Drivers of Fire Occurrence and Local Management Solutions: Evidence from the Sudanian Savanna-Woodland

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ABSTRACT

Fires are considered the most important disturbance agent in various ecosystems including savannas, grasslands, and forest ecosystems. In the sudanian zone, it is estimated that 25 to 50% of the area burns annually. The use of fire as a land management is widespread, but its effects on ecosystems depend very much on the nature of the fire regime. Furthermore, in certain savannah areas of Africa, the use of fire often meets needs that are as cultural as they are economic. This paper presents an analysis of household representative's socio-economic determinants and other the factors that explain the decision to use fire based on data collected through a questionnaire survey of 300 respondents in two surrounding villages of each forest (Tiogo and Dinderesso, Burkina Faso). The Principal Component Analysis (PCA) was used to extract factors. In addition, the multiple linear regression analysis was performed to evaluate the associations between participation indicators and respondent's socio-economic and demographic characteristics. The results showed that two (2) factors determine the application of fire: pastoral and socio-economic benefits, and food consumption. These factors were found to be significantly correlated to socio-economic and demographic characteristics (Ethnic group, religion, gender, source of income, comfort level, education). It is desirable that the policies also take into account these socio-cultural and economic considerations of the practice of fire in the programmes for the management of natural spaces in order to ensure participatory and community-based management and better involvement of the local communities.

1. INTRODUCTION

Savanna are often subject to major disturbances such as fire, pasture and selective wood cutting which affect their structure, composition and functioning [1]. Savanna cover 20% of world surface and are widespread in tropical regions [2]. They constitute a complex ecosystem characterized by the coexistence of herbaceous and one or several shrub layers and /or wooded [2]. Satellite information revealed that more that 350 million ha were burned worldwide [3]. Savannas fires, often referred to as bush fires, are ground fires which operate on the landscape scale [4]. They primarily consume dead and dying grasses, tree litter, shrubs and small trees. The use of fire as a tool in indigenous and non-indigenous land management is widespread in world and particularly in Africa. Anthropogenic fires are historically an integral component of African savannas [5, 6]. The regularity of the annual fire regime in West Africa is a human-ecological phenomenon closely linked to vegetation type and controlled by people's burning practices [5, 7]. The variability of fire regimes in African savannas is more dependent on human drivers than on climate and thus human drivers may regulate the future of savanna fire regimes under changing climate conditions [8].

Fire policy in west Africa has been the source of longstanding and sometimes violent conflict between rural populations and government agencies [4]. Since the colonial era, governments have striven to reduce the amount of savanna and woodlands burned by setting policies that restrict fire use [9]. Rural inhabitants have often reacted to suppression policies by resisting restrictions and continuing to set fires sometimes covertly [10]. Faced with the reluctance of the population, an experiment were set up to study the impacts of fire on savanna vegetation [11, 12].

The findings from burning experiment concluded that the herbaceous species changed in different burning regimes. These burning experiences combined probably with the observed of beneficial aspects of indigenous early burning practices, led some to accept or even promote early burning regime [4]. In Burkina Faso, two decrees were passed in the 1950s authorizing the use of fire in specified vegetation zones for clearing farmland and for the regeneration of pasture [13]. However, after the independence, and with the recurrent droughts, numerous countries in West African, adopted again vigorous anti-fire policies. The laws often carried harsh penalties but there was no indication that the amount of area burned was reduced. On the contrary, the anti-fire policies induced more and large damage of late season fire [10, 14].

Savannas are characterized by a co-dominance of trees, shrubs and herbaceous plants, whose proportions are determined by environmental, ecological and human parameters and fashioned by fire [15]. In Africa, 2.6 million Km^2 of savanna burn every year contributing 48% of global pyrogenic CO_2 emissions [16]. Moreover, the vegetation in savanna is adapted to fire even if the frequency and intensity of theses fire affect vegetation structure and many of its constituent [17]. Although savannas are physiognomically similar, there are major ecological differences among them in soil fertility and rainfall. Soil fertility in savanna and other ecosystem in world is relative to land use which reflects the environment and the human society living in an area [18]. The extraction of energy and materials to fulfill their needs, food by human and animal contributed also to modify the natural environment and the potential

productivity of the land. So, two major components (natural and socio-economic) can be retained (Figure 1). The natural component which are constituted by biotic (Flora and fauna) and abiotic (land, climate and water) have interaction within and between them. The population and his activities constituted the principal elements of socio-economic components. In Africa, the population pressure, poverty, resource degradation, agriculture area and climate change sometimes force people to use natural resources abusively. Most of African communities continue to use fire to manage natural resources necessary for daily livelihood activities such as burning pasture to remove bush and improve forage, controlling pests, cleaning cropland and reducing wildfire treats [19, 20]. Fire is culturally a significant phenomenon [21].

The collection of Non timber Forest Products is also a source of income for many household in Africa [22]. These economic, cultural activities are regulated by laws and the country's resources management's policies. In the present study, we investigated the factors influencing the decision to make fire. We assessed how household characteristics (gender, age, educational level residence status) influence this decision and finally, we analyzed villagers' suggestions for better management of fire in the landscape.

2. METHODS

2. 1. Site description

The study was carried out in Tenado (12°19' 00" N; 2°28' 00" W) in central West and Bobo Dioulasso (11° 11' 00' N; 4° 17' 00' W) in the West of Burkina Faso (Figure 1). The population of Tenado is 45.506 inhabitants (67.74 inhabitants per Km^2) while in Bobo Dioulasso, the second biggest city in Burkina Faso, the population reached 489.967 inhabitants with a density of 3.582 inhabitants per km^2. The population is predominantly composed by Gourounsi in Tenado and by Bobos in Bobo Dioulasso with a migrant ethnic group of Mossi (farmers or traders) and Fulani (herders). In Tenado, the farming system is characterized by traditional subsistence cultivation of cereals (such as sorghum, millet and maize), onion production for department also animal husbandry (specially pig breeding) and a lucrative production system involving extraction of fuelwood and non-timber forest production. However, in Bobo Dioulasso, activities are mostly focused on agriculture, husbandry, fruit-tree plantations, and exploitation of timber and non-timber products.

The climates is South Sudanian at Bobo Dioulasso while Tenado is situated within the Sudanian regional centre of endemism in the transition from North to South Sudanian zone. Both forests are characterized by two main seasons; the rainy season occurs from May to October and the dry season from October to April [23] Vegetation consists in a shrub savanna, and it's characterized by dominant shrub/small trees species. The herbaceous layer is dominated by grasses. The main annual grasses are Andropogon Pseudapricus Stapf., Loudetia togoensis (Pilger) C.E. Hubbard, etc., The main perennial grasses are dominated by Andropogon gayanus Kunth., Andropogon ascinodis C.B.Cl. In the study area, these two perennial grasses are the most important species for fodder, construction (roof-thatching and fences) and handicrafts.

2. 2. Data collection

In each site, two classified forests punctuate social and economic life for surroundings villages. Classified forest of Tiogo (12°13'N, 2°42'W; 300 m above sea level) and that of Dinderesso (11°13'59, 88''N and 4°25'59 59''W; 351 m above sea level) (Figure 1).

Tiogo and Dinderesso classified forests were delimited by the French colonial administration in 1935 and 1940 and cover 8.500 ha and 30.000 ha, respectively. In each surrounding classified forest, two villages were selected: Negarpoulou, Kyon close to Tiogo forest; Dinderesso and Nasso villages which are located around Dinderesso State classified forest.

The data for the current study were collected as part of household survey was conducted during the dry season in April 2015 before the start of fieldwork allowing time to local population to respond to our question. In each village, 75 households were surveyed. The interviews were conducted directly in the households.

Before the household survey, meetings and focus group discussions were held with key informants (local chiefs of villages, forests management leaders, leaders of woman and youngs, helders of villages, governments officials, interest). The aims of these meetings were to obtain qualitative information regarding the determinants of application of fire by local population.

The information acquired in these meetings combined with literature reviews allowed us to identify 14 indicators or factors that justify the application of fire by local population. These factors were finally used to construct the questionnaire.
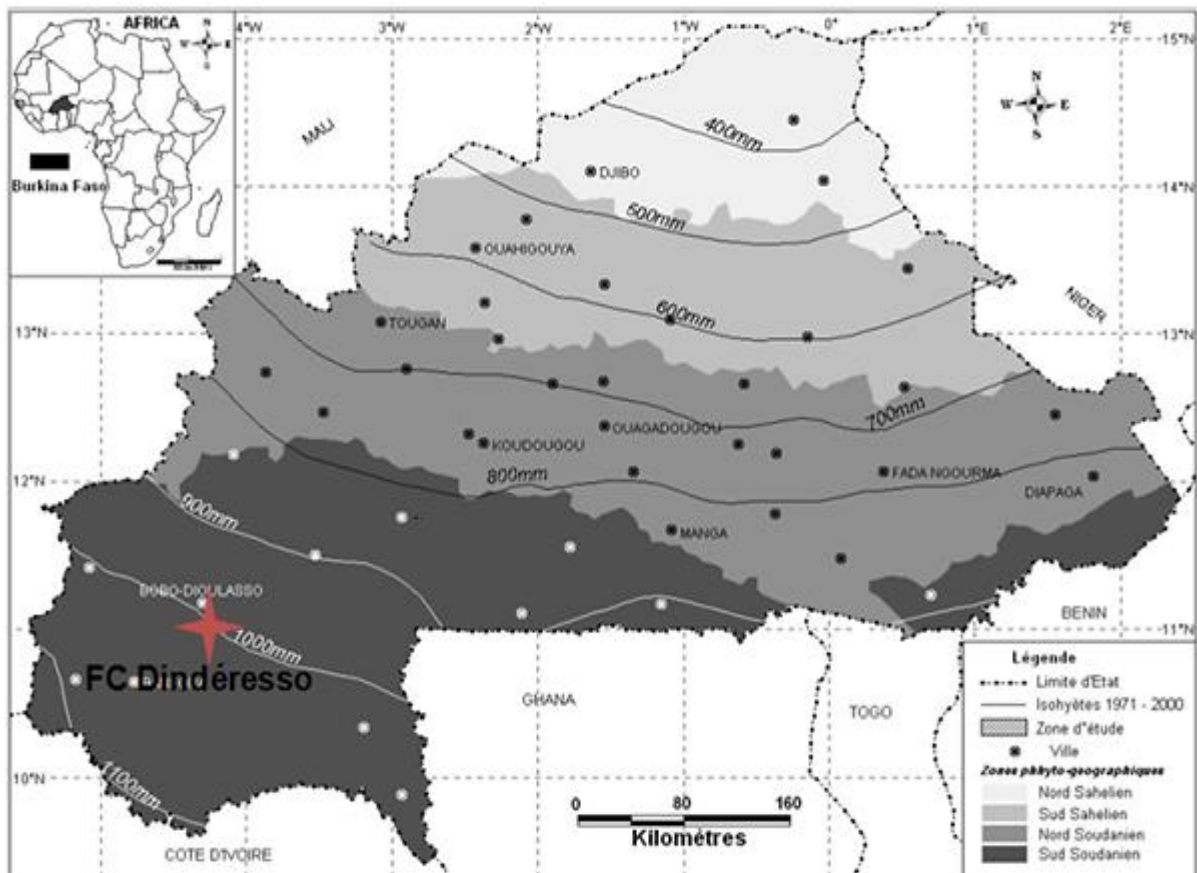
Figure 1. Localization of State forests of Dinderesso (FC-Dinderesso) and Tiogo (FC-Tiogo) toward the vegetation map of Burkina Faso with isohyets and location of the two study sites/

A pre-tested semi-structured questionnaire was used for gathering information, and each interview lasted up to an hour. The interviews were conducted by trained field assistants. The checklists of issues discussed during the interview covered the following points: (1) socio-economic characteristics of the household (household size, gender, age, residence status [indigenous versus migrant], education level, occupation and income-generating activities), (2) the criteria used for household wealth ranking, (3) identification of factors determining the application of fire, (4) the villagers' suggestions for better management of fire in the landscape.

2. 3. Data analysis

Descriptive analysis was used to summarize the profile of the respondents and information related to fire application in Sudanian savanna, while factor analysis was employed to identify latent dimensions underlying indicators that measured fire application [24]. Principal Component Analysis (PCA) was used to extract factors.

The Varimax rotation method was used to ensure that factors extracted by the PCA are independent and unrelated to each other, and to maximize the loading on each variable and minimize the loading on other factors [25]. To test the relevance of factor analysis for the data set, the Bartlett Test of Sphericity and the Kaiser-Meyer-Olkin [25] measure of sampling adequacy were applied. Multiple linear regression analysis was performed to evaluate the associations between participation indicators and respondent's socio-economic and demographic characteristics.

To estimate the subject score for each factor, the Anderson-Rubin approach [24] was applied. SPSS 11 software (SPSS for Windows, Release 2008 Chicago: SPSS Inc.) was used for all statistical analyses.

3. RESULTSAND DISCUSSION

3. 1. Profile of the respondents

Respondents were composed of 76.3% men and 23.7% of women (Table 3). Most of respondents were adults (at least 20 years old) and were also married (86%). Some of them are elders (> 70 old years). The ethnic composition of the respondents was: Gourounsi (48.7%), Bobo (34.3%), Peulh (9%) and other small group (8%) (Table 1).

Peulh people were represented in two sites and are installed around the two State forested. None of respondents had received higher education, 26% of respondents had completed primary education while 54.3 % were illiterates. However, 5.3% received religious education (Coran and Arabic studies) and 5% were fallow adults education (training on local language, school fields). Most of the respondents (77.7%) had acquired land through family inheritance while 17.3% of respondents worked on land that has been obtained as gift (Table 1).

Motherless, 5% are obliged to rent land for cultivation. The natives are the most represented (78%) against only 22% of migrants. The major source of income of the respondents was agricultural (54.3%) but a few of them (5.3%) (Table 1) are doing activities generating incomes (gardening product like onion in Tiogo and small exploitation of cash crop like banana, palm oil, papaya, pineapple, other forests products).

According to the criteria for the classification of household wealth status and against all expectations only 39% of the respondents were poor and at least 26.3% (Table 1) can be considered as rich people.

Table 1. Descriptive and summary statistics of the variables used in the multiple linear regression.

Characteristics	Frequency	Percent (%)
Gender		
Female	71	23.7
Male	229	76.3
Marital status		
Single	42	14
Married	258	86
Ethnic group		
Gourounsi	146	48.7
Bobo	103	34.3
Peulh	27	9
Autres	24	8
Age Class		
[20-30]	69	23
[30-40]	82	27.3
[40-50]	65	21.7
[50-60]	49	16.3
[60-70]	23	7.7
>70	12	4
Educational level		
Illiteracy	163	54.3
Religious education	16	5.3
Adult education	15	5
Primary school	76	25.3
Secondary school	30	10
Residence status		
Migrant	66	22
Native	234	78

Land tenure status		
Inheritance	233	77.7
Lending	15	5
Gift	52	17.3
Source of income		
Agriculture	163	54.3
Agro-pastoral and forestry	121	40.3
Income generating activities	16	5.3
Training on forest management		
Received training	45	15
Not received	255	85
Wealth status		
Poor	117	39
Moderately Rich	104	34.7
Rich	79	26.3

3. 2. Determinants of decision to make fire by local populations

Factor analysis summarized the original 5 indicators of fire application in Sudanian Savanna into two factors, which accounted for 74.93% of the totals of variance (Table 2). The communalities (loadings) which are representing the overall importance of each variable in the PCA were higher than 0.5 for all indicators including environmental, pasture, NWFP (Non Ligneous Forest Products) and wood products, soil fertility, cultural and rituals practices. These results indicated that these indicators are important to the common variability among the variable and contributed a lot to the PCA solution.

The relatively high values for the other communalities indicate that the factors explain most of the variance in the original variables [26]. A variable with a high communality 0.915 (Table 2) indicates a high correlation between that variable and other variable contributing to a common factor.

The dominant variables for the first factor, which explained 50.42% of the variation (Table 2), are mostly indicators related to environment and economic benefits such as pasture, soil fertility, and forest products.

The environmental variable has the highest loading (0.852) followed by the pastural (0.884), soil fertility (0.865) and forest products (0.848) (Table 2). Furthermore, the second factor was almost as important as the first explaining 24.51% of the variation. This factor is mostly related to cultural and rituals practices which factor loading reach 0.950 (Table 2). This shows the important part of cultural and ritual (mostly religious) aspects in the decision of using fire in sudanian regions.

Table 2. PCA loading for indicators of application of fire in Sudanian Savanna.

Description	Factor 1	Factor 2	Communality
Environment	**0.852**	-0.157	0.751
Pasture	**0.831**	0.213	0.735
Soil fertility	**0.767**	0.301	0.680
Forest products	**0.709**	0.401	0.660
Cultural and ritual practices	0.116	**0.950**	0.915
Eigenvalue	2.521	1.223	3.744
Variance explained	50.42	24.51	74.93

Note: Rotation method: Varimax with Kaiser normalization. Rotation converged in Three iterations (N = 300) and factor loading with a value larger than 0.50 in absolute terms are bold-faced

3. 3. Dependence of fire factors on socio-economic and demographic characteristics

The results indicated that some of socioeconomic and demographic variables were strongly significant with almost all two factors of fire application indicators (Table 3, $p < 0.0001$). However, some substantial differences existed among these indicators in terms of the amount of explained variation (Table 3). In fact, Socio-economic and demographic attributes accounted for 32.5% of the variation Environmental and socio-economic benefits and 13.3% of cultural aspects (Table 3).

These results indicated that socio-economic and demographic attributes influenced environmental and economic benefit indicator's more than cultural and rituals aspects. A highly significant and positive relationship between received training on forest management and environmental and economic benefit (Factor 1) indicating that the more the respondent received a training on forest management the more forests received a better management by fire to get a pasture for animals grazing or economics benefits for household. In addition, having a minimum level of education lead to a positive and significant relationship ($p < 0.02$) with environment and economic benefits. However, receiving training on forest management interact negatively ($p < 0.002$) with the use in cultural rites (Factor 2). In addition, the ethnical group had also a significant positive impact ($p < 0.001$) on Environmental and economic benefit (Factor 1).

The results showed also that Gender holds an important place ($p < 0.01$) in the decision to apply fire in sudanian savanna. Nonetheless, the ratio of female over male indicated that the proportion of female influence negatively ($p < 0.04$) the environmental and economic benefit. Moreover, the variables age and land tenure status are significantly correlated and positively with environmental and economic benefit. Overall, the result showed that land tenure status is strongly and negatively relative ($p < 0.001$) to cultural and ritual aspects. The source of income

is related significantly (p<0.0001) and positively to Factor 1. However, the results showed a significantly high and negative relationship (p < 0.0001) between the criteria of wellness and the two factors (environmental and economic benefit plus the cultural and rituals aspects).

Table 3. Estimated regression standardized beta coefficients (β) and significant tests of the latent variable equations for application of fire.

Description	Factor 1		Factor 2	
	Environmental and economic benefit		Cultural aspect	
	Beta	t-value	Beta	t-value
Constant		-4.125		2.070
Gender	**0.128****	2.470	-0.070	-1.190
Marital status	-0.086	-1.628	-0.003	-0.047
Ethnic group	**0.240*****	4.172	**0.227*****	3.471
Age group	**0.175*****	3.142	0.058	0.918
Educational level	**0.147*****	2.741	0.084	1.380
Residence status	0.067	0.928	**-0.185****	-2.264
Land tenure status	**0.191*****	3.030	**-0.290*****	-4.062
Prop.Female/male RH	**-0.100****	-2.087	0.027	0.504
Source of income	**0.119****	2.286	0.023	0.393
Training on forest management	**0.267*****	5.236	**-0.169****	-2.924
Wealth status	**-0.191*****	-3.744	**-0.169*****	-2.917

Prop. Female/male RH: proportion of female/male in the respondent household. Statistical estimates are indicated are indicated by stars * P<0.10, ** P<0.05 and P<0.01.

4. DISCUSSION

The majority of respondent were men. Women represented only 24% of respondent. The low number of females is explained by the fact that women in African societies and more particularly in Burkina Faso represent rarely the head of family even if they are widow. Women were depicted as saddled with home and domesticity [27]. In most of the societies, they are not traditionally allowed to speak in front of men publicly or to take some decisions concerning the community and environment management. This is the responsibility of men and especially of

elderly people. The results showed also that more than half of the respondents (54%) are illiterates and only 25% of respondent went to primary school. Adult literacy rate were below 50% in West Africa countries [28]. The ethnic composition of the respondent was Gourounsi (49%), Bobo (34%), Peulh (9%) and others (8%). Peulh also called Fulani people practice the transhumance breeding and are mostly settle around forest. Conflicts are often noted between indigenous populations and Fulani who generally come from the north of the country. Most respondents were practicing agriculture but a few part (5.3%) were doing income-generating activities. According to the household wealth status classification criteria, over 26% have an acceptable standard of living and live better.

They can be considered as rich. However, only 39% of the respondents were considered poor and have a low standard of living. In Tiogo, the results of previous studies on the analysis of household's income showed that crop (maize, sorghum, millet) and vegetable cultivation or market gardening account for 55% of total income. Livestock products contribute for 15% of the income. The incomes from the forest represent 5% (sale of timber and sale of non-timber forest products) of the overall income. However, this 5% does not conclude the self-consumption of forest products which is very important. Non-timber forest products represent on its own 8% of household income in south-western Burkina Faso [29]. This demonstrates the importance of forests for rural populations.

4. 1. Determinants of decision to make fire by local populations

Factor analysis summarized the original 11 indicators of fire application in sudanian savanna in two factors, which accounted for 75% of total of variance. The communalities (loadings) which are representing the overall importance of each variable in the PCA were high (≥ 0.5) for indicators including cultural and rituals practices, environment, pasture and soil fertility. Results indicated that these indicators of fire application explained much of the variability among the variable and contributed a lot to the PCA solution. The dominant variables for the first variable, explaining more than half of the variation (50.42%) are mostly indicators related to environmental and economic benefit.

The second factor explained only 24.5% of the variation but with the highest loading (0.950) is related to cultural and ritual practices. This indicated that cultural aspects of fire still important for rural populations and the decision to make fire are more social and cultural reasons. The practices of fire are clearly part of the technical and cultural heritage of many people from savanna [30]. Beyond the religious character of fire application, they appear as a traditional power of management and control of the bush and the fires [31]. Survey results showed also that the use of fire is closely linked to the environment for livestock grazing and crop production. Maasai pastoralists have an elaborate system of traditional fire management which is agree with ecological arguments. For Maasai people, fire have been an important tool and probably helped shape and maintain the character of the landscape even at this early date [32]. They burnt to prevent late-season damaging fires and to increase diversity and productivity of the vegetation [4, 33-36]. The Maasai people used a progression of small fires through-out the dry season to create a checkerboard or patch-mosaic pattern of burns as grasses cured to prevent large, catastrophic late-season fires [34].

Fire have been an important tool for all of these groups and probably helped shape and maintain the character of the landscape even at this early date [32]. Rural inhabitants also use fire to facilitate many activities associated with daily life [21]. The nutrition of livestock which has been based on the exploitation of naturally occurring herbaceous and ligneous plant species

become a challenge during dry season for herders and pastoralists. In this hard period, the decreased of quality and quantity of forage and also it's shortage are the major constraints to the extensive livestock system [37]. So, fire is generally used by local populations to induce the regrowth of new grass for animal grazing [7, 38]. These fires contributed also to the evolution of savannas [39]. Therefore, fire is often a necessary management tool for pastoralists since it's the most efficient way to control woody species and keep the vegetation short enough for grazing animal [40]. Most of the studies on savanna pastoralists in Africa indicated that the rejuvenate pasture may be the most important reason for burning [41]. Thus, fire has been used in traditional management systems to control-transmitting parasites, killing diseases-carrying sticks, eliminating cover for dangerous livestock's predators such as lions, leopards and cheetahs [21, 34, 42].

Furthermore, the result showed that people also used fire to collect forest products such as firewood, non-timber forest products (NTFP), and medicinal plants for their own consumption or for selling. This is often the major source of income for these local populations [43, 44]. Hunters who are often agriculture burnt the vegetation to improve visibility, to facilitate the movements and to bring back animals to places, chosen in advance, where hunting becomes easier. There is no technical limitation to this method of hunting which was widely practiced in all countries of open vegetation [30]. In Kalahari region, people usually used fire to manipulate vegetation to attract the animals they hunt [45]. Otherwise, fire was used in agriculture to clean easily the new fields and often to improve soil fertility [46]. The presence of ash after fire play a major role in flow and transport processes and increases soil water retention and nutrient status [47].

4. 2. Dependence of fire factors on socio-economic and demographic characteristics

The results indicated that gender, ethnic group, age, educational level, land tenure status, source of income, training on forest management and wealth status were strongly significant for all two decisions to make fire indicators ($p<0.0001$). A significantly high relationship between environmental/economic benefit and training on forest management (Factor 1) was identified. Those who received training on forest management used generally fire for more environmental and economic benefits. However, training on forest management interacts negatively with cultural rites (Factor 2).

It could be that the forestry and agricultural extension services disseminates good environmental management practices, advises against late fire and fight against slash and burn crops. The training on forest management that they received reduces the burning of forest for rituals ceremonies. Indeed, bush have been longtime burned during some traditional and ritual ceremonies [31]. Natural sites which are selected for the ritual fires are situated in the wider set of sacred places that together constitute a ritual territory of an earth priest [48]. As for those who received training on forest management, those who also have an education level used fire for environmental reasons and to gain economic benefits. It should also be emphasized that a higher level of education increase the chances of being employed and thus less dependent on forest resources [49]. The results showed also that the ethnical group is a positively related ($p < 0.001$) to the environmental/economic benefit and cultural aspect (Factor 1 and Factor 2).

In the rural context of Burkina Faso, residence status is generally embedded in the ethnic composition [50]. Thereby, the indigenous people that represent generally the majority in each locality are responsible for carrying out traditional and rituals activities. Some migrants who usually acquired land as gift or by informal renting agreements are not allowed to carry out

cultural rituals on land loaned, leased or purchased. However, some of them who have lived in the village for a long time may be accepted and integrated into the traditional system. Which explains why the relationship between land tenure status and cultural aspects is significantly negative (Factor 2).

Therefore, we can also note that the Fulani people (herders) who are settling generally around forests used often fire as management tool. For them, it is the most efficient way to control woody species and rejuvenate grass for grazing animal. Some of migrants who are mostly farmers used also fire to prepare field or land cleaning for crops. Thereby, we can conclude that the ethnic group and land tenure status are majors' determinants in fire making decision. Results showed also that age and gender are both positively related to environmental and economic. In the context of African society, elders play an important role in decision-making. They are the guarantor of tradition and are those who determine the starting point of fires related to the ritual activities of the village. However, concerning activities requiring physical strength such as laborious agricultural tasks, the youngest in the households and women who are solicited [51].

Previous studies showed also that age and access to Non timber forest products (NTFPs) depends on the type of forest products [50]. Nonetheless, access to forest resources may be positively dependent on the age of the household's head as long as his or her are physically fit for it [52]. NTFPs are important to rural households in terms of their contribution to health, food, energy, cash income and contribute considerably to local livelihoods [51, 53]. NTFPs are often presented as a major survival strategies more for women compare to men in dry forest [54]. Some products are processed (in butter, animal feed) by women often organized in associations. In addition to NTFPs, firewood provides an important source of income for women and local livelihoods [55]. Study in in Dendi, District (Ethiopia) [56] showed that more than 59% of household's income are from the firewood collection. Fire is often used to induce the rapid production of certain plant species, for producing firewood and charcoal. Fire is known for its effect on stimulation of some species increasing their flowering and seed germination by heat or smoke [17, 57].

Fire promotes also the development of woody species [58] and the appearance of new species which represent a high forage value [59, 60]. Women are so active and involved in socio-economic activities but decision to set fire are yet the responsibility of men specially, the elderly. Fires are usually set for socioeconomic reasons including land management, livestock grazing and crop production [21]. These kinds of activities are most of the time conduct by men. The practice of hunting for household consumption or for sale can be enough reason to burn large spaces [61]. The bush meat market is growing due to high demand [61, 62]. All this shows that rural populations are heavily dependent on forest resources. Forest income contributed 39% of the average household income [63] in Dendi, Ethiopia. In Malawi, forest income contributes around 15% of total income. In southwest Burkina Faso, [29] showed that the economic dependence of households on NTFP is estimated to 12%. In Mali, [64] showed that income from NTFP sales contribute for 26 to 73% to rural household. In Northern Benin, 39% of local household income is generated by NTFPs [65].

However, Dependence decreases with income reflecting greater dependence of poor households on NTFPs. Poorer households depend more on forests income than wealthier households [53]. Therefore, [66] study in western region of Nepal showed that rich households collected almost ten times less fuelwood than the poorer households. Poverty is often blamed as primary reason for resource destruction [66]. Thus, the pressure on the forest resources can

lead to their degradation over the years. Hence, the necessity to review existing forest resources management policies for much more participatory and rational management.

5. CONCLUSIONS

Fires are one of the main anthropogenic factors influencing the structure and function of savannah ecosystems. Environmental resources and especially non-forest resources were shown to be a major source of income for rural households. Forests play a multifunctional role (production of goods and services, protection of biodiversity, soil, etc.). They provide goods and services to the people for satisfying needs in food, energy, housing and health. The extent to which people use forest products determines their dependence on forest resources. The overall aim of our study was to analyze local people perception of fire impact on the sustainability of ecosystem services productivity in Savannas. The socio-economic study of the populations living near the Tiogo and Dindéresso classified-forests indicates that the goods and services sought through fire are economic, health and protection-related. The hypothesis that socio-economic and cultural factors may justify the decision by local people to set fires is borne out. Furthermore, most of the suggestions put forward by respondents focus on the more participatory management of natural resources. Consequently, it is imperative for politics to take into consideration the needs of local populations.

References

[1] Menaut, J.C., M. Lepage, and L. Abbadie, Savannas, woodlands and dry forests in Africa, in Africa, Seasonnally Dry Tropical Forest. 1995, Bullock, S.H., Money, H.A., Medina, E.E. (Eds.), Cambridge University Press: London. p. 64-92.

[2] Scholes, R.J. and S. Archer, Tree-grass interactions in savannas. *Annual Review of Ecology and Systematics,* 1997. 28: p. 517-544

[3] FAO, Fire management global assessment, in FAO Forestry paper. 2006. p. P117

[4] Laris, P. and D.A. Wardell, Good, bad or necessary evil? Reinterpreting the colonial burning experiments in the savanna landscapes of West Africa. *Geographical Journal*, 2006. 172(4): p. 271-290

[5] Laris, P., et al., The human ecology and geography of burning in an unstable savanna environment. *J. Ethnobiol,* 2015. 35(1): p. 111-139

[6] Mbow, C., T.T. Nielsen, and K. Rasmussen, Savanna fires in easr-central Senegal: distribution patterns, ressource management and perceptions. *Human Ecol.* 2000. 28(4): p. 561-583

[7] Archibald, S., A.C. Staver, and S.A. Levin. Evolution of human-driven fires regimes in Africa. in *Proceedings of the National Academy of Sciences of the United States of America.* 2012, vol. 109, no. 3, 847–852

[8] Archibald, S., et al., Defining pyromes and global syndromes of fire regimes. *Proc. Natl. Acad. Sci.* 2013. 110(16): p. 6442-6447

[9]   Wardell, D.A., et al., in Fire history, fire regimes and fire management in West Africa: an overview in J Goldammer and C De Ronde eds Wildland fire management handbook for sub-Sahara Africa Oneworldbooks. 2004 Freiburg. p. 350–81

[10]   Laris, P., Grounding environmental narratives: the impact of a century of fighting against fire 2004, Moseley W. and Logan B. eds African environment and development, programq, realities Ashgate Publishing: London. p. 63-85.

[11]   Ramsay, J. and R. Rose-Innes. Some observations on the effects of fire on the Guinea savanna vegetation of the northern Ghana over a period of eleven years. *African Soils,* 1963. 8: p. 41-81

[12]   Aubreville, A., Les expériences de reconstitution de la savane boisée en Côte d'Ivoire. *Bois et Forêts des Tropiques,* 1953. 32

[13]   Laris, P. and D.A. Wardell, Good, bad or 'necessary evil'? Reinterpreting the colonial burning experiments in the savanna landscapes of West Africa. *The Geography Journal*, 2006. 172 (2): p. 271-290

[14]   Caillault, S., A. Ballouche, and D. Delahaye, Where are the 'bad fires' in West African savannas? Rethinking burning management through a space–time analysis in Burkina Faso. *The Geography Journal,* 2014. 181 (4): p. 375-387

[15]   Furley, A.P., et al., Savanna burning and the assessment of long-term fire experiments with particular reference to Zimbabwe. *Progress in Physical Geography,* 2008. 32(6): p. 611-634

[16]   Schultz, M.G., et al., Global wildland fire emissions from 1960 to 2000. *Global Biogeochemical Cycles,* 2008. 22, GB 2002

[17]   Bond, W.J. and B.W. van Wilgen, Fire and plants. 1996, London: Chapman and Hall.

[18]   Young, M. and O.T. Solbrig, Savanna management for ecological sustainability, economic profit and social equity, ed. M.D. 13. 1992, Paris: UNESCO

[19]   Sheuyange, A., G. Oba, and R.B. Weladji, Effects of anthropogenic fire history on savanna vegetation in northeastern Namibia. *Journal of Environmental Mangement*, 2005. 75: p. 189-198

[20]   Shaffer, L.J., Indigenous fire use to manage savanna landscapes in Southern Mazambique. *Fire Ecology,* 2010. 6(2): p. 43-59

[21]   Laris, P., Burning the seasonal Mosaic: Preventative burning strategies in the wooded savanna of Southern Mali. *Human Ecology,* 2002. 30(2): p. 155-186

[22]   Ouedraogo, M., et al., The effects of fire on soil mineral content and biological activity. *Journal of Agriculture and Environment for International Development,* 2013. 107(1): p. 45-72

[23]   Van Straaten, O., et al., Fire and soil greenhouse gas fluxes in West African savanna woodland (CO_2, N_2O, CH_4, NO). *Journal of Arid Environments,* 2019: p. 132-140

[24]   Tabachnick, B.D. and L.S. Fidell, eds. Using Multivariate Statistics. ed. H.C.C. Publishers. 1996: New York.

[25] Bryman, A. and D. Cramer, eds. Quantitative Data Analysis with SPSS 12 and 13. Guide for Social Scientist. ed. E.S. Routledge. 2005.

[26] Coulibaly-Lingani, P., Factors influencing people's participation in the forest managment program in Burkina Faso, West Africa. *Forest Policy and Economics,* 2011. 13: p. 292-302

[27] Sudarkasa, N., "The Status of Women" in Indigenous African Societies. Spring, 1986 ed. Vol. 12. 1986: Feminist Studies.

[28] UNESCO, "Adult and Youth Literacy" UIS Fact Sheet. 2014, UNESCO Institute for Statistics

[29] Ouédraogo, M., et al., The effects of fire on soil mineral content and biological activity. *Journal of Agriculture and Environment for International Development,* 2013. 107(1): p. 45-72

[30] Bruzon, V., Les pratiques du feu en Afrique subhumide. Exemples des milieux savanicoles de la Centrafrique et de la Côte d'Ivoire, in Blanc-Pamard Chantal 'éd.), Boutrais Jean (éd.). Dynamique des systèmes agraires: à la croisée des parcours: pasteurs, éleveurs, cultivateurs. 1994, Orstom (Paris). p. 148-162.

[31] Dugast, S., Incendies rituels et bois sacrés en Afrique de l'Ouest: une complémentarité méconnue. *Bois et Forêts des Tropiques,* 2008. 296(2): p. 17-26

[32] Cooke, A.E., Subdividing the Savanna: the ecology of change in Northern Tanzania. 2007, University of North Carolina. p. 246.

[33] Mbow, C., T.T. Nielsen, and K. Rasmussen, Savanna fires in East-Central Senegal: Distribution Patterns, resource management and perceptions. *Human Ecology,* 2000. 28(4): p. 561-583

[34] Butz, R.J., Traditional fire management: historical fire regimes and land use change in pastoral East Africa. *International Journal of Wildland Fire,* 2009. 18: p. 442-450

[35] Russell-Smith, J., P.G. Ryan, and R. Durieu, A LANDSAT MSS-derived fire history of Kakadu National Park, monsoonal northern Australia, 1980-1994: seasonal extent, frequency and patchiness. *Journal of Applied Ecology,* 1997. 34: p. 748-766

[36] Abbadie, L., et al., Lamto: Structure, functioning and dynamics of a savanna ecosystem. 2006, New York: Ecological studies Springer-Verlag.

[37] Fernandez-Rivera, S., et al., Nutritional constaints to grazing ruminants in the millet-cowpea-livestock farming system of the Sahel. 2005, Ayantunde, A.A., Fernandez-Rivera, S., McCrabb, G. (Eds), coping with feed Scarcity in smallholder livestock system in developing countries. *International Livestock Research Institute* (ILRI): Nairobi. p. 157-182.

[38] Mbow, C., K. Goïta, and G.B. Bénié, Spectral indices and fire behavior simulation for fire risk assessment in savanna ecosystem. *Remote Sensing of Environment,* 2004. 91: p. 1-13.

[39] Trollope, W.S.W., et al., Characterization of biomass and fire behavior in the small experimental burns in the Kruger National. *Journal of Geophysical Research,* 1996. 101: p. 531-539

[40] Johansson, M.U., et al., Tending for cattle: traditional fire management in Ethiopian Montane heathlands. *Ecology and Society,* 2012. 17(3): p. 19p

[41] Angassa, A.M. and G. Oba, The accuracy of vegetation stand boundaries derived from image segmentation in a desert environment. *Photogrammetrie Engineering and Remote Sensing*, 2008. 64: p. 59-66

[42] Johansson, M.U., et al., Tending for cattle: Traditional fire management in Ethiopian montane heathlands. *Ecology and Society,* 2012. 17(3): p. 19

[43] Lescuyer, G., Economic importance of non-timber forest products in selected villages of southern Cameroon. *Bois et Forêts des Tropiques* 2010. 301(2): p. 15-24.

[44] Shackleton, S., P. Shanley, and O. Ndoye, Invisible but viable:Recognising local markets for non-timber forest products. *International Forestry Review,* 2007. 9(3): p. 697-712

[45] Sheuyange, A., Landscape level vegetation change in relation to fire history in Eastern Changwena Region, Namibia. 2002.

[46] Cochrane, M., ed. Tropical fire ecology: climate change, land use and ecosystem dynamics. 2009, 1st ed. Springer-Verlag Berlin Heidelberg.

[47] Adriano, D.C. and J.T. Weber, Influence of ash on soil physical properties and turfgrass establishment. *Journal of Environmental Quality*, 2001. 30(2): p. 596-601.

[48] Luning, S., Ritual territories and dynamics in the annual bush fire practices of Maane, Burkina Faso, in Natural heritage in the South ; territories, identities, local strategies. 2005, M.C. Cormier-Salem et al. (éd.). Paris, France, Ird, coll. Conferences and Seminars: 443-473.

[49] Mamo, G., E. Sjaastad, and P. Vedeldp, Economic dependence on forest resources: A case from Dendi District, Ethiopia. Policy and Economics, 2007. 9: p. 916-927

[50] Coulibaly-Lingani, P., et al., Determinants of access to forest products in southern Burkina Faso. *Forest Policy and Economics,* 2009. 11(7): p. 516-524

[51] Cavendish, W., Empirical Regularities in the Poverty-Environment Relationship of Rural Households: Evidence from Zimbabwe. *World Development,* 2000. 28(11): p. 1979-2003

[52] Godoy, R. and M. Contreras, A Comparative Study of Education and Tropical Deforestation among Lowland Bolivian Amerindians: Forest Values, Environmental Externality, and School Subsidies. *Economic Development and Cultural Change* 2001. 49(3): p. 555-74

[53] Leßmeister, A., et al., The contribution of non-timber forest products (NTFPs) to rural household revenues in two villages in south-eastern Burkina Faso. *Agroforestry Systems*, 2016: p. 1-17

[54] Shackleton, S., et al., Opportunities for enhancing poor women's socio-economic empowerment in the value chains of three African non-timber forest procducts (NTFPs). *International Forestry Review,* 2011. 13: p. 136-151

[55] Kamanga, P., P. Vedeld, and E. Sjaastad, Forest incomes and rural livelihoods in Chiradzulu District, Malawi. *Ecological Economics,* 2009. 68(3): p. 613-624

[56] Mamo, G., E. Sjaastad, and P. Vedeld, Economic dependence on forest resource: a case from Dendi District, Ethiopia. *Forest Policy and Economics,* 2007. 9: p. 916-927

[57] Dayamba, S.D., et al., Seed germination of herbaceous and woody species of the Sudanian savanna-woodland in response to heat shock and smoke. *Forest Ecology and Management*, 2008. 256: p. p. 462-470

[58] Scholes, R. and S. Archer, Tree-Grass interactions in Savannas. *Annual Review of Ecology and Systematics,* 1997. 28: p. 517-544

[59] Gillon, D., The effects of fire on soil mineral content and biological activity. *Rev. For. Fr.* 1990. 42: p. 295-302

[60] Gillon, D. The fire problem in tropical savannas. 1983: In: F. Bourliére (ed.) Tropical Savannas. *Ecosystems of the World* 13, 183-243.

[61] Lindsey, P., et al., llegal hunting and the bush-meat trade in savanna Africa: drivers, impacts and solutions to address the problem., in Panthera/Zoological Society of London/Wildlife Conservation Society report. 2012: New York. p. 74 pages

[62] Lindsey, P.A., et al., The bushmeat trade in African savannas: Impacts, drivers, and possible solutions. *Biological Conservation* 2013. 160: p. 80–96

[63] Mamo, G., E. and e.a. Sjaastad, Economic dependence on forest resources: A case from Dendi District, Ethiopia. *Policy and Economics,* 2007. 9: p. 916-927

[64] Faye, M.D., et al., Contribution of parkland trees to farmers's livelihoods: a case study from Mali. *Dev. Pract*. 2010. 20: p. 428-434

[65] Heubach, K., et al., The eonomic importance of non-timber forest products (NTFPs) for livelihood maintenane of rural west African communities:a case study from northern Benin. *Ecol Econ* 2011. 70: p. 1991-2001

[66] Sapkota, I.P. and P.C. Odén, Household characteristics and dependency on community forests in terai of Nepal. *International Journal of Social Forestry*, 2008. 1(2): p. 123-144