Sustainable Agriculture Research; Vol. 11, No. 2; 2022
ISSN 1927-050X E-ISSN 1927-0518
Published by Canadian Center of Science and Education

Sustainable Agroforestry Crop Rotation System for the Tropics: A Theoretical Exposition

Sir Anthony Wakwe Lawrence[1]

[1] Chief Consultant - Sustainable Development/Management of Stakeholders, Community Inter-Relations and Conciliation Initiative (CIRCI), Port Harcourt, Nigeria

Correspondence: Sir Anthony Wakwe Lawrence, Community Inter-Relations and Conciliation Initiative (CIRCI), 7, All Saints' Street UPE Sandfill, Borikiri, Port Harcourt, Nigeria. E-mail: tonylawrence942@gmail.com

Received: February 19, 2022 Accepted: March 22, 2022 Online Published: XX, 2022

doi:10.5539/sar.v11n2p58 URL: https://doi.org/10.5539/sar.v11n2p58

Abstract

Population pressure is the key reason that has been reducing the duration of fallow in shifting cultivation. In many places, it has changed to bush fallow and subsequently is going towards the need to use available arable lands continuously. As a result, soil productivity is declining since long fallow is required for its regeneration after land is planted for a few years. An agroforestry tree crop/arable crop rotation system was proposed to mimic the natural fallow system and improve nutrient recycling through litter drops, which will improve soil organic matter. As soil organic matter improves the soil structure in addition to the ability of the soil to retain nutrients and water, the land becomes suitable for continuous crop production with appropriate fertilization regimes. The proposed tree crop/arable crop rotation will therefore result in continuous generation of income from harvestable produce in the rotation system year in year out. The paper, equally elucidated on other benefits of rotating tree crops with arable crops on the same land towards achieving maximum land productivity and obtaining benefits from the land without subjecting the land to the traditional fallowing system. This intervention will reduce abject poverty (SDG1), reduce acute hunger (SDG2), promote sustainable economic activities and growth, increase employment and decent work (SDG8) and promote sustainable industrialization and foster innovation (SDG9). The paper also identified the challenges associated with this type of rotation system and proffered suggestions on how to ameliorate such challenges.

Keywords: agroforestry, crop-rotation, litter-drops, soil-productivity, economic-returns, improved-employment

1. Introduction

Crop cultivation is as old as human civilization. In the early times, a farmer would usually cultivate a piece of land until the land's productivity significantly declined, then the farmer leaves that land for another mature fertile forest land to satisfy his/her food needs.

The science behind the progressive decline in soil fertility of farmland under cropping is routed in four main phenomena: that crops take up nutrients as they grow, clearing of vegetative covers opens up the land to increased nutrient leaching, and increased soil erosion with rains. Equally, the burning of the debris after the fallow, converts the slow releasable nutrients in the mulch into soluble nutrients that are more easily leached or eroded away. These phenomena are more pronounced in the high rainfall areas of the humid tropics with highly acidic and leached soil conditions (Tibbits 2017; Gichuru and Kang 1989).

The high human reproductive rate in Sub-Saharan Africa is further compounding the need for continuously increasing the cropping season/phase of their shifting cultivation system before the temporary land abandonment phases. In addition to this major problem, land ownership in these African communities are highly fragmented and does not lean itself to large-scale cropping, mechanization, or permanent tree cropping programmes (Bassey, 2003).

This paper will conceptualize how we can explore and attempt to mimic the attributes of tree crop vegetation to achieve continuous harvesting of economic products from our lands (year in year out) i.e. continuously get economic returns from agricultural lands both during the arable crop farming season/phase and the tree fallow season as a continuous cropping agroforestry system. The beauty of the tree crop/arable crop rotation system is that just like in the shifting cultivation system, harvests are made by the farmers during the arable cropping phase as produce are harvested for food and income. In addition, fruits are harvested during the tree cropping phase, mainly for income while little or nothing is harvested from the land during fallow of the shifting cultivation system. The other point to note is that the enormity of the harvestable quantity of fruits during the tree cropping phase serves as enough incentive for stakeholders to undertake value addition ventures to increase shelf-life of the produce from the tree crops. This eventually will usher in industrialization in the place if well implemented.

If we can successfully conceptualize an agroforestry system or systems that can achieve these lofty ideals, then the communities that adopt such will gain in many ways: improved economic returns, increase in agro-related economic activities including attracting opportunities for stakeholders wanting to establish industries in such places, improvement in employment opportunities among others, and such an attractive system will sell itself easily for adoption by many stakeholders (communities, companies, and governments). This intervention if properly implemented has the potentials therefore to: reduce the proportion of people in abject poverty (SDG1), reduce the number of people that are suffering acute hunger (SDG2), promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (SDG8) and build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (SDG9), United Nations Report (2022). In this paper, we shall elucidate on the benefits of rotating tree crops with arable crops on the same land towards achieving continuous cropping and obtaining benefits from the land without subjecting the land to the traditional fallowing system in its true sense. We shall also identify the challenges associated with this rotation system and proffer suggestions on how to ameliorate such challenges.

2. Shifting Cultivation

Shifting cultivation is a traditional land-use system that is a major source of livelihood and sustenance for many people in the third world. It involves clearing relatively matured forest, allowing the cut debris to dry up and then burnt to enable the land to become suitable for arable crop farming. It is noteworthy that burning fallow debris is counter-productive in the effort to ensure nutrient retention since a good portion of nutrients like those of organic nitrogen etc. are converted to mobile or gaseous nitrates and are more easily lost through emission or leaching. Also bush burning destroys soil organisms, soil structure and causes a host of other harmful effects (Tibbits, 2017). The land is usually farmed for two to three years then the farmer moves to another land to repeat the process all over again (Parkey and Shourov, 2020; Punitha et al., 2018).

Putri et al. (2019) carried out a study to identify the population pressure on certain land carrying capacities and to identify the correlation between land pressure and food sufficiency in West Kalimantan. They posited that population growth does not only affect pressure on agricultural land but the land is taken up for the construction of settlements and related amenities. Virgin forests are also cut down to satisfy timber and other needs. They further explained that population increase caused shifting cultivation changes towards continuous cultivation of available land spaces.

Verma et al. (2017) listed 4 strategies that can be applied to improve shifting cultivation: fallow management, integrated farming system, multi-storey agroforestry and watershed management.

3. Problems of Population Pressure and Land Use

As the human population continues to increase, the available land per individual progressively decreased. While the population of Nigeria was only 37.1 million people in 1950, the population has increased in 2020 to 206.1 million people (Worldometer, 2022; CEIC Data, 2022). At the same time, the land space of Nigeria over the same years span remained at 910,770 km^2. The clear logic of the above information is that the population of the country has increased more than five times within 70 years but the land space remained constant. Though this is true, the population density changes differ from region to region and the pressure is higher in the southern parts of Nigeria and in the bigger cities of the nation (World Bank, 2022; Worldometer, 2022). Lawrence (2018) used the following words to explain what was happening *"Nigerian population is increasing and our resource base and economy are stagnant or are deteriorating. … Overpopulation affects every aspect of our national life. The Forest ecosystems suffer because we cannot end firewood harvesting in most of Nigeria, as there is population pressure and there are no feasible alternatives… We have a rapidly growing population and Nigeria for example, may become the third most populated nation on earth within the next 40 years with the current growth rate."*

This phenomenon of population pressure implies that the luxury of abandoning land to rest and regenerate its crop productive support systems after farming it for some time is gradually becoming a luxury that is no longer feasible. The traditional cropping phase of about two or three years before fallowing began to suffer pressure from the need to prolong the number of years before temporary land abandonment to meet the increasing need of feeding the increasing population.

4. Some Strategies to Ameliorate the Situation

4.1 Soil Fertility Issues and Manuring

Nature restores soil fertility after cropped land has been fallowed for some years as the land is re-vegetated first by grasses, then shrubby weeds, and finally forest trees. Soils in the humid tropics are relatively poor in nutrients and are acidic. These conditions necessitate the need for appropriate fertilizer and/or manure application. I will elucidate more on the importance of improving soil fertility through manure application in this section.

Trees play a major role in soil fertility regeneration as the deep roots of the trees take up leached-down nutrients and return them to the topsoil when the leaves drop off the trees as litter and are decomposed in the natural ecosystem. Apart from that, the litters when decomposed become stable organic manure in the soil improving the humus content of the soil.

Demand for arable land will keep increasing as the population keeps increasing correspondingly because the length of time to keep land fallow will inevitably have to keep reducing. It is for this reason, the peasantry continuously reduced the fallow length and subsequently shifting cultivation changed to bush fallow system but as can be noted, that was a temporary solution since the population increases continued. It is, therefore, necessary to evolve a system that will ensure continuous economic returns to the poor farmers through continuous cultivations of the land. International Institute of Tropical Agriculture with stations in Ibadan and Port Harcourt over some decades spent time and resources trying to resolve this problem. They conducted several types of research in alley cropping using suitable local fallow/arable crops combinations (IITA 2011). However, one of the setbacks of the alley-cropping system they evolved is that the economic returns during the fallow seasons were negligible which may be only firewood or yam stakes as harvestable products after the fallow. The major benefit of the alley cropping system they evolved was improved organic manure content of the soil which increased soil fertility with the improved fallow litter droppings during the short fallow and through pruning and mulching during crop cultivation phases. The other objectives included the possibility of using some of the pruning from the alley cropping to provide fodder for small ruminants. The primary purpose of alley cropping in this regard is to produce organic mulch in-situ and in so doing provide its benefits to the crop component. Organic mulching is the placement of plant material on soil for purpose of enhancing crop production. Cutting down plants or pruning the branches and leaves is a good way of mulching in an artificial way catalyzes and boosts the natural nutrient recycling processes. The literature is replete with publications on how mulching improves soil nutrients including nitrogen, calcium, potassium, soil structure through aggregate formation, nutrient retentive abilities with increased Cation Exchange Capacity (CEC) and improved soil ability to reduce water evaporation, etc. (Lal et al., 1975; Hahn et al., 1979; Gichuru, 1990; Gichuru and Kang, 1989; Lawrence, 1993).

Lawrence et al. (1993) also suggested three ways of producing organic matter: Alley cropping as explained earlier, rotation fallow with legumes, etc. and finally producing mulch on separate land. This last method of producing mulch on separate land is more tedious and is only suitable for small-scale farming including that of backyard farming and garden agriculture.

4.2 The Principles of Crop Rotation

Alhameid et al. (2017) defined crop rotation by Martin et al. (1976) as "*a system of growing different kinds of crops in recurrent succession on the same land*".

Crop rotation helps in controlling soil disease build-up, insect pest build-up, etc. as it helps in starving off the build-up of such crop pests and diseases which are adapted to the particular crop but not the succeeding crop in the sequence.

Further improving on the benefits of crop rotation, Magdoff and Harold (2000) listed some principles to guide crop rotation, ranging from legume fallowing, not following related crops with each other and following with crops that will leave enough residue.

While it will be difficult to introduce crop rotation in perennial systems, agroforestry can help modify perennial systems using either alley cropping and rotating the intercrops within the alleys.

4.3 Tree Crop/Arable Crop Rotation System

During fallow, the natural vegetation regrows and eventually trees grow as the vegetation matures. Therefore deliberately growing trees after the arable cropping cycle will enhance soil regeneration. However, growing economically beneficial tree crops to the farmer as fallow crop means that while the soil is fallowing the farmer is making some harvests that have economic benefits. We do know that there will be nutrient losses along with the harvest of fruits during the tree crop growing phase. So, in the technical sense, soil fertility may not improve since some produce harvesting will result in nutrient depletion. The implication is that soil fertilizers are needed during the fallow cropping phase as well as during the arable cropping phase in the rotation sequence being proposed. At the same time, the other aspect of fallowing is the accumulation of litter drops (decaying of leaves that drop to the ground). The litter drops improve the soil texture and also improve nutrient retention in the soil with increasing soil manure content. Both accumulations of nutrients and organic matter are critical for soil productivity after fallow. Growing suitable tree crops with suitable fertilizer regime applications can enhance continuous and sustainable cultivation of agricultural lands in the tropics. This otherwise would not have been possible without the tree crop and arable crop rotation systems as proposed. It is known that initially, it takes time for tree crop establishment, so the tree seedlings are inter-cropped with arable crops until the tree canopies begin to overshadow the intercrop. At that time, the trees are allowed to grow as mono-crop for a while as their fruits are harvested for income. Then after a while, the trees are pruned down to allow for the arable crop rotation phase for maximal component contribution in the rotation system. Depending on the coppicing abilities of the tree crop, they can be pruned down reasonably to reduce competition for nutrients and light. Also, occasional pruning is encouraged not only to reduce shading of the intercrop but also to continually introduce organic mulch for the continuous productivity of the soil and nutrient supply to the intercropped or arable component in the rotation.

5. The New Concept towards Continuous Cultivation

5.1 Possible Crop Combinations

This concept is suitable for many regions of the world. The type of tree crop to be used will depend on the region. For example, at the fringes of the rain forest or in the savannah forest lands of Nigeria the use of tree crops like the Cashew plant (*Anacardium Occidentale*) is suitable. In the rainforest region of Nigeria, possible tree components can be the Cocoa plant (*Theobroma Cacao*), Rubber plant (*Hevea Brasiliensis*), Mango plant (*Mangifera Indica*) among others. After growing arable crops as is the normal tradition for some years and when productivity begins to decline then, the land can be grown to one of the economic trees mimicking the natural fallow system. As explained, fertilizations will be required during all the phases to complement the natural regeneration process.

5.2 Sequencing and Timing of Rotation

5.2.1 Possible Tree Crop/Arable Crop Rotations

I shall give some possible rotation cycles that a farmer can choose for this system. All the proposals assume that the land is relatively large enough for the commercial growth of economic trees. And the land will be divided into portions to ensure the rotations are effective and the optimum benefits of the tree crop components are not compromised, also the sequence gives the farmers adequate time to properly utilize the land in phases, learning as the phases progress and bringing in modifications where necessary.

Rotation 1: Land is divided into 5 portions. At the start of the programme, only one-fifth of the land is grown to the desired tree crop. Depending on the sequence (especially with regards to the ultimate age of the tree before the tree crop will be cut down to give room for the arable crop rotation phase), it is developed. For example, if the ultimate age of the tree crop for this sequence is determined to be 20 years, then for a 5 portioned rotation land, the first portion will be planted in year 1, the next portion will be planted after 5 years of planting of the first portion and the third portion will be planted after 10 years of the planting of the first portion and 5 years of planting of the second portion, this sequence of 5 years interval will continue until all the 5 portions are planted as shown in Table 1 below. It follows that by the time the 5th portion is planted, the first portion is already 20 years old and is due to be cut down and grown to the arable crop. Subsequently every 5 years, the arable cropping will move to the next land that has been grown to tree crop for 20 years and the cycle continues in perpetuity.

Depending on the type of tree crop and the type of micro rotation that is planned for the portion for the arable crop, the age of the mature tree crop is determined to know when the tree is pruned or cut down and so also will be the age of rotation. Arable crop rotation phase can last between 3 to 5 years depending on the micro arable crop regime implemented and the types of the arable crop planted. While ultimate age of maturity before cutting down of the tree crop can range from 9 to 20 years depending on the biological information on when fruit production begins to decline or when the opportunity cost of maintaining the tree crop is no longer as favourable.

5.2.2 A Possible Tree Crop/Arable Crop Rotation Sequence for Continuous Land Utilization Scheme

Table 1. A sequence of tree crop of maximum 20 years before cutting down to grow arable crops for 5 years in a land divided into 5 portions

	PLOT SECTION 1	PLOT SECTION 2	PLOT SECTION 3	PLOT SECTION 4	PLOT SECTION 5
Year 1	Start growing tree crop	Grow other crops	Grow other crops	Grow other crops	Grow other crops
Year 5	Tree crop grown is 5 years old	Start growing tree crop	Grow other crops	Grow other crops	Grow other crops
Year 10	Tree crop grown is 10 years old	Tree crop grown is 5 years old	Start growing tree crop	Grow other crops	Grow other crops
Year 15	Tree crop grown is 15 years old	Tree crop grown is 10 years old	Tree crop grown is 5 years old	Start growing tree crop	Grow other crops tree crop
Year 20	Tree crop grown is 20 years old. **Cut tree crop down and grow an arable crop**	Tree crop grown is 15 years old	Tree crop grown is 10 years old	Tree crop grown is 5 years old	Start growing tree crop
Year 25	Start growing tree crop	Tree crop grown is 20 years old. **Cut tree crop down and grow an arable crop**	Tree crop grown is 15 years old	Tree crop grown is 10 years old	Tree crop grown is 5 years old
Year 30	Tree crop grown is 5 years old	Start growing tree crop	Tree crop grown is 20 years old. **Cut tree crop down and grow an arable crop**	Tree crop grown is 15 years old	Tree crop grown is 10 years old

Table 1 above explains a two-rotation sequence of unequal crop component lengths. While the tree crop is grown for 20 years, the arable cropland is cultivated for 5 years. However, the land is divided into 5 parts with 4 parts at every time grown to the tree crop. That follows that by the time the land is fully used up 80% of available land is under tree crop cultivation at any particular time. However, each of the 5 land portions is maturing at different times in line with the planting sequence and the arable crop cultivation is therefore rotating at a 5-year interval.

The above is for a sequence of 5 years interval. If however the interval is shortened to, for example, 3 years instead of 5 years, the tree crops will have a maximum age of 12 years before they are cut down to grow arable crops for 3 years in a land divided into 5 portions sequence as above.

Table 2. A sequence of tree crop of maximum 15 years before cutting down to grow arable crops for 5 years in a land divided into 4 portions sequence

	PLOT SECTION 1	PLOT SECTION 2	PLOT SECTION 3	PLOT SECTION 4
Year 1	Start growing tree crop	Grow other crops	Grow other crops	Grow other crops
Year 5	Tree crop grown is 5 years old	Start growing tree crop	Grow other crops	Grow other crops
Year 10	Tree crop grown is 10 years old	Tree crop grown is 5 years old	Start growing tree crop	Grow other crops
Year 15	Tree crop grown is 15 years old. **Cut tree crop down and grow an arable crop**	Tree crop grown is 10 years old	Tree crop grown is 5 years old	Start growing tree crop
Year 20	Start growing tree crop	Tree crop grown is 15 years old. **Cut tree crop down and grow an arable crop**	Tree crop grown is 10 years old	Tree crop grown is 5 years old
Year 25	Tree crop grown is 5 years old	Start growing tree crop	Tree crop grown is 15 years old. **Cut tree crop down and grow an arable crop**	Tree crop grown is 10 years old
Year 30	Tree crop grown is 10 years old	Tree crop grown is 5 years old	Start growing tree crop	Tree crop grown is 15 years old. **Cut tree crop down and grow an arable crop**

Table 2 above explains a two rotation sequence of unequal crop component lengths. While the tree crop is grown for 15 years, the land for arable crops is cultivated for 5 years. However, the land is divided into 4 parts with 3 parts at every time grown to the tree crop. That follows that 75% of available land is under tree crop cultivation at any particular time.

Similarly as in Table 1 if the sequence duration is shorten to 3 years then the tree crops will have a maximum of 9 years before they are cut down to grow arable crops for 3 years in a land divided into 4 portions.

5.3 Possible Challenges

5.3.1 Fertilization Issues

For optimum returns from both the tree crop and arable crop components, an appropriate fertilization regime must be developed for use during the cropping phases of both components. The fertilization practice to be adopted for the arable component will depend on what is cropped. For example, the intercropping of cassava with maize or yam with maize will require different fertilization from cultivating pineapple, banana/plantain. Pineapple, banana/plantain, and normal garden crops will do much better with the application of animal manure fertilization together with inorganic fertilizers to grow such crops beyond 3 years effectively and continuously on the same piece of land. It follows that having poultry production for example to generate manure in the farm or having access to such manure in sufficient quantity elsewhere can help sustain sustainable production of the crops for upwards of 5 years and beyond as proposed in the sequence.

With the litter production during the tree cultivation phase and possible pruning of the trees during the arable crop cultivation phases, there will be adequate organic matter produced to stabilize the soil condition for continuous large-scale cropping.

5.3.2 Coppicing versus Replanting

Most fruit trees coppice easily. That means they easily regrow bringing out new shoots if they are cut down at a good height so long as it is not at the root level. This particular attribute is important if a tree crop has to be used as a component in this type of rotation cycle. Cocoa, Rubber, Mango, Cashew trees all coppice well. However, a tree cropping phase that had lasted for more than 15-20 years before the cropping of arable crops on that same piece of land can as well be replanted altogether for any agronomic or other compelling scientific reasons after the older crop had been growing for so many years.

Depending on the intentions of the farmer, the tree crops can be pruned during the arable crop phase to reduce shadow and introduce organic mulch for the arable crops.

5.3.3 Removal of Tree Roots (Stumping) during Arable Crop Phase

Rooting up (stumping) can be an expensive operation for those using mechanization to prepare the land during the establishment of the arable crops after the tree cropping phase. Though this might not be a challenge for those using zero or minimum tillage system as a practice, adequate provisions for mechanized land preparation is required for large scale crop farming.

5.4 Role of Government

Traditionally, the government's role is to identify the development needs of the people and then point stakeholders towards such directions. To do this, the government applies several strategies: tax incentives, provision of land at attractive rates for projects, provision of other amenities like electricity, roads, etc. At other times, the government starts a pilot scheme or takes up the implementation of the projects. However, it is well known that governments or generally publics/communities are usually unable to manage income-generating or commercial ventures because of the selfish influence of the non-owning managers or the influence of political meddling with pure commercial decisions. In addition, often to keep their jobs in public-owned corporate organizations, projects managers often try to please many supervisors who have powers to get them sacked. While a project owner, who had invested a lot of capital into the business, will see the growth of the business as a priority, a supervisor who is not a business owner but prone to corruption may see what will benefit him in the business as a competing priority to the continued and fast growth of the business. That means that such a supervisor may exert pressure on the project manager to take along his self-interest with the goal of making a profit. A project manager may therefore have conflicting needs of pleasing the supervisor along with making maximum profit. Such influences imply that the project managers have to make subjective decisions to please such bosses instead of taking the best-unbiased decisions in the interest of the business. These tendencies exist in government and other publicly owned businesses. It is for that reason controls are always critical to the survival of publicly commercial businesses. The establishment of corruption-proof policy guidelines and the use of a good management information system along with regular performance assessment reviews will help ensure business profitability. A more long-term strategy will be for the government to divest the majority of its shares in the business to both the public and a management consultant who will also have shares in the business. Such Public-Private Partnerships (PPP) have greater chances of becoming sustainable and profitable. Another reason why government involvement is needed at least at the initial stages is to encourage large crop plantations or the establishment of large-scale industries because of the complicated process of acquiring large contiguous land from numerous units of people. Government is more able with the current land use law in the constitution of

Nigeria to ensure such large parcels of land can be acquired successfully. Also, many private entrepreneurs are not willing to take the initial risks of investing huge capital in a business. They would, however, like to come in after the businesses have been established to participate in the profit-making and sharing of dividends.

Many state governments in Nigeria had economic crop plantations some decades ago which by implication are commercial ventures. However, agricultural production as the mainstay of the national and sub-national economies took the back seat when crude oil production and sales became the most prominent source of revenue for the Nigerian nation. Many agricultural plantations were neglected or abandoned as a result. In Rivers State, for example, rubber plantations were established, and they are occupying more than 10,000 hectares of land and were at peak production some decades ago (Iroegbu et al., 2021; Abolagba et al., 2016). Those expanses of land can be used for this programme to enhance agricultural and economic productivity. Also about a decade ago, the government was to start a partnership with some private entities as consultants to cultivate about 5,000 hectares of land for Cocoa That project had been suspended. With this new concept, that project can be revived in line with this proposal and that would lift the state as a major producer of Cocoa and would generate a lot of income for the government and other shareholders. The large acreage of land under the rubber plantations that were established in the same state several decades ago can be revived or the land can be converted to grow better revenue-generating crops. A holistic approach where this crop rotation system is encouraged and also post-harvest value-adding industries established can improve the economy of all the stakeholders. Entrepreneurs can go into that adding value aspect to these crops and improve the market availability to encourage the increased cultivation of the crops. Apart from making effort to add value to the product before they are marketed internally and externally, Cocoa has high market value and there is an export market in Europe, America, and even Asia (FAO, 2021).

Many partnership opportunities exist with other nations. The United States of America had announced a possible partnership in the past with Cashew farmers including those in Nigeria https://www.thecable.ng/nigeria-to-benefit-from-60m-prosper-cashew-project/amp. This also applies to many other export opportunities with many crops from Nigeria and beyond.

6. More Research Needed

Research will be required to identify suitable tree crops that can be used in this rotation system. Some possible economic crops like Cocoa, Rubber, Cashew, and Mango can be assessed towards identifying their suitability as good candidates from the agronomic and economic perspectives. The growing of these crops as individual crops permanently is fairly known but for the proposed system, they will be cut down after several years to give room for arable crop planting. The cutting down of these crops will generate massive litter and mulching materials during the arable crop cultivation phase. Research is needed on the best ways of mulching and adequacy fertilizer application that will equally be required. The ways of coppicing and frequency need to be studied, so too is the need to understand the various agronomic/economic returns using the different tree crop/arable crop rotation durations.

7. Conclusion

This paper had explained the benefits of tree crop/ arable crop rotation. I have stated that this system improves soil fertility through tree crop cultivation that builds up organic matter, which invariably increases nutrients and better soil structure. I have also established in the paper that these attributes improve soil productivity.

Usually, shifting cultivation involves cultivating land for about 3 years and leaving it to fallow for not less than 5 years. Percentage utilization of the land is therefore less than 38%. No income is derived from the land during fallow. Prolonging the cropping duration will mean poor yield so no net economic benefits. If soil productivity is improved by this tree crop/arable crop system then land utilization is increased to nearly 100% hence derived income too to the farmer is improved. This tree crop/arable crop rotation system therefore ensures greater income for all stakeholders.

The massive cultivation of economic tree crops and that of arable crops requires that the system is accompanied by post-harvest value-adding facilities to reduce post-harvest losses. That means the introduction of new facilities either for storage or increasing the shelf lives of the produce. Apart from the large-scale production which will need a lot of sub-contractors, suppliers, and other services for the smooth running of the businesses; others will provide direct and indirect services needed by employers of the business. There will be many retailers, many people requiring accommodation, transportation, catering, and many other services. The location of the business will have a large influx of people and the accompanied increased economic activities will bring more income to the people.

As stated above, every large-scale business generates much direct employment and also many indirect employment opportunities. The post-harvest facilities and subsequently the industries that should be established to process the raw materials of this business will equally generate a lot of employment. For example, a massive Cocoa farm should generate the need for farmhands, those to tend the plants, those to harvest the fruits, and those to dry the seeds before transportation to market or industries. There will be national gains too as industries far detached like the airlines will all benefit from the export business that will ensue.

Government has a major role to play to bring this model into mass implementation and adoption.

Every region should work out what tree crops it wishes to specialize in and plan how to set up ready market and industries to take up the produce. That way, even smallholder farmers may wish to grow these crops since they are assured of a ready market when they make the harvest.

Acknowledgment

I thank Mrs. Nkem E. Odoya, the Director of Forestry in the Rivers State Ministry of Agriculture who gave me some insight into the cultivation of tree crops.

References

Abolagba, E. O., Abolagba, T. U., Esekhade, B. N., Agbonkpolor, E. S., Osazuwa, H. Y., & Musa, E. (2016). Decline in Activities in Nigeria Rubber Industry: A Case For Government Intervention. *Direct Research Journal of Agriculture and Food Science, 4*(10), 294-299. Retrieved from http://directresearchpublisher.org/aboutjournal/drjafs

Alhameid, A., Tobin, C., Maiga, A., Kumar, S., Osborne, S., & Schumacher, T. (2017). *Soil Health and Intensification of Agroecosystems Chapter 9 Intensified Agro-ecosystems and Changes in Soil Carbon Dynamics*. Elsevier. https://doi.org/10.1016/B978-0-12-805317-1.00009-9

Bassey, E. E. (2003). *The Effects of Land Tenure on Natural Resource Conservation in the Nigerian Rainforest Ecosystem*. Paper submitted during the XII World Forestry Congress 2003 at Quebec city, Canada. Retrieved from https://www.fao.org/3/XII/0138-B1.htm

CEICdata.com. (2018, June 1). *Nigeria Population*. CEIC. Retrieved from https://www.ceicdata.com/en/indicator/nigeria/population

FAO publication. (2021). *Analysis of incentives and disincentives for Cocoa in Nigeria: The Monitoring and Analysing Food and Agricultural Policies (MAFAP)*. Retrieved from https://www.fao.org/in-action/mafap

Gichuru, M. P., & Kang, B. T. (1980). *CaNiandra caNhyrsus* (Meisn) in an alley cropping system with sequentially cropped maize and cowpea in Southwestern Nigeria. *Agroforestry System, 9*, 191-203. https://doi.org/10.1007/BF00141083

Gichuru, M. P. (1991). Residual effects of natural bush, Cajanus cajan and Tephrosia Candida on the productivity of an acid soil in southeastern Nigeria. In R. J. Wright, V. C. Baligar, & R. P. Murrmann (Eds.), *Plant-Soil Interactions at Low pH*. Developments in Plant and Soil Sciences, Springer, Dordrecht. https://doi.org/10.1007/978-94-011-3438-5_46

Hahn, S. K., Terrey, E. R., Leuschner, K., Akobundu, C. O., & Lal, R. (1979). Cassava improvement in Africa. *Field crops Research, 2*, 193-226. https://doi.org/10.1016/0378-4290(79)90024-8

International Institute of Tropical Agriculture report-IITA. (2011). *ALLEY CROPPING-A Stable Alternative to shifting cultivation*. Retrieved from https://issuu.com/iita/docs/u84bkkangalleynothomnodev

Iroegbu, I., Okidim, I. A., & Ekine, D. I. (2021). Profitability of Natural Rubber Production and Processing: A Case of Delta Rubber Company Limited Okomoko/Umuanyagu Etche. *Rivers State International Journal of Innovative Science and Research Technology, 6*(5).

Lal, R., Kang, B. T., Moorman, F. R., Juo, A. S. R., & Moonon, J. C. (1975). Soil management problems and possible solutions in western Nigeria. In E. Bomemiaza & A. Alrarado (Eds.), *Soil management in Tropical America North Carolina State University* (pp. 372-408). Raleigh. American Soc. Agron. Medison. W. L.

Lawrence, A. W. (2018). Towards better performance in achieving sustainable development goals in Nigeria. *International Journal of Development and Economic Sustainability, 6*(3).

Lawrence, A. W. (1993). Organic Mulching for Increased Crop Productivity in the Nigerian Humid Tropics. *Journal of Sustainable Agriculture, 2*(4), 101-106. https://doi.org/10.1300/J064v02n04_09

LR-Group. (2016, May 2). *Adama Rivers, Nigeria*. LR Group - Making Vision Reality. Retrieved from https://lr-group.com/project/adama-rivers-nigeria/

Magdoff, F., & Harold, van E. (2000). *Building Soils for Better Crops* (3rd ed.). SARE. p. 102-3. Retrieved from www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition

Okon, D. (2022, February 13). *Nigeria to benefit from $60m Prosper Cashew project*. The Cable. Retrieved from https://www.thecable.ng/nigeria-to-benefit-from-60m-prosper-cashew-project/amp

Parkey, G., & Shourov, D. (2020). *Improvement Strategy of Shifting Cultivation or Jhum in NE India*. Agriculture and Food: E-Newsletter. Retrieved from https://www.researchgate.net/publication/344253782_Improvement_Strategy_of_Shifting_Cultivation_or_Jhum_in_NE_India

Punitha, P., Ansari, M. A., Pandey, D. K., Ram, D., Datts, S., Sharma, P. K., Aheibam, M., Jyothi, S. S. P., & Prakash, N. (2018) Shifting cultivation in North East India: Social dimension, cross-cultural reflection and strategies for improvement. *Indian Journal of Agricultural Sciences, 88*(6), 811-9.

Putri, R. F., Naufal, M., Nandini, M., Dwiputra, D. S., Wibrama, S., & Sumantyo, J. T. S. (2019). *The impact of population pressure on agricultural land towards food sufficiency (case in West Kalimantan Province Indonesia)*. International conference on environmental resource management in global region 10P Publishing 10P Conf. Series Earth and Environment Science. https://doi.org/10.1088/1755-1315/256/1/012050

Tibbits, D. (2017). *The effects of bush burning on soil conditions*. Retrieved from https://sciencing.com/the-effects-of-bush-burning-on-soil-conditions-13427774.html

United Nations' Department of Economic and Social Affairs Sustainable Development Report. (2022). Retrieved from https://sdgs.un.org/

Verma, P. K., Kumar, V., Chandra, A., & Thounaojam, B. (2017). Alternatives of Shifting Cultivation in the North-eastern region of India. *Report and opinion, 9*(12), 1-8.

Worldometer. (2020). Nigeria Population (2022) - Worldometer. Worldometers. Retrieved from https://www.worldometers.info/world-population/nigeria-population/