Consequences of fire in agricultural sector in Banga Bakundu, Cameroon: A review

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Abstract: Genesis of fire is tied to the origin of plants, and has been a closed companion to human for land preparation, harvesting and hunting. Fire is caused by natural phenomena and human activities which can either be deliberate or accidental. In the Sub-Saharan Africa (SSA), smallholder farmers are the breadbasket of the economy. In Banga Bakundu, farmers practiced slash and burn method of land preparation for the production of annual and perennial crops for home consumption and sales. This review was aimed at identifying the causes of fire and its consequences in the agricultural sectors and propose solutions to abate the disaster of fire so as to promote sustainable agricultural system in the study area, developing countries and the world at large. Small-scale farmers need relatively enough individuals in the farmland before deliberate burning and should precede with the creation of fire breaks at the edges of the farm land. Deep containers are good for holding charcoal during brooding and can prevent fire outbreak from charcoal spark. Meanwhile, burning is responsible for several premature deaths, psychological stressors and also causes several health complications including cancer, cardiovascular diseases etc. The government of Cameroon needs to intensify sensitization on the negative externalities of bush burning to the environment and offering of health assistance to farming communities.

Keywords: psychological stressor, bush burning, biodiversity, small-scale farmers, Banga Bakundu

1. Introduction

Genesis of fire is tied to the origin of plants, and has been a closed companion to humans for land preparation, harvesting and hunting. However, the existence of fire is promoted by oxygen, fuel (e.g plant) and heat source including lightning, sparks from rock falls and/or meteorite impacts [1]. Fire may occur in the environment in one of the following ways: naturally, and by human activities which can either be deliberate and/or accidental or ignorant. Burning is used by smallholder farmers to transform forested land to agricultural land for cultivation of crops and growing of animals. The merits of agriculture burn include hunting, harvesting, improvement of pasture for grazing animals, forest management and also, improvement of fauna and flora in ecosystems that depend on fire for their existence (i.e fire-existence ecosystem). However, demerits of fire can be caused by natural, deliberate and accidental or negligent act due to human activities, and has a devastating consequences in agriculture, environment and the livelihood.
of humans. Farmers in Sub-Saharan Africa (SSA) as well as those in other developing regions mostly practiced slash and burn method of land preparation during ENSO events. These small-scale farmers (SSF) are the breadbasket of most developing countries, contributing to food and nutrition security. In some parts of the world, like in Brazil, fire is used for harvesting crops such as sugar cane. Despite it uses, fire destruction in the world is very devastated ranging from agriculture, industry and degradation of human health. Currently in the world, it is a serious challenged to many countries worldwide and affecting ecosystem composition and distribution [2]. Worldwide, an estimated 150 to 250 million ha (Mha) of the recorded 1.8 billion ha of tropical forests are affected by fire annually. From 2001 to 2018, Cameroon has lost 1.20 Mha of tree cover, equivalent to a 3.8% decrease. Agriculture is a comprehensive word used to denote the cultivation of crops and the domestication of animals for human consumptions and the markets. According to [3] is a spectrum of areas and activities involved such as cultivation, domestication, horticulture, arboriculture, and viticulture, as well as livestock management integrated to form crop-livestock farming, pastoralism, and transhumance.

Banga Bakundu is a village located along the Buea- Kumba main road in the South West Region (SWR) of Cameroon. It is an agrarian community involved in the production of annual, and perennial crops and growing of animals. The staple food crops produced include: cassava (Manihot escuclenta Crantz), corn (Zea mais), egusi (Colocynthis citrullus L.), sweet potato (Ipomoea batata), Musa sp and plantation crops include; cocoa (Theobroma cacao), coffee (Coffea sp), palm oil (Elaeis guinensis), rubber plant (Ficus elastica) Citrus sp. and mixed with agroforestry fruits: African plum (Dacryodes edulis), and Avocado sp. in cocoa farms. Currently, coffee is not been produced due to the poor prices earned by farmers in the 1990s, among other reasons, decided to transform their coffee farms into cocoa farms. Animals kept include; goats, pigs, sheep, broilers and layers poultry. Farmers practiced slashed and burned method of land preparation during the dry season. These farmers as well as those in other developing countries are faced with myriad of production challenges including; lack of managerial skills, poor agricultural policies, climate change and environmental degradation caused by fire, soil erosion, landslide and drought. Banga Bakundu contributes enormously to the gross agricultural output of Cameroon. Research on fire has been conducted in Mt Cameroon Forest and other parts of the world regarding agriculture, environment and socio-economic coupled with management policies. Conversely, no research has been conducted in this agrarian community to ascertain the consequences of fire in the agricultural sectors including health related challenges faced by these farmers.

This review was aimed at identifying the causes of fire and its consequences in the agricultural sectors with propose solutions to abate the disaster of fire so as to promote sustainable agricultural system in the study area, developing countries and the world at large. Secondary data were utilized from 2000-2019 found in published journals, policy papers, conference proceedings and also, authors experience to help explained the intricacy. The paper is structured below as follows; consequence of fire in agriculture sector: crop production, animal husbandry, forest, biodiversity, climate change, health constraints and conclusion.

2. Consequences of fire in agriculture sector
In Banga Bakundu (BB) as well as in communities of other developing countries, most smallholder farmers practice slashed and burned method of land preparation with limited knowledge on the consequences associated with it uses such as reduction of soil nutrient, low crop production, crop losses, and degradation of the environment. Hence, consequences of fire in the agricultural sector can be analysed in the following areas: crop production, animal husbandry, forest, biodiversity, climate change and human health constraints. Luca [4] reported that the three main fire-related policy problems identified with Indonesia fires include: 1) smoke haze, carbon emissions and related impacts; 2) forest degradation and deforestation, and loss of products and services, including timber, non-timber forest products, soil erosion and flood control, biodiversity; and 3) rural sector losses from escaped fires and fire-induced weather anomalies. These problems are same in Cameroon particularly in the study area and needs urgent actions to abate the challenges.
2.1 Crop production

Crop production is an art, science and process involving land preparation, seed sowing or planting (i.e. vegetative materials), maintenance and harvesting of crops. Approximately 95% of farmers in Banga Bakundu prepare their farmland for cultivation at the beginning of dry season usually in December month by practicing slashed and burned method. Some farmers used fire as an agent to clear and burned in an uncleared forest whereas others cleared by using cutlass, allowed to dry and set fire. In Banga Bakundu, bush burning is used to open new farmland which is responsible for most of the agriculture burns (Figure 1). Owners of plantation crops including rubber, cocoa and palms, use fire as a cheap tool to clear old plantation and preparation of new ones [5]. Some of these small-scale farmers used fire directly in an uncleared farmland because of lack of money to hire labours to clear. IFFN [5] reported that an average farmer places themselves at a very poor position arguing that a labour force of about 100 men including operator for the cutting down of trees is needed for a land surface area of about 2 hectares which cost a farmer US $6.81 per day. As estimated by some farmers a total sum of US $ 680.75 is needed to prepare a land at the beginning of cropping season. Conversely, to a farmer 1 stick match from a box which cost less than US $ 1 can do the job of putting the forested land in destruction or flame.

Figure 1. Slashed and burned method of Land preparation in Cameroon (Photo, Cyril Njume)

Moreover, farmers consider slashed and burnt method of farming cheap, fast and yield more compared to unburned farmland. Annual crops which are usually cultivated in the burned and unburned farms include; egusi (*Colocynthis citrullus* L.), maize (*Zea mais*), yams (*Dioscorea alata*), cocoyams (*Xanthosoma sp.*), and taro (*Colocasia esculenta*). IFFN. [5] conducted an experiment in Mbalangi, a village closed to Banga Bakundu, to evaluate the yield of egusi between burned and unburned land on a surface area of 1.2 km$^2$. Their comparison was based on total amount produced per year in kilogram (Table 1). The average yield recorded from unburned plots for 4 years period was 256.83 kg compared to the burned plots, 354.5 kg. The production for the burned land increases from the first to third years and dropped sharply in the fourth year (Table 1). Reason which could be attributed to this dropped maybe due to long-term negative externalities of the action such as, leached nutrient from burned organic matters began to extinct in the fourth year. Additionally, the soil decomposers (micro- and macro-organisms) which are responsible of mineralisation were destroyed. Nutrients adhered to soil organic matters, hence, depriving soil of its physico-chemical and biological properties. Whereas, the unburned land recorded an increase in yield from first year till the fourth year at a consistent rate. Although the amount of yield for unburned farmland was smaller compared to burned farmland with inconsistent production over time.
Burning reduce the amount of soil moisture making tillage of soil and planting difficult for small-scale farmers to cultivate. Additionally, the low soil moisture affects crop development, quality and quantity. The limited amount of soil moisture leads to flower abortion (dropping of flowers) during fruiting, poor fruit development and reduction in nutrient composition.

**Table 1. Comparative egusi yield for burned and unburned farmland for a period of 4 years [5]**

| Plot (200m²) | Crop yield (kg) 1st year | Crop year (kg) 2nd year | Crop yield (kg) 3rd year | Crop yield (kg) 4th year |
|--------------|--------------------------|-------------------------|--------------------------|--------------------------|
| Plot 1 burned | 362                      | 360                     | 348                      | 342                      |
| Plot 2 unburned | 242                      | 235                     | 246                      | 248                      |
| Plot 3 burned | 366                      | 368                     | 350                      | 325                      |
| Plot 4 unburned | 240                      | 244                     | 242                      | 248                      |
| Plot 5 burned | 364                      | 366                     | 358                      | 345                      |
| Plot 6 unburned | 244                      | 285                     | 296                      | 312                      |

*Note: Kg is kilogram and m² is squared meter

The soil is referred to as black box and the basic natural resource of agriculture that determines the large part of production of crops [6]. Farmers cultural activities carried out on soil influenced its productivity ans suitability such as bush burning coupled with other crop management technique affects the yield potential of soil in a long term. William [6] reported that an immediate needs priority be considered over long-termed soil conservation because what is convenient today could be damaging in future, especially with reference to burning. This reason may be considered to depict the dropped in egusi yield earned by the burned farmland. Repeated burning degrades soils particularly in rocky areas [7], and causes erosion [8; 9]. Farmers should avoid burning of farmlands rather they should clear far ahead of time, allowed for plant debris to decompose. Otherwise, in a situation where burning is unavoidable, spot burning could be performed with burn being carried out on stones and/or wood storms.

2.2 Animal husbandry

Animal production is a sub sector of the agricultural production system which include; piggery, poultry, fishery, rearing of goat, cattle rearing, bee and snail farming. Animal production system is prone to consequences of fire. Bee farmers usually established bee farms in cash crop plantations especially those that produces flowers such as cocoa, coffee and oil palms, however, some do place it in rubber plantations and also, besides flowers producing trees in the farmland. Reason being that the bees will have easy access to nectars for increase production of honey juice. In a decade, approximately 60% of farmers have lost their hives by fire which occurred during ENSO events (dry season). Because during ENSO period places are dry with trees dropping their leaves and dry grass all over. Majority of burnt occurred due to farmers failure to completely put off fire in their farmlands particularly inside wood storm which burned gradually into a nearby forest and/or uncleared field. For instance, in Banga Bakundu, a farmer and the family failed to completely put off fire in a wood that laid across his farm and the neighbour’s cocoa farmland. The wood burned continuously into the neighbour’s cocoa farm and ravished the entire farmland including the bee hives. In order to abate this situation farmers are advised to put off any trace of fire before living the farm. Meanwhile, during burning of a field a relatively enough individuals should be present to prevent the fire from moving into other farmlands located beside and enough fire extinguishing substance like water should be present.

Poultry farmers have lost thousands of birds due to fire outbreak caused due to ignorant and carelessness. Some broiler growers use charcoal while others kerosene lamp (local lamp) to heat day old chicks (brooding) in order to course adaption with the environment. Brooding process which involves growing day-old chicks till their system become adapted with the environment. It usually takes an estimated maximum period of 21 days. Furthermore, some wood produces charcoal (heat source) which are not good for poultry production because it sparks. Sparks drop on wood shavings on the floor, resulting in fire outbreak and obvious burning of the poultry farm (Figure 2 left). In 2018, South Asian news portal reported of a poultry farmer who lost 450 birds through fire outbreak in the night at Mirzapur Upazila, Bangladesh.
(Figure 2 right). To remedy such situation farmers should avoid using shallow containers to hold charcoal for heating but rather deep containers and raise to an appropriate height. Charcoal that sparks should be avoided. For those using electricity as source of energy, short circuit connection could result in fire outbreak. Thus, good electric appliance should be used for either solar or hydro powered source.

![Figure 2. The burning of poultry farm (left) and burned poultry farm (right)](image)

Bush burning affects aquatic organisms due to smoke haze and carbon emission (toxic gases) such as carbon monoxide and carbon dioxide released into the environment. Moreover, in USA, cumulative fire effects, fire size, and post-wildfire rainfall were strongly associated with the siltation of river beds, decreases in chlorophyll concentration, and decreases in the biomass of most insect taxa and 6 of 7 native fish species. For example, the Headwater Chub Gila nigra (100% loss) and Spikedace Meda fulgida were lost from streams in burned watersheds for up to 2 years postfire. Fish kills are thought to have resulted from hypoxia, and elevated concentrations of NH4+, trace metals, and ferrocyanides generated by wildfires [10]. According to [11] fire is a natural disturbance, its occurrence can have devastating impacts on forest vertebrates and invertebrates, not only killing them directly, but leading to longer-term indirect effects such as stress and loss of habitat, territories, shelter and food. The loss of key organisms in forest ecosystems, such as invertebrates, pollinators and decomposers, can significantly slow the recovery rate of the forest [11]. In 1998, estimation from fires in the Russian Federation suggested that mammals and fish were badly affected. Mortality of squirrels and weasels, estimated immediately after the fires were about 70 to 80%; boar 15 to 25%; and 90% rodents [12].

2.3 Forest
Forest fire have several causes, majority are due to human influence with few from natural causes such as lightening [6]. Fire occurring in developing countries is caused mostly by negligence and carelessness of farmers who permitted agricultural burns to get out of control. Farmers in the study area and those in other developing countries set fire in forest to clear and burn as a means of land preparation. The fire burnt beyond their farmland into other farmlands including; cocoa farms, oil palm, rubber, privately owned forest, etc creating conflict among farmers. Created fire breaks did not stop fire from moving to nearby farmland because it was set during period of high wind velocity. Burning farms during windy hours of the day should be avoided and if one is constrained to burn enough individuals should be present to prevent it from going beyond control. Most fire outbreak in Banga Bakundu started with a deliberate attempt to burn farmland for cropping and/or for hunting. Hunters particularly those that hunt during the day are responsible for about 10% of fire outbreaks in forest and farmlands. Because they used fire to smoke out games in dried wood and ground. Animal is chased out until it is caught either nearby or far off. At far off, it cannot be put off and obviously, burns gradually and spread wildly in the forest especially in dry season destroying habitats
and animal species. Manufacturing of a hunting device that can produce smoke-like substance with similar effect like that of fire may help in reducing the problem of forest fire of this sort. Additionally, negligence of cigarette smokers who threw cigarette storms in a bush which later flame and spread wild when it comes in contact with dry leaves and also in poultry farm and other businesses.

Some adoptive policy measures developed in Zambia could be applied in other developing countries. In Zambia, 5% of a total amount of establishing a plantation is kept aside for controlling wildfire [13]. Fire breaks of 5 m wide are established around plantations to reduce the risk of a fire crossing over to the next plantation. The cost of control burning in that period, using 8 persons and two vehicles was calculated at US $ 0.50/ha with a capacity to burn up to 80 ha per day [13]. Because of the winds and dry months that occur in Zambia, control burns are carried out at night, whenever possible. This approach can be used only by organizations that are financially viable, not individuals.

2.4 Biodiversity

The nature of fire-related threats varies depending on ecosystem responses and the adaptations of species to fire. A wide variety of fire-sensitive ecosystems in the tropics and elsewhere are threatened by land use activities and vegetation conversion efforts that either use fire or increase the probability of ignitions. Forest vegetation that rarely burns and normally resists fire is being modified by human activities such that fire is entering these ecosystems at shorter intervals. Small-scale farmers use fire for eradication of noxious weed on the farmlands include; elephant stalk (Pennisetum purpureum), and bahama grass (Cycodon dactylon) (Panicum maximum), (Rottboellia exaltata). Noxious weed species can be controlled by combination of physical (burning) and chemical methods by using systemic herbicide called glyphosate (active ingredient: paraquate). Fire in both forested and cultivated farmland directly led to loss in vertebrate, invertebrates and vegetation whereas indirectly it can cause stress, loss of habitat, displacement of territorial birds and mammals, destruction of shelter and food [14]. Hence, fires in a particular area can leads to change of species composition and/or extinction of flora and fauna. For example, in Mount Cameroon, South West Region, Cameroon, [5] reported that forest fire has led to scarcity of bush meat needed for human consumption and the extinction of important wildlife and plant species. Meanwhile, Woods [15] reported that forests which are not adapted to fire, fire can kill virtually all seedlings, sprouts, lianas and young trees due to lack of surface protection like hard back. Damage to seed bank, seedlings and saplings hinders recovery of the original species. Thus, succession cannot be achieved [17].

Fire at regional and local levels have led to change in biomass stocks, altering of hydrological cycle with subsequent effects for marine systems such as coral reefs, and impact plant and animal species’ functioning. Smoke from fires can significantly reduce photosynthetic activity [16] and can be fatal to humans and animals. Governments, land management entities and scientists attempt to address fire-related threats through policy changes, incentives and community-based prevention and suppression programmes, there is a danger that the vital role of, and need for, fire in many ecosystems will be overlooked, as was done in much of the United States over the last century and has occurred in Australia and Canada.

2.5 climate change

At the global scale, fires are a significant source of emitted carbon, contributing to global warming which could lead to biodiversity changes. While at the regional and local level, they lead to change in biomass stocks, alter the hydrological cycle with subsequent effects for marine systems such as coral reefs, and impact plant and animal species’ functioning [18]. Currently, the climatic condition in the study area is harsh with high afternoon temperatures of about 20 to 30°C. In the past years, the climatic condition of the area has degraded because of deforestation to establish oil palm and cocoa plantations. Climate change affects disturbance such as timing, magnitude, and frequency of drought, storms, insect outbreaks, grazing field, fire outbreak, and a changing climate will bring about changes in disturbance regimes to forests and farmlands [19]. Both human-induced and natural disturbances shape ecosystems by influencing species composition, structure, and function (productivity, water yield, erosion, carbon storage, and susceptibility to future disturbance) [19]. Over the past years, scientists have learned the magnitude and impact of these
disturbances and their response to climate revival are expected from changes in temperature and precipitation. IFFN, [5] reported change in climatic conditions at the Mount Cameroon reserve areas from the usual cool, foggy, fresh climate to a rising temperature and less rainy seasons prevailing for the past 20 years today. The most important pollutant of wildfires and burning is visible smoke, which principally is a mixture of particulates and water vapour [20]. Particulate matter in smoke include cities-induced (transportation, industry, and domestic) (13.6%), forest fire (2.5%), and agriculture and forestry burns (0.2) [21]. Sulfur dioxide is virtually absent from emissions caused by forest fires [21].

The primary products of agriculture and forest fires are carbon dioxide and water vapour, with a lesser proportion of carbon monoxide and some hydrocarbons. These gases are in proportions as follows carbon dioxide (67%), water vapour (25%), carbon monoxide (6%) and particulate such as soot and ash (1%) [22]. Gases such as carbon monoxide, and carbon dioxide destroy the ozone layer of the earth surface which permits direct penetration of short wavelength radiations dangerous to human health. Short wavelengths are prevented from living the earth surface, so, greater portion of the radiations are absorbed. These radiations cause greenhouse gases effect, affecting humans and other living organism in the planet earth. Natural forests are valuable as a source of carbon sequestration (sink) and contribute enormously to a nation growth when utilized properly.

2.6 Health constraints
Success in farming season can be achieved when a farmer is in good health coupled with good managerial skills. However, burning affects farmers’ health gradually over a period of time. Humans are exposure to smoke pollutants via the following routes; inhalation, ingestion, and dermal [23]. The negative externalities of fire to farmers’ health are extrapolated from research conducted in different parts of the world (health research needed in study area). Skin cells directly absorb free radicals which contribute to the development of emphysema, adult/acute respiratory distress syndrome (ARDS), and lung cancer [24]. Gastrointestinal absorption is another pathway of exposure to pollutants emitted by burning and through consumption of burned products such as plants that have absorbed pollutants in the soil or ash, wildlife that have inhaled or ingested pollutants, and freshwater species such as fish that have absorbed or ingested contaminated water [23]. Fowler, [23] explained the medically significant of biophysical effects of biomass smoke include acute, sub-chronic, and chronic effects on public health. Researcher went future to explain that spectrum of adverse physiological effects ranges from temporary, relatively minor eye, nose, and throat irritations, to dangerous and persistent cardiopulmonary conditions, and less-commonly to premature death.

There is direct relationship between biomass smoke and the degree of chest pain illness experience by humans. In 1998, Floridians exposed to smoke from burns were found to develop chest pain and bronchitis [25]. Ozone, a secondary product of biomass combustion is also a causative agent of chest pain and other respiratory complications such as pulmonary edema, pre-existing asthma, pre-aryrhythmia and headaches [26]. Biomass smoke and air particulate are responsible for serious health problems such as cardiopulmonary, carcinogenic, premature deaths, suppressed immune system, physical and cognitive impairments and direct injury [23]. In USA, firefighters comprising farmers, family members and passer-by suffers from the following psychological stressors (Table 2). Farmers in the study area as well as developing countries are suspected to face the same psychological stressors and other health conditions mention above. Therefore, fire is responsible for many unrecognized premature deaths of farmers which governments in developing countries should take urgent measures to readdress this phenomenon by engaging into meaningful educative talk on the demerits of burning in cropping system and also offering health services to farmers. In additional, deploy extension officers to accompany smallholder farmers in their production and provide firefighting equipment including head mask, farm boots and protective cloths to reduce the severity.

| Psychological stressor | Degree of effect (%) |
|------------------------|----------------------|
| Frustration            | 76                   |
| Irritability           | 69                   |
| Anger                  | 63                   |
Sadness 62
Sleep disturbance 62
Mood swings 59
Avoidance of feelings 56
Loss of enthusiasm 56
Fatigue 54
Relationship problem 56
Anxiety 53
Depression 52

3. Conclusion
In the world, deliberate burning is carried out to reduce the amount of biomass in the forests and for agriculture burns. In the world, human activities are responsible for fire disasters: degrading human health, socio-economic (industries) and the environment. Smallholder farmers in Banga Bakundu as well as those in Sub-Saharan Africa used slashed and burned method for land preparation. The land preparation is done usually in dry season before the start of cropping season (rainfall). Before burning a farmland, farmers should establish fire breaks at the edge of their farms and/or forest and enough individuals need to be present in order to prevent the fire from moving into the nearby land. There are several psychological stressors and diseases gotten in the course of putting off fire, so, farmers should ensure they are and the necessary equipment to utilize. The government of Cameroon needs to intensify sensitisation on the negative externalities of burning to the environment. Research on the effect of fire to human health needs to be investigated in the study area in order to ascertain the health status of these farmers in order to reduce the amount of premature deaths. Economic losses, tangible and intangible needs to be evaluated to know the economic worth of fire disaster in the community.

Conflict of interest
Authors declare no conflict of interest

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