Indigenous Knowledge Systems (IKS) and Adaptation of Climate Smart Agriculture (CSA) in Nigeria

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Abstract

This review is focused on Indigenous knowledge systems (IKS) and adaptation of climate smart agriculture (CSA) in Nigeria. Specifically, this paper discusses the role of indigenous knowledge in farmers' perception of climate change; indigenous knowledge used by farmers in responding to climate change; challenges in applying IKS in CSA adaptation and opportunities to integrate indigenous knowledge and CSA into extension education. The impacts of climate change are observed at various spatial scales; from local to global and are a threat to global environmental sustainability, particularly its consequent risks to indigenous communities and their livelihoods. Climate Smart Agriculture (CSA) offers an integrative approach to adaptation within the context of agriculture that involves services to farmers and farm activities with the intention of creating greater resilience of farming systems in the face of environmental change and reducing the environmental effects. The concept of CSA is new and still evolving, howbeit, many of the practices that make up CSA already exist worldwide and are currently used by farmers to cope with various forms of risks. To foster CSA using IKS, it calls for in-depth analysis of successfully completed and on-going practices as well as their relationship with current and future agricultural and environmental outlook. IKS can help to achieve food security and broaden agricultural development in this time of a changing climate and rising food demand.

Key words: *Indigenous knowledge, Climate Smart Agriculture, Adaptation*

Introduction

The ability to predict the weather has been a great advantage over time. Even without the modern way of dividing time into minutes, hours, days, weeks, months and years, humans have been able to understand these diurnal and seasonal changes of the environment (Svotwa, Manyanhaire and Makanyire, 2007). Such knowledge could be used in determining timing of important agricultural activities and in predicting disasters. However, over the years, this has become

increasingly difficult due to climate change. Climate change is a long-term change in the statistical distribution of weather patterns resulting from human activities and from natural climate variability. The impacts of climate change are measured and observed at various spatial scales; from local to global and are a threat to environmental sustainability, particularly its associated risks to indigenous communities and their forms of livelihoods (Manyanhaire and Chitura, 2015).

Indigenous knowledge (IK) is Knowledge unique to a given culture or society, acquired through accumulation of years of experiences of local people, informal experiments and intimate understanding of the natural systems stressed by climate change and socio-economic development. According to Ihenacho, Orusha and Onogu (2019), the term indigenous knowledge system make reference to knowledge and know-how that is accumulated over generations which guides human societies in their innumerable interactions with their surrounding environment. Indigenous knowledge has been considered as social capital for the poor and is relied upon for food production and to ensure survival. However, IK is gradually disappearing due to the invasion of development concepts, which promise development goals or solutions, which are largely not sustainable.

Adaptation in the context of development has changed significantly since the beginning of the new millennium. Existing public debate is dominated by planned adaptation as a reaction to climate risks. Additionally, adaptation to climate change and variability as a research topic has gained popularity in the natural and social science disciplines (Eguavoen, Schulz, De Wit, Weisser and Müller-Mahn, 2015). In Nigeria, as well as in other parts of the developing world, rural communities already practice different forms of adaptation practices in response to climate change in their local area. These practices rely heavily on indigenous knowledge, which plays great role in climate change adaptation at the local level (Theodory, 2016).

Climate-Smart Agriculture (CSA) is defined by the Food and Agriculture Organization (FAO, 2013) as agriculture that sustainably increases productivity, enhances the resilience of livelihoods and ecosystems, reduces and/or removes greenhouse gases (GHGs) and enhances the achievement of national food security and development goals. The term CSA was invented by the Food and Agricultural Organization of the United Nations (FAO) in 2010 following The Hague conference on food security, agriculture and climate change. CSA aims to: increase food production, increase the resilience of farming systems to environmental change and increase the sustainability of agricultural systems through reduced Green House Gases (GHGs) and environmental foot-prints emanating from agriculture. The options for CSA must be like the word, "SMART" itself i.e., S for Specific, M for Measurable, A for Attainable, R for Relevant, T for Time-Bound (Terence and Christopher, 2016). Indigenous practices are reviewed in this paper through the lens of CSA.

Climate change may be a global phenomenon, but the impacts are not evenly distributed among the world's population. Indigenous groups are projected to be among the communities most heavily affected by climate change (Parrotta and Agnoletti 2012). Today, climate change problems have become a vital scenario to guarantee the sustainability of livelihood. The rate of climate change, coupled with population growth, threatens food security in Nigeria and Africa at large. Countries, such as Nigeria have been making serious efforts to unweave these problems, which include declining agricultural productivity, soil degradation, soil water loss and a host of

other socio-economic issues. Global climate change is altering our relationship with the environment, modifying relatively stable climate factors and making them uncertain, unpredictable and threatening (Findlater, Satterfield, Kandlikar and Donner, 2018; Merino-Saum, Baldi, Gunderson and Oberle, 2018). Changes in land use and an increasing demand for water resources have affected the capacity of ecosystems to sustain food production, ensure freshwater resources supply, provide ecosystem services and promote rural multi-functionality (Gori, Brito and Ruiz, 2018).

However, being aware, having apt understanding and use of local knowledge systems is one strategy that can help facilitate efforts to deal with these problems (Adedotun and Tunji, 1995). Indigenous knowledge remains the best local adaptation strategy among the rural farmers to combat climate change in Nigeria. According to Theodory (2016), If existing strategies on climate change adaptation will not integrate indigenous knowledge, then government initiatives on poverty eradication are likely to fail. In as much as the question of what makes up a successful adaptation of climate smart agriculture at local level remains largely unanswered, the drive of this paper is to create an understanding of different CSA adaptation practices, particularly indigenous knowledge-based practices used by farmers to adapt to climate change. Specifically, this paper discusses the following:

i. Role of indigenous knowledge in farmers' perception of climate change;
ii. indigenous knowledge used by farmers in responding to climate change;
iii. challenges in applying IK as CSA practices: and
iv. Opportunities for integrating Indigenous knowledge into extension education.

This paper is a literature review and as such, secondary data was the main source of information.

The Nexus of Farmer's Indigenous knowledge and Perceptions of Climate Change

There are diverse views and perceptions about climate change. These views can be seen across different political, cultural, and socio-economic spheres. Many have perceived climate change in terms of: Reduced productivity, delayed rainfall, drought, flood, soil water loss, prolonged sunshine, excruciating temperatures, among others.

Onyekuru and Marchant (2017) researched on "Climate Change Perception, Awareness and Adaptation Decision Among Forest Communities in Nigeria", their results on climate change perception showed that majority (88%) of the respondents have noticed climate change in one form or the other in all the zones with the highest occurrence in the Sudan savanna and the least in the montane forest where only 33% noticed climate change impact. According Grimberg, *et al.* (2018), perceptions regarding the causes of climate change varies among farmers. In their study, some perceived that anthropogenic activities are the principal drivers of climate change, while others considered natural causes as the main cause for climate change.

Research has shown that indigenous knowledge and it relative practices is one of the viable options in responding to climate change impacts (Smith and Lenhont, 1996; Grimberg, *et al.*, 2018, Onyekuru and Marchant, 2017). It is a process which involves management of risks generated by climate change, including variability, using 'natural wisdom and strategies'. Mafongoya and Ajayi (2017) defined such traditional, ecological knowledge system as "a

cumulative body of knowledge, practice and belief, evolving by adaptation processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with their environment." Indigenous knowledge is used to describe the knowledge systems developed over a long period of time by a community as opposed to the knowledge that is generally referred to as 'scientific' knowledge. It is the wisdom, knowledge and practices of indigenous people gained over time through practical experiences, which are orally passed on from generation to generation and has over the years played significant part in solving problems, including problems related to climate change and variability (Manyanhaire and Chitura, 2015).

Before the advent of modern scientific practices, rural communities must have realized that certain animals, and plants had the capacity to detect and respond to changes in the atmospheric conditions. They also mastered the positions of stars, the sun and associated shadows and the moon, the wind strength and direction and the cloud position and movement and the lightning patterns, animal and vegetation physiological changes (First Science, 2004). The knowledge about past disasters and climate in Nigeria and Africa at large are the accumulated experiences that have been handed down to generations through oral traditions in what is referred to as Indigenous Knowledge System (IKS). IKS is the basis for local-level decision-making in many rural communities. Such systems are cumulative, representing generations of experiences, careful observations and trial and error experiments. People's memories and activities are the store houses of IK. It is expressed in stories, songs, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local languages and taxonomy, agricultural practices, equipment, materials, plant species and animal breeds. It has value not only for the culture in which it evolves, but also for scientists and planners striving to improve conditions in rural localities. IK is the spring board for effective climate change adaptation studies and applications by local communities (Manyanhaire et al, 2015).

Local communities in Africa have developed intricate systems of gathering, predicting, interpreting and decision-making in relation to weather. Ajibade and Shokemi (2003) observed that Nigerian farmers were able to use knowledge of weather systems such as rainfall, thunderstorms, windstorms, harmattan and sunshine to prepare for future weather. Whilst the current western trained meteorologist bases weather forecasts on global models and satellite imagery, the traditional perspective is based on lived experiences. Indigenous communities have long been recognized as particularly vulnerable to the impacts of climate change due to the close connections between their livelihoods, culture, social systems and their environment (Ihenacho et al., 2019). Simonelli (2008) asserted that deep and long-established relationship with the natural environment affords many indigenous people with knowledge that they have long used to adapt to environmental change, and are now using it to respond to the impacts of climate change.

Indigenous knowledge used by farmers in responding to climate change

Indigenous Crop Management Strategies: Evidence from several studies, such as that of Bogale and Bikiko (2017) shows that local people have used different indigenous strategies to adapt the current climate change. Such Crop management strategies include Crop rotation, manuring, multiple cropping to diversify production; early or late planting; mulching for soil water retention, soil temperature moderation, suppression of diseases and harmful pests; terrace building to prevent soil erosion; fallowing, raising mounds and ridges, Crop diversification,

Timing of planting and Pest & weed control, among others, as indigenous strategies to overcome climate change menace. Also, changes in ground preparation and harvesting times; wind erosion prevention measures (retaining bushed strips in lands, or planting of wind breaks, which reduced loss of food crops due to wind; and traditional water conservation measures, are some of the strategies practiced by indigenous people for crop management (Tunde and Ajadi, 2018).

Indigenous farming systems such as mixed farming system, which is the integration of livestock closely with crops, helps in reducing the risk of crop failure as a result of climate change. This is because livestock helps such farmers to accumulate capital, thereby acting as insurance against crop failure. This system also encourages farmers and rural people to protect their rangeland and use them sustainably for raising livestock rather than putting them to the plough, which can lead to soil compaction and other negative effects. Farmers incorporate compost, animal waste and domestic wastes into the soil to boost fertility. This helps to maintain microbial activities in the soil and promotes absorption of nutrients by plants.

***Indigenous* Water and land Resource Management Strategies:** Water is a crucial requirement in every stage of crop development. Agriculture is largely dependent on water and its availability or otherwise determines when and how crops are cultivated. This is evident in the seasonality of some crops, which depends on rainfall for its cultivation. The FAO forecasts that '*by 2050 global water requirements for agriculture will increase by 50 per cent to meet the increased food demands of the projected population*'. Also, statistics such as the FAO-AQUASTAT have shown continuous increase in fresh water withdrawal over the years. For example, in one of their reports, global fresh water withdrawal ratio revealed that agriculture takes up 69%, municipal 12% and industrial 19%– although this is largely dependent on climate and location. Furthermore, in a continent wise comparison, Africa topped the chart, followed by Asia, while Europe ranked least (see *Fig*. 1).

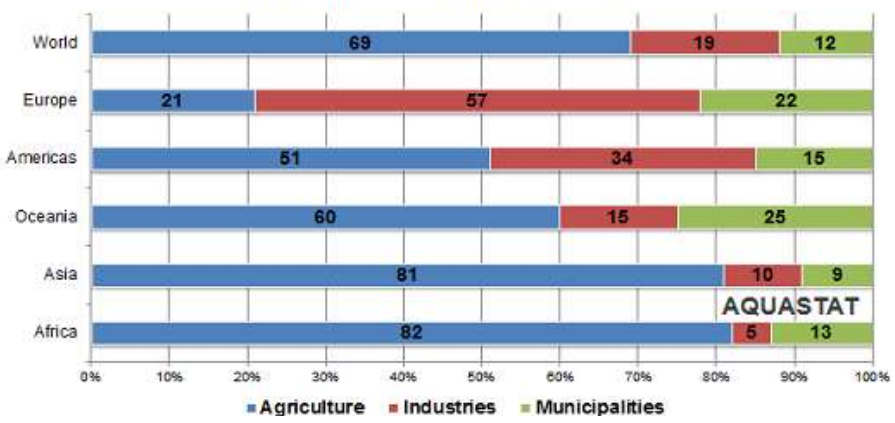

Fig. 1: Chart showing water withdrawal by

Thus, any attempt on sustainable water management is a breakthrough not just in agriculture but in sustainable livelihood. For example, local drip irrigation technique, combined with mulching has allowed farmers to maximize any little available water for an extended period of time – this is because the technique allows for the control of water flow, while minimizing run off. This

technology is cheap and sustainable, because resource can be sources locally from hospital waste and empty plastic containers (which will otherwise pollute the environment).

Climate change has it toll already on water availability, in the form of drought, flood, rapid evaporation, etc. Many indigenous adaptation strategies have positive impact on water management. Practices such as mulching, bush fallowing, shifting cultivation, has been observed to increase the water retention capacity of soils. According to West and Post (2002) Improved cropland and grazing management can increase water storage and infiltration, reducing loss through runoff and leading to greater water availability in the soil and enhancing ecosystem water balance. In semi-arid areas, small-scale farmers use planting pits to harvest rainwater and rehabilitate degraded land (see Fig. 3 and 4). This technology improves infiltration and increases nutrient availability in soils, leading to significant increases in yields, improved soil cover and reduced downstream flooding (Stern, 2006). Ihenacho, *et al.* (2019) discovered that farmers use strategies such as planting pits, underground earthen jars, construction of infiltration pits, construction of wells/basins for water storage, construction of soil/stone bunds, use large calabashes and traditional taboos for water protection.

Harvesting and diverting of water from rooftops, which used to be done for household benefit alone, is currently practiced by farmers. Some even divert water from natural springs in the time of abundance, into tanks for future use. This provides farmers with substantial amount of water stored up in case of drought, which the farmer will draw up water to irrigate their farms. As reported by International Water Management Institute, farmers in Burkina Faso have been using this technique since 1989 to improve crop production and increase their income. In Nigeria, this is commonly observed in vegetable farming, where farmers construct earthen ponds or other forms of excavations to trap water or channel run off into it. Also, recent indigenous trial has led to the use of banana stem as planting material, because its amazingly high in water retention capacity which will help to sustain crops (see *Fig*. 6).

Indigenous Livestock management strategies: Indigenous knowledge is also greatly applied in livestock management. For instance, farmers have used bitter leaf solution for de-worming, making pepper/salt solution for treating cough in chicks, use of banana peels with salt for animal delivery, use of ashes for pest control, and the use of cannabis to control new castle disease of poultry (Ihenacho, *et al.* 2019). Also, in adapting to climate related impacts on Livestock production, local people practice Production of livestock through modern highbred system, and sale of some livestock to reduce the number of animals, to alleviating shortage of foods because of climate change. Even though farmers have employed different indigenous adaptation mechanisms, the impact of climate change is still felt. As a result, some farmers venture into off-farm activities as coping strategies, which may include hunting, fishing, basket weaving, Daily labor, etc., to augment for reduced income.

Shifting Cultivation: Shifting cultivation has attracted the attention of agriculturalists, foresters, conservationists, economists, social scientists and administrators in SSA. On close study, shifting cultivation is found to be generally accepted as a reasonable and effective method of maintaining fertility and output under appropriate circumstances (Bunting and Bunting 1984; Adedipe, Okuneye and Ayinde 2004). This is based on the fact that shifting cultivation is often characterized by a season-to-season progression of different crops which differ in soil nutrient

requirements and susceptibility to weeds and pests. The specific crops and choice of succession may differ from country to country, but the general principle of this IK remain the same, although the essential character is being modified by emerging farming systems such as zero tillage and alley cropping (Kang, Wilson and Sipkens, 1981).

***Indigenous Pest Management strategies*:** Application of IK practices to manage pest both in the field and at post-harvest have been in existence in Nigeria since time immemorial. In a study by Peter-Onoh *et al.* (2014) in Southeastern Nigeria, it was discovered farmers use indigenous knowledge to store crops such as Rainforest Spice (*Monodora myristica*) using baskets, plastic containers, clay pot and calabash, to prevent infestation by insects and pest. A common post-harvest disease/pest prevention practice is hanging crops such as okra, unshelled maize, sorghum and millet cobs, on a string over fire point in a hut roof, where the heat from the fire prevents infestation. Ihenacho, *et al.* (2019) uncovered that farmers use ashes for on-farm pest control. Also, chilli pepper (*Capsicum annum*) has been widely used to preserve harvested crops such as beans in the store. In the case of cocoa, life plant (*Jatropha gossipifolia*) and tobacco (*Nicotiana tabacum*) plants were used to prevent insect build-up on the cocoa plantation.

In other places, indigenous knowledge has also been greatly applied in pest management. Example, in China, citrus growers place nests of the predacious ant *Oecophylla smaragdini* (green tree ant) in orange trees to reduce insect damage. In India, local farmers intentionally plant sunflower in wheat fields so as to aid the bio-control of rats by owls at the stage of grain development (Sinha 1994).

***Indigenous Weed Management strategies*:** Livestock, particularly sheep, are efficient in controlling weeds. They are used in many places to reduce forest undergrowth to keep it clean and reduce the cost and drudgery of chemical or mechanical weed control and at the same time, reduce the risk of bush fire proliferation. For instance, in rubber and oil-palm plantations in Malaysia, the integration of livestock to utilize the vegetative ground cover under the tree canopy has proven to increase overall production and saved up to 40% cost of weed control. It is also used in Columbia, in sugar-cane fields to control weed, suppressing the use of herbicides and reducing half of the cost of weed control. Such practices also safeguard the environment and avoid chemical pollution and other forms of ecosystem degradation.

In a study by Adedipe, *et al.* (2004), it was discovered that in Nigeria, use of local pesticides is a common practice among farmers. Neem (*Azadirachta indica*) extracts are commonly used to spray crops especially cowpea in place of the conventional insecticide, which is environmentally hazardous. This practice does not only serve the purpose of weed control, but also incorporates beneficial elements into the soil, enhancing sustainability.

Challenges in applying IKS in CSA adaptation

Lack of practical understanding of the CSA: CSA approach is obviously beneficial and compelling in principle, but its application under Africa's vast agro-ecologies and highly heterogeneous farming systems, socio-economic arrays and policies still requires concrete examples of success. The evidence of how such successes are measured and achieved is of critical importance (Neate, 2013). Gathering empirical messages to educate farmers and policy

makers and supporting any scaling up initiatives will depend on how the inter-relationship of CSA and IK is understood in practice.

Lack of data, information and appropriate analytical tools at local and national levels: In many African countries, there are no long-term climatic and landscape level data. Where some data exist they are dispersed and difficult to access. Global models of climate change are at scale and resolution difficult for local, national or regional managers to work with (McCartney, Rebelo, Xenarios and Smakhtin, 2013). Capacity and analytical tools to downscale the results of global models to regional, national and local levels are not readily available in most countries. As a result, decision makers lack knowledge of current and future projected effects of climate change in their country and the implications for agricultural practices, food security and natural resource management. The lack of information, limited human and institutional capacity as well as lack of research-based evidence impedes the ability of decision makers to target CSA implementation to areas most at risk and to implement adequate financing plans (*ibid.*). this also leaves the farmers with no preparation for future challenges, thus, leading to abandonment of IK.

Socioeconomic constraints: Although farmers have always adapted and coped with climate variability manifested, for example, in delayed onset of rains, seasonal water deficit and increasing seasonal maximum temperature, they often lack knowledge about potential feasible options for adapting their production systems to increasing frequency and severity of extreme weather events (droughts and floods) and other climate changes. Existing customary and institutional factors as well as new drivers, for example, large-scale foreign investment in agricultural land that leads to the displacement of current poor land, users have exacerbated this state of affairs (Williams, *et al.*, 2012; Williams, 2014). At another level, lack of accurate and timely information and technical advisory services, unavailability and lack of access to inputs, including suitable crop varieties constrain their ability to assess the risks and benefits of CSA and make informed investment decisions. Competing resource use (e.g. labour, cash, biomass) at the farm scale have been a major constraining factor. Furthermore, smallholders in particular face obstacles in gaining access to domestic, regional and international markets.

Lack of adequate and innovative financing mechanisms and effective risk-sharing schemes: In many countries there are not yet in place financing plans to promote the uptake of CSA, yet the transition to climate-smart agricultural development pathways requires new investments, such as farmer education to reassure them of the critical role of IKS in climate change adaptation. "As farmers in Africa face major risks arising from the effects of climatic hazards, they also face the challenge of managing risks associated with the high costs (at least initial costs) of adopting new technologies (e.g. conservation agriculture and agroforestry) whose benefits often only come after several years/seasons) of production. Most of the farmers have little or no access to credit, micro-financing and/or insurance" (Mapfumo *et al.*, 2015).

Opportunities for Integrating IK and CSA into Extension Education

Largely, the formal extension education and training curriculum followed the trend of western knowledge -which is mainly top-down, thus, lacking in many local realities, such as climate change and its adaptability or mitigation. As observed by Madukwe (2006), the dominance of the Western knowledge system has largely led to a prevailing situation in which indigenous

knowledge is ignored and neglected. From this exposition, it has been established that indigenous knowledge plays an indispensable role in actualizing climate smart agriculture and mitigating or adapting to climate change. As a result, the integration of Indigenous knowledge and CSA into all levels and avenues of extension education must be treated as top priority by governments, agricultural industry leaders, researchers, policy makers and stakeholders.

it has been observed that a strong relationship exists between indigenous knowledge and sustainable development, presenting new models for development that are both ecologically and socially sound (Aneato *et al.*, 2013). However, since IK is often not a general knowledge, every community (or stakeholders from that community) may want to promote their knowledge, while rejecting those from other localities. To solve this problem, all actors should be pulled together to come up with a selected IK and climate strategies with proven record of climate change adaptation or mitigation. This could be done at meso-level institution (e.g. local government or counties), to expedite action and success. On the other hand, there many researches which have been carried out in the area of CSA, with laudable results and recommendations – which are laying waste in libraries or online platforms where many farmers cannot access. Concerted efforts should be made to retrieved these strategies and disseminate same to the end users.

These earmarked strategies could be remodeled (if need be), following current realities and technological trends, and passed down to end users through different channels of extension education such as:

- Agricultural Radio programmes
- Agricultural TV programmes
- Agricultural fora
- Agricultural columns in Newspaper
- Agricultural blogs and Social media platforms
- Informal training programmes (farmer field school; focus group discussion, etc.)
- Curriculums and training manuals in agricultural institutions
- Government agricultural ministries/ agencies
- Local NGOs, etc.

Future developmental endeavours must also recognize indigenous knowledge in incorporate its stakeholders in its formulation and implementation process, to foster sustainability of such development. Such extension technologies as Farmer Field School (FFS), Farmer Study Circle (FSC), Focus Group Discussion (FGD), etc., that recognize farmers as knowledge-laden, should be encouraged and a linkage should be created between indigenous stakeholders and policy makers, for sustainable policy formulations (Aneato *et al.*, 2013).

Conclusion

Global climate records still indicate various climate changes, including: temperature increases, shifting rainfall patterns, a rise in the sea level and the reduction of snow and ice. All these changes have drastic implication on global ecosystems. These indicates that global climate change has become a pressing global issue of the 21st century. The deterioration of the climate

has become an international phenomenon, which has gained wide attention across different works of life. This is evident by the declaration of Global Climate Convention in 1992.

While the concept of CSA is new and still evolving, many of the practices that make up CSA already exist worldwide and are currently used by farmers in form of IK, to cope with various production risks. Mainstreaming CSA into the fabric of agricultural activities requires keen evaluation of successfully completed practices and their role in curbing the present and future menace of climate change. CSA can help to achieve food security and development goals in the face of climate change and surging food demand. From this discussion, it was recommended that massive public education and training should be carried out to acquaint the general public with the concept of Climate Smart Agriculture and it inter-relationship with IK; Local communities and farmers should be encouraged to hold fast to their indigenous knowledge, as it has been observed to be very useful in climate change adaptation of CSA; and Adequate institutional and political policies regarding climate change and Climate Smart Agriculture should be formulated.

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