# Prototype for watershed management and biodiversity conservation in the degraded western highlands region of Cameroon.

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**Abstract**:
In pre-colonial times villages lived as collective entities under powerful traditional chiefdoms with strong family ties and shared all resources in common. With the coming of independence and the shift in authority from traditional to local government, the ties that bound families and communities together gradually waned giving rise to the destruction of '*sacred forests'* which were a *common property resource*. Successions of offspring lead to partition of land, resulting in fragmentation of these common pool resources making it difficult to manage the latter on a sustainable basis.

Lack of appropriate planning or apathy on the part of the government in the wake of unfolding situations is largely to blame for the present problems. Even where the administration has recognized the problem, it has failed to concretely address them in a pragmatic manner due to lack of political will coupled with economic limitations.

The key problems have been catalogued as soil erosion, siltation, flooding, depletion of soil fertility, diminished water yields, lowering of water tables and landslides affecting the common pool resources. Additionally, these problems have been considered as arising from the use of poor and in-adapted traditional shifting cultivation methods, excessive deforestation especially in water catchments areas, cultivation on fragile (steep) hill-slopes, setting of bush fires, overgrazing by cattle, and building of settlements.

This project was conceived, to serve as a prototype for the management of watersheds in order to serve the interests of the commons as the resources within the watersheds, which are collectively used by the entire communities, are fasting degrading.

Activities being carried out include: soil and water conservation practices, agro-forestry operations, *in-situ* and *ex-situ* conservation of plant species (*fruit trees, medicinal plants, spices, forestry tree species, etc.*) and ultimately monitoring of sediment pollution and water flow with the establishment of the 'climax vegetation". This paper will cover the activities being carried out at the research site and show how it contributes to the study of the *commons* and in the preservation of *common pool resources*.

Key words: *Prototype for watershed management, western highlands of Cameroon, common pool resources, sustainable agro-forestry practices.*

## *1. Introduction.*

### *1.1 Historical Background*

The custom of 'common' goods or Common Property Resources (CPRs) has had a long tradition in the Western Highlands region of Cameroon, where strong traditional rulers exerted their law for many generations. Then this area was basically a rural subsistence society until the early days of independence in the 1960's. At that time communal property resources were widespread and played an important role in sustaining rural livelihoods. The forests surrounding the village settlements were used to collect firewood (for cooking), hunting ground (for meat), timber and raphia bamboo (for house construction and roofing material), medicinal plants and herbs (for traditional healing), wild fruits and leaves (for food), water (for making mud blocks for house construction and household use), rearing of goats and sheep (for meat), forest environments for performing traditional rites, and many others.

Prior to the colonial era this region had a strong traditional setting. The population lived in a very close relationship with their natural environment that was preserved as the tribal groupings lived in equilibrium with nature. This ensured the integrity of the gallery and mountain forests and thus protected the waters and soils contained therein. This relationship between the people and the preservation of the environment has been forged over many generations within cultural and moral settings. The respect for these boundaries was ensured historically through a set of formal and informal rules and norms that were handed down from generation to generation and sustained through traditional and local beliefs. These traditional and local beliefs which were enshrined in the tradition, cultures and laws governing the people were executed with exactitude by strong traditional chiefdoms whose decisions were supreme. Through these traditional beliefs conservation of the environment was ensured as key ecological areas were recognized as the abodes of the gods, and the mountain, forest, river, lakes and underworld spirits and thus constituted environments to be kept sacred for traditional rites to honour these deities. These beliefs have persisted in some of the more powerful traditional chiefdoms in the area and hence till today parts of the natural environments are still held sacred for the performance of such traditional rites. This strong traditional respect for the natural world has over decades been largely responsible for the preservation of the natural environment in this region till the advent of independence in the 1960s.

### *1.2 Post Independence Era*

During the last five decades much development largely initiated by religious missions and the state has taken place in this area. These have been associated with the creation of new administrative structures, which with them has seen an increase in the road infrastructure, creation of new social services, building of schools, creation of cash crop plantations (tea, coffee), markets, etc. With these developments, the social setting

dramatically changed and urban areas emerged with a resultant concentration of population in these areas. The intermingling of people of diverse cultures and values in the urban areas and the increasing demand for agricultural produce resulted in an increased pressure on resources, and an expansion of the market economy in the local areas.

With all these developments, the power of the traditional rulers drastically diminished and with it their hold on their local institutions as the central government apparatus increasingly became manifest even in the most interior regions. Also, traditional structures which maintained law and order and preserved the natural resources and sort the good of all inhabitants in the village setting gradually broke down. The much expectations from progress from the substituting government machinery in the aspect of environmental preservation has been in most cases disappointing as individual goals and values took precedence over collective efforts towards development initiatives in villages.

The impact of these administrative changes has been very unsettling to most of the local areas. As the population concentration in the towns increased the human needs such as wood, water, food, shelter became pressing, with the result that the water, forestry and land resources in the peri-urban areas rapidly dwindled; the streams were polluted with attendant increases in diseases, and malnutrition in the towns. One of the reasons for the dramatic degradation of these resources is because the new settlers view themselves as strangers in their new environment and thus have little **incentive** in using the natural resources sustainably. In the villages one of the contributory factors to the natural environment remaining largely intact was the low population pressure on resources and its inaccessibility, but was also the consequence of a system of beliefs and values.

With the rapid expansion of the towns, and the lack of adequate planning on the part of the government, the injudicious use of water and land resources has led to the demise of the latter to a point where the situation has become very preoccupying.

Either due to apathy or lack of economic possibilities the increasing degradation of watersheds has not received the attention it required from the government. As such, watersheds in the peri-urban and urban areas on marginal and fragile lands have been systematically destroyed; the consequence has been increased land degradation associated with erosion, runoff, loss of biodiversity, and degradation of soil fertility and water of good quality, etc. Equally, the much diminished stream flow has suffered additionally from various forms of pollution: sediment, waste disposal, conduit for toilets, and even in some cases waste disposal sites by the government municipalities**.**

As awareness about environmental degradation and pollution issues are being echoed at the global scale, the local governments have hurriedly started convening conferences and workshops to address these problems, though most of the resolutions have ended up with the end of such seminars. Many NGOs have also mushroomed echoing the

environmental concerns, but apparently equally appear to bring little impact on a problem that seems well beyond their scope.

The management of these resources in the local context is plagued by many problems. The existence of many different tribal entities within short-range distances with different customs and beliefs is a case in point. For example 4-6 tribal villages speaking different dialects can be found within a small watershed area. Many of these tribes have different customs which affect the way these resources are managed along the line from the top of the watershed to the streams and rivers below.

Secondly, partition of land to the offspring on the death of the head of the household results in the mushrooming of fractionated individual land holdings within the watershed making management difficult.

Thirdly, disputes over ownership rights among offspring over inherited land is a further compounding factor in watershed management as such land can be sold to more than one buyer by the family members, thus breeding many conflicts.

## *2.0 Nature of the Problem.*

### *2.1 Basis of the Present Investigation*

The Western Highlands region due to increased demographic pressure has experienced an increasing environmental degradation of its land resources associated with cultivation of fragile marginal lands, erosion and runoff water and soil losses which bring about reduction in soil fertility and siltation of streams. The poor cultural practices and repetitive annual fires (Fig 1) destroy the watershed and reduce water capture. Increased cattle herds/unit area also brings about soil compaction (Fig 2), reduced infiltration rates leading to increased water runoff losses. Streams which used to have water all year round are now dry for more than 3 months during the year.

SNEC, the Cooperation supplying water to most municipalities while extracting the water, till now has no policy to ensure sustainability of its water sources through protection of the watersheds and improving its water yield and quality. The result is that in many areas supply of pipe-born water is cut off during the dry season as the water stocks in the aquifers cannot serve till the next rainy season. A similar situation exists in the rainy season because as most of the watersheds are cultivated, sediment pollution makes it difficult to treat the water in the catchments tanks fast enough to meet up with public demand. The result is that eventually pipe-born water supply is suspended for extended periods to ensure adequate water treatment. Often due to high demand for water from the public the water is pumped out without adequate filtration/treatment; the result is supply of water with high particulate concentration.


Fig. 1: Recently burnt area in the research park.

Fig, 2: Overgrazing results in soil compaction.

Given that the watershed areas constitute some of the best or most fertile lands, they are thus subject to increased population pressure to grow crops or other economic activities (Fig 3). Such areas would have been left under forest cover or planted to grass. These two options have some limitations.


Fig. 3: Degraded watershed area in the western highlands; lake is partially filled with sediments.

First, the farmers would not like to plant forest tree species that would only have a watershed protection role because they would derive little economic benefit from it in their life time. Thus, they prefer to cover the area with crops (often annual crops), which would negatively affect soil and water conservation through enhanced erosion, surface runoff and loss in soil fertility.

Secondly, if the land were left under grass it would capture rainfall and increase water infiltration. As this grass dries up during the dry season evapo-transpiration rates would be reduced hence conserving water in the aquifer. The problem is that during the dry season, most of the areas are set on fire either accidentally, to flush out game, to prepare land for the next crop, or to kill pests and diseases, etc. This thus removes the vegetation that would collect the water during the beginning of the rainy season thus reducing the amount of water collected in the aquifer within the year.

The main “Commons” issues here are related to the degradation of the watersheds and attendant losses in water supply to the public, the destruction of raphia palm bushes used for traditional rites, cultures and other economic ends leading to the drying up of springs and increased siltation in bottomlands. These lands in the peri-urban areas are rapidly being bought by wealthy individuals who have no notion of the importance of these resources to the public and their implications for the sustainability of the

environment. The raphia is systematically dug up and destroyed and the area backfilled and used for building of settlements.

Settlements in watershed areas lead to pollution of surface waters and groundwater from runoff of wastes, absorption of the contaminants by soil particles and, leaching of wastes into the aquifers and streams. These pollutants deprive the public of badly needed good quality water.
With the destruction of the gallery and mountain forests the forests which had a sacred value are gradually being eliminated, while plants with medicinal value that has served the population over generations are fast disappearing.

Climate change is resulting in increased temperatures leading to mosquito prevalence and frequent malaria incidence in areas where this problem was hitherto unknown. Overgrazing on fragile marginal lands is increasing soil degradation associated with soil erosion and runoff losses due to diminished water infiltration rates.

These problems affect the livelihoods and way of life of a whole community of people. A regulatory land use planning framework set up by the government that defines the different types of use activities that are permitted within the watershed area would be a way forward in addressing these problems of the 'commons'. This would ensure sustainable use of the natural resources for posterity and equally facilitate the judicious use of *common property resources*.

### *2.2 Common Pool Resources and Watershed Management in Cameroon.*

In Cameroon a number of property rights systems can be identified. These can be used to regulate *common pool resources* though by law any land that has no title deed belongs to the state. These include: Government property (*state owned*); individual property (*privately owned*) with limited access to others; group property ((***Communal***) *whose resource rights are held by the group - most common in the former traditional setting*); and open access in which there is no enforced property rights (*this category is a transition between the communal and government owned property but is fast becoming rare as most lands now have some type of ownership rights*).

The Government of Cameroon created an enabling environment for the conservation and rational use of biological resources through the enactment of the Forestry Policy of 1994 and it's Decree of implementation of 1995 and the 1996 Policy relating to Environmental Management and the accompanying Decree on Environmental Impact Assessment. Despite all these efforts that were put in place to balance Conservation with Development, low staffing, weak capacities and lack of sufficient means to function effectively within the concerned Ministries of Forestry & Wildlife and that of the Environment and Nature Protection have been an impediment to the dissemination of these important policies at community and grassroots levels whose lives and livelihoods depend on these resources (Forest Government Facility, 2007).

In order to achieve the government's goal of sustainable utilization of natural resources, the state has put in place an enabling environment for the creation of 'Community Forests". A ***Community Forest*** is an area of forest allocated by the Government to a particular community. The forest must be managed by the community itself in a way that benefits the local population and ensures that the forest will be preserved. The land still belongs to the Government, the latter signs an agreement with the communities stating that the community may enjoy all the resources and benefits coming from the forests. However, the community must take care of the forest, by tree planting either for enrichment, agro forestry, watershed protection or all. The community must respect the rules of use that have been agreed upon. These rules are set out in a ***Management Plan*** that is usually proposed by the community and must be approved by the Ministry. Despite all these efforts no significant progress has been made towards the conservation of *common pool resources* as envisaged by the Government law.

For the proper management of the watersheds, it is therefore necessary to understand what '*property rights'* each party has in terms of the ownership of the natural resources. However, due to the fact that the procedure for the acquisition/ attribution of property rights is still in a state of flux, often there is confusion and misunderstanding among planners, and administrators about the origin and nature of those rights and the extent to which decisions about legal use can be made without infringement of the rightful owner's rights. This is still a real problem in the management of *common pool resources* in the western highlands region and often has been a source of much litigation.

For example, during the construction of a public road, adjoining private property lands that are within the demarcated road confines can be used by the state without any form of compensation given to the owner if the former has not made any developments on it. Often, even when erected fences exist, their destruction by the road construction crew gives no compensation to the owner. Equally, during the laying down of water pipe lines, trenches can be dug across private property lands which constitute the shortest or most appropriate pathway for the road to pass. Often no compensation is given to the land owner by the local government on the premise that such work is for the development of the entire community. This arbitrary manner of action even with the existence of a legal framework to which the oppressed has little chance of seeking redress when it is the state or one of its branches that is implicated poses a serious problem in resource management.

### *2.3 Lessons from Studies Involving Watershed Commons.*

Discussions on the commons has been going on for decades, but the definition of the *commons, common property resources* and *common property* has been a subject of debate (Hardin, 1968; Ostrom et al., 1999; Berkes and Farvar, 1989; Mckean, 2000; Watt, 2000). *Common pool resources* are a class of resources for which exclusion is difficult and joint use involves subtraction which could lead to depletion (Berkes et al., 1989; McKean, 2000). For this class of resources some form of institutional mechanisms is necessary to address the excludability or subtractability nature of the common pool resources (Ostrom et al., 1999; McKean, 2000).

Many studies (Berkes, 1989; Wittayapak, 1994; Ostrom et al., 1999) have shown that the successful management of *common pool resources* involves resources that are effectively managed by small to large groups.

Watershed management is central to most developing country natural resource management strategies as the problem of good quality and quantity of water has become a worldwide concern. The importance of watersheds in the study of the commons stems from the fact that in most cases it contains competing multi-purpose functions such as settlement areas, agricultural lands, pastures, forests, surface and ground water which are linked together through hydrology (Kerr, 2006). Despite many efforts and studies to see how watersheds can be properly managed to optimize the use of natural resources to increase productivity, poverty alleviation and resource conservation a number of challenges have thwarted these efforts. These challenges have been catalogued as the uneven distribution of benefits and costs of technical interventions, multiple and conflicting uses of natural resources within watersheds, multiple and overlapping property rights regimes in watersheds, and the difficulty of encouraging social groups to organize a spatial unit within the hydrology (Kerr, 2006). The fact that hydrological linkages do not respect property boundaries poses further problems in collective action among all watershed users in watershed management even if the lands are privately owned (Ravenborg and Guerrero, 1999). Another complication stems from the fact that since water flows downhill decisions about natural resources upstream can have strong implications for resource use opportunities downstream (Kerr, 2006). This concern is equally true at the global level. The example of Ethiopia/Uganda and Egypt which have been a source of tension and continuing negotiations on user rights of the Nile River for a long time now is a case in point (Yerima and Van Ranst, 2005). This situation is evident in many areas at the local scale and is increasingly becoming a source of local conflicts.

In nearly all watershed projects, soil erosion control is often the most specific objective, though in some areas the natural resource base includes soil, water, agricultural land, forest and pastures or other environmental concern. Equally, most watershed projects begin by implementing soil and water conservation measures in the upper often hilly sections through vegetation of the area as bare ground are more prone to erosion. This vegetation increases water capture and infiltration into the aquifers through increased retention, rooting by trees and increased microbial activity that increases soil porosity and favors water infiltration (CTFT, 1979). Also, water harvesting can involve construction of small damps to capture runoff from upland areas after heavy floods. This reduces the silt loads of runoff water thus lengthening the life span of water harvesting structures by reducing siltation resulting increases in both surface water and groundwater recharge.

It has been argued that stone or vegetative barriers eventually lead to the creation of terraces which trap down moving soil which would be used for agriculture (Kerr, 2000). This assertion is only true if the origin of the sediments is from surface organic matter-rich horizons. However, what is often not considered is that when erosion attains an

advanced stage, the transportation and subsequent deposition of the more highly weathered poor subsoil material down hill can be a night-mare for the farmers down slope. This process is presently ongoing in the study area (Fig. 3).

Kerr (2006) also observed that since erosion in the watershed is subject to natural filters in the landscape, and much of the eroded material moves from one place to another without entering a waterway (Swallow et al., 2001), a watershed project could focus its erosion control efforts close to a waterway and eliminate much of its order work. This would imply that erosion control works in the upper watershed areas would be given little priority. Considering the fact that the upper watershed areas serve to trap water into the aquifer, and that as indicated above, deeply eroded upland areas eventually end up with poor subsoil material low in nutrient content, it is questionable if such a proposition would be really attractive.

Despite observations by Kerr (2006), a point shared by many other researchers (Calder, 2002), that planting of some tree species in watersheds may not have the desired effects of increasing water yields and even may have an opposite effect, it is also true that in areas with advanced erosion (gully), this may be the most plausible option. This has been proven to be true in China on *The Loess Plateau*, formerly China's sorrow but which presently is the Earth's hope (New Agriculturist 2008-2, file:////Cyber3/My%20Documents/New%20Agriculturist%202008...). This issue of *The New Agriculturist* also carries success case studies in Nepal (*Livelihoods in Nepal-No longer an uphill struggle*), the Sahel in Africa (*Bio-reclamation of degraded lands in the Sahel*) and in India (*Harnessing the healing power of nature-natural regeneration in India)*, where forest regeneration has helped stabilize soils, reduced soil erosion and increased water yields. In many of such areas building of terraces may be near impossible and the only options appears to be revegetation of the eroded areas as the first line of action.

As observed above, one of the importances of vegetation would be to halt further erosion or arrest eroded soil material in down slope areas though such vegetation might have negative effects in the upland areas through increased water uptake. The trapped soil could then enhance water infiltration and increase water yields in the aquifer apart from its role on agriculture if the right type of sediments is collected. Trade offs about the advantages and disadvantages of such action need however to be carefully weighted before costly watershed management structures are contemplated. It may also be argued that while the planted trees may have negative side effects in water yields, the favorable micro-climate effects obtained, the stemming of soil erosion and its associated effects may more than compensate for the water lost. Further, these trees, which serve as $CO_2$ sinks, may also enhance increased rainfall in the adjacent areas.

Many studies indicate that the upland watersheds are covered by pastures and trees rather than for agriculture. In most watershed studies a paucity of literature on the use of economic tree species that have medicinal/agricultural value (*e.g. fruit trees*) incorporated into watershed development schemes exist. Where this was the case, it would enhance adoption by most landlords in upland watershed areas. Such action

would be beneficial to up-hill and down-hill landowners, the one benefiting from income from sale of agricultural crops (*mainly fruit trees, spices, etc, that may or not be adaptable for watershed management*) and the other deriving benefits of increased water yields and sediment retention.

### *2.4 Recommended Approaches to Watershed Management.*

A communal participatory approach by the community has for long been advanced as the best way forward in watershed management. Other reports indicate a contrary view because in some cases the watershed areas may also be made up of '*landless people'* whose interests may need to make uncultivated areas off-limits to help them regenerate (Fernandez, 1994). In the peri-urban watershed area under study it has been observed that the population is very heterogeneous. Settlers that buy lands from the natives do not owe allegiance to the latter with the result that the properties which were formerly held as common goods are destroyed by the buyer after purchase. The destruction of raphia which has multiple uses (*making of bags, chairs, furniture, house construction, wine, etc*) in swamp areas is a case in point. The loss of raphia bushes is often associated with increased siltation and diminished stream flow in the basins. This in many instances has led to very high environmental degradation.

One of the handicaps to get appropriate solutions for the management of the commons has been the inability to find solutions acceptable to every situation and environment because of the socio-culture and economic differences that exist among nations. In Hardin's (1968) view, since freedom in the commons brings ruin to all, his response to the situation was that the commons could be privatized or kept as public property to which rights to entry and use could be allocated. However, many observations worldwide (Bhattacharya and Mittra, 2002) indicate that where state property is poorly delineated and high population pressures exist, widespread poaching of such government lands is ever the case. In Cameroon forests are state property. In most cases state ownership is often hardly associated with successful management as most people view it as property belonging to every citizen irrespective of origin. As such enforcement of legislation on use rights is often not very successful. Bhattacharya and Mittra (2002), observed that increasing population pressure and immigration of outsiders, greater commercialization of the products of resources, and technological change that encourage alternative use of land contributed to increased differentiation within communities that reduces communal cohesion and uniformity of interest. In agreement with the latter, in the context of the western highlands area, it makes sense for the state to continue to play a role in resource conservation and allocation among communities of users as conflicting interests of use of such lands by individuals could lead to overuse and degradation.

The state or local Council could make legislation to define a land use plan which would define the activities that can be carried out in such areas by motivating sustainable resource use and putting in place dissuasive measures for overuse or misuse of such resources. This is probably the most plausible manner to serve the interests of the poor who have already sold all rights to their lands.

The lack of compensation to the people in the upper sections of the watershed by the beneficiaries in the lower part of the watershed has been indexed as a drawback in the implementation of watershed activities (Kerr, 2000). There is need to propose a watershed management practice which while preserving and increasing water yield and quality would equally provide the farmers with immediate economic and agricultural benefits. Unfortunately, technology or technological packages which provide optimum vegetation mixt of short-term economic benefit, which while increasing water yield and quality would equally provide economic benefits to the farmer are inexistent in the study area.

### *2.5 Need for Watershed Conservation in the Western Highlands Region*

The watershed areas constitute the most prized agricultural lands in the area. As such it is heavily cultivated. The land in the area is also very fragmented. This aspect is a major constraint in a holistic sustainable management of the watershed. Further, land is owned collectively by family members and selling it requires the consent of the rest of the family members; consensus on the matter is often difficult. The present surface area of the Park (3.5 ha) has been acquired over a period of 10 years from 7 family entities. Some parts of the area are subject to a lot of litigations of ownership, making it impossible to carry on with the research activities. Further, the local traditional authorities and quarter heads assert their authority over the same piece of land making exploitation of the land difficult.

While it is clear to many people that the water and soil resources and biodiversity are steadily diminishing, a committed effort has not been put in place to address these issues in the study area, a situation which is true for most parts of Cameroon. The main concern appears to be the growing of the necessary food to feed the family on an increasingly diminishing unit of land/family unit, which is equally increasingly giving lower and lower yields/ unit area due to loss in fertility and poor cultural practices. Thus, the action of conserving biodiversity and planting of trees, whose immediate benefits cannot be established are a deterrent to the adoption of biodiversity and watershed regeneration process.

The reluctance to adopt innovative packages whose effects can only be felt in the long run makes the resolution of this problem difficult. The result has been increasing land degradation, diminishing crop yields and dwindling water resources which are often sediment and waste polluted.

With the above in view, it was necessary to initiate research which is broad-based and has a holistic approach to the resolution of the multi-faceted problems within the watershed area, by introducing innovative sustainable technological watershed management systems through adaptive agro-forestry systems.

This paper seeks to address this problem by proposing technological packages which would increase the resource base of the upland people of the watershed through adaptive agro-forestry research.

A comprehensive watershed management plan, which would completely reforest the watershed with appropriate vegetation species, appears to be the most plausible solution. This reforestation would protect the soil against erosion, regularize the water flow within the basin, and protect and improve the watershed through its influence on infiltration rate associated with: increased interception and breakage of raindrops and reduced splash and runoff, aggregation of primary soil particles by organic matter, roots, which act as conduits for water down the soil, and organisms, which burrow the soil enabling water infiltration.

***OBJECTIVES:*** ***The overall objective of this project is to create a watershed area, which would be covered with medicinal plants, fruit trees and other plant species of economic value, which would be of interest to the local population, and that would protect the watershed leading to increased and sustainable water yields****.*

The specific objectives are*:*

- Determination and modeling of the optimum mix of different tree species that would be most adaptable and appropriate for reforestation and watershed management purposes in the area to improve the watershed's physical condition (water quality and quantity, flood prevention and sedimentation, etc).
- Create a gene bank (*in-situ* and *ex-situ* conservation) for collection and research on medicinal plants and other plants of economic value, given that most forested areas are disappearing with resultant loss of these vital species. Observe adaptability of plants species not endemic to the region to ensure sustainable development within the watershed.
- Provide an environment for water management research (micro-catchments basins, water retention holes, mulching effects, etc).
- Create a prototype for watershed management, which will ultimately serve projects in similar agro-ecological zones of the country undergoing systematic destruction.
- Provide increased water yield potential for the small stream in the farm area, which would serve as a demonstration site to the local population on the advantages of watershed preservation.
- Monitoring of soil organic matter accumulation and nutrient cycling over the years in the environment with progressive establishment of the plants to improve the quality of the land and forests.
- Monitor changes in water levels across seasons and increases in water yield with progressive vegetation establishment.
- Sensitization of local population on biodiversity and ecosystem preservation for sustained water yields through demonstrations during field days thus improving the community's awareness, skills, and involvement in watershed management.

## *3.0 PROTOTYPE FOR WATERSHED MANAGEMENT*

### *3.1 METHODOLOGY*

#### *3.1.1 Study Area*

*Location and site characteristics*

The experimental site is located at the Yongka Research Park in Nkwen, Bamenda, NW Province of Cameroon, which is part of the Western Highlands of Cameroon with altitudes of about 1000 m prevailing (Fig. 5); slopes vary from 1 to 45%. The Western highlands are part of the so-called 'Cameroon line' of weakness with tectonically uplifted zones. Geomorphologically, the area has a staircase configuration dominated by high lava plateaus.

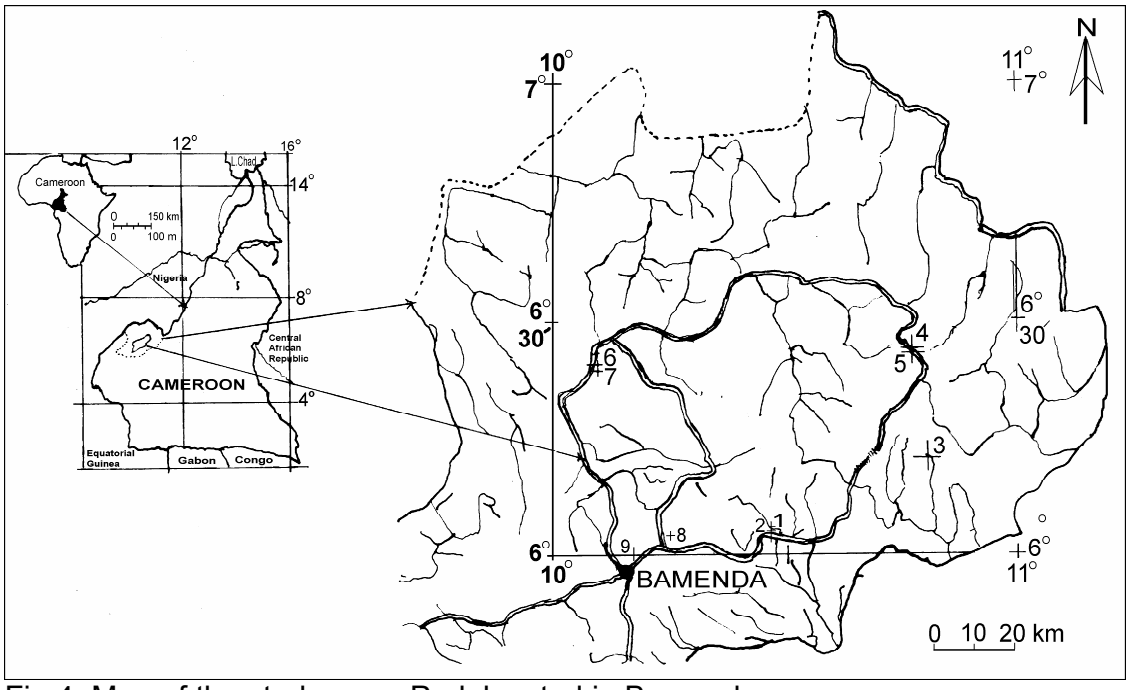


Fig 4: Map of the study area. Park located in Bamenda.

Geologically, the parent material is composed of granite, basalt and alluvio-colluvial materials, with the granite dominating.

*Vegetation*

With increasing population pressure much of the natural forest vegetation has degraded to secondary formations, or has been replaced by more or less wooded grasslands and by agricultural land; this process is advanced most in areas with least relief. *Hyparrhenia* and *Sporobolus* grasslands occur above 1500 m; *Hyparrhenia* and wooded savanna below 1500 m; *Pennisetum purpureum* in seasonally flooded grasslands; and

*Imperata cilindrica* on fallow lands. The valley flows are covered with raphia bushes which are rapidly giving way to farms and housing estates. Land use in the adjoining area is largely fragmented individual plots ranging from about 20x30 m sq m to about ½ ha, using a slash and burn and "***Ankara***" (*Ankara is practice whereby grass is covered in ridges or beds with soil and set on fire, the whole bed slowly burns and the soil is charred leaving behind ashes which are very rich in readily available nutrients but very susceptible to leaching*) subsistence farming systems. With increasing population pressure, part of the flat to slightly undulating areas formerly put to cattle grazing are giving way to farmlands and habitations with the cattle relegated to the adjoining nearby more elevated fragile marginal lands.

*Climate*

The climate in the area is distinctly seasonal. There is one rainy season and one dry season. The amount of rainfall varies from less than 1700 mm in the Ndop plain to over 3000 mm in the highland areas exposed to the west; rainfall at the research site averages about 2500 mm/year, with peak occurring in September. Mean annual temperatures at the research site average 19-22 $^{0}$C and are closely related to altitude with small differences linked to topographic position.

*Soils*

The soil patterns in the study area are complicated by the variety of rock types and landforms present and the overall hilly to mountainous terrain. Soils differ over short distances in such characteristics as texture, effective depth, gravel content, compactness and water infiltration rates aggravated by prior cattle rearing activities. Important differences in chemical characteristics and soil fertility exist, and are related to parent material and stage of soil development and would impact on forest regeneration.

The dominant soils in the area are: **Inceptisols** (*soils with minimal development found in lower slope positions*); **Oxisols** (very highly weathered soils with low nutrient contents); and Entisols (*young soils which have no definite horizons yet; found in very steep slopes and in alluvial and colluvial materials)*. Generally, these soils are compact and dense and have low nutrient status with soil acidity and high aluminium levels as limiting factors for optimal growth; steep slopes are an erosion hazard and unsuitable for sustained crop production.

*Zoning of the study area*

To stop fires (*both natural and man-made*); halt soil compaction due to overgrazing; reduce destruction of the vegetation within the watershed associated with deforestation for wood, agriculture or other purposes, which activities tend to increase erosion runoff, flooding frequency, increased sediment loads in streams and rivers, slope instability, loss of water and nutrients ( UNDP, 1994), the watershed catchments was fenced off using barbwire, which was subsequently reinforced with life sticks and cypress trees.

*Collection of medicinal plants, economic plant species and fruit trees*

Plants were obtained from plant nurseries in the urban areas and by nursing of seeds collected from all over the country.

*Experimental Design for Planting of the Trees and Crops*:

- Experiments on the responses of the two passion fruit (*Passiflora edulis* Sims) varieties, papaw (*Carica papaya L.*), cashew (*Anacardium occidentale L.*), and rattan (*Calamus spp.*) to different levels of manure application were carried out following a Randomized Complete Block Design (RCBD).
- For the experiments on the optimum mix of vegetation, four tree varieties including Cinchona (*Cinchona spp.),* Avocado pear (*Persea americana* Mill), Mysopsis and Plum (*Prunus domestica* L.) were used*; a RCBD e*xperimental design was used. Due to the compact and dense nature of the soils, profile modifications was done by digging holes for planting of the trees measuring 70 x 70 x 70 cm deep. These holes were back-filled with organic materials to provide nutrients and increased water retention capacity and an appropriate environment for plant growth. The different tree species were planted in pure stands and in varying mixtures using 4x4 m planting spacing.
- Experiments on the effect of profile modification on plant growth was carried out using different hole sizes to include 40x40x40 cm, 60x60x60 cm and 80x80x80 cm spacing. Grafted or marcotted pears, mangoes, and plum trees (pictures), which have potential for use in the watersheds and which start yielding within 3-5 years and would give immediate economic benefits to the farmers in the watersheds were used.
- Tree growth and performance are being determined from plant height, plant girth and appearance (Fonweban and Houillier, 1995).

*Soil sampling and Laboratory Analysis*

Soil analysis at the research sites will be carried out to evaluate tree growth performance, as a function of the variability in the soil properties, for subsequent technology transfer of the research results to potential watershed establishment and regeneration areas. Representative soil pedons will be described, sampled and characterized following standard methods (Soil Survey Staff, 1975, 1984; Soil Conservation Service, 1984; FAO, 1990; and Pauwels *et al.,* 1992).

### *3.2 Present Activities at the Site*

- Collections of fruit-trees, spices and forestry trees species of different provenance to observe species adaptability and identify those most adaptable for vulgarization for watershed management (> 30 plant species including fruit trees and spices have been collected).
- Conservation of native tree species (in-situ and ex-situ conservation).
- Collection of different Cameroon export crops (coffee (*Coffea spp.*), tea (*Camelia sinensis*), rubber (*Hevea brasiliensis*), cocoa (*Theobroma cocao*), etc), spices and medicinal plants species for teaching purposes.
- Collection of variable plant seeds and nursing of seedlings for transplantation and distribution to farmers (done near the house).

- Carrying out experiments on the response of rattan, mulberry fruit plants and different varieties of passion fruits to different levels of organic manure (cow dung, decomposed grass material, pig manure) applications.
- Water conservation management methods (micro-catchments water basins, water retention holes, mulching, etc, and fruit yield responses (plums, mangoes (*Mangifera indica*), pears, etc) to variation in hole sizes).
- Maintenance and expansion of a gallery forest and a savanna ecosystem.

### *3.3 Problems Encountered*

Many problems have been encountered in the execution of this study ranging from the acquisition of land through the collection of planting materials to the digging of holes and planting of plants within the experimental sites. The major problems can be catalogued as follows*:*

- High cost of land acquisition.
- Near yearly damage to planted trees from man-made wild fires and fires set to regenerate grass pastures for cattle, to catch rat moles or intentional destruction.
- Encroachment by cattle and man and destruction of present forest by people looking for firewood and raphia bamboos.
- Limited land in the watershed area, which is in competition with alternate uses (cattle grazing, crop cultivation (*vegetables, maize, cassava, Irish potatoes, etc, which do not perform very well under vegetation*)), which are incompatible with the forest regeneration objectives.
- Acquisition of additional land is constrained by the fact that the land is fragmented and also owned collectively by many family members. As such, consent of all family members is required before the land can be disposed of.
- Many conflicts of land ownership exist; land is often sold to more than one buyer at a time bringing about a lot of conflicts and litigations.
- High costs of establishment of fence around the park to keep out intruders.
    - The eucalyptus poles to which the barbwire fence is attached is removed by intruders for wood;
    - The cypress plants planted as fence rows are easily consumed by fires and also attract snakes which scare off some workers;
    - Other life trees do not establish easily due to the compact and dense nature of the soils which inhibit fast growth;
    - Theft of barbwire along the fence row. There is need to try other plant species such as thorny shrubs and sisal helm.
- High costs of labor for maintenance and opening up of new areas (*weeding, cultivation, digging of holes, preparation and application of mulch material, clearing, fire tracing, mulching, etc)*.
- Difficulty in collection of the different planting materials e.g. seeds and plant cuttings for vegetative propagation.
- High costs associated with the purchase and/or collection of planting materials from far distances to the research site.

- The compactness and denseness of the soils of the site which are of granitic origin with low native fertility are an impediment (picture).
- Destruction by termites of some plant species (ornamental palms), and difficulty in the tillage of the termite mounts.
- Where the farmers would have managed the watersheds themselves, the fragmentation of the land makes it difficult to propose appropriate and sustainable forest regeneration packages for watershed management.
- Difficulty to contain drainage water channeled by farmers situated above the Research Park; this water causes a lot of erosion damage to the site.
- High cost and difficulty of transporting material and personnel to the site.

### *3.4 Conclusions*

With concerted efforts, establishment of watershed is practical and possible. Developing and conserving watersheds in the area is a challenge. These challenges are largely in form of:

- Human destruction of the watersheds for fuel wood, farming activities, etc.
- Frequent fires, both accidental and intentional.
- Infertile or compact and dense natures of the soils, which impede root penetration and plant growth.
- Different competing uses for the limited land resources.
- Non availability of appropriate planting materials.
- High cost of acquisition of land.
- Problems of land ownership and inheritance with the result that the same piece of land is sold to more than one buyer resulting in much litigation.
- Land that is fragmented, and owned by many individuals so that taking decisions concerning the use of the land would entail many interventions.
- High labor costs for maintenance and upkeep of the watershed.
- Apathy or lack of knowledge about the importance of watershed protection and conservation.

### *3.5 Recommendations*

- Due to the high cost of the resources involved, it is absolutely necessary for the government or the local Municipal Councils to intervene by bearing some of the costs for the establishment and upkeep of the watersheds.
- Selection of appropriate tree species for given agro-ecological zones and their optimum population densities would be useful in watershed conservation efforts in the area.
- Exclusion of animals and man and use of appropriate soil and water conservation methods would enhance establishment of trees in watersheds.
- Information on climate, vegetation, parent material, relief and soils of a given area are useful in plant species selection and establishment of vegetation in the watershed area and for technology transfer of findings from a given site to similar agro-ecological zones.

- In view of the wide scale degradation of watersheds in the area, and considering the consequences that have been observed historically due to neglect or apathy in the old civilizations of the world, it is imperative for immediate and sustained efforts to be initiated to tackle this situation. Approaches to resolve the problem would be multi-faceted:
  - Sensitization of the local population and Municipal Council on the way forward.
  - Creation of a reward system for those actively engaged in sustainable watershed management practices while inflicting penalties on those not complying to appropriate watershed management practices.
  - Answer such questions as: Do people who buy their land have the right to do whatever they want with the land, even if it affects the whole population? What are the types of practices that the owner may or may not carry out there?
  - There is need for the property to be bought by the government and managed collectively with the local population for the common good so that it is given the protection it deserves when it is observed that management by individuals is not sustainable.
  - Local communities could also buy such land and manage it sustainably to insure sustainable water supplies of good quality and increases in the agricultural production.
  - NGOs instead of only planting trees could see to it that they also buy lands and insure that these lands are protected for the benefit of the commons.
  - Privatization where possible by philanthropists could result in better management of the watersheds for the good of all the population.

### 3.6 Contribution of Proposed Project to the Study of the Commons.

The project will contribute to the stock of knowledge on watershed management; on the optimum vegetation mix and the appropriate tree species that would be used for watershed management; on the adaptability of some tree species of economic value, which are alien to this environment; and on the creation of a gene bank for medicinal plants at risk of disappearance. All of these aspects are crucial in the management of CPRs. Because of debates dealing with resource values in the area uphill and down-hill of the watershed intervention area, this work offers some information on possibilities to have increased revenue in watershed uplands. The information obtained from the study will be useful in formulating policy matters related to watershed management in similar ecological zones and in replicability/scaling up of this activity to different areas. It will also provide a great opportunity for students in forestry/agroforestry, agriculture or those carrying out research on medicinal plants to have hands on experience on the cultivation of these crops. This project will contribute to green spaces in the locality leading to the regulation of local climate, decreasing $CO_2$ levels in the atmosphere, and thus, solving some of the global climate change problems as well as problems related to the management of common property resources.

The project has been going for more than nine years. The multitude of specific objectives mirrors the complexity and the interwoven and multi-disciplinary nature of the research problem. The present study greatly contributes to “study of the commons”

through a holistic approach, which examines the water issues, how forest regeneration has implications for both increased water yields and biodiversity conservation and rehabilitation, which indirectly impact on the health of the community. The gene bank for collection of medicinal plants and fruit trees has implications for present and potential future health needs, while the soil and water conservation techniques and the use of organic manure have great implications for increased crop yields. Increased crop yields, adequate water supplies, green spaces in the peri-urban areas increase the quality of life of inhabitants in the adjoining urban and peri-urban areas. Many studies on the management of common pool resources (Ascher, 1995, Bhattacharya and Mittra, 2000), recommend a system of incentives to reward the sustainable use of forest resources.

## 4.0 OVERALL CONCLUSIONS

Watershed management in the area, as is the case in most developing countries, is still in its rudimentary stage and is given low priority by governments, with very few resources affected to it despite its importance. This work offers the possibilities for farmers in the watershed areas to use their land resources sustainably thus improving soil and water conservation on farm and ensuring sustainable water yields through time. If successful it could take care of one of the main problems of the 'Commons', that of preserving the watersheds, having sustainable water supplies and deriving economic benefits both uphill and downhill. This would resolve the health problems linked to poor water quality, pollution, etc, reduce disease risks (malaria), improve the standard of living and wellbeing by providing an environment for eco-tourism and students' learning and research. The farming methods being tested involve minimal soil disturbance (only hole in which plants are planted are disturbed) which have the effects of reducing soil erosion and runoff losses.

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