 J Hum Ecol, 30(1): 19-25 (2010)

Ecological Adaptability and Slope-Trait Considerations for Water and Soil Conservation on the Vulnerable Oku-Kom Plateau in the Western Highland of Cameroon

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KEYWORDS Land Degradation. Geohydrological Divide. Conservation Strategy. Regreening. Agroforestry

ABSTRACT The Oku-Kom highland morphological and human stronghold of West Cameroon with rich volcanic soils has attracted farmers and breeders thereby rupturing the mountain ecological equilibrium through slope gulling and mass movements. Overwhelmed, the indigenes adapted unsuccessful regreening approaches but without slope gradient considerations. This paper identifies native and exotic plant species whose growth traits and ecological adaptability rates can be combined with varied slope gradients to permit devegetated slopes to regain natural greenness. The methodology involves field survey and observations, slope measurement on the fields correlated with the topographic map, identification and spatialization of landscape degradation phenomenon. It then matches agronomic regreening efforts and cultural specialised measures to current trends in land use and slope gradients to suggest local and exotic grass and tree species to be combined with crops that are most suitable for each slope. The results then present an optimum slope gradient-specie combination. This could be a new approach to halt landscape degradation on fragile tropical mountains especially those plagued by long dating degradation histories like the Oku-Kom tropical highland.

1. INTRODUCTION

The Oku-Kom Highlands is part of the topographic unit of the Western Highlands of Cameroon, with remnant but fast degrading forests. This part of the High Lava Plateau is a cluster of mountainous blocks whose topography is a succession of deep valleys and volcanic mountains. The terrain is deeply dissected by a dense network of dendritic inter montane streams being a geohydrological divide for streams.

According to Hawkins and Brunt (1965), Letouzey (1968) the moist montane forest was the climax natural vegetation covered the Oku-Kom highlands. Successive phases of intense deforestation by anthropic activities that began since early historic times Nkwi and Warnier (1982) has ruined well over than half of the area and resources of this forest. This devastation was most alarming between 1963 and 1987 when 50% of forest area was lost. Dongmo (1983) estimated a 41.6% forest loss in just five years from 1978 to 1983. Macleod (1987) and Mbinkar (1991) reported 50% destruction between 1963 and 1983. Fogwe (1997) measured a 70% destruction of climax natural forest between 1963 and 1996.

This escalating rate of forest degradation is indicative of the economic, social, ethnological, and cultural value and exploitation of this forest by the high density montane population that averages 350 inh/km^2. The province has over 1.4 million inhabitants with 64% settled on 40% of the 17000 km2 total area. Nucleated settlements have replaced gallery forests within inter montane valleys so that the steep slope areas are over exploited and degraded rendering many areas bare. Lambi (2001) considers that the barren, rugged and infertile regions and some grasslands sceneries of Cameroon today are mere legacies of the environmental trauma and ecological holocaust which some parts of Cameroon have undergone. Kips et al. (1987) noted that these highland slopes suffer from a severe erosion hazard that lowers their agricultural potential so that they are not capable of sustained cultivation and cattle breeding. They recommended afforestation on the parts with moderately steep slopes and steep slopes (of more than 30%) with tree

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crops. The Oku-Kom area with an omnipre-sence of such steep slopes deserves such an attention with regards to landscape conservation. This work emphasises that for such conservation specific slope areas require specific tree species with specific characteristics.

2. METHODOLOGY

Field reconnaissance survey and observations was carried out from September 1998 to March 2000 with the assistance of the Divisional chief of post for Agriculture at Fundong (for the Kom side of the plateau) and the Technician at Oku (for the Oku-Babungo side of the plateau). Together with the two conservationists from the Oku (Kilum) Mountain Forest Project (KMFP) and Ijim (Kom) Mountain Forest Project (IMFP) we made an inventory and identified the local and exotic species of maximum plant growth potential, especially those that have a high foliage potential that could possibly favour land surface regreening. Slope gradients were measured for sampled devegatated areas on the field and then correlated with the topographic map Nkambe 1b, at 1:200.000. The above procedures then permitted an identification and spatialisation of landscape degradation phenomenon between 2000 and 2003. We also identified and correlated the local (indigenous) agronomic regreening efforts and cultural techniques to current trends in land use and also the slope gradients. This then permitted us with the help of the IMFP and OMFP botanists to recommend several local and exotic grass and tree species that should be combined with suitable crops for each slope. The strength of the proposals was that the local specificities (size, lifespan, rate of propagation, ecostability and various uses) of the species recommended were taken into cognisance. As such, the tree species were juxtaposed with slope gradients to choose the best species to regreen the devegetated Oku Kom mountain slopes.

3. RESULTS AND DISCUSSION

3.1 The Morpho-topographical Traits of Oku-Kom

The Oku-Kom highlands are mountain ridges and peaks with steep slopes. They extend from the Bambili-Sabga dorsal (south east) to the Boyo Hills in the west and culminate in Mount Oku (Fig. 1). Fast flowing streams have dissected the post-volcanic topographic surface into deep, steep-sided valleys which produce a relative relief of more than 500 metres in some places. Being the watershed of the River Menchum and Katsina Ala, the altitude attains 2400 m around Lake Oku, and then falls to about 800m at Mbonkissu to the west of Fundong.

This topography offers ideal conditions in several areas for mass movement and water erosion that have produced slope scarification (very alike to lavakas) on the flanks of some topographic ridges. These occur on the plateaus of Mbingo, Njinikom, Abuh, Aduk and on slopes of peaks like Boyo (2400m), Aboh (2200m) and Laikom (2500m). Altitudinal variations are common on the Njinikom plateau. Taking the Mungom-Lumugof (20.5 km^2) drainage as an sample, the average altitude is 1765m, while the gorge-like valleys have depths of about 800m. Some 30% of the sampled area has an altitudinal range from between 1200m to 1600m approximately 60% of the area lies above 1200 m. This means that the Oku-Kom Highlands is a high-energy geomorphic environment where the dissected relief, slope gradients combine with the torrential rainfall (2200 to 3000 mm) of 8 months rainy season to trigger rapid geomorphic change.

The relative relief reveals that about 7.2 km^2 or 32.58% of the area is between 221m and 320 m. Approximately 81 km^2 (36.65 %) is made up of summits of between 321m and 540 m. The modal class altitudinal range of 221 m to 320m, indicates the mountainous, hilly and deeply dissected topography. These slope elements (relative relief, altitudinal range and slope gradients) were calculated from the topographic map. The slope gradients for the sample area (Mughum-Lumugof drainage basin) produced the results (see Table 1).

Table 1 reveals that the Kom area of the study area has very steep slopes with the modal gradients being over 30%. The highland around Mount Oku and its eastern flanks have deeply entrenched valleys. Dense settlement clusters like

Table 1: Slope characteristics of the Mungom-Lumugof Drainage Basin

Slope gradient		*Area*		*Observation*
%	*Degree*	*(km)*	*%*	
61-75	31-40	00.4	01.89	Cliff Like
41-60	22-30	03.6	16.62	Exceptionally steep
21-40	11-21	14.0	16.82	Slope with major breaks
<20	<11	03.6	16.67	Rolling relatively flat

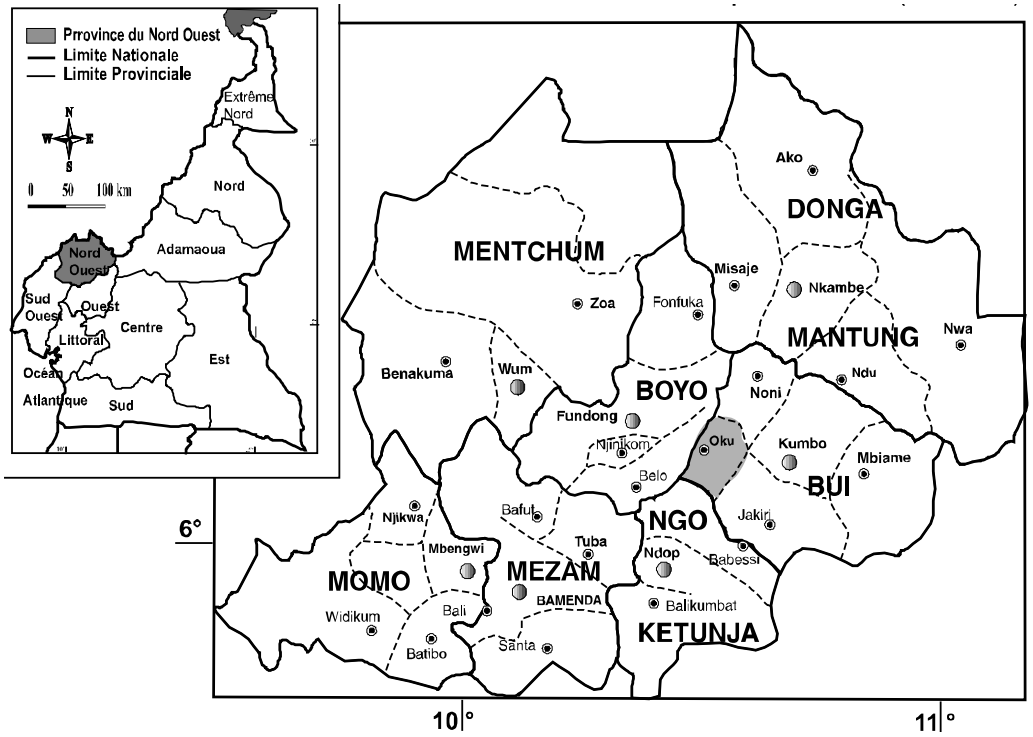

Fig. 1. Location of the study area

Belo, Njinikom, Ibal-Oku and Fundong are situated on gentler gradients where perennial cropping is carried out. The marginal steep slopes of these areas are rather used for shifting cultivation and annual cropping. They are thus subject to soil erosion and wash processes.

The soils of the Oku-Kom region are developed on basaltic rocks (recent basalts, trachy-rhyolites, and andesitic basalts). These volcanic soils and rock types are also developed on pyroclastic deposits (ash and cinder) around the crater lake of Mount Oku. These volcanic soils are moderately deep, well drained, deep brown and yellowish red clay with weathered rock fragments. They are moderately deep, well drained, brown and reddish brown, very stony and boulder silty clays. The soil texture ranges from loamy sand to sandy loam. The topsoil contains granular aggregates with a non-sticky, non-plastic and very friable structure. A few tested samples show that the soil texture has a granulometric composition of 33% clay, 40% silt and 27 % sand. The soils are thus well drained and very permeable thereby favouring-mass movements in the zone where water and gravity join to influence slope dynamics on this mountainous landscape.

3.2 Characteristics of the Devegetation

The climax vegetation of the Oku-Kom mountain summits was the bamboo forest which today exists as ecological remnants, altitudes between 1900 to 2300m, followed by the moist evergreen forest form 1300 to 1900m and finally the south Guinea savanna woodland at below 1300 m (Fig. 2). It could thus be inferred that before anthropization started in this area, the bamboo forest occupied most (if not all) parts of the Oku-Kom highlands. In great contrast, the present vegetation of the Oku-Kom highlands is discontinuous. It does not even show any relationship with the volcanic soil types. Systematic human imprints, since about the 5th millennium, on the climax vegetation now reveals soil and vegetal degradation due to agriculture and settlement related activities. Figure 2 shows how the forest had receded up to 1995. Some parts are partially

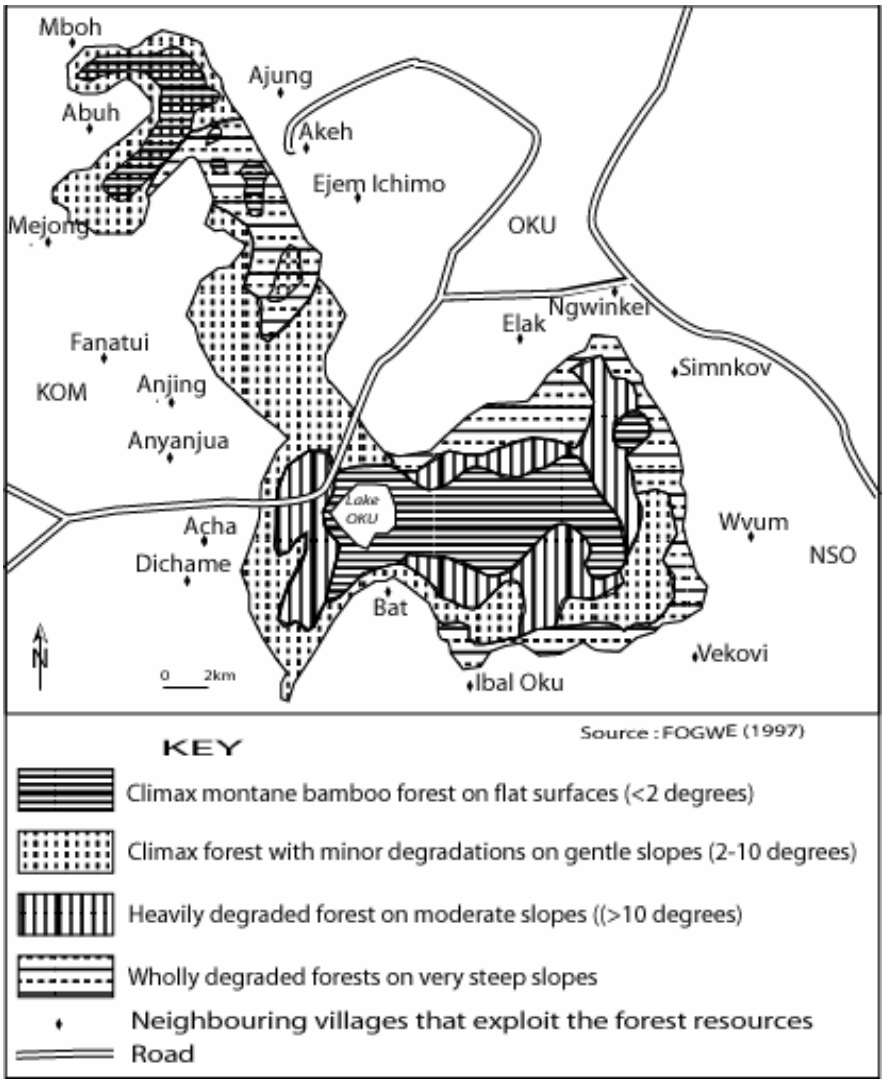

Fig.2. The degradation of the Oku-Kom Forest by 1995

destroyed while some are completely destroyed. The areas of greatest vegetal destruction unfortunately correspond to the areas where the climax vegetation developed on steep slopes. There exists a relationship between the degree of slope steepness and the degradation element (Table 2).

The degradation of the Oku-Kom virgin forest stems from the complexities of the man-environment relationships that harm the ecostability of this fragile mountainous geographical milieu.

3.3 Landscape Regreening Using Local and Exotic Species

Based on field observation and data collected, the regreening of the degraded Oku-Kom highlands can be done with local and exotic tree, grass and herb species. Grass species with a good performance at high altitude like the Oku-Kom region identified include *Brachiara recumbens, Brachiara ruziziensis, Setaria sphacelata* and *Trypsacum laxum* (Guatemela) at altitudes

Table 2: Slope and degradation categories of the Oku-Kom Highlands

Slope		*Degradation element*	
Angle	*Type*	*Event combination*	*Degradation indicator*
>25°	Very high	Deforestation, farming, excavation, heavy rainfall, soil saturation	Very high rate of widespread slope failure occurs or likely to occur of the rapid type: landslides earth and rock fall.
11 - 24°	High	Farming, heavy rainfall, animal movement, soil saturation, soil vibration, and deforestation	Highly eroded and gullied slopes producing ravines and semi lavakas topography
3 - 10°	Moderate	Heavy rainfall, farming, animal rainfall	Major sheet erosion, minor rill and gully erosion around areas of residential and agricultural landscape
<2°	Least	Light rainfall, no farming	Splash and sheet erosion in areas of least management

between 1300 and 1600. These and other grass species possess special characteristics that have a great regreening potential (Table 3).

Of these species the *Pennisetum purpureum* is high yielding at 1300 –1500 m and *Pennisetum clandestinum* is also high yielding at 1500-2000 m. Wandering and grazing animals easily spread the latter. These species occur abundantly even along the wet valleys of the *Sporobolus* and *Hypperhenia* grassland of the highlands. Some of the grass species have physiological and ecological traits that enhance their landscape protection potential.

Agrarian and pastoral activities have invaded sub and climax montane forest that also provide fuel wood and wood for infrastructure construction to the 120 000 Oku and Kom population. The deep gorge-like valleys have population that reach 350 inh/km^2 while most of the region has about 80 inh/km^2. Such high densities cause vegetal and soil degradation because of their involvement in vegetal degrading economic activities as logging for handicraft activities, carving, fuel wood, iron smelting, hunting weapons, bee exploitation, overgrazing, intensive and extensive cultivation of cereals like maize and beans and Irish potatoes on steep slopes without any fertilizer input. This multiple uses complement the ethnobotanical uses of the trees in the Oku-Kom area as identified by Mbenkum and Fisy (1991). This sets in an imbalance between a rapidly increasing population and the capacity of the volcanic soils to sustainably meet up with their agrarian needs and even assure its vegetal succession.

Since scrub grasslands now make constitute the secondary climax vegetation, regreening should involve both grass and tree species. We

Table 3: Good ground cover grass species for Oku-Kom landscape protection

Grass species	*Characteristics*	*Protection potential*
Bermuda *Cynodon dactilon*	Fine leafed creeping perennial	Resists heavy grazing
Elephant grass *Pennisetum purpureum*	Tall bunch perennial with dense and deep root system. Good fodder when combined with legumes	Erosion control when sown in strips and periodically slashed
Guatemala grass *Tripsacum laxum*	Bunch perennial, dense and deep root system, very productive as fodder, little management	Good to be planted in strips or hedges for erosion control
Lemon grass *Cymbopogum citratus*	Perennial, grows on poor soils, good soil cover	Deep roots for soil stabilisation not eaten by animals
Kikuyu grass *Pennisetum clandestinum*	Low growing, deep rooted perennial forms dense turf and spreads by stem	Excellent grass for erosion control, very palatable and nutritious fodder
Para grass *Bracharia mutica*	Creeping perennial with hairy leaves 30 cm high. Shallow root system and fibrous roots	Good mat of organic matter rapidly develops
Vetiver grass *Vetiveria zizanoides*	Perennial	Grows on bad soil, not eaten by animals provide good cover, used as erosion control strips, dense root system good for embankment stabilization.

Table 4: Land use and slope gradient combinations for the Oku-Kom Highlands

Slopeangle	*Land use*	*Crops*	*Trees*	*Grass /Legumes*
0^0 - 11^0	Stream valley, no intense farming	Green manure crops like *Crotolaria, Canavalia, Desmodium mucina*	*Pygeum, Vocanga, Maesopis kaya, Angoma, Fagara*	
11^0 - 17^0	Contour farming	Maize, beans, Pumkin, sweet potatoes, yams groundnuts, soybeans Cassava, cocoyams,	*shifferia, Lasiosphon, Glauous, Vitex, Polycia*	
17^0 - 22^0	Alley cropping Agroforestry	Bananas, Plantains, Sugarcane, coffee	*Callindra, Leuceana Dry, Cordia spatedia,Croton, Albizia,Sesbania, Pidgeon pea, Tephrosia, Erythrina, Cassia,* Spectabillis	
22^0 - 27^0	Grazing land		Live fence trees at margin	Sporobolus
27^0 - 31^0	Improved Pastures		Live fence trees at margin	*Kikiyu brachiara, Guatemala, Desmodium*
35^0 and above	Reforestation due to steep gradient	Permanent crops: banana cola nuts, raffia, pear, plum, pepper, and other species	*Pygeum, Vocanga, Maesopis kaya, Angoma, Fagara shifferia, Lasiosphon, Glauous, Vitex, Polycia*	

recommend that it should include local species that grow well in the region. Table 4 identifies some local crops, trees, grasses and ecologically appropriate land uses to be combined on slopes of varying gradients so as to regreening the degraded landscape of the Oku-Kom area.

These plant species are chosen as a function of their ability to resist slope failure and erosion. Their soil and slope adaptability, rapid growth rates, good ground cover and multipurpose are special characters that are capable of regreening even the steepest of the Oku-Kom slopes.

4. CONCLUSION

The Oku-Kom highland mountainous topography of steep slopes at high altitude where some 5000 to 6000 years ago thrived a flourishing climax montane bamboo forest and others. The socio-cultural traits of the time accounted for its peculiar agricultural land use and calendar (traditional shifting cultivation and short duration bush fallowing) that was concordant with the land tenure system and traditional perception of space. Such agrarian techniques reflected a stable civilisation of typical Oku-Kom peasants. These montane landscapes have succumbed to various forms of exploitation of the forest and land surface resources. The ensuing degradation stems from the dysfunctioning of the socio-agrarian set-up in the marginal areas where human activity has been long and intense on the vegetation. Current socio-demographic pressure and unequal access to land has ruptured the old land use functional equilibrium through the perception and organisation of space, lands use reversal and transformation, reduction in fallow periods, land speculation and the socio-economic empower-ment of the rural woman folk. This results in a delicate system of steep slope colonisation in Oku-Kom. The rural economic and subsistence revolution of the late 1990s and early 2000 that involve seasonal vegetable market gardening and annual cash food (irish potatoes) cropping in steep slope areas hitherto reserved for forest vegetation. Profit-seeking peasants now under look the traditional techniques that preserved the primary forest and prevented vegetal degradation

5. RECOMMENDATIONS

Faced with increasing population, there has been an impending need to rehabilitate this mountains landscape. Such rehabilitation through mechanical and cultural measures have not generally gained as much acceptance amongst the Oku-Kom population as the agronomic approach. This work takes cognisance

of the popularity and wide applicability of this method in the region to suggest a realistic and high-success geared agronomic technique. This necessitates the planting of *Guatemala, Kikiyu brachiara, Desmodium* and *Sporobolus* grasses and herbs. The recommended local tree species include Pygeum, *Vocanga, Maesopis kaya, Angoma, Fagara shifferia, Lasiosphon, Glauous, Vitex, Polycia, Callindra, Leuceana Dry, Cordia spatedia, Croton, Albizia, Sesbania, Pidgeon pea, Tephrosia, Erythrina, Cassia, Spectabillis, Pygeum, Vocanga, Maesopis kaya, Angoma, Fagara shifferia, Lasiosphon, Glauous, Vitex* and *Polycia.* The relief elements are integrated to give the best regreening output when various slope gradients are taken into consideration

ACKNOWLEDGEMENT

We acknowledge the contributions of the agricultural Chief of Post Fundong and the botanist of the IMFP, Anyanjua with whom we worked throughout the five years in order to obtain these results.

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