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Terracing as an Old-Style Scheme of Soil Water Preservation in Djingliya-Mandara Mountains- Cameroon

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Abstract:- The relief and high population densities of ≥150 inhabitants/Km²in the Mandara Mountains and the drastic displacement of internally displaced persons towards these Mountains have brought about severe effects on water and soil resources. This environmental and socio-political crisis, have made agricultural production not to meet demand for food and hundreds of these rural people go hungry each day. This has constrained the inhabitants to develop various tactics of soil water preservation and landscape restoration towards fighting deficiencies in crop production to ensure food security. This study analyzes terracing as a traditional system of soil water conservation adopted by the farmers in Djingliya villages found on the Mandara Mountains. Through secondary source of information, field observation, interviews and questionnaires administered on 100 persons in five villages of the study area, results show that: soil degradation via soil resources overuse and erosion is checked by terraces. Also, the tendency of adopting local techniques is harnessed through the cultivation of plants which increase infiltration, agroforestry, crop rotation practices, Forest Landscape Conservation, Mosaic Landscape Restoration and Valorizing Local Plant Species to ensure sustainable farming activities that restore degraded land in general and terraces in particular.

Keywords:- *Terracing, Soil Water Preservation, Landscape Restoration, Sustainable Farming, Rural Development, Djingliya -Mandara Mountains.*

I. INTRODUCTION

Many parts of Africa are experiencing annual population growth rates between 2 and 4 %, degradation of the natural resource base, recurrent droughts and a growing dependence on food aid as well as the import of cereals to cover food deficits (Lipton, 1988). During the last two decades increasing financial outlays for agricultural research in Africa have neither produced significant breakthroughs nor led to agricultural growth (Lipton, 1988). Soil erosion is widely perceived to be a major problem in sub-Saharan Africa. Most agency reports and government publications highlight the degradation of soils as a major development challenge, but soil water preservation (SWC) efforts in Africa have had an unsuccessful history.

Since the 1920‘s, numerous reports against the disastrous effect of increasing erosion, land degradation, desertification, mismanagement of natural resources due to increasing demographic pressure, and as a result, soil conservation emerge at the end of the 1930s as a central concern in East Africa (Andernson,1984). In many African countries considerable effort had being made since colonial period to conserve soil and water resources. Most soil water preservation in Sub-Sahara Africa has failed due to the use of techniques which are complicated to design and expensive both in terms of labour and capital, a heavy reliance on machinery for construction of conservation work.

In Africa in general and Cameroon in particular, the Mandara Mountains are the reference of terrace farming (Seignobos, 2007). Northern Cameroon is a place where the population is facing water deficit especially on the Mandara Mountains due to climatic and topographic constrains. Conscious of these environmental difficulties, the inhabitant of this zone (Mafa, Mofou, Kapsiki, Hina, Goude, and Daba) had put in place a tradition system of farming in order to improve on their agricultural productivity. This system is known as the soil water preservation system.

Soil water preservation technique have been practiced on the Mandara Mountain in northern Cameroon to maintain the soil fertility and reduce soil loss. Since the 1960s, mountain settlers have been encouraged to move to lowlands and recent attempts to settle these people on lowlands have proven futile. Development efforts have so far not yielded fruits nor have they utilized the existing indigenous knowledge (Riddell and Campbell 2014)

So agriculture is possible on mountain through the regular maintenance of terracing. It is based on this analysis that we came out with our research topic known as « The indigenous system of soil water preservation on the Mandara mountain: The case of terracing farming in the Djingliya village ».The reason for the choice of Djingliya

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village as the frame work study zone is due to the fact that among the 27 villages that count the council of Koza, Djingliya Montagne is the poorest village of the Koza subdivision due to poor soil, the presence of mountain, scarcity of arable farm to cultivate crops, and lastly a low agricultural yield. This study focuses on soil water preservation system on agricultural yield, ecology and rural development through terracing.

II. METHODOLOGY

A. Study Zone

The Mandara Mountains are found in the Western part of Far North Region of Cameroon and the North Eastern border of Nigeria and Cameroon. It is one of the mountainous zones located in Africa where the mountain people are identified (Van Andel, 1998).This zone represents one of the last areas of Central and Western Africa to be modernized (Van Beek, 1987). It is a zone with a chain of mountains and large dissected plateau with several undulations. It is part of the Cameroon backbone emerging from the nearby plains to a height of about 1500m. The soils are largely young, sandy and shallow, making them to have low fertility and water retention capacity. The rainfall regime is unimodal with rainfall between April and October and with a maximum in July and August averaging between 800mm and 1100mm per year, but is highly variable and contained. Storm intensities also occur up to 70mm per hour. Such torrential storms noticeably carry a large risk of soil erosion. Therefore, a very good soil management technique is required to ensure sufficient infiltration, prevent soil loss and ensure efficient conservation. Mean evapo transpiration amounts 1,750 mm per year indicate that the water availability for crop production is subject to substantial doubt.

Djingliya our zone of study is a village located at the northern slopes of the Mandara Mountains. It is within the Koza council, Mayo Tsanaga division of the far north region of Cameroon near the borders with Nigeria. This Mafa tourist village stands out from its neighboring villages due to its mastery of terrace cultivation techniques which has enabled her survival and marks her social structures. Djingliya is divided into several districts: Guild, Mbouroum, Tchine, Mbouzoum, Varkalda, Jele, Dzahand Oumtchilikeke and it neighboring village Makadia, Souledey Rouaand Kozacenter Figure 1.

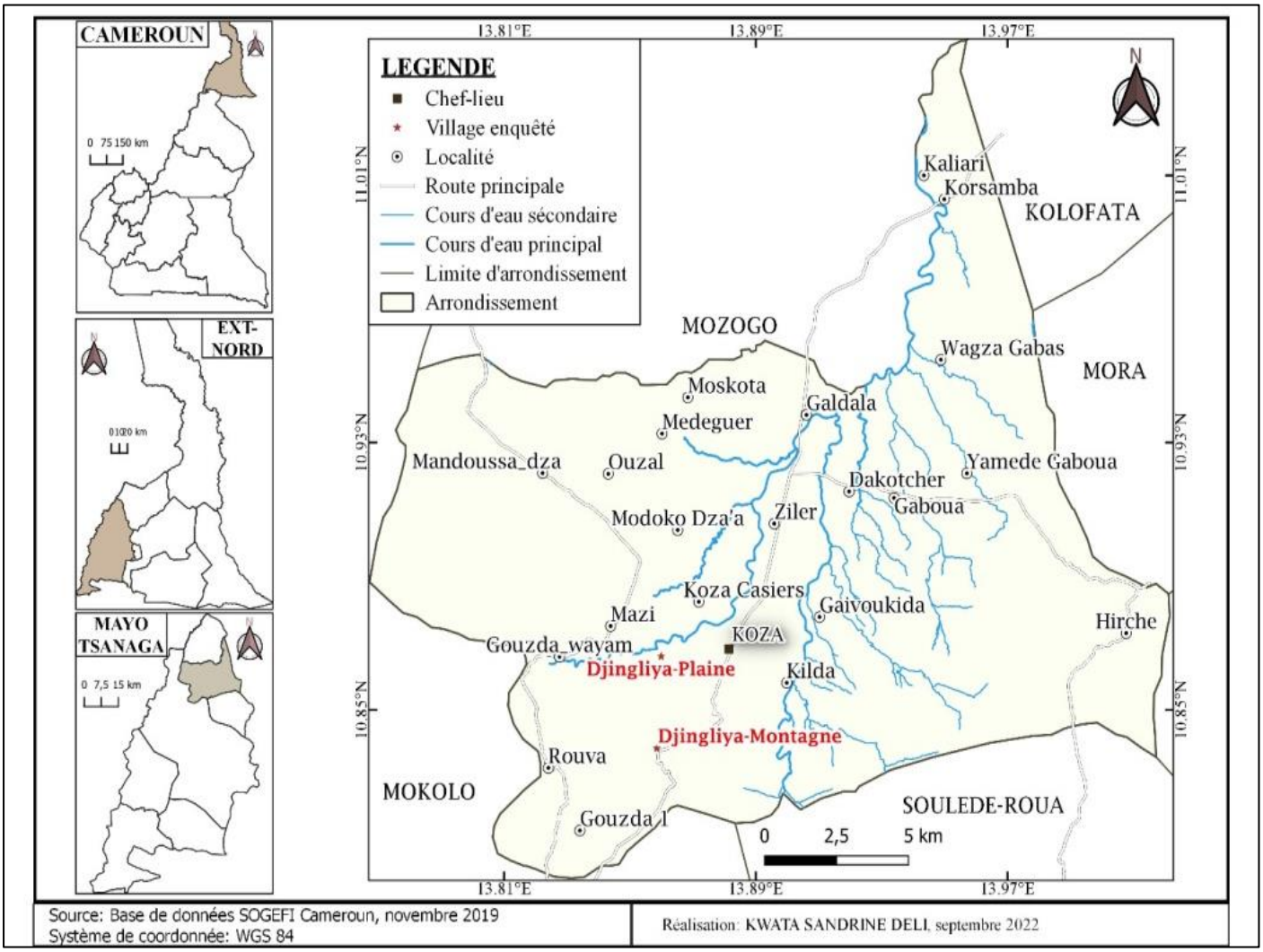

Fig 1: Location of the Study Area

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B. Data Collection, Analysis and Interpretation

Secondary data were collected in the library of the University of Ngoundere, FALSS, MIDIMA and SODECOTTON in Koza, MIDIMA as well as from the internet. Primary data from resources persons were gotten through questionnaires and interview guides elaborated on the kobo collectapplication. The sample constituted5 villages of Djingliya mountain and three stakeholders: *small holder farmers* (30 in Tchileke village as well as 30 in Guidmbrom village due to their large population as they welcome internally displaced persons; 20 in Doulom village due to small population but having undulating large farmlands; 10 in Tchime and 10 in Guidza as they have smaller population densities and sloppy farmland) Table 1; *government stakeholders*(MINADER, MIDIMA, MINDDEVEL and MINEPDED) and *non-governmental stakeholders (*CRS-CARITAS, SOLIDARITE, CROIX ROUGE, GIZ, RESILAC and PNDP).

Table 1: Investigation Sample Distribution

Village	Tchileke	Guidmbrom	Doulom	Tchime	Guidza	Total	Rate
Population	756	340	835	228	227	2386	100%
Sample	30	30	20	10	10	100	100%
Men	19	10	14	06	07	56	56%
Women	11	21	06	04	03	44	44%
Rate	30%	30%	20%	10%	10%	100%	100%

Source: Field Survey 2020 and Data from Djingliya Health Center)

The methodology for researching terracing as a traditional system of soil water preservation in the Djinglya-Mandara Mountains, Cameroon involves a systematic approach to understanding, documenting, and evaluating the practices and impacts of terracing. We explored existing literature on terracing, soil conservation, and water management in mountainous regions, as well as the historical records, indigenous knowledge, and scientific studies related to traditional terracing practices in the Djinglya-Mandara Mountains. This permitted us to understand the cultural context, local beliefs, and socio-economic factors that influence terracing practices. Added to this were Field Surveys and Data Collection. We conducted field surveys in the Djinglya-Mandara Mountains to gather primary data- in identifying terraced landscapes, interview local farmers, and document their experiences with terracing. Data was collected on:

- Terracing techniques (e.g., types of terraces, materials used, construction methods).
- Soil properties (erosion rates, fertility, moisture content).
- Water availability and usage patterns.
- Crop yields and vegetation cover.

Mapping and Geospatial Analysis was also done, photographs taken for illustrations of terraced areas and using Geographic Information Systems (GIS) to map the study area aspects. We analyzed the spatial distribution of terraces, their orientation, and alignment. We also overlay soil erosion risk with terraced locations to assess their effectiveness.

On hydrological Studies, we measured water runoff from terraced fields during rainfall events and then compared runoff rates between terraced and non-terraced areas. Evaluation of the impact of terracing on water retention and groundwater recharge was also done.

On soil analysis, we collected soil samples from terraced plots and adjacent non-terraced areas to understand water retention ability. Soil properties were also analyzed (texture, organic matter, nutrient content) to assess soil health, compared soil quality between terraced and non-terraced sites. Interviews and Participatory Approaches were engaged with local communities, farmers, and elders to conduct focus group discussions and participatory workshops. This was to understand traditional knowledge, beliefs, and practices related to terracing. As for decision-making regarding terracing improvements we involve community members to that effect.

Quantitatively, we quantified the impact of terracing on soil erosion reduction and calculated sediment retention rates and compare them with non-terraced areas. We also sketchily assessed the economic benefits (crop yield increase, reduced soil loss) associated with terracing.

Qualitatively, we explored cultural significance, social cohesion, and community resilience linked to terracing through document stories, myths, and rituals related to terraced landscapes. This was to understand the role of gender and generational knowledge transfer in terracing practices.

In line with policy and implementation recommendations, based on research findings, propose policy recommendations for integrating traditional terracing into modern land management practices. This is to highlight the importance of preserving indigenous knowledge and sustainable practices and to advocate for community-led initiatives and capacity-building programs.

III. RESULTS

A. Physical and Biotic methods of Soil Water Management in Djingliya

One of the salient features of the agricultural schemes in the Mandara Mountains is the use by local farmers of traditional soil water preservation techniques. Among these are the building and upkeep of stonewall terraces, stone bunds, canals and wells, as well as the use of organic procedures such as agro forestry, composting, mulching, numerous cropping and crop rotation. Native farmers in the

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Mandara Mountains have been applying these soil water preservation methods for generations and have been effective, so far, in upholding a suitable level of soil richness. The massif farming scheme comprises of three major features:

- *Terrace management*, which is the physical mainstay and edifice of the scheme, has as major function to hold soil water.
- *Nutrient and organic matter handling* serves to keep the quality of the soils at a proper level.
- *Plant management* serves to get the most out of this in terms of production, risk decrease and product assortment needed for independent survival. The term 'plant management' rather than crop management is used here to specify that mountain agriculturalists know and treat almost every plant distinctly.

➢ *Physical Methods of Terraces*

Annual water runoff turned out to be very minor, viz. 3% of the early rainfall on the cultivated plots and almost zero on the unplanted plot. Water runoff was greater under heavy rains, increasing to 20% of the storm's rainfall on the cultivated plots. This 20% is, of course, the highest threat for the terraces themselves, which may overflow and be washed away if runoff amasses. The picture as far as erosion is concerned is equivalent. Soil loss under the old fallow was measured as virtually zero, while the cultivated plots averaged 4 tons/ha per year (0.3 mm/y), which is very low.

The classic terrace has a wall of up to one meter high, built of stones placed upon each other without binding material, in such a way as to attain maximum fit, density and strength. The average bench width is about two meters. There is considerable variety. Some terraces are as narrow as 30 cm, while some walls may reach up to more than two meters, especially at the sites where houses are built. A special terrace type, indicating land scarcity, is the *guilmeteteu*, which is built on bare rock outcrops, and to which soil is carried to fill the space behind the wall. Most terraces have a zero slope or a slight back slope (up to 4%) to ensure water retention. The orientation of the top of the walls is usually strictly horizontal, with the farmer adapting the wall tops every year, if necessary. Some terraces especially those having excess water during torrential rain to be retained safely, have a slight inclination. This leads to a perpendicular drainage channel.

Terrace farming in the Mandara Mountain is the cultural activity of cropping system apart from other local strategies being adopted by inhabitants of the zone. Farmers collect the stones and arrange them in curvilinear manner, horizontally across the slopping land. This technique is practiced by these people, not only to block run-off and erosion, but also to restore the habitat of soil biodiversity. Soil biodiversity such are the macro and microorganisms and the zonal soil's components which gives life to plants by its nutrients.

Terracing, stone paving and watershed as main drainage divide are local activities which portray the inhabitants of mountains, different from those of flat Northern plain of Diamaré at the foothills of Mandara Mountains, who are committed to other schemes of soil nutrients' up keep. The distance amid two consecutive terraces increases with slopeabruptness. Photo plate 1, shows thestyle of terracing in farm lands by the people of Djingliya.

Photo Plate 1: Different Methods of Terrace Construction in Djingliya-Mandara Mountain
Source: Field Data 2020

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From Photo plate 1, terraces are being built conferring to slopesteepness. Their features depend on slope steepness; Photo A demonstrates terraces building on piedmont (600m) while photo B shows terraces building on highland (2220m).The number of terraces depend son the inclination of the slope. The steeper the slope, the smaller the distance and the higher the number of terraces while, the more gentle the slope is, the larger the distance and the lower in the number of terraces.

In Mandara area, there are different types of terraces having different characteristics depending on the nature of the slope as shown on the Table 2.

Table 2: Types of Terraces on the Mandara Mountain and their Principal Characteristics

Types of Terraces	Name in Mafa	Topographic Situation	Wall Like Characteristics	Border Characteristics
Hillside terraces of middle to steep slope	*M'dzigala-a*	Slope> 10%	Dry stone, height increase with slope angle	Border width issmall and reduces with slope of angle
Levelling off terraces	*M'belduldenz-e*	Break of slopes with slope of =10% plateau	Stones Height 20cm-60cm	Width of borders can attain 20m
Piedmont terraces	*Ingaleans*	Piedmont with slopes of 0%-10%	Blend of stones, soil and grass Height 10cm-30cm	Width of borders can reach20cm
Compound terraces	*Maralechgai*	Steephill side slopes	Average to large stones with regular structure height can attain 300cm	The platform supports all compounds and is often intertwined by small walls that borders terraces which supports particular production scheme
Small valley terraces	*Guimelther*	Small valleywithstreams	Stone walls can be directly positioned at the edge of small valleys or on the edge of stream height. Terrace walls increase with slope length	The distance between two consecutive wall upsurges with slope of the terrain (2.5m to 4m at Goura)

Source: fieldwork 2020

From this table, it is shows that the steeper the slope the upsurge in the number of terraces and vice –versa. The terrace at the piedmont are mostly gentle usually with a height of 20cm to 30cm and width of not less than 20cm and this types of terraces are found around the Koza plain and the piedmont-mountain of Djingliya plain. The *M'belduldenz-e* (leveling off terraces) and the *M'dzigala* (Hillside terraces of mean to steep slopes) are the kind of terraces found in Djingliya Mountain with a height of 20cm to 60cm and the width border can attain 20m. The relief map (Figure 2) reveals the different heights and the likely characteristics in the study areas.

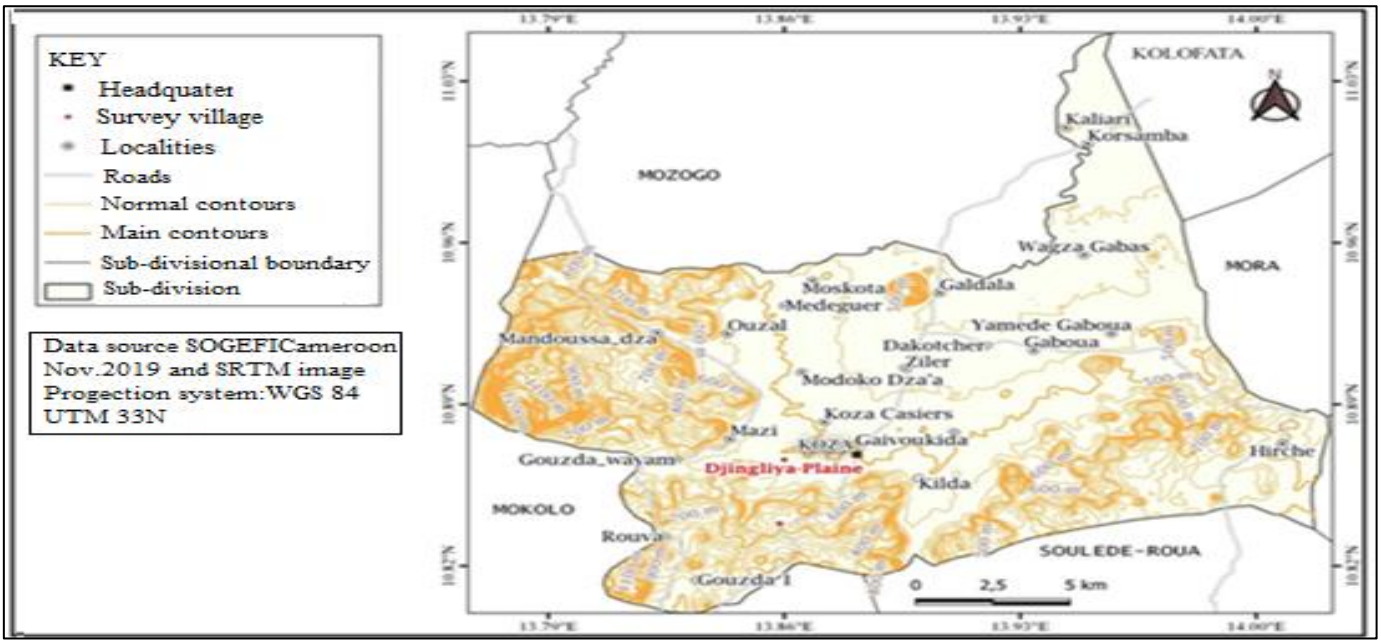

Fig 2: The Relief Map of Djingliya

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Assessment and description of techniques of soil management and water amongst the Mafa of Mandara Mountain is demonstrated in four different know how:

- *The "Guimelther" (Prepared Plot For "Taro")*

The "*Guimelther*" is a set of terraces equipped in a small valley for the cultivation of "taro" (photo 1). The word "*Guimelther*" means literally in Mafa "House of taro". Sometimes one dresses up a wall of dry stones around the plot of "taro" if the water flowing from the stream inside the small valley is very strong and in this case the plot of "taro" is not built directly at the end of the valley but along the stream slope. A water canal is then situated for the catchment to take water in and out of the plot.

Photo 2: *"Guimelther"* a Type of Terrace in Djingliya
Source: Fieldwork 2020

Picture 1 shows the type of terrace built in Djingliya, in an altitude of 800m the terrace are being crammed together inorder to hold water and soil organic nutrient.

- *The "Guimnda" (Plot Of "Souchet")*

This contains of elevated seed plot for the cultivation of "souchet". The seed plot on one hand is bounded by fringe drainage and on the other hand, a series of small drainage or gutters. These drains have a width of 10 cm to 20 cm and a depth of 25 cm. They help to stop prolong rhizome/water contact. The surface area of a "*Guinmda*" varies between $35m^2$ to $100m^2$ on average. This structure is generally concealed with thorny, grass mat to stop rodents and birds from destroying it.

- *Ridging ("Gid-dankali")*

This method is chiefly accomplished in the valleys on flat areas of mountains, plateau and piedmont where the soil is particularly deep. It involves of building ridges of 50 cm height & 50cm width following the slope. In these ridges are buried all weeds while clearing during preparation of the piece of land. Ridging is exclusively done during July, in sweet potatoes farms by young male adults, but the choice of planting site is the privilege of the household head.

- *Stone Embankments*

It consists of stone lines on which are placed grasses and shrubs from the weeding operation. Where stones are rare, grasses and shrubs are simply cut and covered with soil to constitute the embankment. Neither the height nor the width exceeds 30 cm. The embankment built on lands of low slope (2% average), serve to retain water in the land piece, reduce runoff, favour infiltration and attenuate erosion.

B. Nutrient and Organic Matters Management

The low nutrient and organic matter levels in the soil are often a severe bottleneck in perpetual cropping schemes such as those in the Mountains. They cannot take gain of the regenerative effect of fallowing, nor create the cash needed to buy external nutrient supplements such as fertilizer. The Djingliya farming scheme contains a number of very intricate mechanisms of nutrient and organic matter recycling that jointly act to minimize losses to such an extent that the system can be sustainable. Livestock, stabled up during the cropping season, is central to most of these; farmers see to it that every available leaf is fed to the animals and the dung is treated with great care to avoid quality loss before it is applied to the fields. another method, in which termites are used to digest millet and sorghum stalks (only to be fed to fowls later).

Farmers keep the various types of dung (from cattle, fowls, sheep, goats, donkeys and horses separately, in order to apply them to different crops. The litters are regularly composed and put at a corner of the compound with view to the eventual ultimate usage. The other charged element is mixed with urine, collected and piled up in open air for a complete decay. The transport and application at the start of the month of May are done by men, women and children. The compost thereby obtained is applied on the farms in heaps of 15 cm of diameter, spacing of 45 cm on an average. Photo 3, illustrates, cattle dung, composts animal wastes, and domestic small ruminants dungs manuring as well as biological decomposed sewages on aterrace.

Photo 3: Nutrient and Organic Matter Recycling
Source: Field Work 2020

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The photo above explain how nutrient and organic matters are being introduce in farmland, this organic matters plays important role in the management of soil since it help to improve the fertility level of soil, prevent evaporation, retains water and restore degraded soil.

C. Biological Techniques

The major practice of plant management in the mountains is the yearly rotation of Sorghum vulgar is and millet. In even years all farmers plant sorghum, while millet is planted in every odd year. Though sorghum is the superior crop in virtually all respects, the rotation is upheld for two motives:

- Sorghum is more delicate to striga and other pests, and having no sorghum in the mountains for a full year escapes the pests' propagation;
- The deep roots of the sorghum easily consume the soil and planting the shallow rooted millet is a kind of imperceptible fallow for the deeper soil layer, stopping soil degradation;

Besides these two staple crops, the Mafas plant an astonishing array of other crops, such as groundnuts, sesame, bambara groundnuts, beans, oseille de Guinée, gombo, pumpkins, eggplants, calabash, peppers, tiger nuts, tobacco, irrigated taro and rice. Most of them are planted in numerous diversities, all known by different names and having their precise uses. Each variety has its own way of planting and manuring, adapted to specific soil types and taking account of their vulnerability to drought and pests.

Legumes, for example, are grown in a way that they work as a 'trap crop' to striga, while drought-resistant varieties are planted close to the terrace special mountain with long and pointed hoe. Thus, farming becomes an intricate relationship of hands and brain. A farmer who is weeding, for example, is not just weeding, but at the same time making little compost heaps at the suitable places, refining the soil profile, doing some overhaul on a terrace, solving small-scale plant problems and applying manure where needed. This is called "maya-maya", the true Mafa way of farming. Besides the food crops, several species of grass and shrubs are planted for fodder, roofing, ropes, medicine, fencing and other uses.

Trees are also combined into the farming system, carefully pruned to enhance their use and minimize their disadvantages such as shading. It plays an important role in the farming system as a cash provider. Soil water preservation measures are not used and the cattle are usually allowed to roam around freely, without their dung being collected.

The variety of crops cultivated in Djingliya Mountain is categorized into specific itiesgroupedunder big crop types (Table 3).

Table 3: Crop Variety in Djingliya Mountain

Crop types	Cereals	Leguminous	Fruiter	Marketgardening	Root and tubers
Specificities	Maize	Groundnut	Fruiter plant	Onions	Sweetpotato
	Sorghum RS	Beans		Leafyvegetation	Arishpotato
	Sorghum DS	Soya beans		Carrot	Cassava
	Pluvial rice	Bambara groundnut		Cabbage	Macabo
		Sesame		Lettuce	
				Green pepper	
				Parsleybasil	

Source: Fieldwork 2020

IV. STRATEGIES OF SOIL WATER PRESERVATIONIN DJINGLIYA

The global policy contest for hills and mountains of Mandara as in other developing countries is the challenge of sustainable development: mainly to enhance both environmental quality and human welfare. To meet this challenge, policy makers have recognized that population growth and decline create new microeconomic conditions of households that induce changes in technologies and institutions, that have different impacts on ecological and economic well-being. As a result, people expect higher returns from tree planting, terracing and other land investments.

Erosion control strategies introduced in Nord Cameroon improve productivity, reduce runoff impact and reverse yield decline. The adoption of soil conservation practices has attracted much attention from scholars, with a wide range of local level considerations. Studies examine the conditions under which farmers adopt soil preservation practices. And the continuous soil protection, via different strategies: the practices of agroforestry, water derivation, watershed, wood reserve, terracing.Hence, in the system of landscape restoration, the main actors for farmland restoration are: local population, government sectorial branches like MINADER, MINFOF, MIINEPDED with certain NGOs like LWF, GIZ all interrelated with the council (MINDDEVEL).

A. Traditional Strategies to Conserve Soil and Water on the Mandara Mountain

➢ *Terraces*

Terrace farming has existed in the Mandara zone since time immemorial land so, the network of curvilinear terrace practice is a traditional culture of Mandara inhabitants Therefore, ridge construction by these Montagnards is a

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remarkable practice. Apart from terraces, other local techniques are: irrigation, multi and intercropping, multi-cropping, manuring, soil enrichment, mulching, agronomic restitution trees plantation, stone paving as run-off embankment, the practices of soil restoration with vegetal detritus, agroforestry, the development of crop rotation, the maintaining of soil fertility with agronomic plants like *Acacia polyacantha and faidherbiaalbida*in certain valleys, anti-erosion integration in agro-systems, the planting of certain trees that help to improve infiltration like *Acacia ataxacantha* and *ziziphusmucronata*, organic soil additives like animal dungs and compost are used as fertilizer to raise outputs and retain water.

However, farmers who correctly implement local techniques of farmland management have good harvest although; this local system of farming is presently interrupted by the integration of chemical fertilizers (Figure 3). Their argument is to add to soil fertility and have better crop output. The curvilinear terracing across undulant and accidented surface of Djingliya is a cultural system that is very efficient for erosion control, run-off check and mass movement.

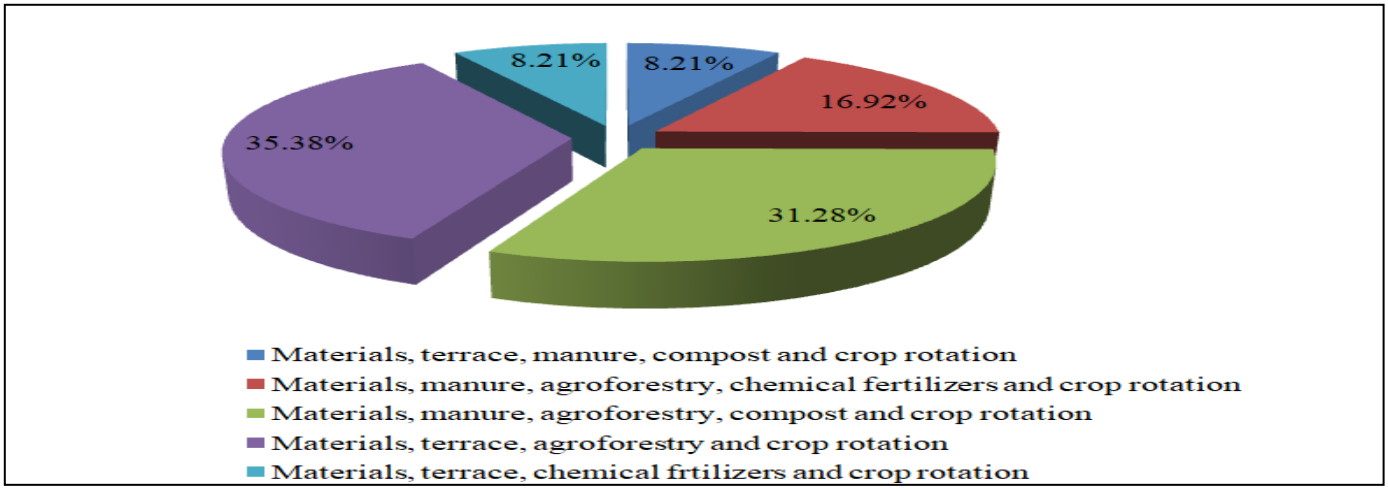

Fig 3: Traditional Strategies of Soil Water Preservation
Source: Field Work 2020

Figure 3 illustrates that about 08.21% of the actors are practicing local techniques of soil and water restoration using organic and chemical fertilizers(such as Nitrogen (N), Phosphorus (P) and Potassium (K)) reason being to increase output. However, more than 91.79% of the actors are really engaged in the implementation of local techniques through organic fertilizers to add up soil nutrients.

➢ *Crop Rotation on terraces*

The implementation of crop rotation is universal in Mount Mandara zone. Agricultural actors in Djingliya have adopted crop rotation since it stabilizes the soil and maintainsits fertility. Farmers are cultivating both cereals and leguminous crops in order to facilitate rotation between these crops. These farmers do multi-cropping, mixed farming, and at the same time rotate crops from one year to another including the construction of terracesand embarkmentsto prevent run-off is an added advantage. Leguminouscrops generally have more leaves of dicot character and they constitutelitter which decomposesto add humus to the soil. Crop rotation is one of the most efficient local techniques practiced by all the villages that comprise Koza Sub-division. Farmers continue to develop crop rotation practice on skeletal soil on the slopes to support fast demographic explosion with current population density of about 150 people / km^2.

Legumes are currently present the best potential to contribute significantly to the maintenance of nitrogen level, organic matter content and physical properties in intensified cereal-based farming systems. Leguminous crops like cowpea and groundnuts play an important role in Mandara zone as source of food and local kitchen oil production. Therefore, crop rotation cereal-leguminouscereal adoption by is so important to maintain soil nutrients for sustainable cropping system.

➢ *Agroforestry Practice by Small Farm Holder on Terraces*

The practice of agroforestry is another system of farming widespread in Mandara zone. Farmers are used to planting trees in their farmland to use as firewood and many other domestic uses like house construction. This agroforestry equally acts as another cultural system of Mandara Mountains people. There farmers do crop with large park of trees in their cereal and leguminous land. The trees present are tropical plants like *Faidherbiaalbida*and *acacia senegalensses.* A varietyof crops practiced by the local population (Table 3) support agroforestry cropping system. SODECOTTON put in place a project known as*Eau Sol Arbre* abbreviated (ESA 1 & 2) which was implemented to protect the environment and increase agricultural yield. The crops that support agroforestry practices and percentages in which they are grown under this system are demonstrated in Figure 4.

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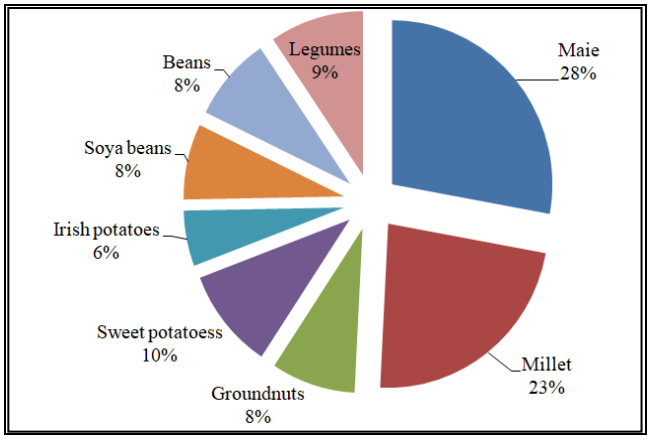

Fig 4: The Crops That Support Agroforestry
Source: Field work 2020

Figure 4 illustrates that, cereal crops like Maize and Millets (Sorghum) are the main crops that support shed. Maize is identified as the most agroforestry supporting crop with 28.0% followed by Millets with 20.0%. And the mixed cropping: cereal and legume is 11.5% and 10.5% respectively. Then the legumes equally support the system with maximum 9.0%. All other crops equally support agroforestry but, not as cereals.The local techniques practiced by Djingliya Mountains people as in other parts of Mandara mountains area is evident in farm holdings on the land use/land cover map figure 5.

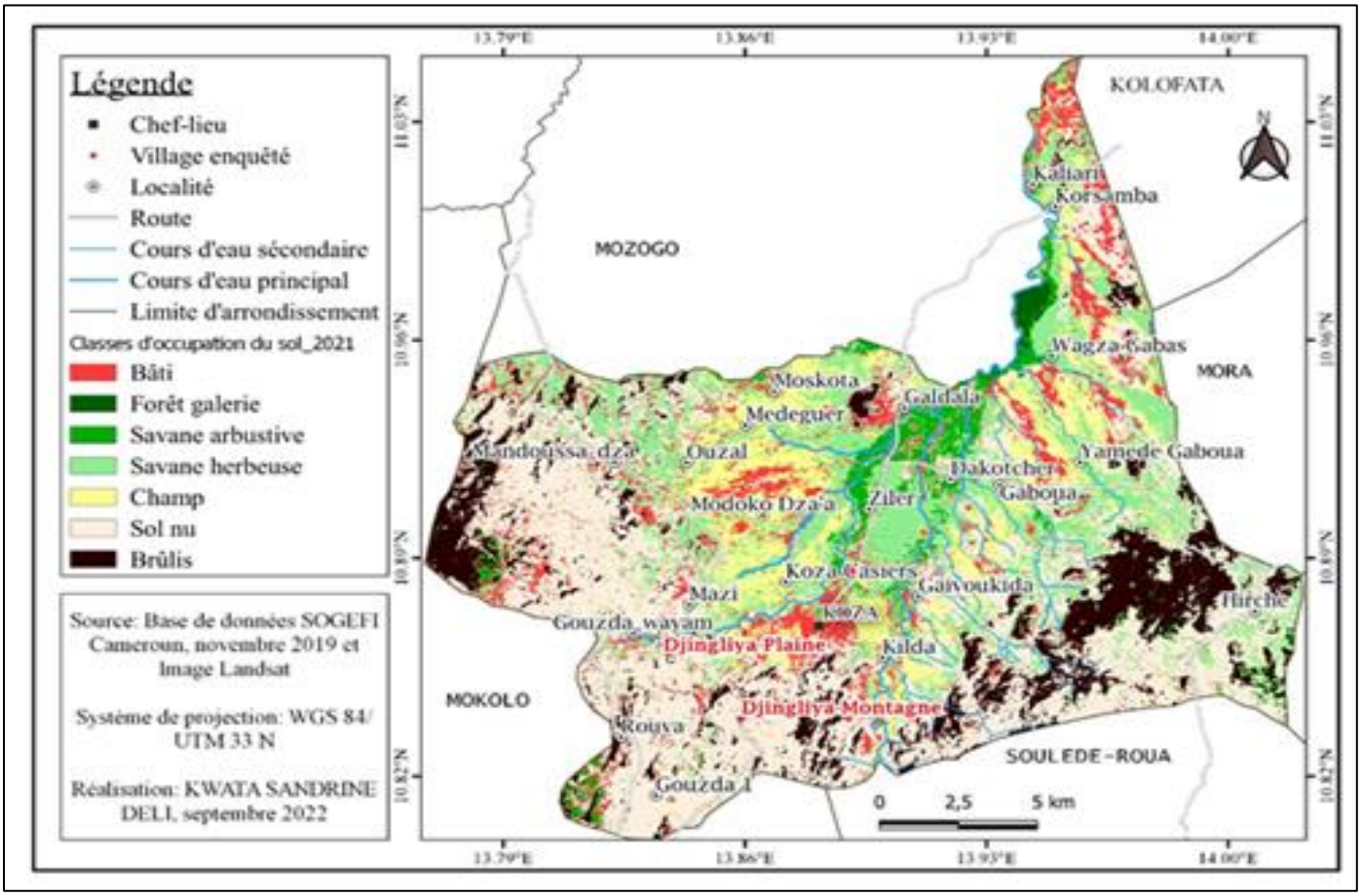

Fig 5: Land Occupation Map of Koza Council Area

The distribution of land use is everywhere on the map of Djingliya, but more concentrated in the South. The concentration of villages and land use are found on less accidented area of the mountainand the plain surface is for more agricultural practices. This is because the areas benefit from soil mineral deposits, colluvium, potassium, phosphorous, calcium and silica at the mountain-foot. They practice terrace farming, agroforestry and soil conservation mechanism in their farmlands in between hills and mountains and on the rough Tsanaga south plateau.

On figure 5, artificial land use consist of using land with high attention for sustainable crops output on one hand; and on the other hand, represents settlement area and other forms of anthropogenic effect on lands. The agricultural place in the south-eastern edge of Djingliya is made up of burning grasses and trees. On the plain, cereals as well as certain tubers like onions are farmed at large-scale precisely on the plain of Koza. The environment of Djingliya is mostly mountainous. So, more of communication networks are footpaths linking one village to another and farmlands and also the lack of farmland for agricultural activities influence many youth to abandontheir land to settle in Koza

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plain for farming, the main agricultural practice is terrace farming. Equally, productive landscape permits to meet the social, economic and environmental needs of present and that of future generations at the local, national and global level.

The general landscape approach by-passes the traditional watershed management process. So, with a strong focus on a better integration of social development, environmental sustainability and economic development efforts, traditional watershed is not therefore the only satisfied need when enhancing landscape management. In Djingliya, like in many other places in the Mandara zone, the traditional terracing and other local environmental management strategies are the best. Then, the actors and the implementation of local strategies for mountainous farmland or agricultural land in Djingliya by the Montagnardensure the effectiveness of the techniques of soil and water restoration enhanced.

➢ *Agricultural landscape and soil fertility maintenance on terraces*

Based on the state of agricultural landscape, farmers succeed to develop strategies of soil fertility maintenance. Farmers in Mandara area are used to anti-erosive horizontal and perpendicular system of ploughing on the slopes in between the paved stone ranges of erosion and run-off embankments. They plant trees which favour water infiltration; they also till the *hardé* areas to create fissures through which water infiltrates and in mountainous area of Mafa, with well stone paving, high level rock ridging, continuous usage of animal dungs and agroforestry encouragement are strategies of soil fertility maintenance strengthened by crop rotation practices which maintain soil fertility with a fascinating agricultural landscape.

B. Actors Implementing Local Strategies of Soil Water Preservation in Djingliya

➢ *Local Population*

Local population that act in the method of local practices fall within the ages of 15 and 70 years old, with adults of 33 years engaged in the implementation of these local practices of soil water preservation.The main actors are the local smallholder farmers, agriculturalists, and farmer-breeders. All these categories of actors are supported and stimulated by the agronomic and environmental engineers, besides the personnel of urban and rural councils and those of the ministry of agriculture and rural development (MINADER) and SODECOTON.NGOs equally inspire environmentally friendly local system of farming.

However, there are more smallholder farmers than the medium and major ones in the Djingliya village. These are according to the available arable land which is continuously decreasing compared to increasing number of inhabitants. The division of farmlands between the numbers of persons in each family resulted to small surface area per farmer in average. And so, high local technics of land management are enhanced. The over cultivationof farmlands results in low output but, local strategies ofcompost application help for better output.

- *Profession of Actors Implementing Soil Water Preservation Strategies*

Figure 6 illustrates field reality as it represents the different categories of actors practicing agriculture and implementing local techniques of soil water preservation.

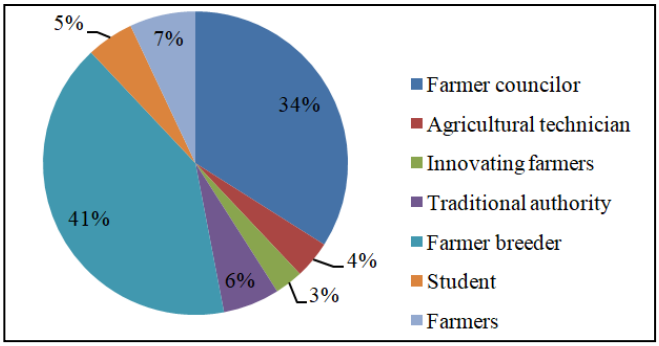

Fig 6**:** The Professions of the Actors on the Case Studies

On figure 6, 6% are traditional authorities,3% of rural councilors; 3% of innovating farmers, 4% of agricultural technician,7% of agricultural student actors; about 34% pure farmers having no livestock and finally 41% of farmer-breeders. All the actors are integrating local technique in their system of farming. More than 85% of actors having livestock are using the dungs as manure to fertilize their lands, 8.0% of the actors use manure and prepared compost apart of experienced terrace farmers.

- *Ages of Actors Implementing Soil Water Preservation System*

Actors implementing local strategies are gender sensitive. The actors are adults, males and females, of ages between 15 to 70 years old. In rural areas, a person of 65-70 years is stillvery active for daily activities. They are experienced agricultural local specialists as they are full of local knowledge. To this effect, they can differentiate the periods of changing landscape in space and time, based on the know-how of local milieu. The most active workers in the case study villages are persons aged 36 and the less active persons to adapt new system of farming beside traditional local techniques are aged 65years old and above. The young persons of around 20 years are the amateurs of local semi-modern strategies to boast crop production and animal production. But most of the active population made of youth around 10 to 40 years are absent in Djingliya, this lead to lack of work force for construction of terrace, most of the remaining population are old persons and women aged 65 and above.

Table 4 represents the number of farmers per crops and the usual farmed and the considerable variations of farmers according to their preferable crops for farming.

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Table 4: Identification of Agricultural Exploiters Per Crops and Farm Surface

Crop types	Speculations	Small workers≤3ha Marketgardeners≥1ha	Medium workers ≤10ha Market gardeners≥3ha	Major workers ≥10ha Market gardeners≥3ha
Cereals	Maize	8215	6455	612
	Sorghum RS	11600	10200	460
	Sorghum DS	12500	11155	2200
	Pluvial rice	993	9200	220
Leguminous	Groundnut	9122	1055	331
	Beans	6116	635	20
	Soya beans	1111	2888	15
	Bambara grounut	225	11600	300
	Sesame	255	650	115
Fruiters	Fruiter plant	95	60	2
Marketgardening	Onions	11500	3555	0
	Leafyvegetation	220	2222	0
	Carrot	2255	1	0
	Cabbage	111	2	0
	Lettuce	220	0	0
	Green pepper	110	0	0
	Parsleybasil	200	0	0
Root and tubers	Sweetpotato	115	2	0
	Arishpotato	700	11	2
	Cassava	95	2	5
	Macabo	112	22	0

Source: MINADER, 2021

Table4 represents the speculations per type of crop cultivated in Djingliya, the number of smallholder workers which exceeds the number of medium and major farmers. And the number of hectares (ha) thus occupy the small workers each, is small. They occupy arable lands of ≤3 and <1ha of land for market gardening individually. This class of farmers carries more than 60% of active agricultural workers of the village, about 75% of the exploiters of cereal and legumes are greater in number. Also, the producers of other crops such as market gardening, fruits farmers and harvesters and with the tubers and roots producers are all tied to this category of exploiters. Then, the medium and major producers are mostly cereal and leguminous exploiters. Hence, hundred percent (100%) of the producers here are partially cereal and legumes workers.

Most of the medium and major farmers are working on lowlands of Koza and on undulant surface area of Djingliya plain. Worker occupies the surface area of ≤10 ha market gardening surface is ≤2ha per persons. While major farmers are usually working on the surface areas of ≥15ha cereals and legumes (fruiters≥5ha), and with market gardening of ≥5ha. Therefore, both medium and major workers are cultivating at a large scale surface area (extensive farming system).

Due to scarcity of land in Djingliya village, major farmer often move to Koza plain for more space to practice their extensive farming system, this major farmers are mostly CIGs that joint their forces and income with the support of organization to produce in large scale, they also move to abandoned bushes for more land to practice their extensive farming system.

However, the actors implementing traditional strategies are mostly the smallholder workers who are working on considerably small surface areas; and are mostly occupying the fringes of Djingliya Mountain, valleys and well drained areas of the plain apart from *hardé* and plateau. Also, medium and major workers are equally implementing such techniques, with more of modern techniques enhancement.

➢ *Institutional Actors*

The institutional actors constitute the ordering board which gives directives and the process to get results of the implementation, to what concern large-scale FLR and MLR. They are both governmental and non-governmental organs. The council development plan (CDP) programme of the country is implemented and managed by the PNDP and councils in collaboration with other sectorial such as: MINADER; MINEPDED; MINFOF; MINEPIA and NGOs such are: GIZ, LWF, IUCN, FAO are contribution equally in the guidance of the implementation of soil and water management. Therefore, the local actors and institutional actors are all engaged the implementation of Forest Landscape conservation (FLC) for its numerous advantages.

- *The Forest Landscape Conservation (FLC) and its Benefits to Farmers*

Thereis small-scale and large-scale Forest Landscape Conservation (FLC). The large-scale FLC consists of large forest restoration and the small scale consists of mosaic restoration. This environmental landscape conservation is

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having far reaching importance. For instance, the benefits of FLC to farmers are seen mostly on agricultural improvements.Its benefits are significant on the natural environment and the biosphere, to the government, and the modification of harsh climatic condition in favour of the biosphere of the study areas. For rural development, the FLC brings humid climatic condition and more rainfall abundance for cropping; the restoration of nonagricultural production lands to crop production sites; improvement in the drainage systems of arable lands;createsa subsurface mat of agricultural environment and maintenance of humid soil landscape and soil fertility; brings about germination of good grass; it supplies construction wood and fire-wood; provides medicine; provides non-timber forest products like fruits, provide habitat for wildlife on trees and good water quality where springs constitute potable water sources; acts as a communal reserve zones on enhanced terraces. Therefore, FLCis beneficial to Djingliya Mountain farmers through the moderation of agricultural systems and environmental character.

The most pronounced strategies with high efficient techniques is the introduction of water infiltration facilitator plants applied by farmers of Djingliya Mountain toconserve soil and water in Koza council area. The farmers also focus on forest regeneration programme and policies to combat land degradation. Therefore, the tools of local strategy for soil water preservation are:

- Agroforestry: farmers know the advantages and so encourage each other to implement it;
- Forest landscape conservation (FLC): for automatic landscape restoration since it calls forrestored agricultural landscape too;
- Mosaic landscape restoration (MLR): such as small-scale restoration strategies inclined toward SWC system to restore local ecology, agriculture landscape, local ecosystem, soil biodiversity regeneration and enhance the local biosphere;
- Valorizing local plant species (VLPS): certain plant species are currently valorized through planting in farmlands;
- They implement the above efficient local strategies of soil water preservation which reduces fallow period and improve crop rotation system;

V. DISCUSSION

This study that was aimed at analyzing terracing as a traditional system of soil water preservation adopted by the farmers in Djingliya villages found on the Mandara Mountains reveals that the physical and sociopolitical constraints favoured the development of local techniques (terraces) for crop production and to fight degradation of soil resources overuse and erosion as well as conserve water for plant use thereby increasing crop output.

The archeological character of Mount Mandara sites with multiplexes of dry-stone terraces and then the platforms of complex historical culture of the inhabitants in the Mandara Mountains of northern Cameroon has been described by Scott (2013). This researcher has limited the overview of Mandara Mountains around archeological facts and historical events. The negative impact of population growth is the degradation of landscape the impacts of which falls on soil nutrient loss due to erosion resolved by stone paving and terraces in Djingliya. This was the major source of rural poverty, hunger, disappearance of domestic ruminants and mosaic landscape in the study areas. He therefore failed to bring out the effects of population pressure on mountainous zones like Djingliya and the strong holds of the consequent strategies to curb the effects.It is therefore suggested that, productive land is capable of providing a wide range of products and approves ecosystem services (Chavez Tafur*et al*., 2014) just revealing again what this research brought out.

Moreover, results obtained portray that it is difficult for a farmer to cultivate more than 2 hectare of land in Djingliya Mountain.This is due to their topographic constraint of hills and mountains, making agriculture very difficult. So, agriculture in Djingliya Mountain is highly subsistence rather than extensive commercial like in Koza and its surrounding villages.

The impacts of soil water preservation in Djingliya have positive result according to data collected on the field. Small holders input has increase from 485kg/ha to about 1000kg/ha there have been degraded land restoration and conservation thanks to different projects put in place by the local population to improve agricultural yieldBoutrais, 1973. Despite a growing awareness of its importance, Indigenous SWC techniques continue to be neglected by African researchersand SWC specialists as well as government staff in the study areas. The results gotten through detailed descriptions and analyses of indigenous Soil water preservation systems in this work goes in line with major findings of other researchers such as Hallaire, 1971; Boulet, 1975. This goes in line with the work portraying that terraces are very successful water and soil retainers (HiolHiol, 1999; Van Beek, 2003; Seignobos, 2007).

The work of Zuiderwijk (1998) reports on ancestral varieties' of sorghum, while HiolHiol (1999) mentions five varieties of tiger nuts. Most of these crops are intercropped on the same terrace. This is not done randomly but instead there are reasons governing the locations at which the various crops are planted. As reported by Zuiderwijk (1998), they generate firewood, fruits, soil fertility, forage, insecticide for seed storage and stabilize terrace walls. HiolHiol (1999) refers to an average of 70 trees per hectare in the study area, while this increases to 300 in the more western parts of the mountains. This ties with the results of this work as it emphasizes on the same characteristics of terraces.

The tendency of local technique has increased via adoption and development of other new local techniques such as: superphosphate chemical fertilizing, composting, planting trees that facilitate infiltration and soil fertilizing plants as well as improved crop rotation. Also, the

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intervention of stakeholders for landscape restoration of Djingliya, are some of the actual tendencies; through reserve sites creation, Operation Green Sahel (OGS) and Green Space (GS) implemented locally on large terraced surfaces.To fight land degradation, crop rotation is very important as demonstrated by this article on the Djingliya zone. Same findings were made by Critchley *et al* (1994) where the researcher showed that in the mid altitudes of Cameroon, crops are rotated on originally rich volcanic soils that are degrading due to acute land pressure, erosion and lack of practices for soil fertility maintenance. However, cereal specific pests within the parasitic weed complex of *striga*, or cereal nematodes can increase to major constraints if crop rotation is neglected as discovered by Weber *et al*., (2019). Hence, farmers experience similar problems of ecological and economic conditions in our study area but, agroforestry which restores soil fertility indirectlyensures for better future landscapes healthiness on the terraces.

There is improvement in rural development as progress is seen in the study villages.There is moderate prices of agricultural produce, the number of children going to school has increased, road works enhanced, water boreholes development as well as improved building: The Model of Mountain Environment Degradation by Huanchen Z. the Boserup theory on population, environmentalist vision of F. Ratzel,the possibilism approach of Paul Vidal Incorporation and sustainabilitythe basic concepts Zuiderwijk (1998) are observed in reality in the Djingliya. “Theability to maintain agricultural production through the maintenance of theagricultural resource base” Reijntjes*et al*. (1992: 2), *i.e*. the Model of mountainous environment degradation which explains the system of debris flow and soil sediments down the slope, are very recognizable and are fact appealable in Mandara zoneReijntjes (1991). Since most of Djingliya environment is mountainous with the presence of massive hills and dissected plateau, erosion effects are indispensable. The mark of sediments through accumulation of soil material, soil chemical bases, colluvium and alluvium along the valleys and at the foothills of Mandara toward Northeast of Djingliya, confirms Mountainous environmental degradation model.Bosrup theory of population which stipulates that population growth result to innovation and adaptation to living standard, as she argues that population growth increase man power for development and productivity. Though soils decline in fertility and agricultural production incomes reduce, the Mandara people only intensify agriculture through local strategies on terraces which goes in line with the work of Tchotsoua and Fotsing (2008) on the traditional strategies of water management and soil fertility around Mokolo Mandara mountains of Nord-Cameroun..

VI. CONCLUSION

The traditional soil water preservation technique of terracing on the MandaraMountains has permitted the demonstration and the description of the influence of relief and population pressure on land degradationand its effects onagricultural productivity in Djingliya. Theexisting strategies for soil water preservation toimprove as well as sustain farms and is geared towards promotingrural development. The Djingliya inhabitants living on a total surface area of 140 km²with 80% of the surface area is made up of mountains and hills. Hence, the population pressure on the rest of the surface land, degrade and the rate of such degradation is high. Then, the impacts of the degradation are felt.

The impacts of soil water preservation on loss of soil nutrients, presence of a hard pan in the soil, skeletal soils on rugged landscape result in low output of agricultural production as well as revenue of the Djingliya people. As a supplementary activity, animal breeding and poultry becomes difficult. This made more than 95% of these rural households to give-up the activity, since pasture is difficult to get in the rainy season. Local animal and plant species loss has been registered due to degradation of the environment by population pressure. Wildlifehunt in forest reserves as well as their habitats is damaged with low reproduction rates experienced.

The Djingliya population implements local strategies of soil water preservation based on experienced cultural system of terrace cropping, with lots of trees like *faidherbia, ziziphusjujuba, ziziphusmucronata,* the using of animal dungs and manure, crop rotation between cereal and legumes, agroforestry (trees planting in farmlands). These local strategies are mainly for soil fertilization, soil water conservation and soil fertility maintenance. Other adapted strategies include:Forest Landscape Restoration (FLC) and agroforestry practices with main actors being Mokolo council in collaboration with certain sectorial administration (MINFOF, MINADER)and NGOs like LWF, GIZ.

These local strategies implemented have restored a total land surface of 250 ha and conserved a surface area of 100ha. The results ensure that, despite the degradation of landscape, farming is sustained, thank to environmentally friendly local strategiesbased on terracing. Despite the degradation of landscape, people are nevertheless adapting soil fertilization and landscape restoration techniques to maintain sustainable farming on the MandaraMountains. Globally, the management of soil and water are improving sustainable farming for rural development in Djingliya, ensured the actual state of holistic landscape and rural potentiality for development. Great landscape degradation characteristics where presented with their effects, the strategies implemented are shown and the state of sustainable agriculture and rural development are represented with the positive perspectives for landscape restoration and the prevention of further degradation and maintaining healthy environment. Djingliya villages in mount Mandara has been the area of case studies of many researchers, who researched and arrived at certain results of the phenomenon of indigenous system of land management, but many other results were not got by such researchers.

From the results obtained during this study and the insufficiency in it, the frame of our next research will foresee the mapping of villages where local management technique are being neglected and we envisage to great new

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techniques of soil and water management, through the training of smallholders on the natural way of producing fertilizer rather relying on chemical fertilizer which pollute the small underground water. Therefore, wepropose the following to political authorities,NGOs for the Djingliya rural dwellers:

- The Mafas in Cameroonian society should not be integrated by bringing more Mafa to the plains, but by bringing Cameroonian society to the mountains for national integrity and development of mountain area.
- The seasonal migration of youth to town influences the development of the village, since youth are the forces of development in the society. So, youths are encouraged to stay in their locality and create small jobs, and innovation for the future development of their locality.
- Development projects and state projects should greatly assist the mountain dwellers on the modern method of management of land, so as to limit land degradation; this is through the opening of training institutes in mountain areas. To measure the sustainability of mountain cotton cultivation and act rapidly on the outcome, Cotton is the first and key aspect to prevent the increased seasonal migration to towns.
- To bring government,NGOs services and offices to the mountains since thisclear policy component pertains to the whole of Mandara Mountains. They include: schools, clinics, agricultural extension workers, cereal banks, small-scale acclaims, roads, and mobile communications network for social justice to thesemountain population.

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