation of our forests by means of policy, administration, social, economic, environmental and technical aspects [6]. It is furthermore, a critical process which determines the existence and preservation of our forests for continued and/or sustainable development across the world. Hence, the concept of Conservation Agriculture (CA), seeks to preserve and where possible improve the natural resources humanity has access to, for the production of food and fiber. Conservation Agriculture refers to a farming system that aid in the preservation of arable lands and natural resources while improving degraded lands [7]. This is possible when the three principles of CA are practiced across the Agriculture and Forestry sectors. The three pillars of CA are Minimal soil disturbance, permanent soil cover and crop diversification [7, 8]. CA has the potential to help achieve Sustainable Development Goals 13 and 15, namely: Climate Action and Life on Land, respectively. Therefore, this paper delineates the concept of CA in the context of forestry, highlights the CA practices for forest management, and presents the implications of CA in forest management. On the implications of CA in forest management, the chapter is mainly focused on the environmental aspects instead of a broader scope around social, economic and environmental aspects.

1.1 Delineation of conservation agriculture

Conservation Agriculture (CA) was first introduced in 1930, aiming at improving agricultural production and performance, profitability as well as sustainable farming and food security to fight poverty across the world [7]. Significantly, CA helps to further achieve Sustainable Development Goals 1, 13 and 15, that is Zero Hunger, Climate Action and Life on Land, respectively. Minimal soil disturbance, optimal soil cover and crop diversification are the three main pillars of CA [7, 8]. According to [8–11], CA is a resource-saving farming mechanism. Therefore, forestry cannot be an exception in the use of this beneficial farming system. This is to be done in line with the aim of forest management outlined in the introduction of this chapter, which is to ensure the preservation of forests and improve degraded forests across the world. **Figure 1** illustrates the three pillars of CA. The CA pillars are very practical, even in forest management. These come with enormous benefits such as reduced production costs, reduces soil compaction, improves soil health and structure, reduces soil

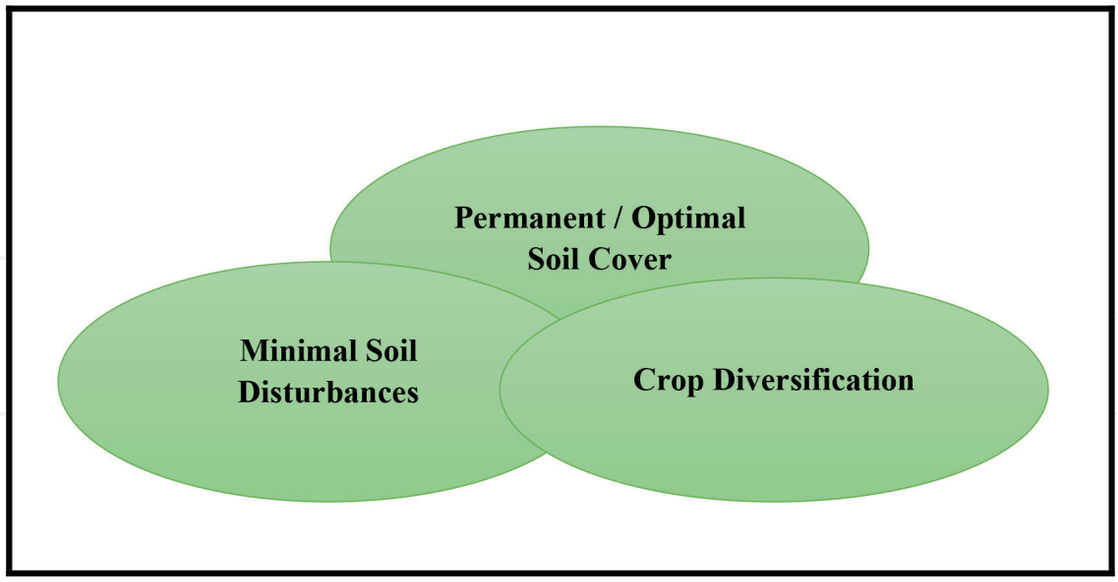

Figure 1.
The pillars of conservation agriculture.

erosion, minimized soil water evaporation, enhanced soil nutrient status, enhanced biological and microbial activities, improves soil water-holding capacity, improves Cation Exchange Capacity, improves the management of weeds, pests and diseases and leads to improved livelihoods and food security [9, 12–14].

Conservation Agriculture (CA) is an agricultural system with the power to conserve natural resources, reduction of greenhouse gas emissions as well as enhancement of soil health and fertility [10]. In the quest to conserve nature, the powerful, agricultural system (CA), uses its three pillars (already highlighted in sections above) as guiding principles to be practiced simultaneously. Conservation agriculture, through the application of the three pillars, prohibits the burning of the crop remains, while promoting the use of integrated pest management and the use of green manure which has the ability to produce residue soil cover. It further limits the movements of humans and machinery on agricultural soils which also leads to soil compaction [9, 12]. According to [15, 16] minimal soil disturbance refers to the tilling of the ground or turning of the soil with an aim of not disturbing the microbial life, without exposing the soil to harsh climatic conditions (especially too high temperatures) and erosion (either by wind or water).

Moreover, this practice involves the conservation tillage practices such as zero tillage and reduced tillage. Zero tillage and minimal tillage both involve direct seeding [17]. Minimal soil disturbance is the first pillar of conservation agriculture, and it helps to retain moisture in the soil, increases soil organic matter content, improves soil health and also helps to mitigate the effects of high climatic conditions [17–19]. On the other hand, permanent soil cover is mainly practiced through the organic mulch, green manure, retention of crop residue as well as plastic mulch. However, conservation agriculture promotes organic mulch as well as the retention of crop residue [7, 8, 20]. Soil cover protects the soil from harsh climatic conditions (such as the sun and rain). Furthermore, permanent soil cover helps to enhance the microbial activities in the soil, enhances soil fertility, and conserves soil moisture and nutrients. Permanent soil organic cover plays a huge role also in suppressing weeds and controlling pests and diseases [13, 19]. Moreover, it positively contributes to the improvement of soil's physical, chemical and biological properties.

Remarkably, an improvement in the soil's chemical, physical and biological properties improves the structure of the soil [18]. The more the soil structure is improved, the more soil fertility is improved. Therefore, permanent soil cover, significantly, benefit farmers in terms of soil water conservation, weeds, pests and diseases management, soil fertility enhancement, as well as the protection of the soil from climatically harsh conditions. Crop rotation assists in the improvement of crop nutrition, improves the farming system's resilience, manages pests, diseases and weeds, and improves microbial activities as well as enhancing the farm's agronomic output and economic efficiency [9, 13, 17–19]. Therefore, the three pillars of CA practiced simultaneously can yield good results. It is also evident, that CA is the vehicle farmers require, in order to achieve sustainable agriculture and adapt to the ever-changing climate. It can never be overemphasized that this powerful farming system is important for forest management for both sustainable development and nature conservation.

1.1.1 Delineation of conservation agriculture in the context of forestry

Agroforestry (AF) and Conservation Agriculture (CA) cannot be separated because they complement each other for the success of nature conservation and the Sustainable Development Goals (SDGs) 1, 13 and 15 as articulated in the introduction of this chapter. Agroforestry refers to a farming system that seeks to manage the land by means of combining agriculture, shrubs and trees [18]. Agroforestry also comes with some known benefits for both the environment and human life, such involves improved soil health, higher yields and chances of maximizing income for improved livelihoods [18, 21]. Forests are a support system for the ecological systems (ecosystems) and they do this through the continuous production and conservation of the soils, water and air [1, 21]. The conservation and enhancement of the soil and water in our forests through Forest Conservation Management Practices [FCMP] guarantees the prevention of land degradation, and desertification [21]. These further reduce the already existing risks of natural disasters such as floods, droughts and landslides. Conservation Agriculture is key to ensuring proper or conservative management of our forests across the world. Therefore CA in the context of forestry refers to a farming system which applies conservation principles in the management of forests to ensure the sustainable development and conservation of natural resources, simultaneously. These are made possible by the key principles of CA, namely: optimal ground or soil cover and minimal soil disturbance.

Ground cover is a strategy employed by forest managers, both in natural and planted forests to ensure reduced surface runoff and erosion in forests in order to achieve optimal forest performance [3, 5, 6]. On the other hand, minimal soil disturbance is the strategy to produce similar results as ground cover, however, it restricts ground tillers to turn the soils deep [7]. Ground cover, therefore, refers to conservation agricultural practice that involves allowing low-growing shrubs and/or planting low-growing plants, shrubs, grasses and wildflowers in order to prevent soil erosion [3–7]. While minimal soil disturbance, by definition refers to the farming practice that involves all ways of farming which avoids tilling the ground or soil [13]. This in the agricultural sector can be understood as direct seeding, which happens mostly, without disturbing the soil with the use of mechanical implements. Both these principles of Conservation Agriculture are essential to yield soil preservation, which then assures forest conservation. In the absence of soils, there can be no trees or forests. Hence, the CA practices aid to conserve and improve the soils in our forests.

1.2 The implications of conservation agriculture in forests management

The practice of Conservation Agriculture (CA) in forestry and agroforestry comes with a number of benefits for humanity. These involve but are not limited to financial benefits, that save money for the farmers by reducing production costs and leading to improved livelihoods. Though CA comes with three principles or pillars, as mentioned in subsequent sections above, its applicability in forestry and/or agroforestry

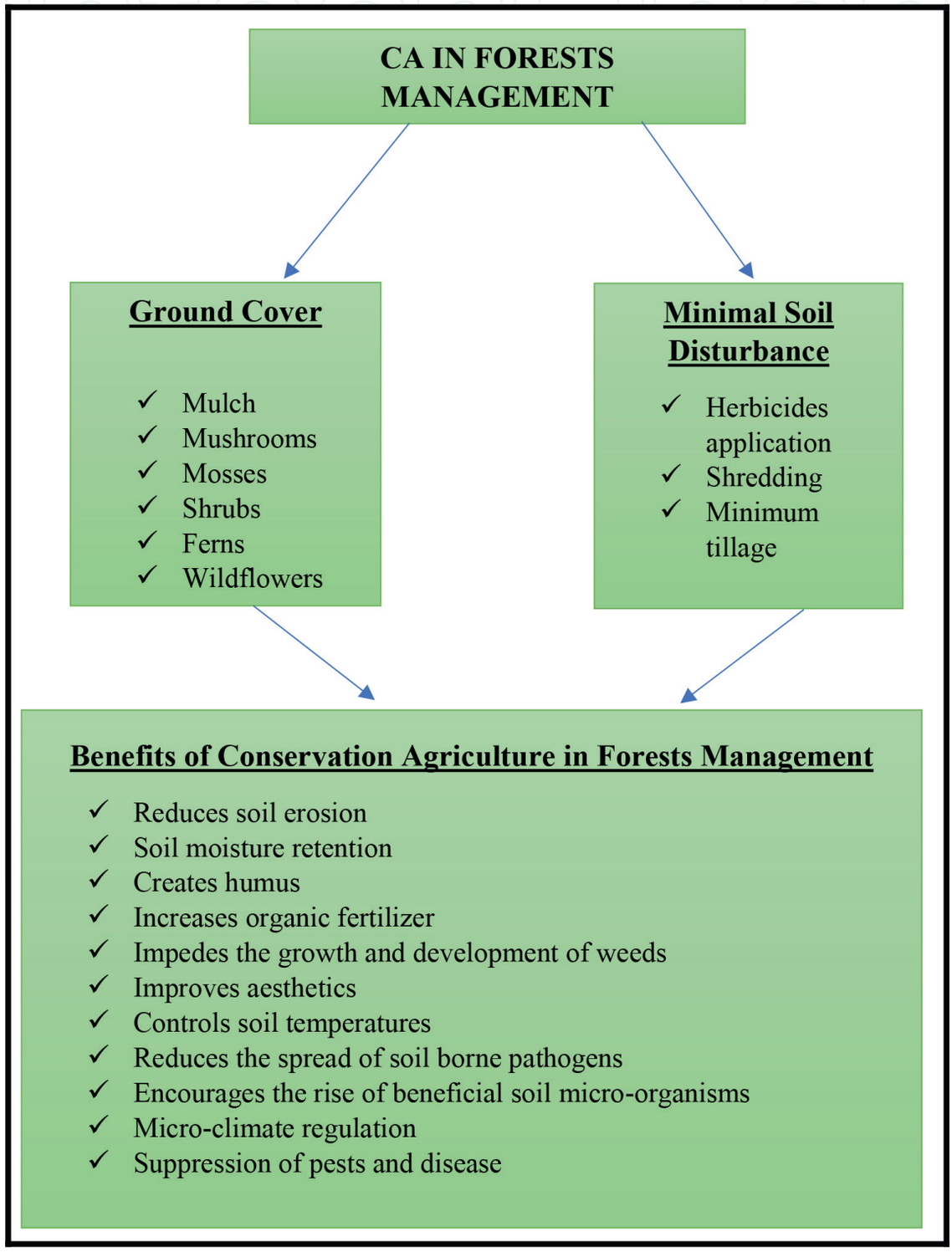

Figure 2.
Implications of conservation agriculture in Forest management (conceptual framework).

involves ground cover and minimal soil disturbance. **Figure 2** shows the CA practices applicable in forest management and their implications for forest management.

Figure 2 summarizes the implications of Conservation Agriculture (CA) in Forest Management and for the management of our soils to prevent soil degradation and erosion. These are achieved over a period of time and with persistence in practice. This means it is not possible to reap these benefits without having patiently and persistently practiced minimal soil disturbance and applied maximum or optimal ground cover for several years. To further expound on the benefits, **Table 1** is provided below.

Successful forest management results in sustainable development. Sustainable development is a complex process that requires numerous actors, including proper and scientific management of our forests. Forestry is one of the key players in economic emancipation, growth and development of both developing and third-world countries. **Table 1** shows the benefits and challenges of Conservation Agriculture (CA) in Forests Management. These benefits and challenges are classified into three groups: environmental, social and economic. The concept of sustainable development cannot be mentioned without touching on the three aspects of sustainability. This is because development that is not sustainable will result in the extinction of the human race. Therefore, the concept of CA in forest management comes with environmental, social and economic benefits. However, there are some challenges that farmers in the

Aspect	Benefits	Challenges
Environmental	• Storage of Carbon • Regulates micro-climate • Development and formation of aerosols • Improves soil health • Captures, stores and supplies water • Suppression of pests, diseases and weeds • Regulates atmospheric gaseous exchange • Promotes species diversification • Decreases pollution • Protects against natural disasters • Improves soil health and quality (soil conservation)	• Policy • Certification and regulations • Authorization of land-use
Social	• Sustainable development • Sustainable livelihood and employment creation • Poverty alleviation • Improves human health	• Insufficiency of technical skills • Lack of knowledge of sustainable (CA) forests management • Inadequate support
Economic	• Supplies wood for wood production output • Tourists attraction sites • Provides resources to produce pharmaceutical • Fuel supplies	• Policy • Certification and regulations

Table 1.
Benefits and challenges of CA in forests management.

forestry business are dealing with regarding CA. These are also categorized into three, namely: environmental, social and economic challenges.

The environmental challenges involve policy, certification and regulations, and Authorization of land use. While economic challenges involve Policy, Certification and regulations. Significantly, there the issue of policy comes in on both the environmental and economic challenges of the implementation of CA on forestry and agroforestry. And lastly, the social challenges associated with the implementation of CA in forestry and agroforestry. These involve the insufficiency of technical skills, the lack of knowledge on sustainable (CA) forests management as well as inadequate support from both government and farmers in the industry. The level of support in forest management has a significant influence on an agroforest's management and success. Moreover, these challenges can be addressed by a collective effort. That is the effort of the government, Non-Governmental Organizations (NGOs), the farmers, and society at large. Everyone has a role to play towards the management of our forests across the world.

1.3 Sustainable forest management and its underpinning pillars

To achieve forest sustainability, researchers have submitted the Sustainable Forest Management (SFM) concept, which comes with three pillars or principles [21–24]. This strategic approach to forest management came as a response to the global issues of deforestation and forest degradation. Forest degradation and deforestation have paused a challenge not only to hiking climatic conditions but to society at large by reducing the productivity of forests and the ecosystem services rendered by forests [21, 23]. SFM refers to a system of forest management through the application of the Sustainable Development (SD) pillars. The three pillars of SFM borrowed from the concept of SD are environmental protection and preservation, economic prosperity and socio-cultural acceptability principles [23]. SFM can be defined as a theory and/or system that seeks to ensure that forests worldwide provide the expected goods and services to meet the needs of both the current and future generations [23]. Furthermore, the SFM system contributes towards the Sustainable Development Goals 1, 13 and 15 as indicated in Section 2.1.1 of this chapter. The SFM framework has been put in place to prevent the massive forest losses experienced globally [23]. The economic loss which occurred as a result of the loss of forests globally has been a resulting decline in total forest area (land), which predominately leads to deforestation and degradation of forests.

The implementation of SFM strategies has been reported to have contributed towards food security, employment creation, economic emancipation, poverty alleviation, and preservation of forest ecosystems. This ensures that society continues to harvest the socio-cultural, economic and ecological benefits presented by well-managed forests worldwide. **Figure 3** shows the pillars of Sustainable Forest Management.

1.3.1 The pillars underpinning the theory of sustainable Forest management

See **Figure 3.**

1.3.2 The principles of sustainable Forest management

Table 2 summarizes the principles of the Sustainable Forest Management (SFM) system which is key to the conservation of our natural resources, food security and sustainable development. In a study by [22] in Sabah, Malaysia, it was discovered that

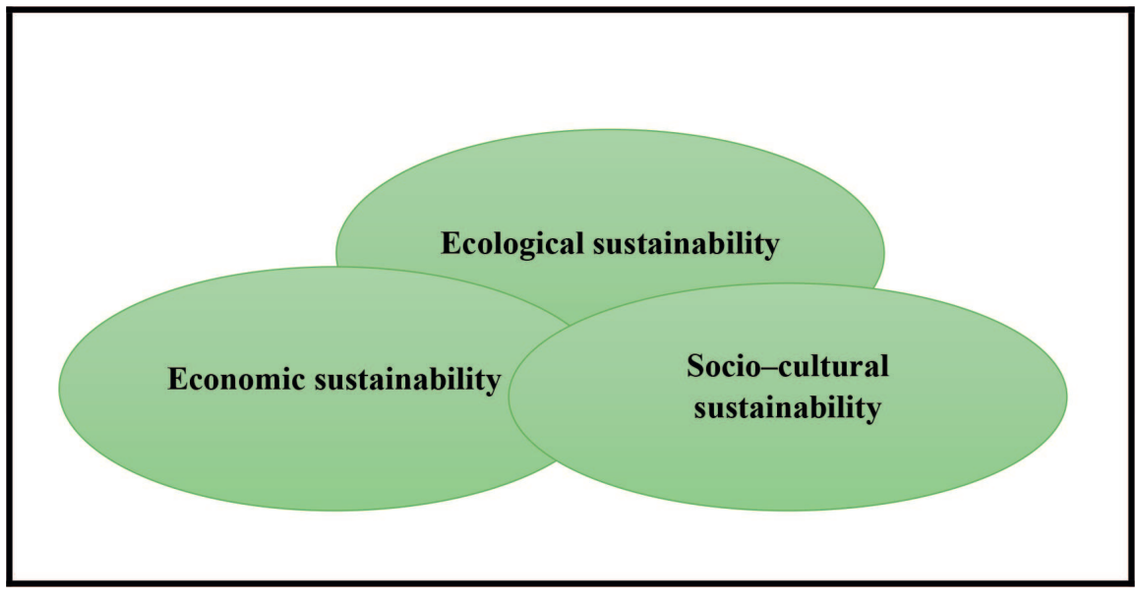

Figure 3.
Pillars of sustainable Forest management.

SFM principle	Pillar of CA in agroforestry	Pillar of SFM
Conservation of biodiversity	Permanent or optimal soil cover and minimal soil disturbance	Ecological sustainability
Maintenance of a healthy forest ecosystem and productivity	Permanent or optimal soil cover and minimal soil disturbance and where possible diversification of shrubs and trees in the forest	Ecological and economic sustainability
Maximizing societal benefits	Permanent or optimal soil cover and minimal soil disturbance	Socio-cultural sustainability
Soil and water conservation	Permanent or optimal soil cover and minimal soil disturbance	Ecological sustainability
Sustainable development of the society	Permanent or optimal soil cover and minimal soil disturbance	Economic and sociocultural sustainability
Forest contribution to world-wide ecological cycles	Permanent or optimal soil cover and minimal soil disturbance	Economical sustainability

Table 2.
Principles of sustainable forest management.

Sustainable Forest Management practices contribute immensely towards food security, with 51% of the participants responding "strongly agree" to the fact that SFM contributes towards food security. Furthermore, SFM was perceived to have a role towards increasing the streams of income generation for individuals and households, which is viewed to speed up economic growth and development [22, 23]. It is further perceived that successful forest management will continue to positively impact locals in terms of economic emancipation and poverty alleviation.

Table 2 shows the principles guiding the implementation of SFM globally. Contemporary literature submits that Sustainable Forest Management (SFM) strategies and practices involve reforestation, replanting forests after harvesting, treating

tree diseases in early stages after diagnosis, a controlled burn of naturally revive forests, control of weeds and pests, as well as thinning out of some trees to allow adequate sunlight [22–25]. It is furthermore, evident from **Table 2**, that the use of SFM strategies can be improved and strengthened by the use and implementation of Conservation Agricultural practices. Following the guiding principles of SFM, implementing the SFM practices, and incorporating the pillars of Conservation Agriculture will ensure the achievement of the SFM objectives, which have been discussed in this chapter in terms of the benefits of SFM and CA. These include economic growth and development, environmental preservation and protection and sociocultural sustainability. Therefore, CA and SFM in forest management should be applied simultaneously to optimize the benefits of both strategies.

2. Conclusion and recommendations

There's a dualistic problem facing the world today, particularly, humankind. That is economic emancipation, growth and development and the degradation of the environment which is happening at a very high rate. This affects our forests which serve as a support system for human life. The forests support human life by providing oxygen, the abiotic and biotic life which is mostly dominated by trees as well as the control or management of the regional climatic conditions (temperatures). Forests play a huge role in producing goods that are essential for developing economies across the world. This is done through the provision of wood which is used to produce furniture and paper, fuel supplies, and supplies resources used in the production of pharmaceutical products. It also serves as a tourist attraction site and works a great deal in employment creation. Hence, the applicability of Conservation Agriculture (CA) in forest management is crucial. This chapter, therefore, aimed at evaluating the implications of CA in forest management and forestry. CA practiced in forestry promises reduced costs of production, improved livelihoods and poverty alleviation (**Table 1** and **Figure 2**). Therefore, it is concluded that CA is very important in forest management because it delivers the objectives of sustainable development. That is economic growth, social care and environmental protection. Therefore, it is recommended that CA be promoted by policy, and implementation of such policies be monitored. Though the applicability of CA in forestry depends on the specifications of each and every region, however, the society of farmers is encouraged to employ all the applicable principles of CA in their agroforest practices to ensure they benefit from this promising technology in the agricultural sector.

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Conflict of interest

The authors declare no interest.

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