

Full Length Research Paper

Agricultural technologies, territorialization from below and land-use conflicts in agro-pastoral areas of Northern Benin

Georges Djohy^{1*} and Honorat Edja²

¹National School of Statistics, Planning and Demography (ENSPD), Research Unit on Agro-Pastoral, Humanitarian and Food Systems (UR-SAPHA), University of Parakou, (UP), Benin.

²Department of Agricultural Economics and Rural Sociology (ESR), Faculty of Agronomy (FA), University of Parakou (UP), Benin.

Received 29 August, 2022; Accepted 28 September, 2022

For some years, the Republic of Benin has promoted mechanization and modernization of its agricultural sector as a driver of food security, socio-economic development and sub-regional solidarity. New agricultural technologies such as tractors and pesticides have been introduced into the small scale farming systems and have reached record adoption rates in various agro-ecological zones of the country. However, rural actors' use of these technologies also leads to new forms of territoriality which make some winners and others losers. This study was carried out in the cotton basin of northern Benin to scrutinize the forms of appropriation of agricultural technologies and the effects on access to productive resources and interactions between farmers and herders who are cultural neighbors. Participatory observation was carried out over ten months in the district of Gogounou where informants who were purposively selected were engaged in 164 individual interviews and 21 focus group discussions recorded by consent, transcribed and thematically analyzed. By analyzing the mechanisms of appropriation of herbicides in rural areas and the related political ecology of land use, the paper argues that herbicides reconfigure tenure systems by inducing new forms of land-tenure insecurity and land-use conflicts between socio-professional groups that depend on the same natural resources for their livelihoods. Community-based discussions can engage stakeholders in exchanges of sustainable production alternatives, just as institutional reforms are needed to better channel the uses of modern agricultural technologies.

Key words: Benin, herbicide, territorialization, tenure insecurity, land-use conflicts.

INTRODUCTION

Agricultural modernization has become one of the main development goals pursued by the Benin Government

over the last decades. Although it requires significant resources, the political will to make agriculture a driver of

*Corresponding author. E-mail: gdjohy@gmail.com.

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

economic growth, social development and food security is evident in several policy documents, including the National Agricultural Mechanization Strategy Document (DSNMA) and the Strategic Plan for Agricultural Sector Development (PSRSA, 2011). Political discourses that envisage Benin as a West African agricultural power in the medium term are backed up by the sub-regional solidarity momentum, which demands that countries with agro-ecological conditions favorable for cultivation invest in this, in order to help people living in less favorable environments, such as the Sahel.

The Benin Government's recent donation of 150 tons of local maize to Niger to address the drought-induced food crisis is an example: *"At the donation ceremony, the Head of Benin delegation expressed to the Nigerien authorities the satisfaction of the Government of Benin to fulfill a duty of solidarity towards a neighboring country linked to Benin through longstanding friendly and fraternal relationships"* (Kinninvo, 2010).

The promotion of labor-saving technologies is in line with these objectives and aims at enabling small-scale farmers not only to reduce the difficulty associated with crop farming, but also to increase their crop areas and especially to improve their productivity in the context of agricultural intensification (Saizonou, 2009). Tractors have been introduced for crop production through various mechanisms to reduce access costs. The approach of Agricultural Machinery Use Cooperatives (CUMAs) introduced in the late 1990s in the context of North–South technology transfer, which has been successful in some municipalities in Benin, was adopted as a replicable model across the country (Balse et al. 2015).

The Program for the Promotion of Agricultural Mechanization (PPMA) made available to farmers, individuals or groups various types of tractors of Indian and Chinese origin that were widely adopted. Apart from individual acquisition of tractors and collective access through groups and cooperatives, many farmers benefit from provision of agricultural services, in particular for plowing (Saizonou, 2009; Gibigaye et al. 2010). The adoption rate of the tractor had been relatively low in Benin, but increased considerably in recent years from 1% in 2006 to 17% in 2010 (Agro-Benin, 2011).

Like the tractor, pesticides have recently become widespread in crop production systems in Benin. Although herbicides were introduced in the 1990s (Gaborel and Fadoegnon, 1991; Marnotte, 1994), their use by farmers increased considerably in a particular context of de-liberalization of the cotton sector, whereby the Benin Government regained control over the supply of agricultural inputs, which led to the development of informal pesticide flows (Meenink, 2013). Chemicals illegally imported from neighboring countries such as Nigeria and Ghana appeared on the local market, where farmers have access to them more easily than before,

with price and credit mechanisms that are totally beyond the control of the state, and benefit small-scale farmers more than the formal input-supply chain does.

Tractors and herbicides are transforming not only human relationships to rural land, but also social relationships between humans, but there are few detailed studies that address the complex relationships between agricultural technologies, societies and environment in the particular context of Benin. This article is based on a study conducted in northern Benin in 2013 and 2014 to explore the changes brought about by labor-saving technologies in general, and by herbicides in particular, into access and land tenure, and interactions between neighboring rural actors. It sought to understand the forms of herbicide appropriation and their implications for land-tenure security, coexistence between actors and sustainability of rural livelihoods.

Theoretical background

Our analysis of changes in land use and rural neighborhood in relation to agricultural labor-saving technologies was inspired by recent political ecology-based discussions on territorialities in sub-Saharan Africa. Territorialization summarizes all practices and strategies – explicit or implicit, open or covert, direct or indirect, isolated or intertwined – which fall under the exercise of a power to control land and natural resources (Peluso, 2005; Gonin, 2014). In their quest for spatial control, social actors can pursue two different forms of territorialization strategies:

Top-down: Territorialization from above includes all the means by which States, in collaboration with international institutions and actors, decree and implement policies that exclude local populations from using land and natural resources they inherited from their ancestors and have used for centuries. These are most often patrimonial policies oriented toward creating forest reserves or game parks or promoting ecotourism etc. (Homewood and Rodgers, 2004; Gascon, 2014; Pochet, 2014);

From below: In this case, site-specific mechanisms are developed whereby local actors take advantage of asymmetry of power in rural areas to exert a certain power of exclusion over other land and natural resource users. This mechanism centered on local actors and their daily practices with regard to land is known as territorialization from below, and mobilizes several kinds of economic, sociocultural and technological resources. Local-level territorialization has recently been observed in several countries in sub-Saharan Africa, notably in Mali, Burkina Faso and Côte d'Ivoire, where local communities have introduced crops such as cotton or cashew

plantations or have taken advantage of emerging wood markets to claim or increase their control over land and specific resources (Benjaminsen, 2002; Gautier et al. 2011; Audouin and Gonin, 2014; Gonin, 2014; Fokou, 2015).

Globalization is perceived to be at the heart of these forms of territory-making politics inspired for the most part by the transformations of local economies and the contact of local actors with global markets and players (Bassett and Gautier, 2014; Gonin, 2014).

Governments want to increase the productivity of small-scale farms in order to increase food security and export earnings and their political discourses support this, a good example being 3N initiative in Niger: Nigeriens Nourish Nigeriens (*les Nigériens Nourrissent les Nigériens*). However, it is impossible to foresee all the possible trajectories that the use of these technologies could take in the hands of the local actors. This perspective comes from science and technology studies (STS), which argue that people are not subject to the dictates of a technology, but develop a culture of reinterpretation or renegotiation that translate technologies during use into new entities that correspond to their aspirations and enable them to achieve their livelihood goals (Mackay and Gillespie, 1992; Pfaffenberger, 1992). Thus, users modify technologies as they see fit or use them in locally inspired ways that designers, sellers or promoters had never imagined. Although this theoretical perspective is generally applied to understand the interactions between societies and hardware, it would be just as applicable to soft technologies or procedures as far as they are involved in modifying somehow the natural environment (Spier, 1970). Combining the approach of political ecology, which guides the scrutiny of asymmetric power relations between actors in access to natural resources, with STS, which lead to flexibility in understanding discrepancies between technology-in-design, promotion and technology-in-use, the study hypothesized that the access of small-scale farmers to labor-saving technologies in general and herbicides in particular induces new local strategies of territorialization. It also hypothesized that farmers would be the winners in these new forms of land-use practices and territorialization from below, while their pastoralist neighbors would be the losers within a framework of community-level social differentiation.

METHODOLOGY

Research setting

The study, which was conducted in Alibori Province as the primary pastoral area of Benin, sought to understand the land-use dynamics and interactions between livelihoods in the era of new agricultural

technologies. Intensive fieldwork was carried out in Gogounou District (Figure 1), an area where Fulani pastoralists are highly organized. It is a municipality covering 4910 km² located in the cotton agro-ecological zone of Benin and borders on the *Trois-Rivières Forest* to the east and the *Alibori Supérieur Forest* to the west. These two forest reserves cover about 36% of Gogounou District. Crop farming and livestock keeping, the two main economic activities in the area are practiced primarily on 35% and 25% respectively, of the local land, according to the district development policy documents (PDC₂ Gogounou, 2010; PDC₃ Gogounou, 2017).

Gogounou District has a total estimated human population of 117,793 in 2013, compared to 27,830 in 1979, an increase of 323% in three decades (INSAE, 2013). Bariba farmers constitute 51% of the population and are engaged mainly in growing cotton as cash crop and maize, sorghum and millet as essentially subsistence crops. Fulani pastoralists, with 42% of the population, constitute the second largest ethnic group in the district. Livestock husbandry is their main livelihood, to which they also associate other activities to diversify their income sources. They are sedentary and have their own settlements in Gogounou. They seasonally practice transhumance to take advantage of the unequal spatial distribution of natural resources and thus to improve the productivity of their herds. In the context of Benin, where cotton is the top priority in agricultural policies, coexistence between these two groups of producers has always been an important issue, the new configuration of which can be understood through the technologies introduced and the transformations they bring about in land-use and social relations.

Data collection and analysis

This study used an essentially ethnographic approach which consisted of a 10 month immersion between July 2013 to October 2014 during which the crop-farming and pastoral livelihoods were scrutinized in their new trajectories in relation to the advent of tractors and herbicides. Participant observation was the main technique of data collection; the practices of the actors and the changes in their social relations were traced by visiting crop fields, pesticide markets, forest reserves, pasturelands and pastoralist camps. Interviews were conducted with individuals and groups of actors to deepen knowledge of various phenomena and triangulated to avoid misinterpretations. A total of 164 individual interviews and 21 focus group discussions were carried out, recorded upon the consent of the informants, transcribed and thematically analyzed using F4 software. Secondary data were also mobilized from various structures, including the local agricultural extension service, municipality, farmer and pastoralist associations. A diachronic analysis of land cover in Gogounou District was made to understand how the agricultural technologies study contributed to evolution of the various spatial units. Satellite images of Gogounou from 1982 to 2012 obtained from the National Center for Remote Sensing and Ecological Monitoring (CENATEL) were used to compare the GIS-based evidence with the ethnographical data.

RESULTS

More people and more tractors for limited land

The mechanization policy has improved access to the tractor in Gogounou District, where there are currently almost 100 tractors for cropping operations (Table 1).

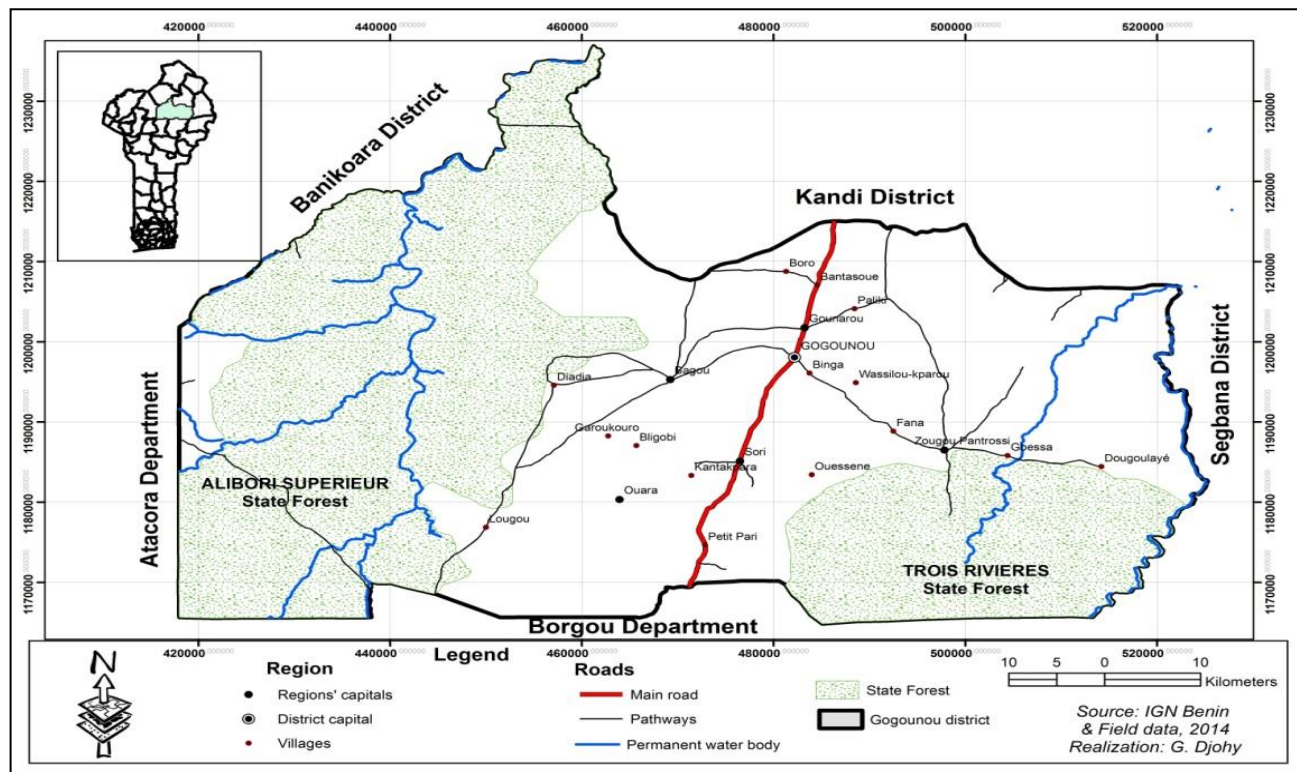


Figure 1. Study area location.
Source: Authors' design (2014).

Added to this are Foreign Service providers from neighboring countries, notably Nigeria, who plow land for 25,000 to 30,000 XOF (US\$ 50 to 60) per hectare. Although frequent breakdowns because of the lack of spare parts and of expertise in repair limit the use of this equipment, it is clear that small-scale farmers in Gogounou make increasing use of the tractor, which is now well embedded in the local cropping systems.

The population of Gogounou lives in 15,250 mainly rural households with an average household size of eight persons (INSAE, 2016). Of the total population, 51% (60,075 people) is Bariba with crop farming as the main source of livelihood. About 35% of the Gogounou area (171,850 ha of land) is dedicated to crop farming. Land pressure is increasing with population growth. Moreover, Fulani pastoralists, who make up 42% of the local population, are increasingly engaged in cropping as an alternative source of subsistence and income. A similar trend has also been observed in other recent studies in northern Benin (Droy and Bidou, 2015; Chabi, 2016; Djohy, 2017). This implies that any local practices oriented towards increasing cultivated areas would be to the detriment of the areas supposedly dedicated to livestock pasturing and the two forest reserves of the

district. Although at present, one tractor must serve for a larger number of crop farmers, further involvement of the tractor in intensification strategies would increase pressure on land and affect negatively the interactions between rural actors.

More herbicides for more changes in land-use practices

Herbicides that were used mainly in cotton production have become ubiquitous in all crops, including cereals and yams. The abundance of herbicide in Gogounou has been noted in recent years. The de-liberalization of the agricultural sector has led to the rapid development of informal channels for marketing pesticides, including three types of herbicides, from Nigeria and Ghana depending upon their distinguished properties:

Kpake: This includes all the total herbicides used by farmers to non-selectively destroy all kinds of vegetation when preparing land to sow crops. Glyphosate-based products, with trade names such as *Kalach*, *Sharp*, *Herbextra*, *Glyohos* and *Awura*, are the most widely used

Table 1. An inventory of farm equipment in Gogounou.

OWNERS	FARM EQUIPMENT				TOTAL
	Cultivator	Tractor 30 hp	Tractor 55/60 hp	Tractor 75 hp	
Individual large-scale farmers	0	3	7	3	13
Individual small-scale farmers	14	3	30	0	47
Farm Equipment User Cooperatives (CUMA)	0	9	13	7	29
Communal Farmer Union (UCP)	0	1	0	0	1
Association of Women Groups (AGF)	0	1	0	1	2
Communal Agricultural Extension Service (SCDA)	0	1	1	0	2
TOTAL	14	18	51	11	94
Not functional equipment	14	3	15	7	39
Functional equipment	0	15	36	4	55

Legend: hp = horsepower

Source: Gogounou Agricultural Extension Service (2017).

in this category of weedkillers.

Yangatime or **tangi**: This category covers a number of selective herbicides used in the pre-emergence phase to eliminate weeds in specific crops such as cotton, maize, rice and yams. Products marketed under the names *Hervextra*, *Heabesta*, *Butaforce*, *Bic*, *Atraforce* and *Amino-force* were included in this group, and were also perceived as improving crop fertilization.

Dame: This is a special category of pre- and post-emergence herbicides that farmers perceive to have compacting effects on soils, in addition to their function of preventing the rapid development and spread of weeds that might compete with the crops. The most cited product of this group is *Atraz*, to which the farmers also associate a fertilizing effect.

This perception of chemicals governs various agricultural practices and strategies that are emerging in Gogounou District. Depending on the nature of the soil-land under crops (*tem toko*) or fallowland/wildland to be newly cultivated (*tem kpa*) - and subject to the differences that may exist between plots, Gogounou farmers distinguish two cropping approaches, one of which is considered modern and the other traditional. Modernity here is defined as the degree of involvement of technologies such as tractors and especially herbicides in cropping systems. Herbicides appear to have revolutionized farming practices far more than draft animals and the tractors that were introduced earlier. This modernity is also often measured by referring to the size of the farmer's cultivated area, the extent of relieving the farm workload and labor requirements and, above all, the

income generated by the agricultural activity. These are important factors of comparison and competition between small-holder farmers. An estimate of the costs incurred in maize cropping revealed for example that, the use of herbicides in land preparation, weeding and other operations provides on average an added value of 35,000 XOF (US\$ 70) per hectare for herbicide users.

The perception of this gain, which is quite easy for farmers through herbicide use, justifies the no-till practices that have developed in cereal production. Farmers apply herbicides over large areas that they do not till before sowing, in order to reduce tillage costs. Beyond the increase in crop area per farmer, which reaches tens of hectares, the dynamics of "*returning to the village*" are also perceptible where unemployed youth in town and Gogounou native non-residents invest locally in certain forms of agri-business through trading in pesticides or setting up crop farms. This socio-economic mobility (Marfaing, 2014) from urban to rural areas to make use of cropping-based resources adds to the local adoption and use of new farming technologies to make agricultural extensification and land pressure even greater. Figure 2 shows the evolution of crop areas, production volumes and yields of the main crops such as cotton, cereals (maize, sorghum, millet, rice), roots and tubers (yam, cassava, sweet potato), leguminous crops (cowpea, groundnut, voandzou, soybean), vegetables (okra, pepper, tomato, sesame, squash - in Gogounou district in recent years. Figure 2 reveals that the overall crop acreage has increased considerably. This is most noticeable in cereals, especially maize, which is increasingly cultivated for commercial purpose, alongside cotton, which remains the main cash crop in the region. The cereal area has quadrupled from 7,258 ha in 1996 to

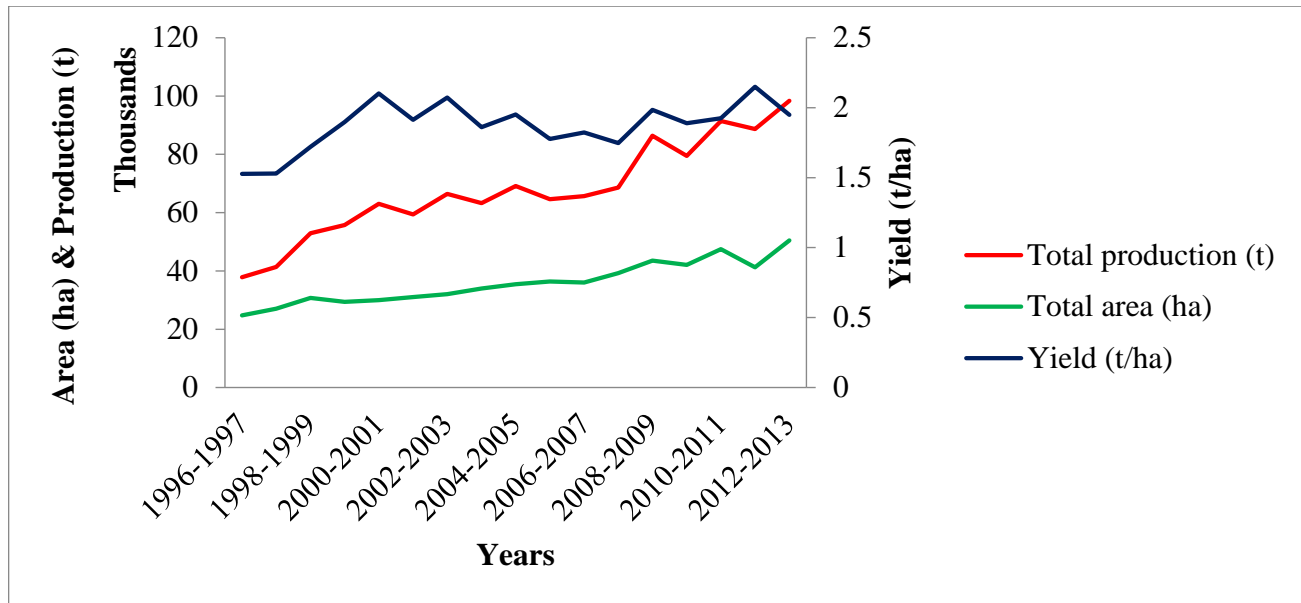


Figure 2. Crop areas, production volumes and yields in Gogounou from 1996 to 2013. Source: Authors from Gogounou Agricultural Extension Service database (2014).

28,525 ha in 2013. The area sown to maize has increased fivefold between 1996 and 2013 from 4,454 ha to 22,686 ha. The area sown to rice has nearly quadrupled from 338 ha to 1,258 ha during the same period; this also implies a greater control of wetlands, which are important for pastoralists in the dry season for cultivation using herbicides.

Despite this drastic change in cultivated area in Gogounou District, the volume of product per unit of land has not increased; it has stabilized overall at around 2 tons per ha. This reveals that the labor-saving technologies are used for extensification rather than intensification as had been planned in the agricultural policies. The labor saved by local farmers is reinvested in cultivating new areas of arable land, therefore reducing the duration of fallowing or ceasing this practice altogether. The results of these changes in land-use practices are more noticeable when analyzing the change in land cover in recent years. The savanna that basically serves for livestock grazing has been heavily encroached by croplands and fallowlands, which have increased dramatically over the last three decades (Figure 3).

In addition to these extensification dynamics, several other forms of spatial control were observed during the study e.g. many farmers use herbicides to strengthen their power over land. Several farmers were able to increase their agricultural areas by expropriating land from their neighboring farmers or pastoralists. Such strategies were silent and typically backed up by another

practice already known in the region, applying herbicides on non-cultivated areas around the crop fields to protect the crops from pests that could be hosted there. Similarly, some farmers spray diluted doses of herbicides on their uncultivated land to make people believe these areas will be cultivated. It appears that this practice helps them avoid disturbances and abuses from land seekers and other farmers who are seeking to borrow land. Following this same logic, some Gogounou crop fields that belong to non-resident natives were sprayed with herbicides, regardless of whether the fields would be cultivated or not. This strategy allows absentee landowners to secure their land-ownership rights.

All these strategies are to the detriment of pastoralists. In fact, pastoralists who are latecomers in the region still carry the stereotype of being “foreigners” and people without land affiliation. Joining the region later through peaceful migratory drifts from the fifteenth to the nineteenth century (Bierschenk, 1997; Brégand, 1998), they were only able to access land through the generosity of the Bariba farming communities already settled before them. The arrival of tractors and herbicides offered the farmers additional means to marginalize and exclude the pastoralists. These are all the more victims of these technologies in that the pastoralists themselves use them because of their limited access to land. A quantitative study with 100 agro-pastoralists in Gogounou revealed that they cultivate on average 1.93 ha of cotton, 3.36 ha of maize, 1.69 ha of sorghum and 0.87 ha of millet. Only

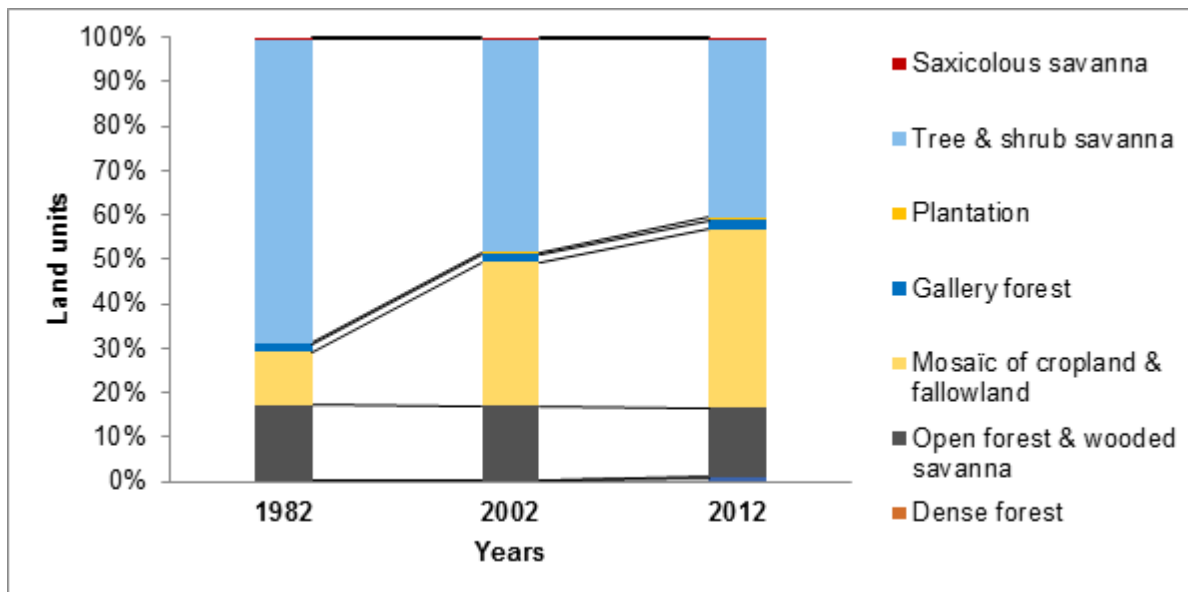


Figure 3. Land units and land cover change in Gogounou (1982–2012).
Source: Authors from satellite images provided by CENATEL-Benin (2014).

9% of them use tractor-plowing services, yet almost 98% of them use herbicides on their small plots of cropland (Adeleke, 2017). This could be perceived as a kind of resistance of the type, “If you can’t beat them, join them” (Bryant and Bailey, 1997). Almost all agro-pastoralists in Gogounou perceive herbicides as a real danger for livestock. Herbicides are increasingly used to prevent animals from passing through crop fields as well as grazing areas and livestock corridors, which are largely encroached on by various non-Fulani crops.

Water resources are increasingly polluted with chemicals. Chemicals sprayed on crops upstream drain towards watercourses. Some farmers also wash pesticide containers in watercourses in order to re-use the containers. There are even cases of deliberate pollution by some farmers who try to attack some pastoralists whom the farmers regard as disturbing and provoking. The effects of such practices are disastrous for small stock (sheep and goats), which constitute nowadays an important part of the pastoral economy of the region and are especially important for Fulani women. It was reported in a Fulani camp called Anten in Wara Region (Gogounou) that several sheep belonging to some pastoralist women were killed by herbicides applied to pasture or put into drinking containers by some farmers who sought to avenge the Fulani pastoralists they accused of damaging their crop fields.

Herbicides are increasingly playing a role as chemical weapon in land-use and social relations between farmers and herders. In this context, some expressions developed

over the last few years in Gogounou signify some ways of taking action with herbicides against competing groups. Concepts such as “*kpake the land*”, “*kpake the forest*”, “*kpake the cattle/herd*”, “*kpake the water*”, “*kpake the Pullo/pastoralist*” appeared in everyday language to refer to the spraying and burning of resources by herbicides. Farmers also use *kalach*-based expressions – *kalach* being the most widely used non-selective herbicide – such as “*kalach the field*”, “*kalach the water*”, “*kalach the herd*”, “*kalach these Fulani people*”. The violent and destructive effect of herbicides is therefore translated into the daily language of interactions of farmers with land and their pastoralist neighbors.

Although this is an isolated case, it was observed during the study a Bariba farmer who placed in his maize field a dozen large tomato boxes filled with water mixed with systemic herbicides. Asked about this practice, he expressed his intention to destroy a herd of cattle that regularly crossed his fields and could be attracted by this “special drink” and thus pay the price of the damage caused by the cattle to the crops. The Fulani pastoralists associate several cases of diarrhea in livestock, changes in animal coat color, excessive flow of oral secretions, early abortions or deaths of animals because they consumed herbicide. However, there is no scientific evidence for this. Adeleke (2017) reported that, out of an average of 25 cattle, 13 sheep and 11 goats per Fulani household, five animals fall sick and two of them die on average per month in Gogounou because of herbicides. The financial costs associated with this loss of livestock

were estimated at about 224,000 XOF (US\$ 450) per month. This loss caused by herbicides to pastoralists is hardly compensated by their own use of these products with their more limited access to land. They can thus be seen as losers in this technological revolution that brings them more disadvantages than benefits, but better serves their crop-farming neighbors who use the chemicals as a powerful weapon in farmer-pastoralist relationships. Labor-saving technologies in general and herbicides in particular are fueling local conflict in the agro-pastoral area of Gogounou in particular and of northern Benin in general.

DISCUSSION

Agricultural technologies have exacerbated the power imbalance between farmers and pastoralists. In fact, the polarization of the crop-farming and pastoral livelihoods that began in Benin with the introduction of animal traction and cash crops, especially cotton (De Haan et al. 1990; De Haan, 1997; Van Driel, 2002) has increased over time. Tractors and herbicides have considerably strengthened the land-control power of the farmers (firstcomers) over pastoralists (latecomers). Particularly herbicides are technologies that farmers have renegotiated through their use. They are not simple labor-saving or agricultural intensification technologies, but are part of an unprecedented spatial conquest and forms of territorialization (and agricultural extensification) from below. Encroachment on grazing areas and livestock corridors, local land grabbing, polluting pasture and water resources for livestock: all fall under the will of farmers to strengthen their control over land and natural resources and to exclude their pastoralist neighbors. Without having to install more obvious forms of physical devices to protect their land, such as fences, farmers easily challenge pastoralists and strengthen their own control over land by increasing the fear of herbicides in fields, grazing areas and watering sources, which causes pastoralists to leave the area in order to avoid damage to their herds.

This territorialization from below shows how local actors strengthen or renegotiate their land rights and security in a context of globalization. The result is that, through using agrochemicals, farmers have already succeeded in obliging several pastoralists to relocate. These have sought refuge in countries such as Togo and Ghana, although their access to land in these countries is not better. The pastoralist professional associations in northern Benin noted in 2012 the relocation from Gogounou of 228 herds with 11,085 head of cattle and 2,578 small ruminants (Boukari, 2012). The Program of Support to Milk and Meat Sectors (PAFILAV, 2014) reported that 223 Fulani settlements had disappeared in

the last few years from Gogounou District, which reduced the local herd from 85,000 to 40,000 head of cattle. The dialectic of winners vs. losers seems to be verified in the context of Gogounou, and confirms that territorialization from below, like that from above, induces a negative social differentiation which offers opportunities of success for some and impoverishes others (Bassett and Gautier, 2014).

At a theoretical level, the analysis of power relations in a framework that integrates the interpretative flexibility of technologies offers new fields for understanding the socio-economic and political dynamics associated with land use in a globalized world. Herbicides that kill weeds also kill animals and influence people's access to land in Benin. This study did not assess the impacts of herbicides on animal health and productivity, human health and environment; these are issues still to be explored in subsequent multidisciplinary studies. The transformations of gender power relations in relation to the impacts of herbicides on raising small stock, which is an important means to diversify income sources and empower pastoralist women, are aspects to be explored in future studies. The process of re-liberalization of the agricultural sector decided by the new regime in power in Benin since April 2016, as well as the updating of the Land and Property Code and the adoption of a Pastoral Code in Benin are all factors that can induce other changes in land governance and the dynamics of access to and control over natural resources among local actors. Subsequent research should address these issues in order to provide useful information in decision-making for more integrated crop-farming and pastoral policies.

Conclusion

This study used an ethnographic approach to analyze new territorialities and changing farmer-herder relationships in relation to agricultural modernization technologies. Local actors, perceived here as cultural neighbors (Gabbert, 2014), were engaged in individual and group discussions to understand their perceptions of agricultural technologies, the uses they make of them, and the forms of appropriation that take place. The primarily qualitative data was thematically analyzed from a political ecology perspective that offers a deep understanding of the interplay of ecological, socio-economic and political processes. The study also interlace with a broad understanding of technology which, in the form of artifacts or procedures, is often not simply adopted, but locally appropriated according to specific interests and goals, to influence the evolution of relationships between co-users of land and other resources.

The results revealed that the mechanisms of

appropriation of agricultural technologies, particularly herbicides, have contributed to a reconfiguration of land-use systems. The resulting uses of various weed control products are at the root of new forms of territorialization from below, land insecurity and land-use conflicts between socio-professional groups that depend on the same natural resources for their livelihoods.

A large-scale quantitative study could help to understand the extent of the phenomena described in this paper in order to provide consistent policy and institutional responses. Community-based discussions should also be initiated to engage local communities in fruitful exchanges on sustainable agricultural intensification and agro-ecology as an alternative sustainable way to feed the world and preserve synergies and peaceful interactions between rural livelihoods.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Adeleke SL (2017). Effets de l'usage des herbicides et tracteurs sur les pratiques d'élevage et déterminants des conflits entre agriculteurs et éleveurs dans la commune de Gogounou [Effects of the use of herbicides and tractors on livestock practices and drivers of conflicts between farmers and herders in the district of Gogounou]. Mémoire de Master en Sociologie des Ressources Naturelles/ Master's thesis in Sociology of Natural Resources. Parakou: University of Parakou.
- Agro-Benin (2011). Remise de machines agricoles aux producteurs [Delivery of agricultural machinery to producers]. In Agro-Benin (18/08/11). Retrieved from: <http://www.agrobenin.com/remise-de-machines-agricoles-aux-producteurs/>
- Audouin S, Gonin A (2014). L'anacarde: produit de la globalisation, moteur de la territorialisation, l'exemple du Sud du Burkina Faso [Cashew: product of globalization, engine of territorialization, the example of southern Burkina Faso]. *EchoGéo* 29 (2014). Retrieved from <http://echogeo.revues.org/13926>. DOI:10.4000/echogeo.13926.
- Balse M, Ferrier C, Girard P, Havard M, Herbel D, Larue F (2015). Une expérience originale de mécanisation partagée en Afrique: les coopératives d'utilisation de matériel agricole du Bénin [An original experience of shared mechanization in Africa: the cooperatives for the use of agricultural equipment in Benin]. Montrouge: Fondation pour l'Agriculture et la Ruralité dans le Monde (FARM). Retrieved from <https://agritrop.cirad.fr/575878/>
- Bassett TJ, Gautier D (2014). Regulation by territorialization: the political ecology of conservation and development territories. Introduction. *EchoGéo* 29. <http://echogeo.revues.org/14038>. DOI: 10.4000/echogeo.14038
- Benjaminsen TA (2002). Enclosing the land: cotton, population growth and tenure in Mali. *Norsk Geografisk Tidsskrift – Norwegian Journal of Geography* 56(1):1-9.
- Bierschenk T (1997). Die Fulbe Nordbénins: Geschichte, soziale Organisation, Wirtschaftsweise [The Fulbe of Northern Benin: History, Social Organization, Economy]. Hamburg: Spectrum 49 and LIT Verlag.
- Boukari BA (2012). Rapport d'activité de l'UDOPER Borgou-Alibori 2012 [UDOPER Borgou-Alibori Activity Report 2012]. Gogounou: UDOPER Borgou-Alibori.
- Brégand D (1998). Commerce caravanier et relations sociales au Bénin: Les Wangara du Borgou [Caravan trade and social relations in Benin: The Wangara of Borgou]. Paris: L'Harmattan.
- Bryant RL, Bailey S (1997). Third World Political Ecology. Psychology Press, London.
- Chabi TR (2016). Place de l'élevage bovin dans l'économie rurale des Peuls du Nord Bénin [The place of cattle breeding in the rural economy of the Fulani of northern Benin]. Thèse de Doctorat/ Doctoral Thesis. Gembloux Agro-Bio Tech: University of Liège.
- De Haan LJ, Van Driel A, Kruithof A (1990). From symbiosis to polarization?: peasants and pastoralists in northern Benin. *Indian Geographical Journal* 65(1):51-65.
- De Haan LJ (1997). Agriculteurs et éleveurs au Nord-Bénin: écologie et genres de vie [Farmers and herders in North Benin: ecology and ways of life]. Paris: Karthala.
- Djohy G (2017). Pastoralism and socio-technological transformations in northern Benin: Fulani innovations in pastoral migration, livelihood diversification and professional association. Göttingen: Göttingen University Press.
- Droy I, Bidou JE (2015). Fragilité de la sédentarisation d'une population pastorale peule au Bénin [Fragile sedentarization of a Fulani pastoral population in Benin]. In Bosc PM, Sourisseau JM, Bonnal P, Gasselin P, Valette E, Bélières JF (eds), Diversité des agricultures familiales: exister, se transformer, devenir / Diversity of family farms: existing, changing, becoming (pp. 75-90). Versailles: Editions Quae.
- Fokou G (2015). Coping with pastoral uncertainties in post-conflict context in West Africa: cross-border mobility, institutional change and livelihood strategies of smallholders in North Côte d'Ivoire. Oral communication at: "Livelihood, Management, Reforms and Processes of structural change" workshop, 22-27 November 2015, University of Göttingen. Göttingen: Volkswagen Foundation and University of Göttingen.
- Gabbert EC (2014). The global neighbourhood concept: A chance for cooperative development or Festina Lente. In Mulugeta GB (ed.), A delicate balance land use, minority rights and social stability in the Horn of Africa (pp. 14-37). Addis Ababa: Institute for Peace and Security Studies, Addis Ababa University
- Gaborel C, Fadoegnon B (1991). Le désherbage chimique du cotonnier et du maïs au Bénin: acquis et proposition de la recherche [Chemical weed control of cotton and maize in Benin: research findings and proposals]. In CIRAD-CA (ed), Rapport Réunion de coordination de recherche phytosanitaire cotonnière / Report of the Coordination Meeting on Cotton Pest Control Research, 26-31 January 1991, Ouagadougou, Burkina Faso (pp. 135-151). Montpellier: CIRAD and CA.
- Gascon J (2014). Patrimoine mondial et compétition politique au Ngorongoro (Tanzanie): l'extraversion comme logique d'adaptation, de projection et de résistance [World Heritage and Political Competition in Ngorongoro (Tanzania): Extraversion as a Logic of Adaptation, Projection and Resistance]. *Mambo* 12(3).
- Gautier D, Hautdidier B, Gazull L (2011). Woodcutting and territorial claims in Mali. *Geoforum* 42(1):28-39.
- Gibigaye M, Adégbidi A, Sinsin B (2010). Proximité géographique et dynamique des organisations paysannes au Bénin: le cas des CUMA dans le Borgou et l'Alibori [Geographical proximity and dynamics of farmers' organizations in Benin: the case of CUMAs in Borgou and Alibori]. In: Atta K, Zougrana PT (eds), Logiques paysannes et espaces agraires en Afrique / Farming Logics and Agrarian Spaces in Africa 5 :67-82. Paris: Karthala.
- Gonin A (2014). Jeux de pouvoir pour l'accès aux ressources et devenir de l'élevage en Afrique soudanienne: le foncier pastoral dans l'Ouest du Burkina Faso [Power games for access to resources and the future of livestock in Sudanian Africa: pastoral land tenure in western Burkina Faso]. Thèse de Doctorat / Doctoral Thesis. Paris: University Paris 1/Panthéon-Sorbonne.
- Homewood KM, Rodgers WA (2004). Maasailand ecology: Pastoralist development and wildlife conservation in Ngorongoro, Tanzania. Cambridge: Cambridge University Press.
- INSAE (2013). Quatrième Recensement Général de la Population et de

- l'Habitation (RGPH4) [Fourth General Census of Population and Housing (RGPH4)]. Rapport provisoire / Interim report. Cotonou: DED/INSAE.
- INSAE (2016). Principaux indicateurs socio-démographiques et économiques: Quatrième Recensement Général de la Population et de l'Habitation (RGPH4, 2013) [Main socio-demographic and economic indicators: Fourth General Census of Population and Housing (RGPH4, 2013)]. Cotonou: DED/Institut National de la Statistique et de l'Analyse Economique (INSAE).
- Kinninvo F (2010). Crise alimentaire: le gouvernement béninois offre 150 tonnes de maïs au Niger [Food crisis: Beninese government offers 150 tons of corn to Niger]. Retrieved from <http://bj.jolome.com/news/article/crise-alimentaire-le-gouvernement-beninois-offre-150-tonnes-de-mais-au-niger-800> (accessed 20/06/2017).
- Mackay H, Gillespie G (1992). Extending the social shaping of technology approach: ideology and appropriation. *Social Studies of Science* 22(4):685-716.
- Marfaing L (2014). Quelles mobilités pour quelles ressources? [Which mobilities for which resources?]. *Revue Canadienne des Etudes africaines* 48(1):41-57.
- Marnotte P (1994). L'utilisation des herbicides en milieu paysan des zones soudanaises et sahéliennes: contraintes, alternatives et perspectives [The use of herbicides in farming areas of the Sudanian and Sahelian zones: constraints, alternatives and perspectives]. In CIRAD-CA (ed), Rapport Réunion Phytosanitaire de Coordination Cultures Annuelles – Afrique Centrale / Report of the Phytosanitary Coordination Meeting for Annual Crops - Central Africa, 26-29 January 1994, Maroua, Cameroun (pp. 134-145). Montpellier: CIRAD-CA.
- Meenink HJW (2013). Faire pression pour une politique agricole et une gouvernance de la filière coton propices aux exploitations familiales [Lobby for an agricultural policy and governance of the cotton sector that is conducive to family farms]. In Wennink B, Meenin H, Djihoun M (eds), La filière coton tisse sa toile au Bénin. Les organisations de producteurs étoffent leurs services aux exploitations agricoles familiales / The cotton industry is growing in Benin. Producer organizations expand their services to family farms (pp. 67-77). Amsterdam: SNV/KIT.
- PAFILAV (2014). Etude des filières lait et viande. Rapport synthèse définitif, Septembre, 2014 [Study of the milk and meat sectors. Final synthesis report, September, 2014]. Cotonou: Projet d'Appui aux Filières Lait et Viande (PAFILAV)/MAEP.
- PDC₂ Gogounou (2010). Gogounou, pôle sous-régional du commerce de bétail. Plan de Développement Communal de Gogounou, deuxième génération - 2011-2015 [Gogounou, sub-regional hub for livestock trade. Gogounou Communal Development Plan, second generation - 2011-2015]. Gogounou: Mairie de Gogounou.
- PDC₃ Gogounou (2017). Plan de Développement Communal de Gogounou, troisième génération – 2017-2021 [Gogounou Communal Development Plan, third generation – 2017-2021]. Gogounou: Mairie de Gogounou.
- Peluso NL (2005). Seeing property in land use: Local territorializations in West Kalimantan, Indonesia. *Geografisk Tidsskrift – Danish Journal of Geography* 105(1):1-15.
- Pfaffenberger B (1992). *Social Anthropology of Technology*. Annual Review of Anthropology 21:491-516.
- Pochet F (2014). Discourse analysis of nature conservation policies in Africa: a Beninese case study. *EchoGéo* 29(2014). Retrieved from <http://echogeo.revues.org/13964>. DOI : 10.4000/echogeo.13964.
- PSRSA (2011). Plan Stratégique de Relance du Secteur Agricole (PSRSA) [Strategic Plan for the Recovery of the Agricultural Sector (PSRSA)]. Cotonou: Ministère de l'Agriculture, de l'Elevage et de la Pêche (MAEP).
- Saizonou J (2009). Quand l'Etat motorise des exploitations agricoles... [When the State motorizes farms...]. *Grain de Sel* 48:28-29.
- Spier R (1970). *From the hand of man: primitive and preindustrial technologies*. Boston: Houghton-Mifflin.
- Van Driel A (2002). *Sharing a valley: The changing relations between agriculturalists and pastoralists in the Niger Valley of Benin*. Research Report 64. Leiden: African Studies Centre.