SPATIAL EVOLUTION AND SOCIO-ECONOMIC CONSEQUENCES OF AGRICULTURAL ACTIVITIES ON THE NORTH FACE OF MOUNT NLONAKO (MOUNGO, CAMEROON)

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ABSTRACT

In recent years, agricultural development has intensified on the faces due to the availability of favourable land for agricultural practices. The objective of the present work is to analyse the spatial evolution of agricultural activities and their socio-economic impact on the north faces of Mount Nlonako. Using a methodology based on literature reviews, this study relies on direct observations, key informant interviews, questionnaires administered to hundreds of farmers, and geo-spatial data. The results of this study revealed that during the period from 2016 to 2022, crop land has increased to 834 ha, followed by built-up areas of 11 ha, while forests have decreased by -1200 ha; this is due to the arrival of internally displaced persons from the crisis regions of the North West and South West. Income from agricultural activities contributes to the economic and social improvement of producers. However, agricultural activities are facing many difficulties on the area.

Keys words: agricultural activities, Spatial evolution, Mount Nlonako.

I. INTRODUCTION

Agriculture in its broadest sense refers to "all work using and transforming the natural environment for the production of plants and animals useful to man" (Tchindjang et al., 2019). At the heart of the international community's concerns, global agriculture must respond to a dual challenge: (i) ensuring the availability of food and non-food products for an ever-growing population, (ii) reducing its impact on the environment (Bellon de la Cruz, 2018). The demand for agricultural products remains important across the world, especially as the UN (2017) projects the world's population evolution and places the threshold at 9.8 billion people in 2050, for an estimated growth rate of 1.24% per year. Although the agricultural sector has been thoroughly modernised over the last fifty years (Le Roux et al., 2012), it still employs 1.3 billion small farmers and constitutes the principal means of subsistence for 86% of the world's rural populations (Arlaud et al., 1997). The agricultural sector plays a key role in reducing poverty, raising incomes and improving food security (World Bank, 2021).

The accessibility of agricultural land in the lowlands is becoming increasingly scarce, pushing farmers to conquer faces around mountain areas in order to find new areas suitable for agricultural activities. In addition, since the colonial era, the town of Nkongsamba has experienced significant immigration of labour from neighbouring regions to the mixed coffee-banana plantations (Tchamgme Njende, 1984). Since then, the population has multiplied from

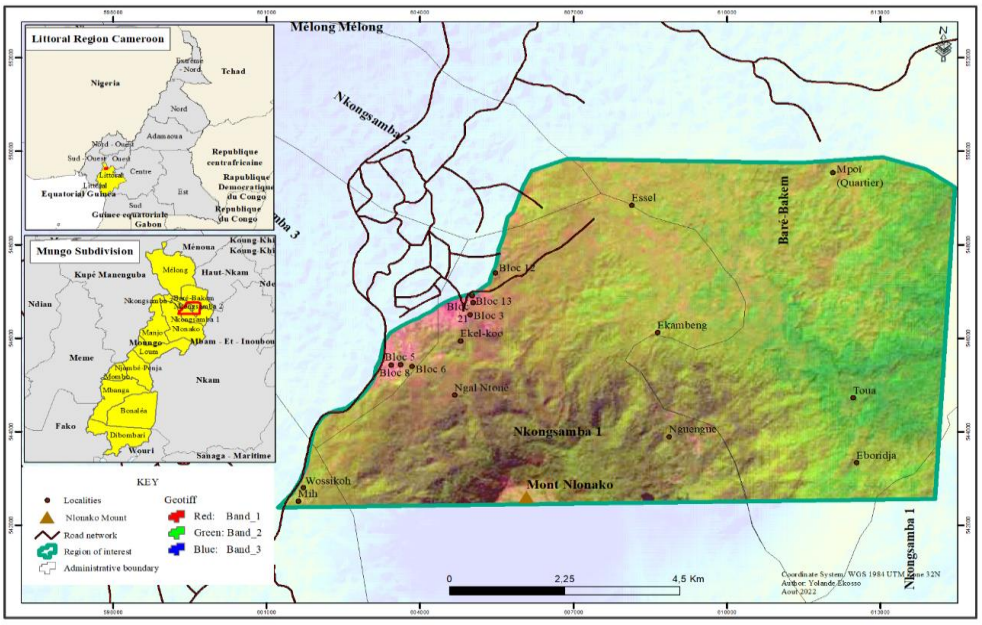
the first BUCREP census (1976), where 25,942 people were counted, to 105,383 inhabitants at the last census (BUCREP, 2005). Recently, following the deterioration of the security situation in the north-west and south-west of the country, this area has experienced a new migration of internally displaced persons estimated at 5,343 people (Kouandje et al., 2019). This is the case of the north faces of Mount Nlonako, which is subject to man's pressure on space and has a significant natural resource use pattern. How to assess the spatial evolution resulting from agricultural activities and what are their socio-economic impacts?

In order to assess the spatial evolution of agricultural activities, especially on the north faces of Mount Nlonako, a diachronic study of sentinel images from 2016 to 2022 was carried out. The choice of these images is related to their resolution (10m) and also to their availability although the middle of the area has a high cloud cover. Questionnaires surveys were administered to about 100 producers. The distribution was as follows: Nguengue 11 producers, 13 in Ekambeng, 12 producers in Wossibeng, 14 in Mih, 14 in Wossikoh, 20 in Nlonkoh 9 and 10 in Ngaltone. 3 interviews were conducted with the heads of the agricultural posts.

The results obtained allowed us to structure the reflection around three main points: the dynamics of land use on the north face of Mount Nlonako between 2016 and 2022 (i) and the socio-economic consequences of agricultural activities (ii), and the difficulties faced by agricultural activities on the face (iii)

II. STUDY AREA

Located in the Littoral region of Cameroon, Mount Nlonako covers the Moungo and Nkam Divisions: it borders the town of Nkongsamba on the north-western side, while on the south-eastern side it shares its boundaries with the undisturbed forest of the Nkam Division. Extending over an area of 64679 hectares (Birdlife International, 2022), with a height of1825m. Its geographical coordinates are between 4°53'North and 9°55'East (IGN, 1971).



Source: National Institute of Cartography 2014, Sentinel 2B image 2016.

Figure 1: Location of the north face of Mount Nlonako.

The area has an equatorial climate with two seasons, and an abundant rainfall regime varying between 1000 -1500/year depending on altitude (1000m and 1825m). The average monthly temperature varies between 18°- 33°C. The area is part of a raised shield of Precambrian granite and gneiss, with a ferralitic soil (ORSTOM, 1965). A few streams flow from it and have their source in the Nkam River. The existing vegetation is marked by sub-montane forests (Letouzey, 1985).

The main economic activities on the north faces of Mount Nlonako are livestock rearing, trade and agriculture. The latter is divided between two types of cultivation: (i) cash crops inherited from the colonial era: coffee, bananas and oil palm; (ii) food crops, the most important of which are maize and tubers, which dominate the agricultural landscape. Indeed, after the fall in the price of cash crops due to the economic crisis of the 1980s, the Cameroonian rural areas has converted to food crops to meet its needs (Nguendo Y. , Mongo E, 2017).

The north face of Mount Nlonako is occupied by a cosmopolitan population made up of peasants who constitute more than half of the local population and agricultural producers from Nkongsamba town.

III. METHODOLOGICAL APPROACHES.

III.1. Geospatial data methods and tools.

The geospatial data method is based on two approaches: (i) a diachronic analysis by remote sensing which aims to study the dynamics of land use and the evolution of the agricultural landscape between 2016 and 2022, based on Sentinel 2 satellite images. Table 1 shows the characteristics of the images processed. Indeed, the spatial resolution (10 m) pixel makes it possible to distinguish between agricultural areas and other land use classes. Nevertheless, the interpretation of the images has some shortcomings due to the mountainous relief of our study area which favours a high cloud cover. To overcome these shortcomings, the study intends to acquire the images in the dry season and in full crop growth. Another solution is the use of high-resolution imagery available on Google Earth. (ii) A statistical analysis of the surface area of the land use classes permet us to analysis the evolution of agricultural areas over time.

Table 1: Characteristics of the SENTINEL2 images

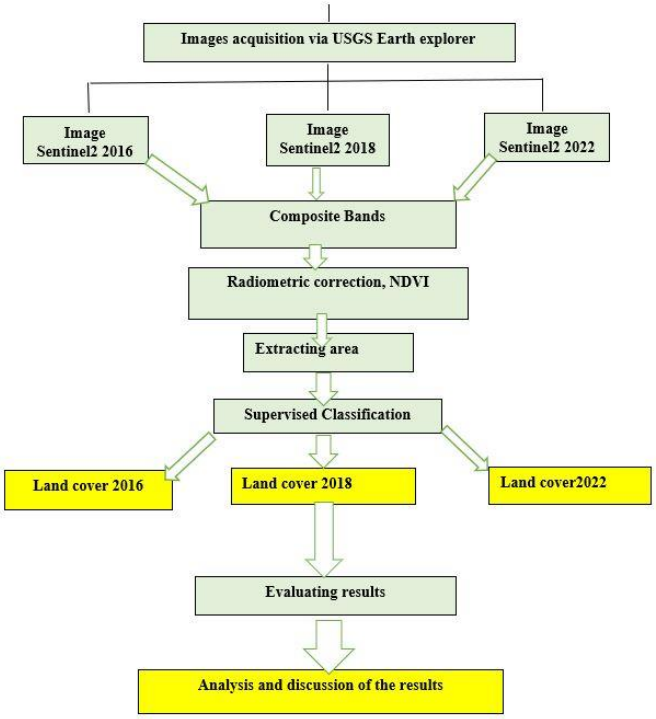
Number of tiles	Acquisition date	used bands	Resolution
T32NPL	Janvier 2016	B2, B3, B4, B8	10 mètres
T32NPL	Février 2018	B2, B3, B4, B8	10 mètres
T32NPL	Février 2022	B2, B3, B4, B8	10 mètres

Source: USGS Earth Explorer.

This table summarises the time frame of our data, the visible bands that were used to obtain the colour composition PIR (8) Red (4) Green (3) Blue (2) and the pixel resolution of each image.

The method chosen for the processing of this series of images is that of Supervised Classification by Maximum Likelihood (Figure 2), because of the spectral response very close to the land cover classes in the forest zone. This statistical-based approach allows a minimal error rate to be achieved (F. BONN and G. ROCHON, 1992).

Based on visual interpretation and field observations, five land cover classes were selected for this study: forest (dense, agroforest, secondary), built-up area, cultivated area, mosaic of bare soil and herbaceous vegetation, and cloud cover.



Source: *Author.*

Figure 2: Sentinel2 image processing

After assembling the bands, a multi-spectral image was obtained. This gave rise to a classification using the maximum likelihood algorithm. A field visit was then made to verify and validate the classification. GPS surveys and control points were recorded and used to correct the classification. The results obtained from this operation allowed the dynamics of the agricultural areas to be highlighted, as well as statistics on the surface areas of the land use classes. The main processing tools used are shown in Table 2.

Table 2: Satellite image processing tools

Logiciel	**Version**	**Caractéristiques**	**Utilités**
Erdas Imagine	2015	Image processing	. Radiometric correction . Colour composition. . Supervised classification . Calculation of the area of occupation classes
ArcGis	10.5	GIS analysis	. Data processing and analysis . Cartographic dressing
Map source	6163	Extraction of GPS data	Database for verification
Microsft office	2016	Word processing	Spreadsheet, input

(Excel, Word)			

The table shows the software used, its version and application.

III.2. Socio-economic data collection

The acquisition of socio-economic data is based on documentary research and surveys administered in the field, either by questionnaire or by interviews with resource persons.

III.2.1. Development of the sampling frame

Given the absence of an official list of farmers in the area and the difficulty of searching through it, a sampling frame was drawn up beforehand from the agricultural areas of the localities covering the area, in order to statistically define the sample size for this study. The random method was adapted. The following table summarises the sampling criteria:

Table 3: Summary of sampling criteria

Villages	Rationale for the choice of location	Population size in 2005	Sampled numbers
Nguengue	Located on a watershed and very fertile soil	**100**	**11**
Ekambeng	Area located at the foot of the mountain with large areas reserved for maize and manioc	**107**	**13**
Wossibeng	Strong growth in cassava production	**130**	**12**
Mih	Area where maize cultivation is much more difficult	**125**	**14**
Wossikoh	Cassava growing area	**120**	**20**
Nlongko	Maize growing area	**129**	**9**
Ngaltone(nyoki)	Area where maize cultivation is much more difficult	**107**	**10**
Total		**818**	**103**

Source: Author Fieldwork 2021

Our base sample consists of 818 people and our questionnaire is addressed to 103 farmers. The number of samples is recorded according to the villages, with 12 questionnaires sent to producers in Nguengue 11 producers, 13 in Ekambeng, 12 producers in Wossibeng, 14 in Mih,

14 in Wossikoh, 20 in Nlonkoh 9 and 10 in Ngaltone. This method made it possible to verify the feasibility of the objective of this work.

IV. RESULTS

IV.1. Land use dynamics of the north face of Mount Nlonako between 2016 and 2022.

IV.1.1. Photo-interpretation of satellite images

The results of the diachronic study on the land use of the north face of Mount Nlonako for the three periods (2016, 2018, 2022) (Figure 3) present distinct classes under different shades. Indeed, the most dominant forest class is represented in green, followed by the crop class in fuchsia; the mosaic class of bare soil and herbaceous vegetation in lime green; the brown colour refers to built-up areas while the beige colour represents snow cover.

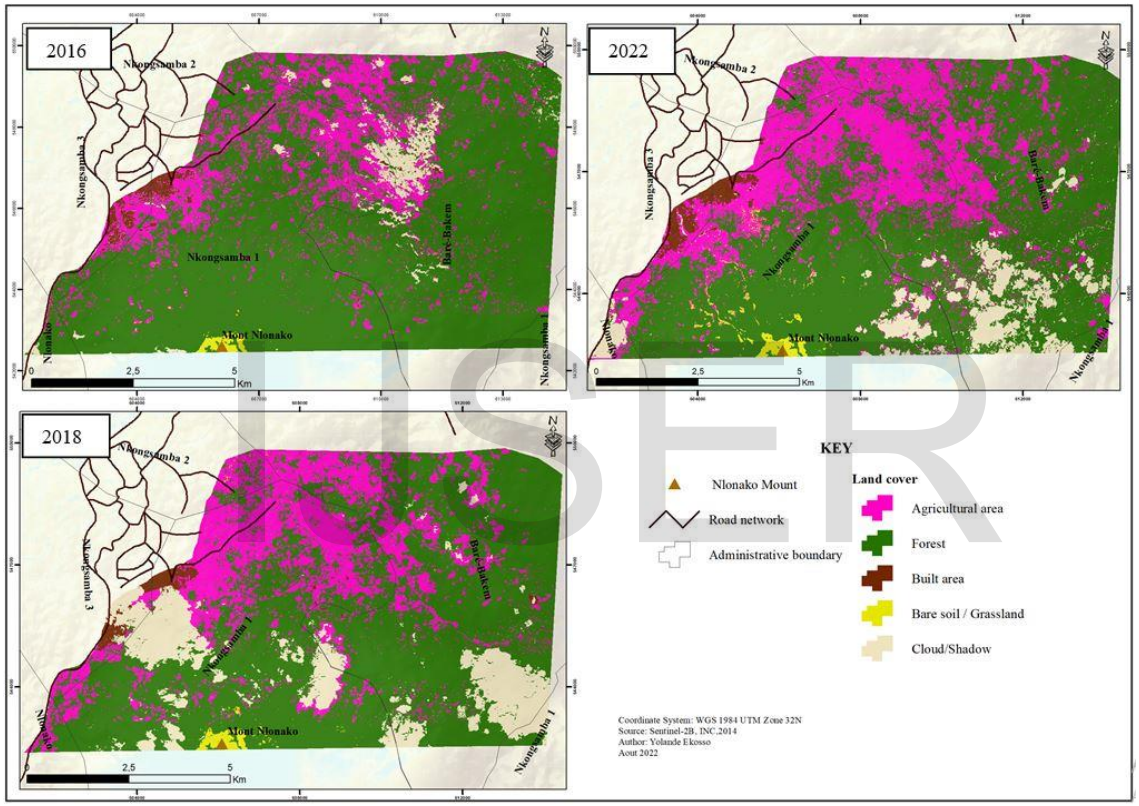


Figure 3: Land use dynamics from 2016 to 2022.

IV.1.2. Analysis of statistical data on land use changes.

The statistical data from the land use maps (Figure 3) show a significant change in classes over the years studied:

- A strong growth in cultivated areas (fields and wasteland). This has increased from almost 1363 ha in 2016 to 1855 ha in 2018 and will reach 2200 ha in 2022. The built-up area class is also grown, estimated at 87 ha in 2016, then 89 ha in 2018, and 100 ha in 2022.

- A significant decline in forest area class. In fact, the forest class of the area in 2016 is estimated at 5815 ha, in 2018 it was 4664 ha and in 2019 only 4600 ha was left.

- On the other hand, the mosaic class bare soil / herbaceous vegetation loses and gains in area over the three periods. These areas vary from 60 ha in 2016 to 54 ha in 2018 to 100 ha in 2022.

Table 4: Area in (ha) of land cover classes from 2016 to 2022.

Land cover	**Surface ha 2016**	**Surface ha 2018**	**Surface ha 2022**
Agricultural area	1363	1855	2200
Forest	5815	4664	4600
Built area	87	89	100
Bare/Grassland vegetation	60	54	100
Cloud / Shadow	263	949	600

Source: Sentinel-2.

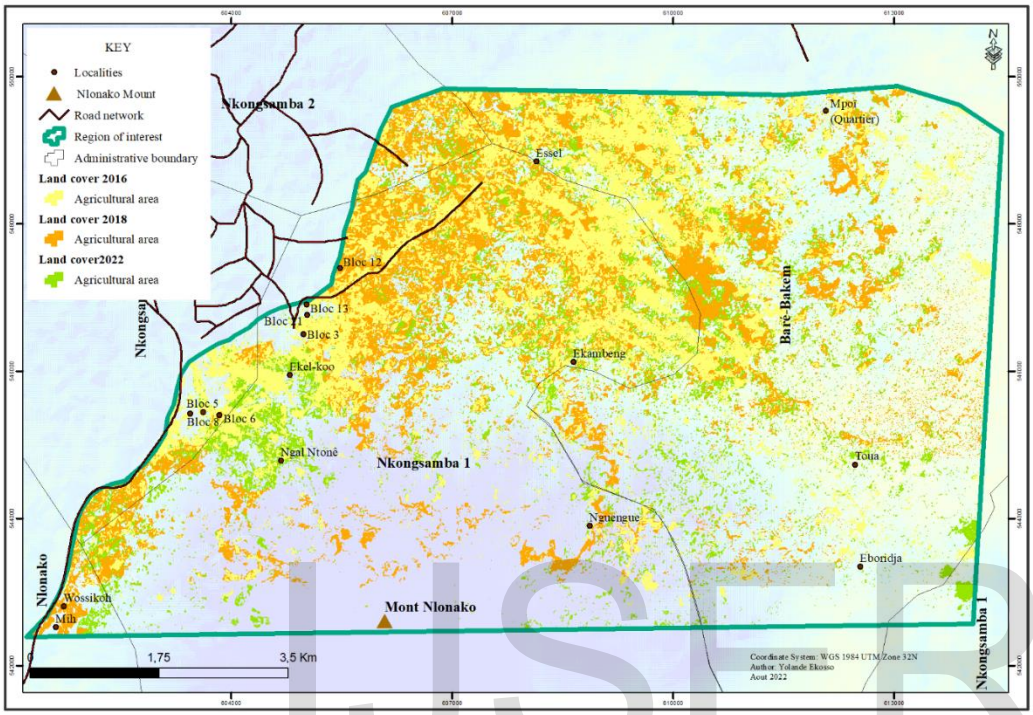
The analysis of these statistical data has made it possible to highlight the gain and loss of areas of land use classes in two series (2018-2016 and 2022-2018) differentiated respectively by a green tint for the first series and an orange one for the second (Figure 4). Cultivated areas have grown continuously between 2016 and 2018, with a gain in area of 492ha on the one hand and between 2018 and 2022 an addition of 345ha. This result confirms the hypothesis that the massive arrival of internally displaced persons from the security crisis regions of the North-West and South-West from 2016 onwards has considerably increased agricultural activities in the area. In the same vein, the surface area of the built-up area class increased by 11 ha between 2016 and 2022.

At the same time, the forest class has seen a significant decline in its area, with a loss of vegetation cover estimated at around -1200 ha between 2016 and 2022.

Source: Sentinel-2 image processing

Figure 4: Loss and gain diagram over the interval 2016-2018 to 2018-2022.

Indeed, the assessment of land use dynamics on the north flank of Mount Nlonako shows an evolution of agricultural areas that marks the natural environment (Figure 5). Although in the north of the area from 2016 to 2022 the cultivated areas have not changed much, on the southern side of the study area, we observe the opening of new agricultural areas which are moving towards the upstream area of Mount Nlonako. The cloud cover which is quite present in the area limited the identification of land use classes and their surface areas.



Source: Sentinel-2 image processing.

Figure 5: Evolution of agricultural areas in 2016, 2018, 2022.

This map only shows the cultivated areas obtained in 2016 in yellow, in 2018 in orange, and in 2022 in green.

All in all, the evolution of the agricultural areas of the north face of Mount Nlonako is a reality. The transformation of the natural environment has increased over time and its consequences can already be seen in the physiognomy of the area and in the direction of evolution of the land use classes. The analysis of the surface areas of these classes makes this reality more comprehensible.

V. INCOME GENERATED BY AGRICULTURAL PRODUCTION AND ITS SOCIAL IMPACT.

V.1. Average income from food crop production (maize and cassava).

The data collected in the field provided the income of an average producer with a plot of at least 1 hectare. The following table shows the operating account for a one-hectare field of maize and cassava:

Table 5: Farming account for an area of 1ha of cassava and maize

Designation	Expenditure Cassava (FCFA)	Expenditure Maize in FCFA	Cassava revenue (FCFA)	Maize revenue in FCFA	Profits Cassava in FCFA	Maize profits in FCFA
Equipment	80000	65000	140x7000=980000	100x6000= 600000	610000	357000
Fertilizers and other inputs	75000	78000				
Maintenance labour	125000	100000				
Transport	90000	100000				
Total	370000	253000				

V.2. Social impact of income from the production of agricultural activities.

V.2.1. Schooling of children

The profits generated enable children to attend school. The producers in this locality believe that schooling is a profitable investment in the medium and long term. The following figure (6) shows the proportion of children enrolled in school by producers according to their age:

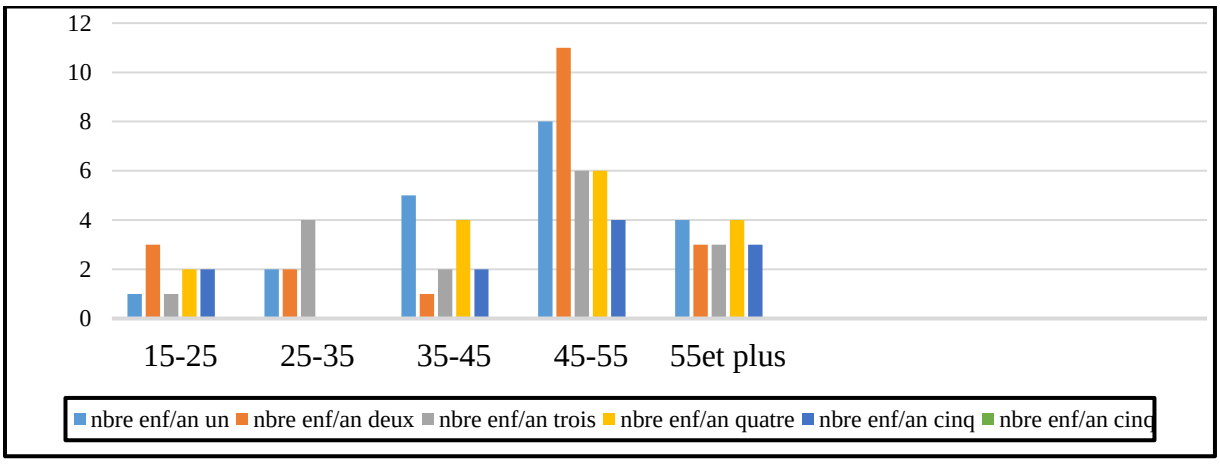


Figure 6: Number of children enrolled by producers

Source: Field surveys 2021

This figure shows that parents aged 45-55 are increasingly sending their children to school. At least two children are enrolled in school by each age group, which also implies that there are young people aged 25 who take on the responsibility of enrolling their younger children in school.

V.2.2. Provisioning of the household basket

Income from food crops enables producers to meet the nutritional needs of their families. Indeed, the important role that producers play in their households is to provide rations for men and to buy household utensils for women. These children eat more than twice a day. The enrichment of the housewife's basket is a luxury for some producers who have great tastes and ration to their requirements. These producers also use their income to buy household equipment. According to them, when the man is not rationed at home, it creates instability in the household and the children are exposed to starvation; therefore, the ration for them is an obligation.

V.2.3. Changing social housing

The sale of food crops allows producers to improve the quality of their social housing. Indeed, once the sales have been made, they try to rehabilitate their old housing or build a new one. Subsequently, this income also pushes some producers to move closer to the city centre in order to have access to decent housing despite the high rent or the higher prices of land for those who want to build. The following plate shows the dwelling rehabilitated or built by a food crop producer:

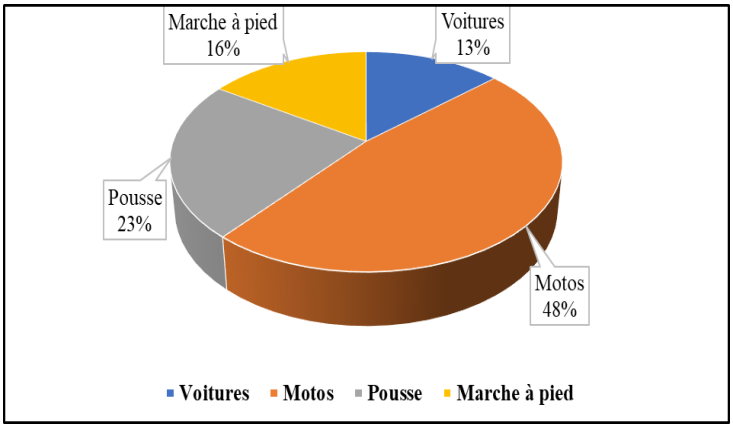
Source: Author's photos, 2021

Plate 1: House

The image on the left shows a house that has been built and the one on the right shows a dwelling that has been rehabilitated with the help of food crops.

V.2.4.Change of means of transport.

In order to improve their working conditions and mobility, producers have opted to purchase motorbikes and other means of transport. These means of transport allow producers to transport products from the fields to the shops and the market, but also to move more easily in order to carry out other tasks. Thus, cars, motorbikes, pushcarts and walking are the most common means of transport in the north Nlonako catchment area:



Source: Field surveys 2021

Figure 7: Travel patterns in the north Nlonako catchment

According to this figure, 48% of producers use motorbikes to move around due to the isolation of the area, 23% of producers use a rucksack to transport products, 16% of producers often walk and 13% of producers also use cars to transport products when they are in large quantities and when they are not far from isolated areas.

V.2.5. Savings and purchase of agricultural equipment

Part of the income from food crops is saved for certain financial structures. This allows the latter to use this income in case of major problems. The savings secured the producer to carry out projects in the future (Epane, 2017). Subsequently, another part of the income is also used to purchase agricultural equipment in order to increase yields. Indeed, the plantations need maintenance and this maintenance requires the purchase of appropriate equipment.

V.2.6. Rehabilitation and development of plantation roads and collection tracks

In the production basin of the north face of Nlonako, the rehabilitation of plantation roads and collection tracks has been observed. Indeed, the development of these infrastructures facilitates the transport and disposal of goods from the production sites to the markets. This development also benefits the populations who have to travel long distances in search of water for household use. The following photographic plate 2 shows the road and a collection track to facilitate farmers' mobility:

Source: author's photos, May 2022

Tracks developed to facilitate the flow of produce from the fields to the marketing areas.

VI. DIFFICULTIES OF AGRICULTURAL ACTIVITIES ON THE NORTH FACES OF MOUNT NLONAKO

VI.1 Poor state of the roads

Characterised by a high-altitude relief, the poor state of the road coupled with the lack of collecting tracks are major problems faced by agricultural activities in the area. Not only for the movement of people but also for the marketing of agricultural products. Indeed, during the rainy season, producers in this locality find it difficult to transport agricultural products from the fields to the local market and to households. Producers coming from peripheral localities are confronted with rising transport costs, which can be as high as 3000frscfa per person for a distance of less than 2km. The photographic plate (2) illustrates the poor state of the roads.

Source: Author 2021.

Plate 3: Poor road conditions

VI.2 Agricultural practices and techniques that degrade the environment and biodiversity

The agricultural techniques and practices used by the Nlonako farmers are of a relatively low quality of fertiliser used to increase their production. However, they contribute on the one hand to soil degradation, and on the other hand to the decline of the land ecosystem followed by the decrease of biodiversity.

The soil is becoming increasingly degraded. This degradation can be observed at two levels: quantitative and qualitative. The quantitative loss of soil, called regression, is essentially due to erosion. It corresponds to a phenomenon of rejuvenation of a soil (return to the state opposite to the climatic stage). Thus, any slight modification is quickly corrected and the balance restored.

CONCLUSION

The evaluation of the spatial evolution of the agricultural areas and the socio-economic impact of the activities on the north face of Mount Nlonako, has made it possible to highlight the dynamics of land use on the face, to analyse the socio-economic impact and to identify the difficulties faced by the agricultural activities. It was found that crop areas gained an area of nearly 837 ha between 2016 and 2022. On the other hand, forestry areas have decreased significantly by 1200 ha. Moreover, the increase in agricultural areas has had an impact on the development of activities. The income from these activities has helped to improve living conditions through the schooling of children, the renewal of housing and the quality of the household basket. However, agricultural activities are faced with many difficulties. These include the poor state of the roads used to transport the products and the degradation of the environment due to poor agricultural practices.

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