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RESEARCH ARTICLE

SUSTAINABLE COCOA MANAGEMENT AND PRODUCTION BASED ON LOCAL KNOWLEDGE IN CENTRAL COTE D'IVOIRE

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Abstract

Central Cote d'Ivoire is home to forest-savannah contact zones with conditions that are not very favourable for cocoa production. However, the existence of cocoa plantations in these areas has been observed and is attributed to the presence of various agroforestry systems in which local and exotic species are combined with cocoa trees to overcome the various environmental constraints. To provide information on the local knowledge and technologies underlying the viability and sustainability of these production systems, an ethnobotanical survey of 102 farmers in the Kokumbo sub-prefecture (central Cote d'Ivoire) was carried out. Floristic inventories were also carried out in the cocoa plantations of the producers interviewed. The data collected was analysed firstly to establish the history of the plantations and their management, and secondly to determine the quality of the woody flora preserved. These analyses show that the main knowledge that farmers have about cocoa growing comes from their parents and from sharing their experiences with other farmers. The average size of cocoa plantations is 2.53 hectares. The Forastero Upper-Amazonian variety is considered more productive by farmers, gradually replacing weak or dead plants. However, farmers use beens from cocoa trees whose pods they visually appreciate. In addition to direct sowing and nurseries, farmers are using flat techniques, which give better results. Lack of resources and awareness of the potential negative effects of herbicides mean that producers resort to manual weeding of their plantations. In addition, trees remain an integral part of cocoa cultivation in the area. Indeed, these trees, associated with cocoa trees, provide essential goods and services to local populations and help meet their needs for timber, firewood, food, and remedies derived from medicinal plants.

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Introduction:-

Cocoa production, a strategic crop for Cote d'Ivoire, faces numerous environmental, social and economic challenges. The country's status as the world's leading cocoa producer and exporter has been built on intensive farming practices (Assiri et al. 2009). These practices have often led to soil degradation, loss of biodiversity and economic inequalities (Climate Change 2018; N'Guessan et al. 2020). To counter this trend of exponential erosion of biodiversity in Cote d'Ivoire, the practice of sustainable agriculture has been recommended for the past few decades by both research organizations and the Ivorian government.

Cocoa growing in the country is characterised by small average areas farmed per producer (Assiri et al. 2009; Kouadio et al. 2021) and limited access to modern resources, such as quality agricultural inputs, technical support and funding mechanisms (Sanial 2015). This situation makes farmers vulnerable to climate change and soil degradation. However, cocoa farmers, particularly those in the central regions of Cote d'Ivoire, possess ancestral knowledge of cocoa growing, which enables them to overcome often the unfavourable environmental conditions while preserving local ecosystems.

Agroforestry, which appears to be one of the best ways of dealing with this situation, has existed for several hundred or even thousands of years as a traditional land-use system for many populations around the world (Beer et al. 2003). Its presence has been demonstrated in several regions of Cote d'Ivoire (Cissé et al. 2016; Sanial 2018; Kpangui et al. 2015), including central Cote d'Ivoire. The special feature of this central area is that it is a forest-savannah transition zone characterised by a long dry season (more than three months), average annual rainfall of around 1,100 mm and an average annual temperature of 26.5°C (Kossonou 2020). In this region, cocoa farmers have been growing cocoa in various agroforestry systems for several generations, making it possible to overcome unfavourable environmental conditions while maintaining soil fertility, reducing erosion and preserving biodiversity (Kouadio et al. 2019).

Taking local knowledge into account in sustainable cocoa management and production strategies in Cote d'Ivoire implies a reconnection between indigenous knowledge and modern agricultural sciences. This integrated approach would make it possible to design farming systems that are both productive and environmentally friendly, while helping to improve the living conditions of cocoa farmers. It was with this in mind that the present study was conducted in the sub-prefecture of Kokumbo. Its aim was to provide information on the local knowledge and technologies that underpin the viability and sustainability of these production systems.

Materials and Methods:-

Study area

This study was carried out in the localities of Niamkey-Konankro and Langossou in the sub-prefecture of Kokumbo (Fig. 1). Kokumbo belongs to the Toumodi department and the Bélier region. It is located in the centre of Cote d'Ivoire and is characterised by mixed vegetation combining forest and savannah. The average annual temperature is 26.3°C, with an average annual rainfall of 1,075 mm (Climate-data.org).

Data Collection

Sociological and ethnobotanical surveys were carried out among 102 cocoa farmers in the Kokumbo sub-prefecture, particularly in the localities of Langossou and Niamkey-Konankro. The sociological surveys aimed to establish a profile of the farmers, addressing, among other things, their age, education level, and sources of knowledge regarding farm management. The ethnobotanical surveys, on the other hand, focused on characterizing the plantations. Questions related to this aspect primarily covered the area of the plantations, their age, management methods, and resources used. In addition to these surveys, direct observations were carried out in the plantations to corroborate the information provided by the respondents. This involved surveying various plantations belonging to the three main cocoa-based agroforestry systems (simple, mixed, and complex) identified in the area by Kpangui et al. (2015) and Kouadio et al. (2018), in order to document the practices implemented by the farmers.

Data Analysis

The data collected were subjected to descriptive analyses (averages, sums, frequencies, percentages, etc.) and textual analyses. The textual analyses were applied to data relating to the history of the plantations, the quality of the woody

flora preserved, and the means and techniques implemented for cocoa tree management. All these analyses were performed using Excel spreadsheet software.

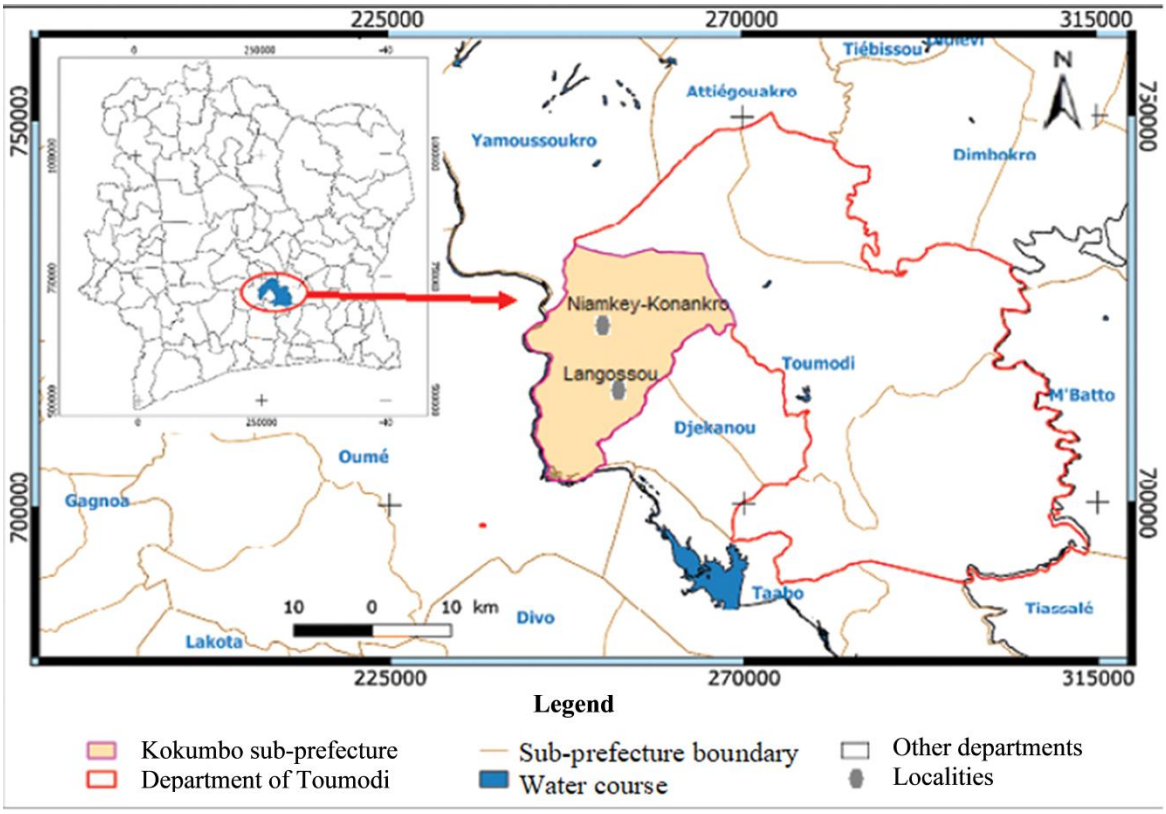

Fig. 1:- Location of Kokumbo Sub-prefecture.

Results:-

Profile of producers

A total of 102 producers were interviewed, including 56 in Langossou and 46 in Niamkey-Konankro. Men represent 83.30% and women 16.70% of this group. Their ages range from twenty-three (23) to sixty-four (64) years, with an average age of 44 years. Those over forty-five (45) years old are the most numerous, accounting for 50.54% of the interviewed farmers. They are followed by individuals aged between thirty (30) and forty-five (45) years (38.71%). The least numerous are producers under thirty-five (35) years old (10.75%). Farmers' age does not influence their choice of system. Indeed, farmers aged between 45 and 55 years are the most represented in the simple cocoa-based agroforestry system (AFSc) (33%), the mixed AFSc (54%) and the complex AFSc (73%). Farmers over 55 years old are the least represented in the simple AFSc (11%), the mixed AFSc (8%) and the complex AFSc (9%). Among all the interviewed producers, only 6% indicated having received training in cocoa cultivation. The main sources of acquisition of knowledge and skills related to cocoa farming are learning from parents and exchanging experiences among producers.

When asked about their level of education, 49% of producers said they had attended school. Among these, 26% had received secondary education. Among men, 56% (30% with primary education and 26% with secondary education) had attended school. As for the women, 35% of them (of whom 12% have primary education and 23% secondary education) have been to school.

Most farmers who adopted complex AFSc did not attend school (45%). In contrast, the majority of farmers who adopted mixed AFSc (46%) had reached a secondary school level. The trend observed among farmers who adopted simple AFSc is more or less balanced, with 28% having reached secondary school, 39% having reached primary school and 33% not attending school (Fig. 2). Furthermore, the type of AFSc adopted by these farmers is not linked to their level of education.

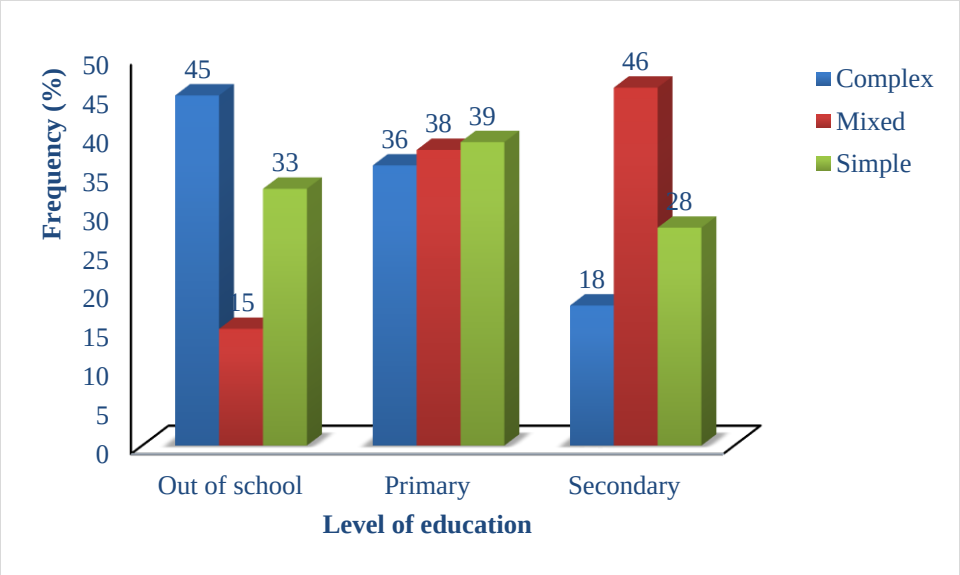

Fig. 2:-Distribution of producers by level of education.

Characteristics of cocoa plantations

Surveys show that the average plantation area is 2.53 hectares. Less than 2 hectares are farmed by 23% of producers. Those cultivating areas of between 2 and 4 hectares are the most represented, with a proportion of 68.18%. Farmers with holdings of more than 4 hectares represent only 7.96% of these farmers (Fig. 3).

Seven (7) methods of accessing land were identified, the main ones being inheritance (81%), gift (6%) and management for the family (5%). The other methods of accessing land were receipt by acknowledgement, a fixed-term contract and being a landowner.

Analysis of data on the age of plantations shows that the average age of plantations is estimated at 19 years. Producers with plantations between five (5) and fifteen (15) years old are the most represented (43.75%). Farmers with plantations between fifteen (15) and thirty (30) years old represent 32.29% of the total. Farmers with plantations less than 5 years old are the least numerous, with a proportion of 7.29%.

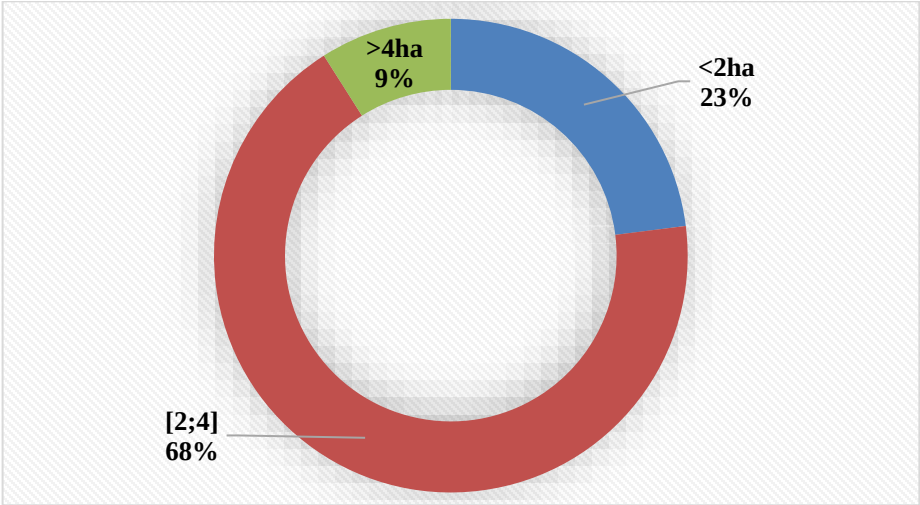

Fig. 3:-Distribution of producers according to the size of their plantations.

Overall, the 'Ghana' variety (Forastero Haut-Amazonienne) is the most widely used by farmers, with a frequency of 68.47%. Next comes the 'French' variety (Amelonado) with a frequency of 23.42%. The hybrid variety commonly

known as Mercédès cocoa is the least used by farmers (8.11%). This variety and the 'Ghana' variety are grown in the simple AFSc. In the mixed and complex AFSc, the 'Ghana' and 'French' varieties are grown.
For the establishment or renewal of the plantation, farmers (82.40%) take their seeds from other plantations. Only 29% of all farmers interviewed use seed from their own plantation. Those who bought their seeds and those to whom they were offered (either by the CNRA or ANADER or by third parties) represent only 10.8% (Fig. 4).
Farmers prefer to use nurseries to sow cocoa trees. This method is used by 80.4% of the producers interviewed. This is followed by direct sowing of cocoa beans in the soil, cited by 55% of farmers. A third technique, not widely used, known as the flat technique (dry nursery on the ground), is used by 4.9% of farmers.

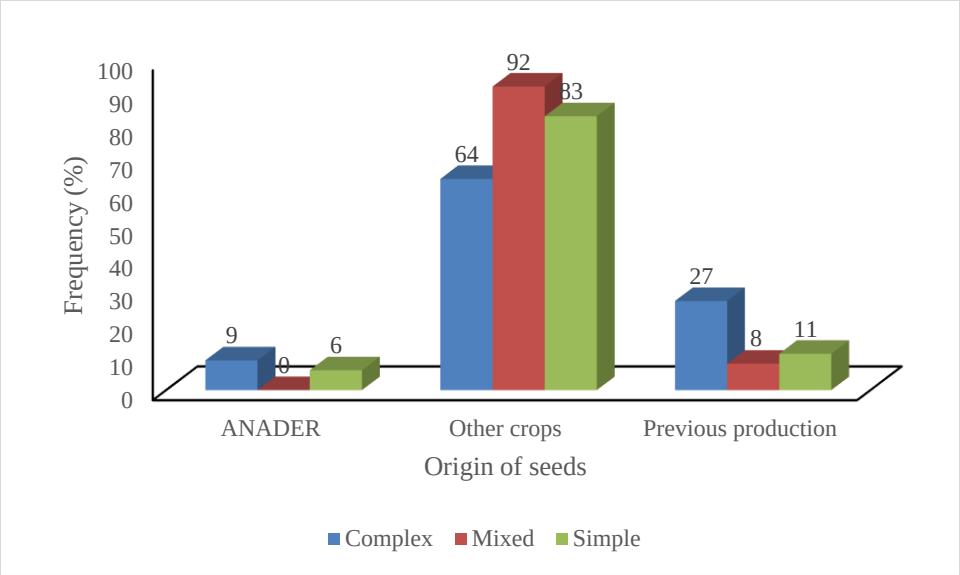

Fig. 4:- Histogram of the distribution of farmers by type of AFSc according to seed origin.

Regardless of the type of AFSc, the type of labour used to maintain the plantation does not change. Family members are the most frequently used labour force for watering nurseries, with 93% of farmers citing them. Only 4.5% of these farmers say they use laborers and 2% use day laborers for this activity.

Manual weeding is generally carried out three (3) times a year. The first weeding operation generally takes place between June and July. The second is carried out between September and October. The third and final weeding takes place between November and December. It should be noted that some farmers who have adopted complex AFSc carry out a single annual weeding operation, while in the group of farmers who have adopted simple AFSc, some carry out more than six weeding operations (Fig. 5).
During the pre-harvest period, some farmers use herbicides and chemical inputs to fertilise the soil and control cocoa tree pests. This use of inputs is aimed at reducing the work effort and maximising the productivity of the cocoa trees on their plantation. The type of input and frequency of use of these chemical inputs do not vary according to the type of AFSc adopted. Generally speaking, 52% of farmers claim to use fertiliser to increase their production, insecticides and/or fungicides to treat cocoa trees and their pods. This category is followed by producers who apply neither fungicides nor insecticides to their cocoa trees. The use of herbicides is the least cited, with 7% of producers. In the complex AFSc, 61% of farmers use insecticides and/or fungicides to maintain their cocoa trees. Only 28% use fertiliser. Those who use neither fertiliser nor insecticides and/or fungicides represent only 11%. The simple AFSc follows the same trend, but this time only 7% of farmers use chemical weedkillers. In the mixed AFSc, on the other hand, 55% of farmers used neither fertiliser, insecticide and/or fungicide, nor herbicide (Fig. 6). Insecticides and/or fungicides are generally applied twice (2) a year. The first application is made during the months of July and August. The second application is made between August and September or in December.

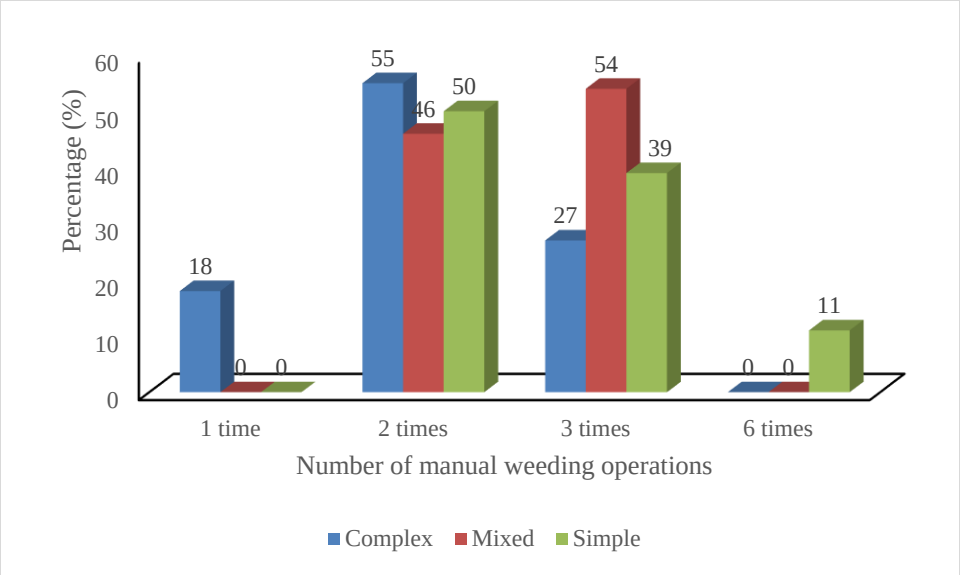

Fig. 5:- Histogram of the distribution of plantations by type of AFSc according to the number of manual weeding operations.

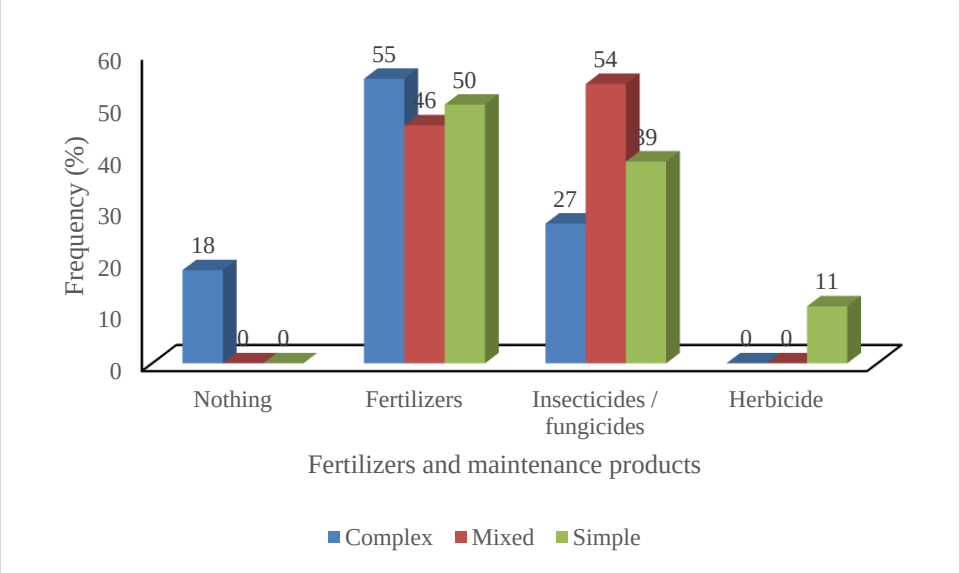

Fig. 6:- Histogram of the distribution of plantations by type of AFSc according to the use of chemical inputs.

Discussion:-

Farmers' know-how in the spatial and temporal management of cocoa plantations

The results of this study show that farmers (men and women) grow cocoa. They are on average 44 years old and farm small areas (2.53 ha). The small size of cocoa plantations is similar to that recorded by Assiri et al. (2009) in Issia and Bongouanou (2 to 3 hectares per farmer). The small size of the plantations could be explained by the fact that farming is not mechanised and by land tenure constraints, which have led farmers to adopt small family farms. The work of Boni (1985) and Assiri et al. (2009) has shown that cocoa farming in Cote d'Ivoire is dominated by smallholders. The small areas cultivated are also similar to those recorded by Konan et al. (2015) at national level (2 to 3 ha). However, Assiri et al. (2009) recorded an average area of 6.3 ha per farmer considering the main cocoa production areas at national level. These large cocoa farm areas are due to extensive cocoa farming, which has increased following the shift of the cocoa loop from east to west.

In the present study, the plantations were generally established in place of pre-existing forests or from the rehabilitation of former cocoa plantations. The young age of the plantations run by women shows that they are increasingly interested in cocoa farming, which has long been characterised as a 'man's crop'. Women generally become involved after the death of their spouse or when they are not living as a couple. They generally inherit the land they farm. In the study area, parents generally bequeath their plantations to their descendants (Kpangui 2015). In the first case, the heirs are young people who have been by their side throughout the creation and management of these plantations. They mentioned the forest and sometimes a former cocoa plantation as their cultural precedent. In the second case, the heirs are people who did not take part in the creation of the plantation from which they benefit. This category mentioned old cocoa plantations as the previous crop. The age and sex of these beneficiaries of bequeathed plantations do not influence the type of AFSc they adopt. When a woman inherits part or all of the plantation, she entrusts it to her husband, who is responsible for management. The size of the family (10 people on average) requires at least one other plantation to be maintained, in addition to the cocoa plantation that the farmer has. These are either perennial crop plantations (cocoa, rubber, teak) and/or food crops (yams, manioc, etc.). The food crops meet the family's food needs and the surplus is sold on the market in the said locality or on the market in the nearest town (Kossonou et al. 2018). This practice is adopted by farmers in the localities of Niamkey-Konankro and Langossou, regardless of the system they have adopted. Farmers prefer seeds from cocoa trees of the 'Ghana' variety and its hybrids. In the locality of Lakota in central-western Cote d'Ivoire, Cissé et al. (2016) made the same observation. These seeds generally come from pods seen, appreciated and harvested during a visit to the plantation of a relative or friend in the village. In complex and mixed AFSc, farmers combine the 'French' and 'Ghana' varieties, with a preference for the 'Ghana' variety. Following the example of farmers in the Department of Lakota, farmers in the Kokumbo sub-prefecture combine these two varieties as part of the rehabilitation and rejuvenation of their old cocoa plantations (Cissé et al. 2016).

Indeed, plants of the 'Ghana' variety, considered more productive by the farmers, replace those that have failed or died. The 'Mercédès' variety is found in a few plantations with the configuration of a simple AFSc. Despite genetic aptitudes that enable it to grow without shade and to produce early (after 18 months), farmers in the Kokumbo sub-prefecture are reluctant to use this variety. Indeed, the use of this variety by some farmers to create nurseries or for direct seeding has resulted in several failures. These failures have led most farmers to take a negative view of the variety. Added to this is the fact that young plants of this variety find it difficult, if not impossible, to withstand the dry season in this area. Furthermore, the failures recorded during the establishment of nurseries, whether for the 'Ghana', 'Français' or 'Mercedes' varieties, can be attributed to the methods used by the farmers. To achieve better results, Kébé et al. (2009) proposed a methodology for setting up nurseries. These authors, working on behalf of the Centre National de Recherche Agronomique (CNRA), suggest that nurseries should last an average of 6 to 8 months, with regular chemical treatment against defoliator caterpillars, psyllids and twig borer. However, the techniques and means used by the majority of farmers in the study area do not differ whatever the AFSc adopted. These techniques do not enable them to achieve the results predicted by these authors. Indeed, they do not have the necessary means to acquire the chemical products recommended by the CNRA. Added to this is the low level of education among farmers, which makes it difficult for them to adopt the techniques proposed by the CNRA. Financial constraints on the purchase of plastic bags and the technical rigour required to create nurseries mean that farmers alternate between planting by direct sowing and planting by nursery. In addition to these two main planting methods employed, the "plat" technique is occasionally used. The "plat" (literally "flat") is used instead of creating traditional nurseries. It corresponds to ground-level nurseries. Its implementation involves placing fresh beans in tilled soil. Sometime later, the resulting young plants are removed and transplanted into the plantation. According to the farmers, this technique has a high success rate, especially as the transplanted plant is young. In fact, this technique has the advantage of better simulating the conditions under which the plants are actually grown. As a result, they reduce the time spent in the nursery to an average of 4 months. Transplantation of seedlings from the nursery, from the 'flat' or direct sowing is generally done without staking. As a result, the seedlings are not aligned and there are too many of them on the farm (Kouassi 2010), particularly in mixed and simple AFSc. This overcrowding, which is generally deliberate, is intended to reduce the impact of the dry season on young seedlings. In fact, large enough spaces between young plants would cause them to dry out in the dry season. The farmer gradually eliminates certain plants as the plantation develops.

Labor involved in farm management

For all activities related to plot maintenance, harvesting, and pod breaking, family labor is the most utilized on farms. This family workforce helps reduce plantation maintenance costs and serves as a means of training young people in farm management. Family labor is exclusively involved in the planting and watering of young plants.

Weeding activities, however, involve both family labor and external paid labor. This external labor consists of general laborers, daily contract workers ("tréclé"), or young people from the village organized into work groups called "sociétés" (Kouassi 2014). General laborers and contract workers are employed by farmers who have adopted a simple or mixed cocoa-based agroforestry system (SAFc). Unlike complex SAFc, these systems require significantly more time for maintenance. These findings are further supported by the low proportion of farmers employing organized "sociétés" for weeding in complex SAFc, compared to other systems. These data clearly illustrate the reduction in labor effort in farming systems that incorporate more trees.

Plantation maintenance

Plantations are weeded manually or with the help of phytosanitary products to control diseases and pests. Contrary to the recommendations made by Kébé et al. (2009) and Konan et al. (2015) regarding the alternating use of manual and chemical weeding, farmers in the localities of Niamkey-Konankro and Langossou generally rely on manual weeding. This manual weeding is done three times a year regardless of the SAFc type and represents the most "time-consuming" activity (Carrière 2003).

The lack of resources for some, and a negative perception towards chemical products for others, are the main reasons explaining the very low use of chemical products for weeding (Koua et al. 2018). Indeed, farmers emphasized that these herbicides do not distinguish between certain non-woody food species (Xanthosoma maffafa, young Musa spp. plants) that they associate with cocoa trees and weeds. Furthermore, they are increasingly aware of the negative impact these chemical products could have on their health and consumer health.

Contrary to the findings of Geilfus (1994) and Boulay (1998), which concluded that the presence of trees increases work and labor costs, this study highlighted a reduction in labor in complex and mixed SAFc but equivalent costs for the maintenance of different SAFc. The decrease in labor in complex and mixed SAFc is due to the presence of shade and leaf litter, which reduce the development of undergrowth weeds (Dufumier 2016).

During manual weeding, the farmer clears the undergrowth to prevent any competition between cocoa trees and other plants (Carrière, 2003; Tondo et al. 2015). Moreover, they take the opportunity to prune suckers growing along the main stem of the cocoa trees. They also remove branches attacked by insects or harboring parasitic plants.

Chemical control against insects and fungi that attack cocoa trees is done twice on average. It occurs after manual weeding, which explains its application by farmers during July and August. This low number of applications, compared to the minimum of 4 recommended by Kébé et al. (2009), is observed across the different agroforestry systems. This can be explained by the high cost of inputs. Added to this is the lack of means to acquire a sprayer. Indeed, some cooperatives provide their members with chemical products and an applicator. However, it sometimes happens that cooperatives only provide insecticides and/or pesticides to farmers, but the latter do not use them due to a lack of a sprayer. This lack, or even absence, of pesticide application was observed by Sonwa et al. (2008) in Cameroon. Another practice observed in the two visited localities is borrowing a sprayer from one of the few farmers who own one and soliciting a person as an applicator.

The harvesting of ripe pods is done in a way that reduces working time. It is done periodically, at regular intervals, according to the farmer's availability and does not depend on the cultivation system. Thus, a farmer may harvest every two, three, four, or even five weeks. However, the observed trend on the ground leans towards a monthly harvest. The farmer, most often, takes charge of harvesting the pods and then breaking them open. They benefit from the help of their children, wife, or some friends. During this task, the woman's contribution is in transporting and piling the pods, transporting the beans, and occasionally preparing meals for the "workers."

All these practices have contributed to the maintenance and sustainability of cocoa cultivation in the central region of Cote d'Ivoire. Local knowledge forms a solid basis on which any scientific contribution to sustainable cocoa production in the region can be built. Indeed, several recent initiatives, such as certification programs and sustainable agriculture projects funded by international organizations, have highlighted the importance of this knowledge in the transition to more sustainable agriculture (International Cocoa Initiative 2021).

Conclusion:-

Sustainable agriculture is at the heart of today's global challenges, particularly when it comes to the production of essential raw materials such as cocoa. In Cote d'Ivoire, one of the world's leading cocoa producers, sustainable management and production of this resource are crucial, not only for the country's economy, but also for preserving the environment and improving the living conditions of local communities. In this context, the ancestral knowledge of Ivorian farmers plays a vital role. This traditional knowledge, handed down from generation to generation, enables the adoption of environmentally-friendly farming practices, while guaranteeing efficient, sustainable production. Integrating this local knowledge into modern cocoa management strategies thus offers an innovative model for combining economic profitability, biodiversity preservation and producer well-being. Traditional knowledge plays a key role in the sustainable management of natural resources, as it is often based on intimate knowledge of local ecosystems and how they function, developed over centuries.

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