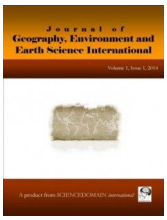

Journal of Geography, Environment and Earth Science International
5(2): 1-10, 2016; Article no.JGEESI.23091
ISSN: 2454-7352

SCIENCEDOMAIN *international*
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Paradigm Change for a Better Vegetation Management in a Context of Land-cover Deterioration: The Case of Gaoua District (Burkina Faso)

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Authors' contributions

This article designed by author YSCS is based on master's thesis of author RS, supervised by author DECD. Author YSCS wrote the first draft. Data collection and analysis have been done by authors RS and DECD. The literature searches and result discussion have been done by author YSCS. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JGEESI/2016/23091
Editor(s):
(1) Pere Serra Ruiz, Department of Geography, Universitat Autònoma de Barcelona, Spain.
Reviewers:
(1) Bintoora K. K. Adonia, Nkumba University, Uganda.
(2) Anonymous, Virginia Tech, Blacksburg, USA.
(3) Nilay Kanti Barman, Hijli College, India.
(4) Siva Kumar, Centre for Development of Advanced Computing, Pune, India.
(5) Yahya Farhan, University of Jordan, Amman, Jordan.
Complete Peer review History: http://sciencedomain.org/review-history/13107

Original Research Article

Received 14th November 2015
Accepted 13th January 2016
Published 28th January 2016

ABSTRACT

Forest resources has experienced natural and anthropogenic pressure various adverse effects manifested by their continued degradation over the years in the district of Gaoua. This degradation is continuing in spite of policies and many investments aiming at changing this dynamics on the basis of a diagnosis which determined its causes. Why is this regressive trend outstanding? Which solutions can be considered? The objective of this article is to contribute to a better understanding of land cover degradation dynamics in the district of Gaoua in revisiting degradation factor hierarchy

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to offer a new orientation for vegetation cover protection policy.
Remote sensing, spatial analysis, social surveys and field observations through toposequences were carried out.
We retain from this study that the degradation is and remains multifactorial and that the causes formerly identified are always actual: agricultural production system, climatic deterioration, using wood as main energy source, timber use in large scale craft production (building construction, production tool etc.).
What has changed is their respective contributions. Now firewood comes in first place among land cover degradation causes due to population growth and energy needs; efficiency of agricultural policies that have led to a gradual intensification of agricultural systems and new production tool importation.
Beyond the continuation of agricultural intensification, preservation of vegetation cover requires, in this context, to fundamentally review the issue of access to energy. The development of alternative energies such as biogas, solar energy, wind energy and improving energy consumption efficiency are required. It is therefore urgent to rethink the question of vegetation resource protection by mainstreaming, as in agriculture, population energy needs.

Keywords: Firewood; wood fuel; vegetation management; land cover; Burkina Faso.

1. INTRODUCTION

Environmental degradation over recent decades is a current issue in Burkina Faso. Many natural factors (rainfall whims, duration of the rainy season, drought pockets...) and especially anthropogenic (agricultural clearings and pasture, firewood cutting) are the causes of this upheaval resulting in the reduction or disappearance of plant species, area denudation [1,2]. FAO indicates that nearly 46% of the countries are affected by this phenomenon [3].

The agricultural sector has long been pegged as the main degradation cause with over 360 000 ha of clearings per year [4,5]. But for a number of years, efforts have been made towards agriculture intensification. The launching of a three struggle policy in 1985 has enabled a real awareness on degradation situation and also contributed to a greater awareness raising [6,7]. The adoption and implementation of Agricultural Structural Adjustment Program (Programme d'Ajustement Structurel Agricole-PASA) in 1992 also contributed to production modernization and diversification by subsidizing agricultural inputs and improved seed use. Therefore, during the 1995-2005 period, cereal production grew by 4.63% per year according to statistics from the Direction Générale de la Prévision et des Statistiques Agricoles (Department of Agricultural Forecasting and Statistics-DGPSA). Moreover, the country has adopted since 2000 the Strategic Framework for the Fight against Poverty (SFFP) aiming at ensuring sustainable, equitable and quality economic growth. This strategy was reviewed in 2003. Today, the SFFP has given way to the Strategy for Accelerated Growth and Sustainable Development (SAGSD). Records in total included a soaring modernization with increased production, reduction of sown areas, and application of tree crops in some areas [8,9].

Despite these satisfactory results in agricultural area, there is a persistency in vegetation cover regressive dynamics.

Strategies to fight against the degradation of the vegetation cover are built on the then statement, which placed in the foreground agriculture as main factor. With evolution characterized by a progressive intensification of agricultural production systems, there was a reversal in the contribution of different factors in parts of Burkina Faso as the district of Gaoua. Hence the need for a paradigm shift in addressing the growing problem of vegetation degradation in those areas to make them efficient. This raises the problem of adequacy in vegetation resource conservation policies mainly in zones situated outside protected areas. This study is part of the problem of changing geographical context impact on the effectiveness of natural resource conservation strategies / policies in general.

This study has as main objective to contribute to a reflection on protection policies for vegetation resources outside protected areas. In specific terms, this comes to:

- describe the process of evolution in vegetation between 1992 and 2010

- Analyze the dynamics in vegetation evolution factors in line with vegetation natural resource conservation policies
- carry out policy review to address biophysical and human environment evolution.

2. MATERIALS AND METHODS

The methodology adopted for this work is composed of four units: The literature review, remote sensing and geographic information systems, field observation and social surveys:

- Secondary data was collected from through gray literature pertaining to policies on environmental protection, to methodological approaches and to study site.
- Remote sensing and geographic information systems have enabled the production and spatio-temporal analysis of vegetation. Collection of spatial data on vegetation was made by supervised classification of Landsat TM and ETM+ images in 1990, 2000 and 2010. The nomenclature used is Corine Land Cover suitable in Burkina case to achieve Land Tenure Database (BDOT) 1992-2002 [10,11].
- Field observation was made by carrying out two toposequences, encompassing the different types of vegetation and land tenure. The first toposequence, 4.17 km long goes through Gaoua city from borough N° 1 to borough N° 3, across Tièlkan Northwest / Southeast direction and the second toposequence that of Djindjinlè is 3.76 km long from Southwest / Northeast direction. On these toposequences complete floristic inventories have been carried out on 25 m x 25 m plots [12].
- Social survey was carried out to collect and analyze information on people perceptions, the implementation of policies on vegetation resource conservation. It was conducted with the following target groups: producers, transporters, and consumers. In addition, a questionnaire was administered to 210 household heads (2.2% of the targeted population). Semi structured interview of direct administration was conducted with producer organizations and transporters in the district. Materials used to carry out this study are:
- for software, Arcgis, Envi, the pack office of Microsoft)
- For survey, chains of arpentaire, GPS, topofil, compasses, collected tools like survey sheets, interview guides
- For analyzing data, secondary databases.

2.1 Gaoua District: Study Area Presentation

Gaoua district is located in south-western region of Burkina Faso, specifically in the Poni province, between 3°22' and 3°06' west longitude and 10°10'and 10'35" north latitude. It covers an area of 874 km² and is the capital city for both the region and the province Fig. 1.

Gaoua is subject to a tropical climate of South Sudan type characterized by alternating two seasons. Rainfall varies between 800 and 1400 mm in six to seven-month rainy season.

The district generally has savannah vegetation with shrub dominance.

3. RESULTS AND DISCUSSION

3.1 Land Cover Dynamics from 1990 to 2010

The diachronic analysis of land tenure, derived from Landsat images of 1990, 2000 and 2010 enables to track trends over twenty years on areas of different vegetation types in the district of Gaoua.

In analyzing the maps above we can observe a significant reduction in areas devoted to agriculture between 1990 and 2010. Indeed, crop areas that are perceived very well in the north and east of the district in yellow experienced a noticeable reduction in 2010 as you can see in the graphic below.

A decrease in agricultural production area is observed, from 18.3% to 16.76% between 1990 and 2000, and finally, from 16.76% to 13.64% between 2000 and 2010. These areas occupied in 1990 by agricultural zones are converted in 2010 to the shrubby savannahs while they have been fitted out on wooded savannahs as evidenced by the reduction of wooded savannahs to the benefit of fields in 2000. The table below shows the statistics of different land tenure units in 1990, 2000 and 2010.

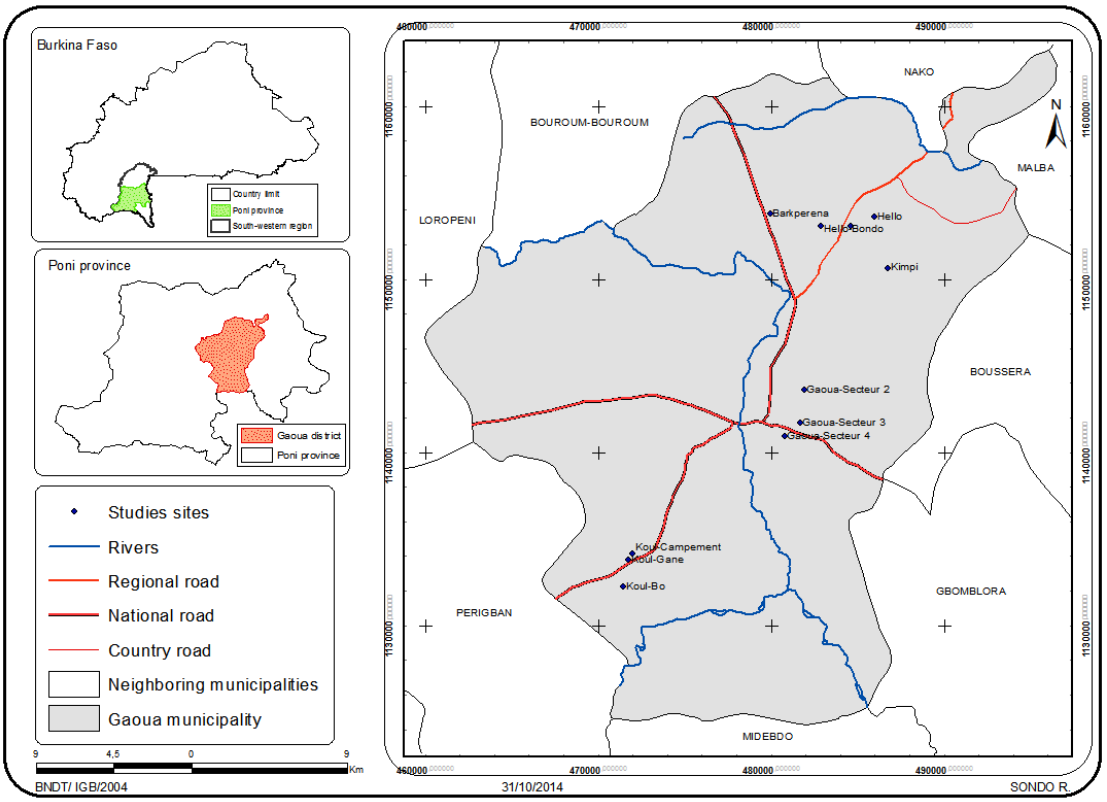

Fig. 1. District of Gaoua situation

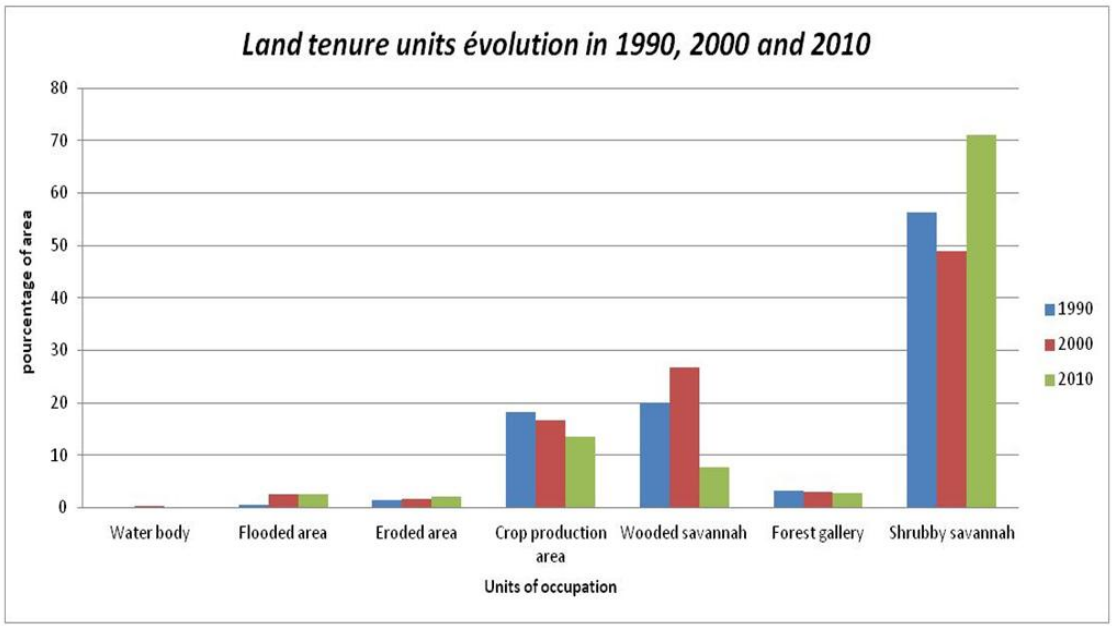

Fig. 2. Land tenure evolution in the district of Gaoua

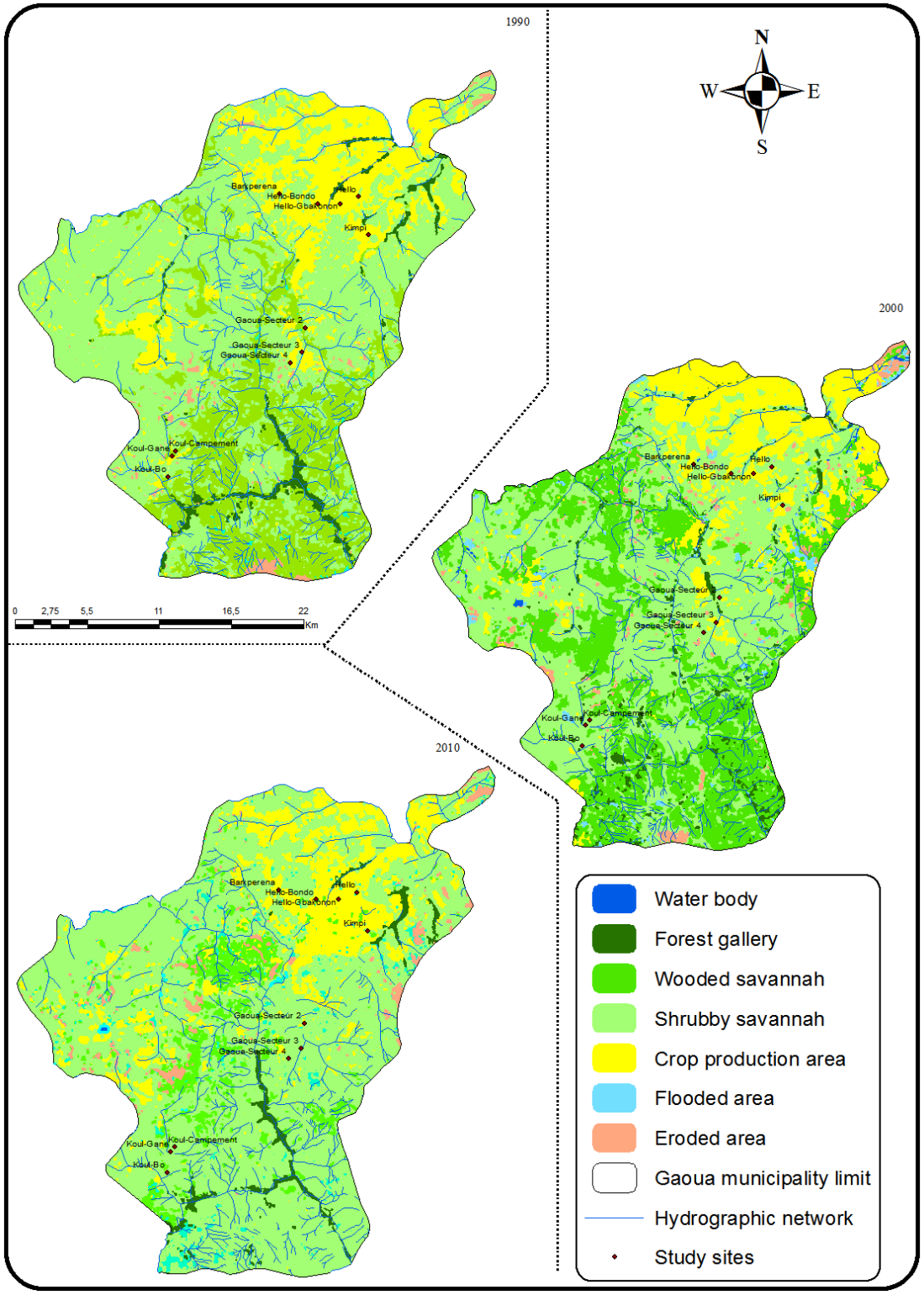

Fig. 3. Land tenure units in the district of Gaoua

Table 1. Land tenure units in 1990, 2000 and 2010

Units of occupation	1990		2000		2010	
	Area/ ha	Percentage (%)	Area/ ha	Percentage (%)	Area/ ha	Percentage (%)
Forest gallery	2821.53	3.23	2657.88	3.04	2391.53	2.73
Wooded savannah	17564.35	20.1	23473.96	26.87	6816.55	7.7
Shrubby savannah	49154.27	56.24	42715.78	48.88	62100.77	71.04
Crop production area	15993.04	18.30	14650.45	16.76	11939.28	13.64
Flooded area	575.01	0.66	2201.25	2.52	2149.5	2.53
Eroded area	1292.72	1.48	1396.72	1.6	1963.16	2.25
Water body	00.00	0.00	304.02	0.35	39.46	0.05
Sum	87400,91	100	87400,01	100	87400.53	100

From Table 1, it emerges that:

- In 1990, shrubby savannah was the dominant unit (nearly 56.24% of the total area), it is followed by wooded savannah (20.1%).
- In 2000, shrubby savannah experienced a slight decrease going down to 48.8% and the wooded savannah area increased by more than 6%.
- In 2010, all units, except for eroded areas, experienced a decline in favor of shrubby savannah

which now occupies nearly three quarters of the district area.

The district land cover experienced a regressive evolution from 1990 to 2010. In more or less dense vegetation is gradually witnessing a conversion of various vegetation units into shrubby savannah and an increase in area of eroded zones. The presence of land degradation was confirmed by local population; Over 89% of the respondents confirmed this observations during the surveys. All the respondents producing firewood argue that forest resource has become difficult to acquire. They must, in fact, travel long distances (between 4 and 40 km) for supplies. These results showing the reduction of crop areas are challenging the primacy of agriculture as the foreground factor in land cover degradation. It reflects a positive evolution of production systems with improved yields since an increase of more than 4% in production on smaller agricultural area was noted.

Given this situation and the importance of logging in this area, we think it could significantly contribute to vegetation deterioration.

3.2 Firewood, the New First Cause of Land Cover Degradation

FAO shows a 778 000 ha decrease in forest areas between 1995 and 2008 [13]. Long time considered as major degradation causes, rainfall vagaries and agriculture are no longer the main factors of land cover dynamics. There is firewood which is Burkinabe households' primary energy source. More than 5 million m^3 of wood are consumed annually in Burkina Faso [14-16].

Furthermore the amount of used charcoal has increased by more than 36 521 tons between 2000 and 2010 [17,18]. In the district of Gaoua, charcoal production, which was limited to deadwood collection, is nowadays an activity that involves over 98% of rural women [1,19]. Field surveys revealed that the district is served by its surrounding villages with up to 40 km radius. More than 253 production sites were identified. Indeed, from results of score and different weighing made on retail sites, the amount of wood consumed in the district of Gaoua is estimated at 55,602.01 tons per year; of which there are 33,510.01 tons of firewood and 44,184 of coal quintals knowing that 5 kg of charred wood produces 1 kg of coal.

From the Table 2, it appears that firewood consumption in the district of Gaoua gained exponential increase over the last two decades. In the Fig. 4, we can clearly observe an increase of yearly consumption, from 1990 to 2010, in spite of the logarithm scale.

From about 10,592.76 tons in 1990 [20], it is estimated at nearly 13,822.15 tons in 2002 [21] and then it rose to 55,602.01 tons in 2013, which is respectively an increase of 3,229.39 tons from 1992 to 2002; 41,779.86 tons from 2002 to 2013. In short we note a consumption increase of 45,009.25 tons in 21 years (between 1992 and 2013) or over 400%. The absolute values of consumption of charcoal and wood hide badly the increase of the consumption by person. In Fig. 5, we plot the evolution of specific

consumption of wood and charcoal. The increase of consumption seemed to not only a problem population expanding but also an increase of quantities needed by person.

Table 2. Annual and daily specific firewood and charcoal consumption in the district of Gaoua

	1990		2000		2013	
	C/year ton	C/day/person kg	C/year ton	C/day/person kg	C/year ton	C/day/person kg
Wood	10 592,760	0,71	13 822,154	0,91	33 510,017	1,74
Firewood	-	-	289	0,13	441,84	0,23

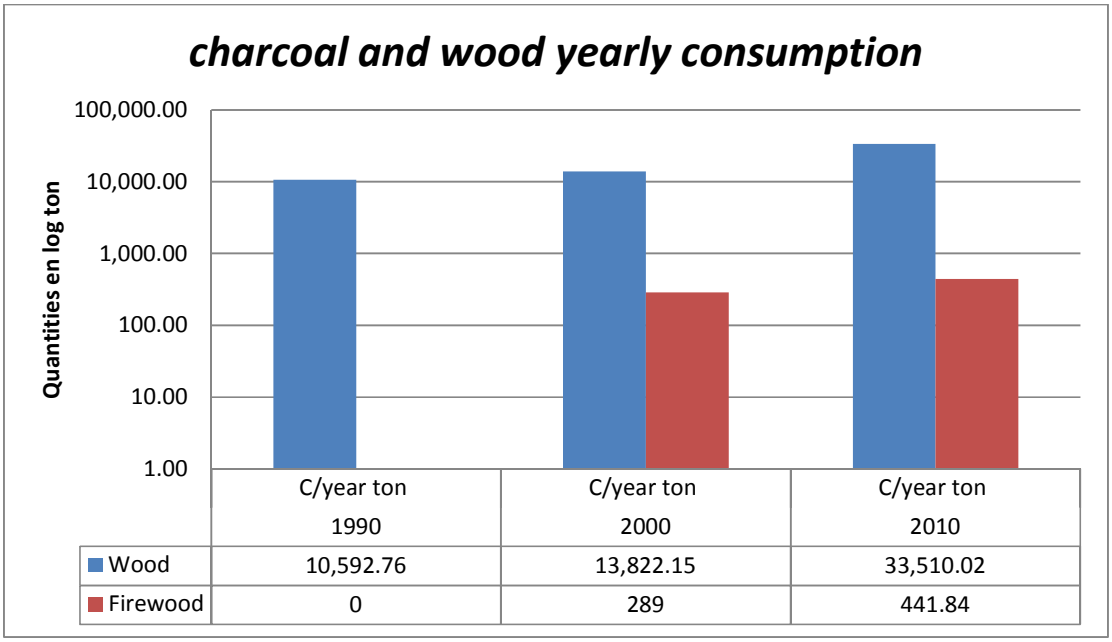

Fig. 4. Evolution of charcoal and wood consumption in Gaoua district

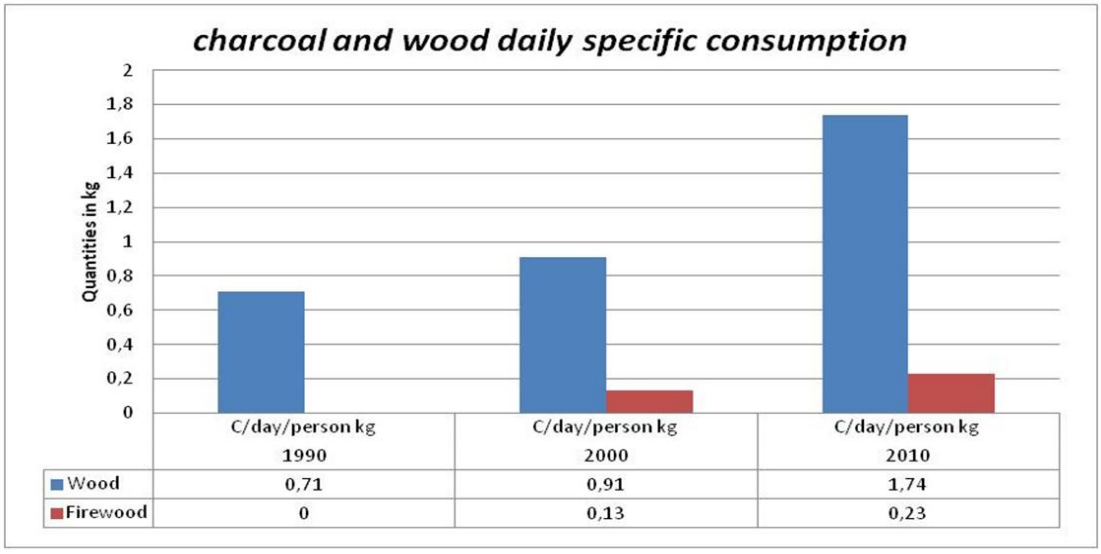

Fig. 5. Evolution of charcoal and wood daily specific consumption in Gaoua district

Moreover, there is an important use of large diameter fresh wood on gold panning sites in the district. To avoid landslides gold prospectors consolidate the rock faces of sample taking wells with tree trunks measuring 45 to 70 centimeters in diameter. For one meter of retaining wall, one needs 10 to 20 tree trunks and each well can reach 40 meters. Let's note also the extensive use of wood for shed and hut construction on the sites. With the proliferation of these sites, there is a great herbaceous destruction and a woody uprooting.

Firewood exploitation has consequences on the entire vegetation. It has negatively affected the distribution, abundance and density of many important species such as *Vitellaria paradoxa, Parkia biglobosa, Prosopis africana, Combretum glutinosum, Mitragyna inermis, Afzelia africana, Anogeissus leiocarpus, Diospyros mespiliformis, Khaya senegalensis*. Social surveys show that 97% of producers use fresh wood for charcoal and gross consumption. In addition, there has been denudation of wood production areas due to non-compliance with wood development periods, the heat generated during carbonization and management of storage areas, and wood and charcoal flow paths. About 4.8ha area of vegetation are destroyed every year to supply only energy needs for the district of Gaoua. This is in compliance with the wooded savannah evolution towards shrubby savannahs observed in Fig. 3.

The destruction of vegetation by wood-energy production activities is illustrated by the four photos of the board (Fig. 6). The first on the top right shows an area where, by the fact of the fire, all forms of plant life is destroyed. We observe only smokes rising from the stove and the white ashes scattered here and there.

Fig. 6. (Plate by SONDO, August 2013): Areas developed for wood collection, carbonization and storage. An action that required the destruction of species existing on concerned sites

The second one, on the upper left corner of the board, shows a storage area of the charcoal packed in bag. These charcoal bags, by tens, are then ready for commercialization.

The two photos on the bottom show two stocks of wood. The first one, on the right, shows alive-wood, ready to turn into charcoal. The second one, on the left, shows some wood conditioned in bundle of sticks and intended essentially in the supply of the households in wood-energy.

The establishment of such areas requires not only the destruction of vegetation on the sitting but also encourages forest destruction by promoting economic activities that opposes the conversation vegetation.

To face the problem of destruction of vegetation, the state of Burkina, designed a land protection policy based on a diagnostic he did. This diagnostic identified and classed the causes of land deterioration. In this classification, the first cause of destruction of vegetation was the Itinerant agriculture on slash-and-burn field. This agriculture was extensive and very destroyer for vegetation. The policy of Burkina Faso was mainly oriented to intensification of agriculture. Today, the effects are visible and we can noticed, a reduction of agricultural areas doubled with an increase of agricultural production.

This situation is observed in many the developing country. Many papers showed firewood as the main cause of deforestation in Uganda [22], in India [23], in Malawi [24], in Nepal [25,26] and in Gangetic Plain [27]. By these scientific productions, the issue of vegetation deterioration due to the problem of energy is one current international problem.

To solve the problem, many strategies are built. They include, the forest production, the selection of species adapted to firewood for the establishment of woodlots, promoting alternative energies adapted to the context, such as biomass energy coming from crops and residues, biogas, solar energy and wind energy. They also include energy saving such as improved stove. According to the context, all these solutions can be combined.

4. CONCLUSION

Firewood production has become nowadays an activity practiced by more than 92% of rural women in the district of Gaoua. This activity contributes to households' economic development, but is also one of the new causes of vegetation resource degradation. Indeed, bush setback, reduction in main species and production area denudation are the negative effects of logging and carbonization. Diachronic analysis of land tenure maps shows systematic degradation of vegetation highlighted by the conversion of wooded savannah and Forest gallery into shrubby savannah.

Despite of this success, the deterioration of vegetation is continuing. The raison of this situation is a modification of the importance of causes. Nowadays, it is the supply of people in wood and firewood that take the first place among the causes of this phenomenon. In addition to the population expansion which increases the consumption of wood and fire wood, there is an increase of the daily specific consumption of wood and firewood.

Because our communities cannot live without fire / energies, the solution of this problem of vegetation deterioration is in a social mutation that integrates new technologies of access to low-cost energy and using local resources different of firewood, such as Biogas, solar energy and wind energy.

To addresses this problem, it is crucial / vital to promote the use of alternative sources of energy, adopt energy saving technology, establish woodlots and rationalize the use of fuel wood.

This study highlights the problem of policies monitoring. It shows in this case that the state has to change his paradigm by re-orienting his main effort to a transformation of the way of accessing and using energy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/13107