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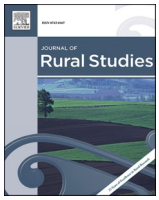

Drought-tolerant indigenous crop decline in the face of climate change: A political agroecology account from south-eastern Senegal

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ABSTRACT

In south-eastern Senegal, Bassari farmers have historically cultivated and consumed a wide diversity of varieties of sorghum, fonio, and Bambara groundnut, most of which thrive in poor soils, are nutritious, and withstand drought. These crops are now on the verge of disappearance from the fields of the Bassari despite their potential fit in the predicted drier climate in the area. To understand why, we explore the intertwining between the local dynamics of crop diversity and socio-economic changes at local, national, and regional scales. We draw upon the critical reading of secondary sources and field data, analyzed through the lens of political agroecology. The abandonment of traditional Bassari crops can be explained by government and international policies that interact with cultural trends and household-level factors. Colonial and post-colonial agricultural policies and research priorities have promoted the expansion of exotic crops with market value or high yield potential (e.g., peanut, cotton, rice, horticultural crops), failing to value indigenous crop diversity. These policies, together with market forces and historical legacies, have intersected with outmigration, dietary changes, decreases in community social capital, and gender-dynamics, favouring the switch from drought-tolerant traditional crops to more water-demanding exotic crops. We then consider what the interplay between social dynamics and crop diversity means under climate change. Our results suggest that current trends in crop diversity might threaten climate resilience in the long-term. Drawing on political agroecology, we discuss potential avenues to support the capacity of Bassari farmers to practice agriculture in a drier climate. We argue that in order to increase the climate resilience of smallholder farmers it is necessary not only to consider the cross-scale processes and multiple dimensions of power that affect crop diversity but also to reconsider research and policy priorities in favour of drought-tolerant indigenous crops.

1. Contentious narratives: The role of agrobiodiversity in smallholder farmers' resilience to climate change

Small-scale rain-fed farming is the main form of agriculture practiced in West Africa and in the world and plays a central role in global food security and agrobiodiversity[1] conservation (Lowder et al., 2016; Ricciardi et al., 2018). Climate scientists predict that West African agriculture will experience a dramatic increase in climate variability and intensity of droughts in the future, which in some regions could compromise crop yields and food security (Sultan and Gaetani, 2016).

Traditionally, selecting, diversifying, and modifying crop species and variety portfolios have been important strategies for smallholder

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[1] Here, agrobiodiversity refers to the species- and variety-level diversity of food plants.

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farmers to adjust to socio-economic and environmental shocks and shifts (Leclerc et al., 2013; Ruggieri et al., 2021; Vigouroux et al., 2011). However, the unprecedented rate and uncertainty of future climate change impacts poses the question of whether the crop and variety portfolios and the crop diversity access mechanisms that smallholder farmers currently have will be enough to cope and adapt to climate change (Labeyrie et al., 2021a; McGuire and Sperling, 2013). There is a certain consensus that supporting farmers' access to and use of crop diversity is crucial in addressing climate change challenges in agricultural landscapes (Lin, 2011; Pörtner et al., 2021; van Etten, 2019), yet disagreements exist regarding the specific actions and strategies that should be implemented.

The debate on how to support smallholder farms' resilience is open to a variety of competing narratives, each suggesting different pathways to ensure farmers' harvest and secure food supplies despite climate uncertainties, including drought (Mockshell and Birner, 2020). A major point of disagreement revolves around whether climate change resilience will be better enhanced by promoting the adoption of research varieties from a limited number of climate-adapted crops, bred for efficiency and homogeneity of traits (from now on "mainstream development" narrative), or by embracing the heterogeneous populations of inter- and intra-specific diversity that smallholder farmers have selected, managed, and cultivated over generations to adapt to place-based cultural and environmental specificities (from now on "agrobiodiversity-based" narrative).

In West Africa, policies and regulatory frameworks have been historically geared towards the mainstream development narrative, favouring highly uniform agricultural systems, centred around few varieties of a handful of crop species in high-input production systems and centralized top-down models of seed and information dissemination. Two well-known examples of policies and interventions rooted in this narrative are the "peanut boom" during French colonial rule (Bernards, 2019) or the "New Green Revolution for Africa" in recent years (Bellwood-Howard and Ripoll, 2020; Patel, 2013), both aiming at intensifying and specializing agricultural production to gain access to global markets. Critical research, however, questions who benefits and who loses from such policies and interventions. At local-level, these mainstream development approaches have systematically ignored farmers' traditional crops and landraces, often resulting in smallholder farmers growing crops not suitable to the local conditions (Clay and Zimmerer, 2020; Dawson et al., 2016; Fischer, 2021). At the global-level, these policies have led to the replacement of diverse traditional varieties with homogeneous certified varieties (van de Wouw et al., 2010), which, beyond posing threats to food security, raises concerns about the narrowing of the genetic base for adaptation to future conditions (IPBES, 2019; Khoury et al., 2014).

The agrobiodiversity-based narrative emerged as an alternative to reconcile agrobiodiversity, climate change resilience, and smallholder farmers' knowledge and practices. This narrative is based on the crop diversity-stability hypothesis, according to which, diversity at genetic and phenotypic level can contribute to stabilize production, buffer risks, and diversify diets and income sources (Cabell and Oelofse, 2012; Renard and Tilman, 2019). Agrobiodiversity-based narratives consider traditional crop diversity and farmers' knowledge as key sources of adaptation to climate change (Altieri and Nicholls, 2017; Bellon and van Etten, 2013; Hellin et al., 2014) and mostly rely on des-centralized, community-based approaches to agrobiodiversity conservation (Jarvis et al., 2011; Labeyrie et al., 2021a). Critics of this narrative emphasize that farmers maintain a diverse set of traditional crop species and landraces at the expense of more productive research-bred varieties that would improve their incomes and wellbeing (Mugwanya, 2019). Besides encountering limited institutional support, initiatives stemming from this narrative face multiple obstacles in their operationalization including insufficient consideration of local power dynamics (Nyantakyi-Frimpong, 2019; Porcuna-Ferrer et al., 2020) and a failure to adequately address smallholder farmers' local realities and situated needs (Jansen, 2015; Marfurt et al., 2023a). Case studies show that agrobiodiversity-based interventions require high labour- and time-investments (Bezner Kerr et al., 2019; Dupré et al., 2017; Laske and Michel, 2022), have limited economic viability (Dumont and Baret, 2017; Galt, 2013), and are often implemented "for the sake of green agendas and white markets" (Marfurt et al., 2023b).

Empirical research shows the complexity of processes and multiple values guiding farmers' decision-making regarding what crops to grow (Demongeot et al., 2022). Thus, shedding light on this debate calls for nuanced and situated approaches that reflect on the myriad of drivers and trade-offs involved in farmers' decision-making and local shifts in crop diversity portfolios. In this work, we explore the situated causes and consequences of local agrobiodiversity dynamics in the light of climate change through a case-study among the Bassari of south-eastern Senegal.

Our research tells the story of three traditional crops, namely fonio, sorghum and Bambara groundnut, which, despite their potential fit in the drier future climate of the region, are disappearing from the local agrobiodiversity landscape. We look at local agrobiodiversity dynamics from two complementary perspectives, bridging the critical reading of published literature and secondary data with empirical research tapping on local ecological knowledge. Drawing upon political agroecology (Gonzalez de Molina, 2013), we aim to move beyond narrow narratives by unveiling the complexity of factors that shape agrobiodiversity dynamics. We highlight the importance of considering historical processes, structural inequalities, and power dynamics when examining crop diversity changes and smallholder farming communities' resilience to climate change.

2. Conceptual orientation: A political agroecology examination of local agrobiodiversity dynamics

To address why and how agrobiodiversity changes and what are the implications for climate change resilience, we rely on a conceptual orientation that accounts for the multi-dimensional dynamics of agrobiodiversity. We build on political agroecology and related scholarship stressing the importance of considering how local processes of agrobiodiversity change interact with the wider economic and political environment (Bezner Kerr, 2013; Nyantakyi-Frimpong and Bezner Kerr, 2015). Central to this conceptual orientation is understanding crop diversity dynamics as politically grounded and embedded in particular views, strategies, and interests between actors and power structures (Gonzalez de Molina, 2013).

Methodologically, political agroecology approaches call to consider cross-scale dynamics (Wittman et al., 2017; Zimmerer et al., 2019), power (Bezner Kerr, 2013; Carney, 2002; Flachs, 2019), and history (Fischer, 2021; Zimmerer et al., 2021) to analyse shifts in farmers' crop portfolios. Following this research line, we take a diachronic, multi-scale, and situated approach to understand local agrobiodiversity dynamics within broader processes of agrarian change.

To understand contemporary rationales of Bassari farmers for crop choice, we place farmers' choices in their historical context, with reference to the particularities of south-eastern Senegal and the Bassari territory. We provide an overview of the historical stages of agricultural development and trace back the story of sorghum, fonio, and Bambara groundnut in parallel to that of socio-economic and political developments at regional, national, and local levels. We then examine current trends in the cultivation of Bassari traditional crops and local explanations for these trends as a point of departure to understand farmers' motivations for crop choices.

This conceptual orientation allows us to capture the complex and iterative nature of farmers' decisions on which crops to grow. We engage with a series of political ecology works – e.g. (Bezner Kerr, 2014; Ribot, 2014) - to elucidate how and why farmers change their crop portfolios, thereby showing how resiliencies and vulnerabilities to climate change are locally constructed.

3. Situating our research

3.1. The Bassari of south-eastern Senegal

Our research is based on a case-study among the Bassari[2] of south-eastern Senegal (Fig. 1). The Bassari inhabit in a region of the tropical savannah with dry-winter characteristics (Peel et al., 2007) characterized by a unimodal rainy season approximately spanning from June to October and a mean annual rainfall of 1096 mm (in 2019) (ANACIM, 2020). The Bassari live in a low density area, with 11 inhabitants/m2 compared to the national mean of 82 inhabitants/m2 (SRSD, 2019). The area has limited access to public health and education. The Bassari territory was not well connected to the centers of French colonial administration nor to the Senegal centers after independence (i.e., Kédougou, Saint Louis, Dakar) (Nolan, 1986), although connectivity has improved over the last fifty years.

Bassari agricultural system is based on slash-and-burn shifting cultivation of cereals and legumes along with minor crops for the kitchen and market needs. Some families grow cotton and small-scale horticulture as cash-crops. Women and men carry their agricultural activities independently and control their own harvests. For the Bassari, some crops are gender specific – e.g., Bambara groundnut, peanut, rice, and fonio are grown mostly by women and sorghum and cotton are grown mostly by men. Maize is equally grown by men and women. Agriculture remains largely un-mechanised and only some families have access to oxen-driven ploughs. Communal labour arrangements based on mutual aid among kin and kith are widespread and embedded in the village traditional social organization. Even though there is no private land titling and access to land relies on customary use and access rights, Bassari increasingly seek to obtain formal land recognition to be able to bequeath and/or sell the land (Porcuna-Ferrer et al., 2024).

The Bassari territory provides an interesting case to understand the complexity of relations between climate, agrobiodiversity, and farmers' decision-making for several reasons. First, rain-fed agriculture is Bassari main economic activity,[3] making them vulnerable to climate change impacts – i.e., high variability of inter-annual precipitation, shortening and delaying the rainy season, and temperature increase (Porcuna--Ferrer et al., 2023a; Sultan and Gaetani, 2016) (see Supplementary material 1). Second, Bassari farmers have historically cultivated a wide diversity of traditional crops and landraces that are nowadays found in the same fields than exotic crops and research-improved varieties (Porcuna-Ferrer et al., 2023b). Third, there is a rare availability of baseline agricultural data for the Bassari. From 1949 until 1980s, ethnographers from the "Musée de l'Homme" (Paris) regularly visited the area producing a rich body of literature that covers aspects related to cultural, environmental, and social life.

3.2. Bassari traditional crops

We focus on sorghum (*Sorghum bicolor* [L.] Moench), white fonio (*Digitaria exilis* [Kippist] Stapf), and Bambara groundnut (*Vigna subterránea* [L.] Verdc.), crops traditionally cultivated in our study area (Fig. 2). These are crops endemic to Sub-Saharan Africa and their domestication history has conferred them with drought-tolerant biological traits – e.g., well-adapted to poor soils, heat, and high precipitation variability; see Hadebe et al. (2017) for sorghum; Abrouk et al. (2020) for fonio; Aliyu et al. (2016) and Mayes et al. (2019) for Bambara groundnut.

In Senegal, these crops are mostly linked to subsistence farming and their cultivation is nowadays marginal (FAOSTAT, 2021), particularly for fonio and Bambara groundnut, which are mostly cultivated in rural areas. The three crops have high nutritional values – see Koroch et al. (2013) for fonio; Anglani (1998) for sorghum; and Tan et al. (2020) for Bambara groundnut.

Sorghum, fonio, and Bambara groundnut have a marked cultural importance among the Bassari (Porcuna-Ferrer et al., 2023b). For example, Bambara groundnut, the first crop cultivated by the Bassari according to their creation myth, cannot be sold, only given, and sorghum beer plays a central role in all Bassari customary practices (Gessain, 1996; Gessain and Lestrange (de), 1987). The mix of sorghum and Bambara groundnut is used to cook "enap", Bassari main staple dish (Gessain, 2010). Fonio used to be a "back-up crop" eaten in the lean season, since its harvest came earlier than the other crops, although nowadays fonio is mostly used to cook meals for major festivities and celebrations.

4. Methods

4.1. Data collection

Our data collection built on two complementary data sources. First, we built on secondary data (literature and statistical data) to understand how externally driven changes in the local ecological, political, and economic systems affect the way in which local farmers and communities manage their agrobiodiversity. Second, to complement the historical sources and better understand contemporary drivers of change, we built on first-hand data on Bassari cultivation trends of traditional crops and explanations of the observed trends. To enrich the insights gathered through more systematic data collection we draw on ethnographic methods – first and forth authors lived in the case-study village over a period of 16 months –, which provided space for informal conversations and daily interactions with community members' agricultural activities and village life.

We acknowledge that our background and positionality might limit our capacity to assess local explanations of trends and drivers of change presented in this paper. Four out of the five authors of this work (including the first author) are from Europe, and the Senegalese author does not belong to the Bassari ethnic group. Our disciplinary backgrounds (ecology, agronomy, anthropology, and economics) also affect our framing of a political agroecology based alternative narrative, which is largely influenced by Western epistemic traditions.

Before data collection, we obtained the permit to conduct research from the village authorities. We conducted meetings with all official and customary authorities, where research was presented and the conditions for conducting it were discussed. We also obtained Free Prior and Informed Consent from each person participating in the research. The Ethics Committee of the Universitat Autònoma de Barcelona approved the research (CEEAH 4903). Data collection took place with the help of local interpreters who translated from the local language (Bassari) to French.

4.1.1. Changes in the cultivation of Bassari traditional crops from an historical perspective

We reviewed secondary English and French literature for different historical periods in West African, Senegalese, and Bassari history. Given that the searched information most likely is not indexed, we did not conduct a systematic literature review. Instead, literature was selected in an iterative process, including author and keyword searching, and snowball referencing.

We compiled all the information available referring to the Bassari agroecosystem and agrobiodiversity dynamics (local scale), and agricultural developments, interventions, and crop diversity introductions between the 1900s until nowadays (national and regional scales). Our

[2] The Bassari ("Ilian" in local language) traditionally inhabited the transboundary area between South-Eastern Senegal and Northern Guinea, and currently have a total population of approximately 20.000 inhabitants. We worked with the Bassari living in south-eastern Senegal.

[3] In the Kédougou region, 69% of households practice agriculture as main activity in 2013 (SRSD, 2019); in the Bassari territory this percentage is probably higher.

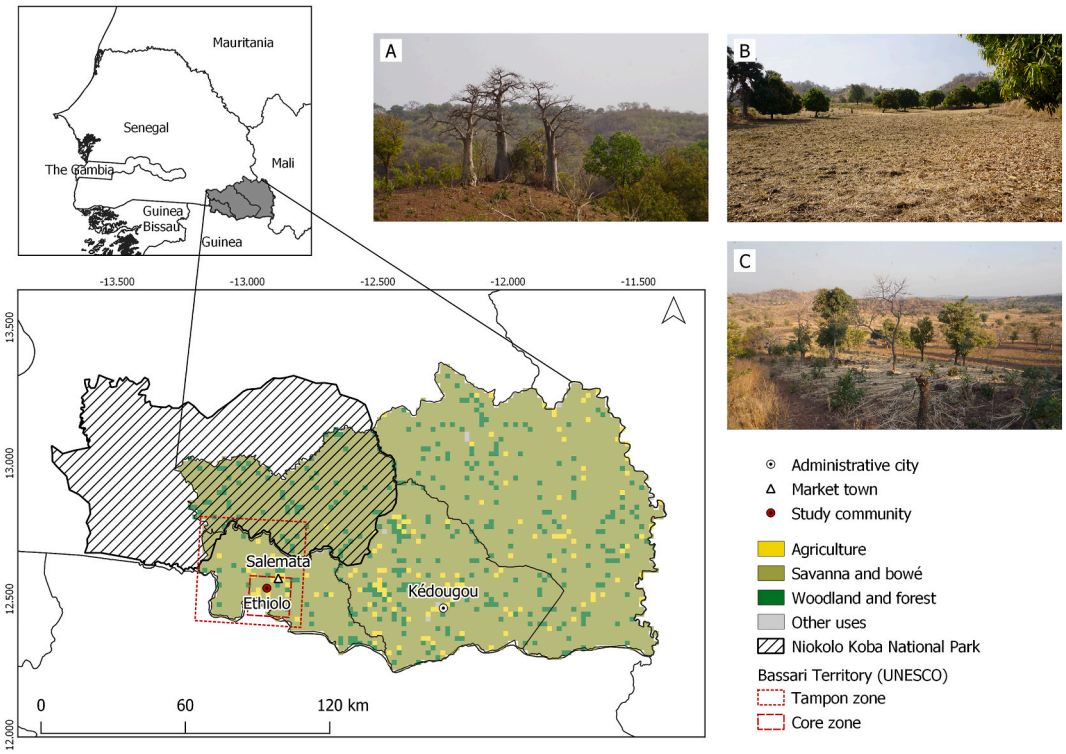

Fig. 1. Study site land-use map and illustrations of the different field types.

Fig. 2. Bassari traditional crops. 'A' Bambara groundnut; 'B' Sorghum, 'C' Fonio.

final review included peer-reviewed literature, ethnographies, historical texts, missionary and colonial agricultural officers' reports, and reports from the department of agriculture (Table 1). For the period of 1960s to nowadays, we also reviewed agricultural policies and reports of development aid in Senegal. We consulted both, published and non-published texts. Archival search was conducted at the National Archives of Senegal (Dakar), the Institut Fondamental de l'Afrique Noire (IFAN, Dakar), the Musée de l'Homme (Paris), the Bibliothèque Centrale du Muséum national d'histoire naturelle (Paris), and Stabi, Berlin (Staatsbibliothek zu Berlin). We also collected statistical data on crop area harvested between 1980 and 2022 for the Kédougou region (ANSD, 2023; DAPSA, 2014).

To fill the gaps between the historical information on trends and the real impact of these trends at the local scale, during October–December 2020 we also conducted key-informant interviews (n = 15, 20% women) with researchers with experience in the area, representatives from Senegal national and private agriculture institutions, farmers co-operatives, extension services officers, and representatives of non-governmental organizations (NGOs) working in our case-study region (Table 1).

4.1.2. *Local explanations of trends and drivers in Bassari traditional crops*

We collected primary data from November 2019 to March 2020 in one of the largest Bassari villages of Kédougou (Fig. 1), with approx. 986

Table 1
Research design.

Unit of evidence	Method	Sample
Regional, national and local socio-economic and ecological context that has driven the trends in the cultivation of Bassari traditional crops	Literature review	• Peer reviewed papers (n = 31) • Ethnographic research documents (n = 99) • Explorer diaries (n = 5) • PhD and Master thesis (n = 19) • Reports from NGOs and international organizations (n = 7) • Reports from colonial officers (n = 12) • Government reports and national policy plans (n = 38)
	Analysis of quantitative data	• Climate trends at regional level, 1922–2015. Source: ANACIM, 2020 (Supplementary material 1) • Crop area harvested at regional level, 1980–2022. Source: ANSD, 2023; DAPSA 2014 (Supplementary material 2)
	Key informant interviews	15 adults, 12 men and 3 women. Participants included: • Researchers with experience in the area (KI #1; KI #2) • Local administrative and customary authorities (village mayor and elders) (KI #13; KI #14; KI #15). • Representatives of: ○ Local NGO (KI #3) ○ National regional agricultural office (KI #4; KI #5) ○ International NGOs (KI #7, KI #8) ○ Regional offices of the cotton company (KI #6) ○ Regional producers union of rice (KI #12) ○ Fonio processing unit (KI #9) ○ Local women group and local women's association (KI #10; KI #11)
Trends and drivers in the cultivation of Bassari traditional crops as perceived by the farmers	Household surveys	49 adults, 29 men and 20 women within an age range of 19–74 years old.
	Semi-structured interviews	47 adults, 34 men and 13 women within an age range of 23–70 years old.

inhabitants (ARD, 2018). Data collection followed two phases.

On the first phase, we conducted a survey (n = 49, 41% women) to get detailed household information on crop diversity trends and drivers. Households were selected using stratified random sampling, aiming at capturing the diversity of socio-economic status present in the local community. Fieldwork was interrupted by the Covid-19 pandemic, for which we could not conduct all surveys scheduled. Within each household, we interviewed either the man or the woman household head, aiming at having a balanced gender distribution. We used a timeline exercise to elicit household information about crop adoption, maintenance, abandonment and change in cultivation surface (i.e., increase, no change, or decrease) for each of the crops cultivated by a household since its establishment. We started by asking 'compared to when you started farming on your own, what changes have taken place in the diversity and abundance of the crops your household cultivates?' This open-ended question was followed-up by more direct questions (e.g., 'since you started cultivating on your own, have you/somebody from your household decreased or abandoned the cultivation of any crop?' If yes, 'which one?'). For each crop diversity change mentioned, we asked about the reasons for the change.

In the second phase, we used semi-structured interviews with a different set of informants (n = 47, 28% women) to gain in-depth understanding of the drivers that make farmers switch crops. Participants were selected with quota sampling, balancing our sample across age, gender, and household socio-economic status. The lower involvement of women was primarily due to logistical constraints, i.e., we had to conduct semi-structured interviews between the main harvest time and the preparation period of men's initiation ritual. Women were less available for interviews compared to men, as women, besides being farmers, also bear the majority of household caregiving responsibilities. We asked respondents to describe the drivers for each trend mentioned during the household survey (i.e., 'why', 'how' and 'when' questions). For each driver mentioned, we continued asking 'and why do you think that happened?' to capture the synergies and cascading effects leading to changes in the cultivation of Bassari traditional crops.

4.2. Data analysis

4.2.1. Explanations of changes in the cultivation of Bassari traditional crops from an historical perspective

Historical literature was reviewed and coded in NVivo. We present the results following three historical periods defined based on the main socio-economic and political changes in Senegalese history: 1900–1960 (pre-independence, colonialism); 1960–2000 (independence with socialist government and structural adjustment programs); 2000-nowadays (liberal period). For each period, we coded information on reported crop diversity, crop diversity trends, interventions, and crops affected by the interventions. We organized the information in a timeline that guided the construction of the narrative.

Statistical data of the crop area harvested in the Kédougou region (1980–2022) was visualized in a trend-line with the help of R package ggplot2 (Supplementary material 2).

4.2.2. Local explanations of trends and drivers of change in Bassari traditional crops

Semi-structured interviews were translated (Bassari to French) and transcribed using f4-software. Open-ended questions in household surveys were not voice-recorded and we only analyzed the paraphrasing of the answers.

To assess crop diversity trends, we first coded verbatim answers in NVivo. We created three different variables: 1) crop species name (e.g., 'maize'); 2) trend (e.g., 'increase cultivated surface', 'abandonment'); and 3) drivers, for which we differentiated among 'environmental' (e.g., shorter rainy season), 'socio-economic' (e.g., decrease in labour availability), 'cultural' (e.g., dietary changes), and 'crop traits' (e.g., organoleptic traits). Within each driver category, we also inductively developed sub-categories (e.g., 'dietary changes' → 'rice-based diet'). We visualized the connections between the different drivers using a concept map.

We analyzed household survey data using descriptive statistics (frequency of times each trend and driver was mentioned). We used R package ggplot2 to visualize such information in a histogram.

5. Looking back: a short history of the agrobiodiversity landscape across scales

In this section, we examine the main socio-economic, political, and ecological events that, from 1400s until nowadays, have shaped the agrobiodiversity landscape that we observe now across regional (West Africa), national (Senegal), and local scales (Bassari territory) (Fig. 3).

5.1. The colonization of the agrobiodiversity landscape: transatlantic slavery and the introduction of exotic crops (1400s-1900)

West African farmers actively contributed to the domestication of

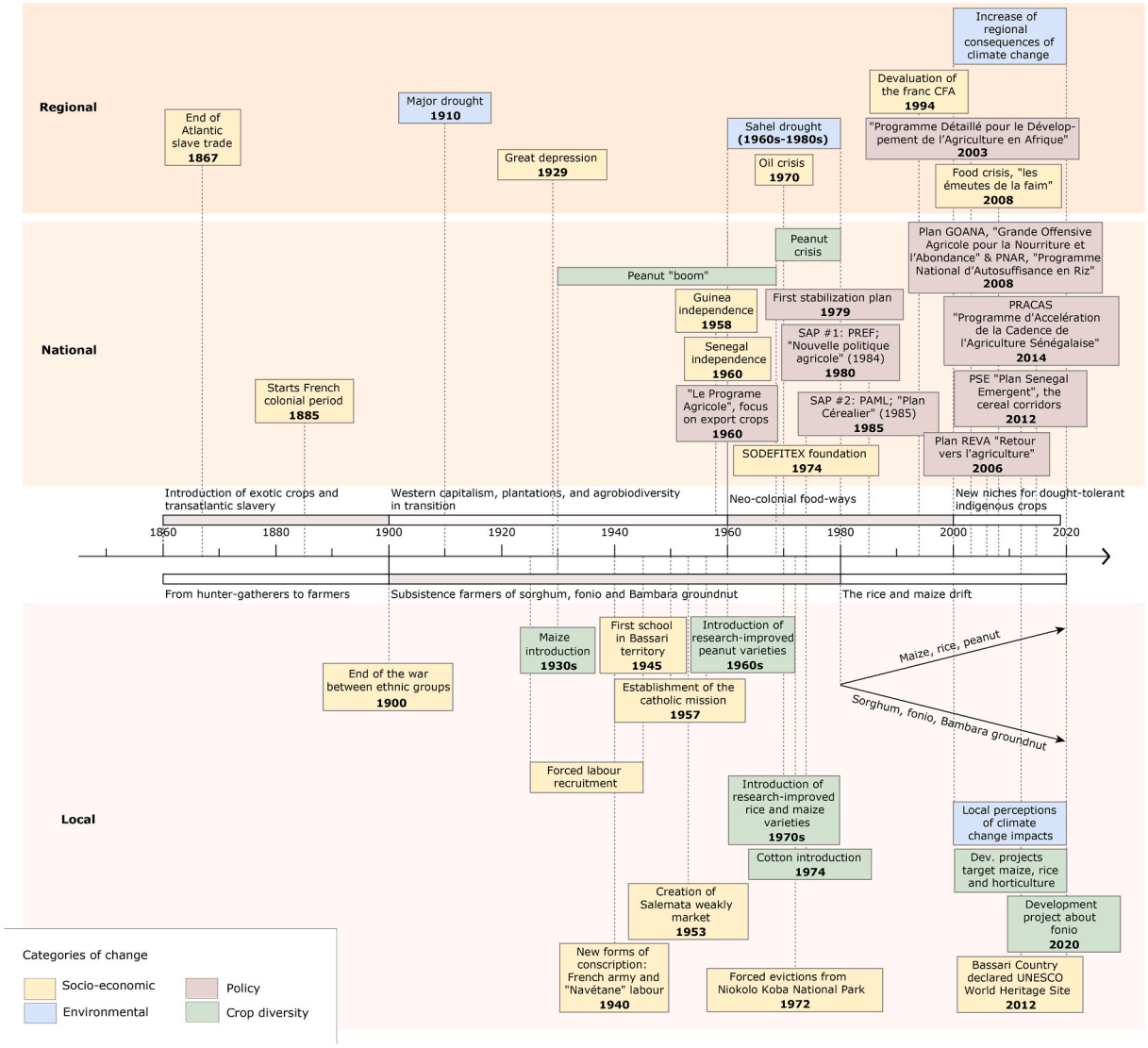

Fig. 3. Timeline of socio-ecological events that influenced the diversity of Bassari traditional crops at the West African, Senegalese, and local scale.

more than 2000 plant species (National Research Council 1996, 2006, 2008). Important domesticates include sorghum, white fonio, Bambara groundnut, cowpea, millet, African rice, and yam (Harlan et al., 1979). The first colonial and trade expeditions, dating from the 15th century, had a big influence on West African crop diversity through the introduction and diffusion of new crop species and varieties (Alpern, 1992, 2008). Peanut (Bernards, 2019), Asian rice (Linares, 2002), maize (McCann, 2005), and manioc (Carter et al., 1994) were introduced in West Africa in the sixteenth century by Portuguese traders.

Little is known about pre-colonial farming practices among the Bassari. Explorer's diaries and ethnographic work suggest that by the 19th century, the Bassari – who were historically hunter-gatherers - had definitively adopted farming (Delacour, 1909; Neveux, 1909; Rançon, 1894) and relied mostly on sorghum, Bambara groundnut, fonio, and native tuber crops like yams and coleus (Gessain, 1975). Rice and peanut were cultivated in small areas. Peanut most likely arrived through exchange with the Coniagui traders. Considering that the neighboring Casamance was the epicenter of African rice cultivation in Senegal (Carney, 2002), it is also likely that during the 19th century Bassari farmers cultivated both the African and the Asian rice species.

5.2. Whose land? Whose crops? Capitalism and agrobiodiversity in transition (1900–1960)

Atlantic slave trade and early colonization destabilized traditional African societies, setting the base for Western Africa to become the plantation land for exotic species for export (e.g., cotton, peanuts, cocoa, coffee) (Carney, 2021). Most colonial agricultural scientists considered West African crops, varieties, and farming techniques inferior to European ones, which led to the imposition of Western agricultural practices (e.g., mono-cropping, pesticides) that did not align well with local socio-ecological farming conditions (Hardin, 2021; Tilley, 2011). In Senegal, the colonial period was characterized by the specialization in large-scale commercial peanut production for export and by the promotion of rice imports from French colonies in Indochina (Bernards, 2019; Brüntrup et al., 2006).

Driven by the growing demand for plant oils in industrializing France, peanut specialization started in the mid-19th century and had a boom after the 1929 Great Depression. Large-scale peanut production was possible due to the mobilization of forced labor through poll taxes and the construction of a transport network that allowed exports and shaped the geography of peanut production (Bernards, 2019; Brooks, 1975). As other ethnic groups, the colonial rule affected the Bassari through the establishment of new labor relations in the form of "forced

labor" in Wassadougou sisal plantation and in local roads' construction (1920s–1940s), and in the form of "navetane labour[4]", which entailed going to the Groundnut Basin to work during the rainy season (Nolan, 1986). With the expansion of peanut cultivation, Bassari also engaged in peanut trading, mainly with middlemen who regularly visited their villages. The possibility of earning cash probably boosted local peanut production (Crepy-Montal de, 1984).

The French colonial regime also developed a network of weekly markets promoting local trade and cash circulation to pay the poll taxes (Fouchier, 1981; Gessain, 1975). The importance of money increased and commerce started to thrive in the Bassari territory (Delacour, 1909; Gessain, 1967, 1975). The new labor geographies and market-settings stimulated inter-ethnic contacts and knowledge and seed exchange, which brought new crops and varieties into the Bassari crop portfolio – e.g., maize was introduced around the 1930s and new rice varieties (e.g., "malu siset"; "malu bandyul") around the 1950s (Dupre, 1965; Gessain, 1975).

Besides boosting the adoption of exotic crops, colonial years remarkably decreased Bassari access to wild biodiversity, an important pillar of their traditional livelihood, through the declaration of the Niokolo Koba National Park in an area that was traditionally used by the Bassari (and other ethnic groups) as hunting and gathering grounds (DPN, 2000; Ece, 2008; Gessain, 1975). Consequently, the importance of wild plant gathering and hunting in the Bassari diet shrink and the surface of agricultural fields gradually increased (Gessain, 2010; Gessain et al., 1984).

Colonial years also impacted the Bassari territory by promoting the contact with (and absorption of) Western culture, favored by two main interventions. First, the imposition of a Western schooling system (the first colonial school in the Bassari territory was constructed in 1947), which resulted in children spending less time in the "Ambofor", the school analogous in the Bassari traditional education system, and having less time for agricultural tasks (key informant 15, KI #15, Table 1). And second, the advancement of Christianity through the establishment of the Catholic and Protestant missions (in 1957 and 1960 respectively) (Gessain, 1975; Guignard and Gessain, 1971), which became a new source of agricultural knowledge, promoting new crops and management techniques.

In sum, colonial rule profoundly impacted the Bassari society and agricultural system through changes in labor regimes and relations, income sources, market settings, access to forests and bushlands, and cultural arrangements. New crops, varieties, and technical innovations permeated the local agricultural system during this period. Although many of these innovations neither had been adopted by a vast majority of the local community, nor replaced traditional practices, the seeds of these changes were already planted.

5.3. Neo-colonial food-ways: changing landscapes, changing vulnerabilities (1960–2000)

Post-colonial governments and international donors and projects, NGOs, and transnational companies promoted mono-cropping for export, dependency on external inputs, and diets based on food imports (mainly rice) and privileged peanut first, and rice, maize, cotton and horticulture later. Agronomic research agendas continued biased towards exotic crops and farmers' varieties were considered of lower value compared to the ones bred in research centers.

In 1960, with Senegal independence, started a period of state-led development that reproduced the structures and the specialization policy of the French colonial state. Senegalese government put into place the 'Programme Agricole' (1960–1980), which promoted peanut production and intervened in the rural areas providing farmers subsidized seed, chemical fertilizer, and marketing channels, and purchased most peanut production (Dieng and Gueye, 2005; Sall, 2015). New upright peanut varieties, easier to harvest and with higher yields, were distributed and rapidly replaced other varieties (Bonneuil and Thomas, 2009). Short-cycle peanut varieties arrived to the Bassari territory in the early 60s (Dupre, 1965) and were given to families within the framework of food aid or distributed at subsidized prices (KI #14).

Initial post-colonial years coincide with critical climatic and economic conditions, which entailed a "double shock" in the national agricultural sector. The first shock was caused by severe droughts, which started in the 1960s and extended to the 1970s and 80s, and which largely impacted (predominantly rain-fed) Senegalese agriculture. This accelerated soil degradation and caused important production losses and famine. The shock reflected the limitations of the rural development paradigm that had driven agricultural policy during colonial and early post-colonial years – i.e., through the promotion of mono-cropping for export, chemical inputs, and land reforms that made large-scale agricultural intensification possible, not giving support to smallholder farmers' and staple food production (Dawson et al., 2016; Mackintosh, 1989). The Sahel drought also hit the Bassari territory, although impacts were milder than in other areas. The mosaic of agriculture and forest patches created by slash-and-burn subsistence agriculture, the diverse crop portfolio, and a complementary livelihood base of wild edible plant gathering and hunting probably constituted key assets for Bassari resilience in the face of the droughts (Gessain, 1975; KI #15).

In Senegal, as in other West African countries, the drought and famine period resulted in additional efforts to increase the agricultural production and triggered scientific agricultural research through the creation of national agricultural research institutions[5] (Raimond et al., 2020). Between the 1972 and 1990, the formal seed system was consolidated and the production and diffusion of research-improved seeds expanded. The crop focus slowly widened, including exotic crops other than peanut, e.g., cotton for export and rice and maize for subsistence. During the years that followed, new short-cycle varieties arrived to the Bassari territory. In 1973–1979, Bassari farmers accessed research-improved rice and maize seeds, herbicides, and fertilizers.[6] In the 1980s, American cotton (*Gossypium hirsutum*)[7] covered the first hills of Bassari scattered agrobiodiversity landscape. Cotton seeds and inputs were provided to Bassari farmers through a debt system, according to which farmers would pay their debts by selling the cotton after the harvest (KI #15).

The severe drought period was followed by an economic shock. The collapse of the peanut sector, together with the 1970s oil crisis and economic recession in the Global North, precipitated the 'debt crisis' in the Global South, which materialized through the implementation of structural adjustment programs. Senegalese policies shifted from state-intervention to price-driven policies, leading to the liberalization of the food sector and to the disengagement of the Senegalese state from agricultural policy. In 1984, the 'New Agricultural Policy' was issued, with a focus on food self-sufficiency (i.e., "Plan Cérealier", 1986 with a strong focus on rice) but lacking the needed economic investments for proper implementation (Oya and Ba, 2013). The state facilitated investments in cash crops for export by foreign (mostly Western) agribusiness firms (Mackintosh, 1989; Ndiaye, 2013; Sall, 2015). State gaps were filled by NGOs and international cooperation agencies (Boillat

[4] *Navetane labour* is a Wolof term that was used by the colonial administration to designate seasonal agricultural workers (Berg, 1965).

[5] The National Institute for Agricultural Research (ISRA, "Institute Sénégalaise de Recherche Agricole") was created in 1974.

[6] BAMTAARE - the rural development branch of the SODEFITEX, the cotton company - was responsible for farmers' training and for the distribution of rice and maize seeds among Kedougou farmers' (KI #6).

[7] American cotton had been introduced in West Africa as a cash-crop due to its higher yield, better fiber quality, and adaptation to mechanization compared to the perennial African-Asian varieties (i.e., *G. herbaceum, G. arboreum*) (Seignobos, 2019).

et al., 2022). During the 20th century, the reliance of national food security on rice imports steadily increased (Diagne et al., 2012; Randolph, 1997). This trend, which had started during colonial times, led to the gradual shift of national consumer patterns from local grains (e.g., millet and sorghum) to a rice-based diet (Colen et al., 2013).

During 1960–2000s, agriculture in the Bassari territory remained diversified and subsistence-based, although the shift to exotic crops continued. Peanut gained importance in women's fields, in detriment of Bambara groundnut, and cotton was rapidly integrated into the traditional crop rotation. Maize started covering the area surrounding the houses. The riverbanks and adjacent areas, previously covered with gallery forests, started to be cleared up for rice cultivation (Gessain 1975; KI #14; KI #15). Traditional crops remained the basis of the diet, but – by the end of the 20th century – rice had already started to find its way into local kitchens, favored by seasonal migration, which gained momentum as a cash-earning strategy (Nolan, 1986). Together with the new crops and short-cycle varieties, the first chemical agricultural inputs and technical innovations, such as the oxen-driven plough, arrived during this period, although their use remained reserved to few (KI #6, KI #15).

5.4. Maize and rice drift, and new niches for Bassari traditional crops (2000s-nowadays)

The start of the 21st century represented for Senegal an inflexion point in terms of agricultural policy, consolidating a shift from traditional to exotic crops. Crop diversity trends at regional level (1980–2022)[8] show a decrease in sorghum cultivation, an increase in rice, maize, and peanut cultivation, and an increase followed by a decrease in cotton cultivation (Supplementary material 2). Agricultural policy during this period was characterized by three main trends.

First, facing the failure of the structural adjustment programs, West African states –including Senegal – re-engaged in agricultural development. The 2008 food crisis revealed the fragility of Senegalese (and global) food system, highly dependent on rice imports, and triggered the return of agriculture to the heart of public policies. In continuation with previous policies, new ambitious programs were implemented in Senegal to reinforce cereal production and national food security, while increasing national production for exports. Examples include the special programs of maize, manioc, sesame, roselle, fonio, and sunflower, the plan REVA in 2006, the plan GOANA and the national program for rice self-sufficiency (PNAR) in 2008, and the PRACAS in 2014–2017 (Fig. 3). Although some Bassari traditional crops were targeted in these national programs, the main focus remained on exotic crops - like rice, maize, and horticulture - which received the biggest share of economic endowment (Ndiaye, 2013).

Second, as happened across Sub-Saharan Africa, there was a resurgence of agricultural intensification programs within the so-called "New Green Revolution for Africa" (World Bank, 2007). The programs implemented during this period relied on market-led agricultural transformation for economic growth, subsidizing chemical inputs, mechanization, and facilitating land and water access for large-scale investors, which gave rise to land-grabbing (Koopman, 2012).

Third, the dependence of policy action on foreign funding, also called "projectorate",[9] increased leading towards an agricultural development agenda ruled by the interests of foreign donors and reflecting the heterogeneous and often contradictory visions of different agricultural development actors (Bottazzi and Boillat, 2021). In this context, agroecological initiatives gained momentum, promoted by peasant organizations, NGOs, research centers and international donors. National and international agricultural research started to direct attention towards West African indigenous crops. Fonio and sorghum were in the spotlight of international plant breeding improvements (Diop et al., 2018; Kaczmarek et al., 2023; Xin et al., 2021). Still, due to the lack of financial and political autonomy of farmers' organizations, and the big economic and political stakes in driving the New African Green Revolution, most of the projects and initiatives (even those self-proclaimed as "agroecological") followed the logics of agro-industrial development and food imports, promoting technology-driven approaches (Bottazzi and Boillat, 2021) and largely focusing on few mostly exotic crops and research varieties.

During this period, agricultural development in the Bassari territory reproduced regional and national-scale trends. State intervention took place through agricultural development projects that distributed subsidized research-improved seeds and chemical fertilizers and increased the dependence on chemical inputs. These projects mostly targeted rice and maize, which continued to gain popularity in farmers' fields and plates. Cotton continued to be promoted through contract-farming arrangements. Different international development organizations and NGOs intervened in the area providing materials, infrastructure, and capacity-building for small-scale horticultural production[10], which mostly targeted water-demanding vegetables for commercialization, increasing water demands for irrigation, groundwater depletion, and conflicts over water use. For the first time, local NGOs started including fonio in their crop repertoire, creating new niches for its production and use.

More broadly, the 2000s stabilized the trends that started in colonial and early post-colonial times, fundamentally changing local communities' access to natural resources, labor relations, income, and consumption patterns. Long-term and seasonal migration entrenched in Bassari livelihood strategies. The classification of the Bassari Country as a UNESCO World Heritage Site (UNESCO, 2012), the establishment of a tourist camp in the Bassari territory, and the improvements of the road connecting it with the administrative town (Kédougou) fueled the small-scale tourism sector. With the development of the gold mining industry in Eastern Senegal (D'Avignon, 2018), working in the mining areas became common among youth. Common agricultural labour, deeply embedded in Bassari traditional social organization and rituals,[11] loss importance (Yamada, 2007).

6. A contemporary look at Bassari traditional crops

To complement the view of global-, regional-, and national-scale dynamics, in the next section we present results from empirical research describing Bassari contemporary adjustments in crop portfolios, which we take as a point of departure to understand farmers' agency on how and why they make crop choices.

[8] Fonio only started being monitored in 2015, which is insufficient time to identify a clear trend. Bambara groundnut does not appear in the national agricultural statistics.

[9] "Projectorate", is a term coined by Carmona (2008) to describe the logic in many countries of the Global South, where policy formulation and implementation is strongly influenced by transnational funding agencies. In the case of Senegal, it refers to the technical and economic support of foreign donors and international partners to implement agricultural development projects (Bottazzi and Boillat, 2021).

[10] Small-scale horticultural production is practiced mostly by women in the Bassari territory. It relies on manual irrigation with well water, it is done during the dry-season, and is mostly for local commercialization (own observation).

[11] Ethnographic texts highlight Bassari hierarchic and highly structured age-class system, which is considered the pre-requisite for acceptance and status in the village and the basis of most village activities, customary practices, and agricultural tasks. From the time young men and women are initiated, until they enter the class of the 'elders', Bassari are expected to conduct a certain number of ritual tasks per year, most of which relate with agricultural activities and communal labour arrangements (Gessain, 2002; Nolan, 1975; Yamada, 2007).

6.1. Current trends in the cultivation of traditional crops

In household surveys and semi-structured interviews, informants mentioned that the cultivation of sorghum, fonio, and Bambara groundnut has decreased in the Bassari territory.

According to household survey results (Supplementary material 3), in the 2019 cropping season, less households cultivated Bassari traditional crops than rice, maize and peanut. Concretely, 59.2% (n = 29) of the households cultivated sorghum, 36.7% (n = 18) cultivated fonio (n = 23), and 51% (n = 25) cultivated Bambara groundnut, compared to the 100% (n = 49), 87.8% (n = 43), and 100% (n = 49) that cultivated maize, rice, and peanut.

Households are also reducing the surface cultivated with Bassari traditional crops. While 20.4% (n = 10), 4.1% (n = 2), and 34.7 % (n = 17) of the households mentioned having reduced the surface cultivated with sorghum, fonio, and Bambara groundnut since the establishment of the household, only 8.2% (n = 4), 10.2% (n = 5), and 10.2% (n = 5) mentioned having reduced the surface cultivated with maize, rice, and peanut. In contrast, since their establishment, households were more likely to increase the surface cultivated with maize (18.4%, n = 9), rice (6.1 %, n = 3), and peanut (14.3%, n = 7), than to increase the surface cultivated with sorghum (2%, n = 1), fonio (0%, n = 0), and Bambara groundnut (0%, n = 0) (Fig. 4).

As the most prominent trend is the decrease of surface/abandonment in the cultivation of Bassari traditional crops, we focus on this change in subsequent sections.

6.2. Local explanations of the abandonment of Bassari traditional crops

In the household surveys, respondents gave 124 responses to the question of why they have abandoned sorghum, fonio, and Bambara groundnut. Responses include 'socio-economic' (38.7%, n = 48 responses), 'cultural' (13.7%, n = 17), and 'environmental' (8.9%, n = 11) drivers, as well as 'crop traits' (36.3%, n = 45), which are indirectly related with the three other categories (Table 2). We complement these explanations with in-depth information collected through semi-structured interviews.

Socio-economic changes, and specifically lack of access to labour, land, or seeds were the most mentioned drivers that explain the abandonment of Bassari traditional crops. Particularly, the decrease in labor availability was the main reason used to explain the abandonment of Bassari traditional crops (23.4%, n = 29).

As middle-aged man explained, "*You need a big family to cultivate sorghum*" and he continued "*the work* [long cropping season, and time-consuming harvest and post-harvest] *is hard. You start the first and finish the last*". Another aspect mentioned to contribute to the higher workload of sorghum compared to maize was the need for bird-scaring labour close to harvest. As an old-man indicated: "*I used to cultivate a big field* [of sorghum] *but, as neighbours abandoned sorghum cultivation and children started going to school, all birds feasted on my field. I was discouraged. I was cultivating for the birds!*" Decrease in labour availability was also tightly linked to the decrease of communal agricultural labour (4.8%, n = 6) - e.g., decrease in neighbourhood or village common working days in one person's field. As a middle-aged woman explained: "*We fail to grow it* [fonio] *because we don't have anybody that helps us in our fields. Before the children from all the neighbourhoods would organize themselves to harvest all the fonio fields of the village. (…) All non-initiated boys had to do it without expecting anything in return. (…) It was their duty. (…) Nowadays everyone is for himself and God for all of us.*" Another commonly mentioned cause of the decrease in labour availability was age. This reason was related with generational change and the lack of relay from the youth within the household for the cultivation of traditional crops. As several young respondents mentioned, Bassari traditional crops do not always fulfil their expectations: "*My mother and my grandmother cultivated it. But the harvest is hard, you need to spend all day bended down in the field to harvest only a small bit. People prefer peanut. It is faster. It gives more and it is easier to harvest. I didn't even ask for the* [Bambara groundnut] *seeds to my mother*".

Respondents also explained the abandonment of traditional crops as a consequence of the high work demands of these crops, either during harvest - 'management-related traits' (24.6%; n = 30) – or processing - 'use-related traits' (3.2%, n = 4). Lower labour requirements were mentioned for maize versus sorghum and for peanut versus Bambara groundnut. The high work demands of Bassari traditional crops were especially important for women. Both, Bambara groundnut and fonio are fundamentally women's crops, which entails that women assume most tasks related to their cultivation and post-harvest. Women are also the ones in charge of household meal preparation and therefore, the ones assuming the burdensome processing tasks of traditional crops. As one young woman stated: "*Preparing fonio is difficult and very time-intensive. It's hard to cook and crush it in the mortar*".

Respondents also mentioned 'trade-offs with other crops' (5.6%, n = 7) as reasons leading to the abandonment of traditional crops. Rice, maize, peanut, and cotton were generally perceived to have higher

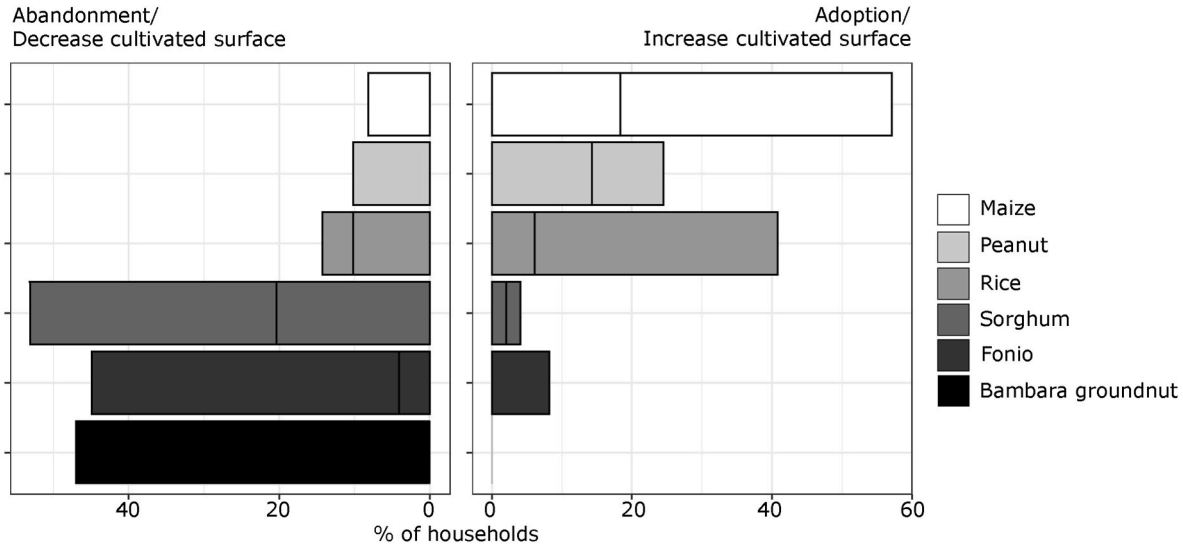

Fig. 4. Percentage of households that adopted or increased the cultivated surface (right) or that abandoned or decreased the cultivated surface (left) for each local staple crop. The percentage is calculated over the total number of households surveyed (n = 49).

Table 2
Drivers of abandonment or decrease in the cultivation of Bassari traditional crops. Data obtained through household surveys (n = 49). Columns contain the number of times each driver was mentioned per crop (in total and in percentage).

		All crops together		Sorghum		Fonio		Bambara groundnut	
		Total	%	Total	%	Total	%	Total	%
Environmental	Shorter rainy season/Rainy season starts later/Rainy season finishes earlier/Decrease mean rainfall	8	6.45	6	13.33	2	4.55	0	0.00
	Increase in the frequency of crop pests and diseases (production, storage)	3	2.42	1	2.22	0	0.00	2	6.25
Socio-economic	Trade-offs with other crops	7	5.65	5	11.11	2	4.55	0	0.00
	Decrease seed access and availability	4	3.23	1	2.22	0	0.00	3	9.38
	Decrease labour availability/lack of manpower	29	23.39	7	15.56	13	29.55	9	28.13
	Decrease land access/availability	2	1.61	1	2.22	1	2.27	0	0.00
	Crop damage/failure/loss	6	4.84	3	6.67	1	2.27	2	6.25
Cultural	Changes in food habits/dietary changes	9	7.26	6	13.33	0	0.00	3	9.38
	Decrease communal agricultural labour	6	4.84	1	2.22	4	9.09	1	3.13
	Loss of traditions/decrease use of ritual foods	2	1.61	2	4.44	0	0.00	0	0.00
Crop traits	Organoleptic traits (colour, taste, smell, consistency)	2	1.61	1	2.22	0	0.00	1	3.13
	Use-related traits (processability, marketability)	4	3.23	0	0.00	3	6.82	1	3.13
	Management-related traits (workload)	30	24.19	7	15.56	13	29.55	10	31.25
	Agronomic traits (crop cycle, yield, height)	9	7.26	3	6.67	4	9.09	2	6.25
Others	Other reasons	1	0.81	0	0.00	1	2.27	0	0.00
	No answer	2	1.61	2	4.44	0	0.00	0	0.00

yields, better response to fertilizer, and easier mechanization than Bassari traditional crops, and thus farmers prioritized them. "*People used to cultivate them* [traditional crops] *because there was no alternative. Nowadays new seeds arrived* [refers to maize and rice]. *With the help of the herbicides and the oxen-plough, everybody wants to cultivate in the plains. (…) Cotton is another thing. (…) For many of us, cotton is the only option to earn the money to pay children's schooling. You can have 100 cows, or 50 sacks of grain, but to whom are you going to sell them to?*" However, cotton is socially considered a men crop and the decision to grow cotton seem to be mostly a men's decision, probably because men are the ones who have contact with the extension services of the cotton company and access to credit. Women complained that cotton cultivation brought household food insecurity due to land and labour trade-offs with subsistence crops. Several women also complained that their husband's "drank" cotton revenues. Men's excessive spending on alcohol was a source of conflict between spouses and affected households' economy, which did not always benefit with cotton sales income. While some men mentioned they could buy status items (e.g., mobile phone, motorbike, etc.) with cotton's revenues, none of the women interviewed mentioned it.

Another socio-economic reason for the decrease in cultivation of Bassari traditional crops were shocks in the farming system causing 'crop damage, failure, or loss' (4.8%, n = 6). For example, several respondents mentioned being discouraged from cultivating Bambara groundnut due to free-ranging cows: "*People leave their cows free at the end of the harvesting season, so that they eat the crop residues. (…) Bambara groundnut is slower than peanut, that's why it's still on the fields when the cows come. If you don't take good care, cows will eat all your harvest*". Similarly, some respondents also noted abandoning fonio due to harvest damage caused by livestock grazing and trampling: "*We have cultivated fonio since we were young. It is an easy crop. It grows everywhere and you don't need to check it closely. After sowing, you can return home without worrying about the birds or the rodents because when you return to your field, you will see that it has germinated. But nowadays, if you don't surveil your field closely, the cows will eat all the grain. Nowadays, it's the free roaming cows that discourages us* [from growing fonio]". Besides free ranging livestock, farmers also mentioned fonio losses due to early grain shattering, which posed problems if they could not harvest on the (short) optimal time window, and low seed quality, i.e., fonio seed mixed with grasses.

After socio-economic factors, the second most important group of drivers contributing to the abandonment of Bassari traditional crops were cultural changes. Within cultural changes, dietary changes, i.e., shift of people's preferences from a diet based on traditional crops to a rice- and maize-based diet, were the most prominent. 7.3% (n = 9) of the reasons mentioned for crop abandonment referred to 'changes in food habits' and 1.6% (n = 2) to 'organoleptic traits' (e.g., colour, taste, smell, consistency). As a middle-aged woman noted: "*Children don't want to eat 'enap' anymore*". Several respondents emphasized that they preferred maize and rice to sorghum and Bambara groundnut for their taste. Some respondents also mentioned that eating "enap" is old-fashion. In contrast, fonio is still a highly valued crop in terms of taste, as a woman respondent said: "*I always cultivate a bit* [of fonio] *because it's very tasty and filling, but light in the stomach*".

Environmental changes were the least frequently mentioned to explain the decrease in the cultivation of Bassari traditional crops. Within this category, the main drivers were the 'shorter rainy season' (6.4%; n = 8) and the preference towards short-cycle varieties - 'agronomic traits' (7.3%; n = 9), both tightly linked. When discussing preferences towards short-cycle varieties, Bassari farmers referred to changes in rainfall abundance and distribution, which includes an increase of the length and frequency of dry-spells, a higher unpredictability, variability and intensity of the rains, and a later onset and earlier end of the rainy season. To react to these changes in rainfall patterns, farmers have started to rely more on short cycle varieties, which can produce during the central months of the rainy season, with lower risks of crop losses. "*Now the rainy season stops very early and the Bambara groundnut is very slow. You need to sow it before peanut and harvest it last*", complained an older woman while we crossed freshly harvested fields. Few meters further, a drab-brown field full of yellowish grasses. "*This is my fonio field*" she stated, and she continued "*It had no time to ripe because the rain stopped too early*".

Finally, Bassari acknowledge that socio-economic, cultural, and environmental drivers result from a range of other underlying factors that mostly relate to lifestyle changes (e.g., people now invest less time in agriculture and other subsistence activities), changes in the traditional value-system (e.g., age-class system and the traditional agricultural labor arrangements decrease in importance), and the effects of these factors on farmers' crop diversity preferences and the way they do farming. Fig. 5 offers a visualization of the complex interactions between drivers that are locally perceived to have caused a decrease in Bassari traditional crops.

An example of this complex interactions is the 'decrease in labour availability', which Bassari acknowledged as simultaneously caused by youth migration, mandatory schooling, and the decreasing importance of traditional customary practices, particularly the age-class system that

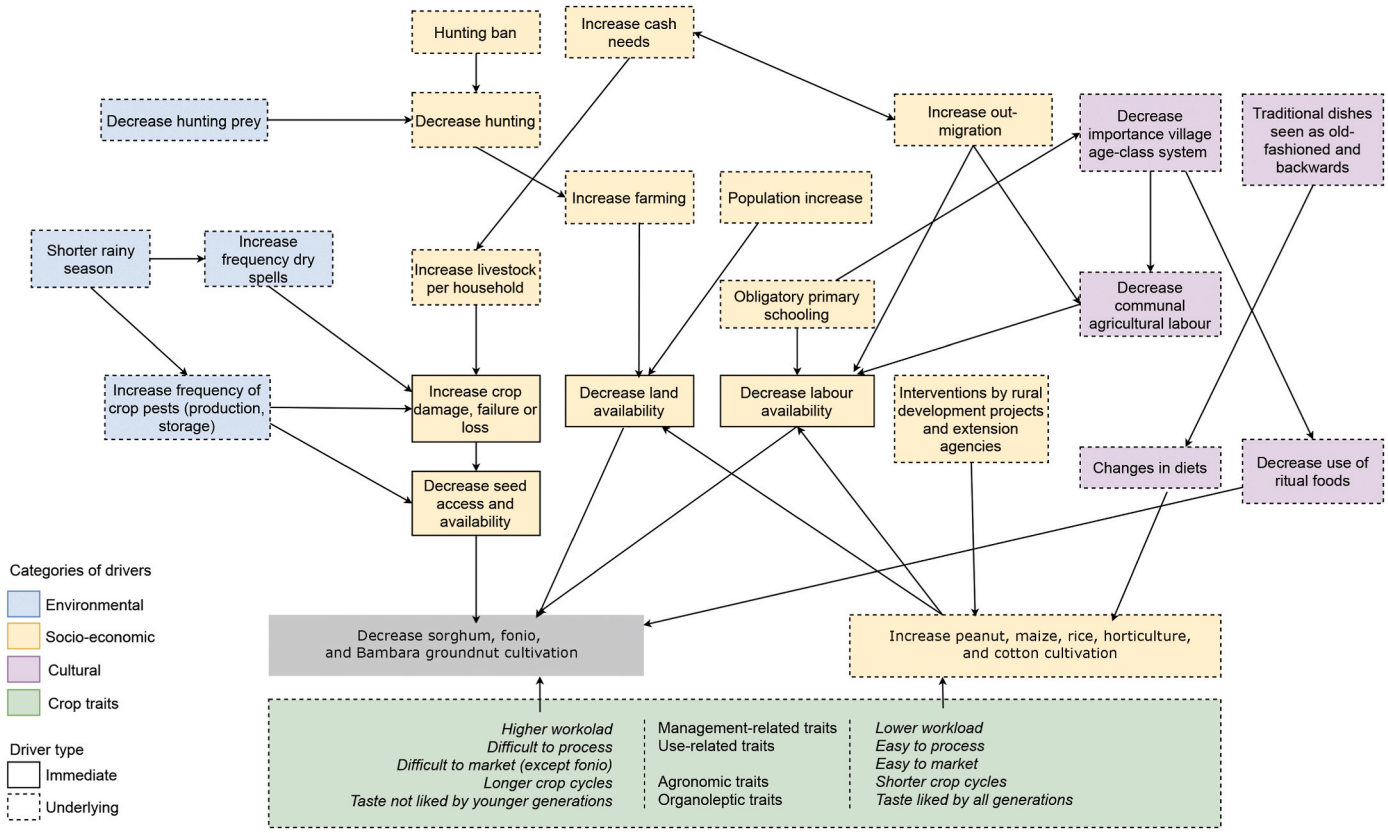

Fig. 5. Example of the locally perceived cascade of change associated to the cultivation decline of Bassari traditional crops.
*For the synergies between the drivers of crop trends, we differentiated between 'immediate' and 'underlying' drivers depending on whether the mentioned driver referred, respectively, to the final cause that led to crop abandonment or to non-final causes that put other drivers in motion.

used to structure communal labour arrangements. For example, as mentioned, fonio harvest was traditionally done by the youth as part of the corpus of ritual duties that conforms Bassari age-class system, but now needs to be assumed by each individual farmer, making it especially difficult for smaller or less wealthy households to mobilize enough workforce.

Other examples of such complex interactions refer to 'increase in crop damage, failure or loss'. According to the Bassari, mandatory schooling resulted in children spending less time in the fields, and therefore doing less bird scaring labour, which, together with the reduction of size and number of Bassari traditional crops' (mostly sorghum) fields, led to an increase of crop losses due to birds. Bassari also acknowledged the complex cascading effects of cow introduction in crop losses. The prohibition of hunting and the increase in livestock market value led to increasing livestock rearing, which in turn led to an increasing conflict between crop cultivation (specially Bassari traditional crops due to their longer cycles and/or higher labour requirements) and livestock free ranging.

Respondents also related the decrease in the cultivation of traditional crops with general lifestyle changes and with changes in the role that these crops play in the Bassari society. Bassari traditional crops used to be essential for the traditional diet and for many ritual practices that have now been abandoned. For example, having a big sorghum field was part of Bassari men initiation ceremony. Nowadays, this does not seem to play an important role anymore. Respondents also explained that the number of rituals in which sorghum beer is consumed has decreased. As one middle-aged man explained "*As a part of the initiation, you had to bring seven vessels full of sorghum to the sacred forest and then all the initiated men would share the beer. (…) Afterwards people started thinking that giving away so much grain for offering free beer was too much waste. (…) They* [the elders] *realized that times were changing and there was no other alternative than accepting*".

7. Discussion and conclusions

In this study we place three Bassari traditional crops at the heart of our analysis to analyse the multiple drivers involved in their decline in South-Eastern Senegal, a region especially vulnerable to climate change. Our results show that farmers' crop choices are multi-causal and point to the importance of understanding how power-laden broader political and economic forces interact with household dynamics materialized through everyday decision-making and labour distribution. We discuss how the shift to exotic crops transformed farmers' fields and intra-household power relations with consequences for farm self-sufficiency, family nutrition, gendered power relations, and resilience and vulnerability to (climate) shocks.

Before reviewing our results, we discus three caveats of our research. First, due to the lack of Bassari written records, all the secondary data analyzed was written by outside observers. These texts mostly reflect mainstream development narratives and likely provide limited understanding of local people's lives, perspectives, and processes of change. Reliance on these texts might bias our understanding of change. Second, we aimed at creating new understandings of agrobiodiversity dynamics by integrating multiple evidences (Tengö et al., 2014). However, the unequal power relations between academic knowledge and Indigenous and local knowledge embedded in imperialism, colonialism, and capitalism make bridging epistemological boundaries a "contested process," with an inevitable reproduction of structural inequalities (Chilisa, 2017). Acknowledging this problem, we ask to consider the Bassari views presented here as our own interpretation, and not Bassari worldviews and knowledge. Third, the case-study nature of our research limits our ability to generalize results. We do not claim that our results

are representative of global dynamics of sorghum, fonio, and Bambara groundnut, but only to the Bassari territory, where our qualitative results are in line with the crop diversity trends observed at broader scales – e.g., Diop et al. (2018); Sidibé et al. (2020). We do argue, however, that our results capture the complexity of local agrobiodiversity trends, and the interactions and interdependencies of these trends with historical and political changes taking place at larger scales, which eventually affect communities' and agroecosystem's resilience to climate change, in the Bassari territory and elsewhere. We discuss our results from this perspective.

7.1. Current farmers' crop choices reflect multi-scalar and diachronic complexity

Our findings highlight how Bassari farmers see their choices increasingly dictated by external forces. Since the 1900s, West African regional agricultural policies and interventions have promoted exotic commodity crops through different strategies, ranging from coercion and poll-taxes during the colonial period to seed and inputs provisioning, agricultural extension, marketing boards, and NGO intervention more recently. Besides introducing new crops and varieties, colonial processes changed the structural and material context in which farmers' decisions took place – e.g., cash needs and migration increased, the time and labour available for farming decreased, and dietary preferences changed. In parallel, researchers privileged work on exotic crops with higher competitive advantages in terms of yield and management-related traits compared to the available varieties of Bassari traditional crops (Chivenge et al., 2015; Manners and van Etten, 2018; Tadele and Assefa, 2012). Combined, these drivers affected Bassari farmers decisions to switch from traditional to exotic crops, which materialized in the explanations farmers provided for the abandonment of sorghum, fonio, and Bambara groundnut – e.g., emphasizing how changes related to cultural norms and traditions led to workforce constraints, changes in farmers' cultivation and dietary preferences, and land/labour trade-offs with other crops.

Our findings speak to research in other parts of the world that explore the situated effects of policies and market integration on local agrobiodiversity and farmers' decision-making. This literature shows how colonization, globalization, and in general policies and initiatives that orient agriculture towards global markets lead to a loss of traditional crops and varieties (Maikhuri et al., 1997; McLean-Rodríguez et al., 2019; Teeken et al., 2012). Additionally, our results highlight labour relations as a key element that materialized the local effects of broader socio-economic forces. Bassari traditional crops depended on labor-intensive forms of agriculture. Broader socio-demographic changes, such as children schooling and youth migration, acted synergically with the decrease in importance of rituals and cultural norms steering agricultural common working days, thus affecting household labour availability. Nonetheless, our results further advance that broader drivers are crucial, but not enough, to explain changes in labour relations and the decrease in cultivation of sorghum, fonio, and Bambara groundnut. Hence, an exclusive focus on how broader political and economic structures and processes interact with household dynamics considering households as one whole can obscure oppressive interactions taking place at household-level, i.e., by silencing gender-relations (Bezner Kerr, 2014; Razavi, 2009; Scurrah-Ehrhart, 2007).

To reach a comprehensive understanding of farmers' agrobiodiversity choices, in the second part of the analysis we attempt to disentangle the processes embedded in local agricultural labour relations by looking at how intra-household power dynamics interact with broader socio-economic changes. Previous research has demonstrated that a large share of the lived experiences (and contestation) of power takes place at household-level (Agarwal, 1997; Bezner Kerr, 2013; Ravera et al., 2016; Razavi, 2009). In the Bassari case, men's migration in search for off-farm work and the allocation of a big share of their time to cotton cultivation deepened gender inequalities in household labour-division. Women became increasingly responsible of household's subsistence crops, which added to their already burdensome task bundle of reproductive and care responsibilities. As priorities changed, women had less time available for food preparation. Because the processing and cooking of sorghum, fonio, and Bambara groundnut is time- and labour-intensive, women did not contest the switch to maize, rice, and peanut, which cook faster.

Thus, the decline of Bassari traditional crops show how government policies, broader socio-economic structures, and cultural changes, can interact with labour relations and gender dynamics at household level driving changes in crop portfolios.

7.2. Beyond simple narratives: implications for climate change resilience in the light of political agroecology

The Bassari case exemplifies how economic factors seem to be more important than climatic ones when driving shifts in crops diversity portfolios, a finding also highlighted in other studies – e.g., Labeyrie et al. (2021b). These results highlight that agrobiodiversity dynamics and climate change resiliences/vulnerabilites need to be framed paying attention to political economic structures and the way farmers engage with these processes.

Interpreting the local shift in crop portfolios through contrasting narratives can lead to very different stories. According to the mainstream development narrative, the fact that Bassari adopted maize, rice, peanut, cotton, and horticulture can be interpreted as a "success story", as this narrative privileges a productivist and technology-driven approach to agricultural development. In the phase of climate change, farmers' access to research-bred varieties of exotic crops with short cycles can facilitate their adaptation to the shortening of the rainy season.

Interpreting the shift to exotic crops through an agrobiodiversity-based narrative, however, would lead to more critical evaluations. The shift to exotic crops entails a decline of Bassari traditional crops, which can reduce the ability of the local agroecosystem to face future (climate) shocks. Sorghum, Bambara groundnut, and fonio grow well in poor soils and drought-prone areas and require low levels of fertilization. Moreover, they possess traits well-adapted to the local environment and culture. Beyond entailing a simplification of the local farming systems and diets, the loss of diversity of Bassari traditional crops, also narrows the pool of locally available genetic diversity, an important asset for climate change adaptation (Altieri et al., 2015; Bardsley et al., 2018).

Linking the argument back to political agroecology and based on the myriad of drivers affecting Bassari farmers' cropping decisions, it becomes clear that both narratives hide weaknesses. The 'mainstream development' model weakens the resilience of farms by making them more dependent on commodity markets and price volatility (de Roest et al., 2018; van der Ploeg, 2021). In this regard, the current trends in the cultivation of Bassari traditional crops could eventually lead to long-term limited (or mal-) adaptive capacity, increasing agroecosystem's vulnerability to climate. However, 'agrobiodiversity-based' approaches risk reinforcing pre-existing power dynamics at household level and locking small-scale farmers in labour intensive crops. In this regard, gender dynamics and labour relations pose barriers to the transformative potential of agrobiodiversity-based practices.

Both 'mainstream development' and 'agrobiodiversity-based' narratives embody opposite visions of what the future of farming could look like in the Bassari territory. Our research provides an example of the new perspectives that emerge from using a political agroecology framework. Paying attention to the intersectional processes and multiple power dimensions that shape agrobiodiversity dynamics can help move beyond dichotomic academic debates into identifying potential pathways to foster resilience in rural agrarian communities in a climate change context.

7.3. Looking at the future: what role will new and old crops and varieties play in south-eastern Senegal?

From an agroecosystem's resilience perspective (Cabell and Oelofse, 2012), the introduction of high-yielding short-cycle varieties of new crops does not necessarily conflict with the maintenance of a diverse portfolio of traditional crops and landraces, as access to a diversity of crop species, varieties, and sources improves smallholder farmers' resilience in the phase of climate change. Our research, however, highlights that policies and interventions rooted on agro-industrial modes of production resulted in a reduction of the local diversity of traditional crops and landraces, despite their potential fit in the predicted drier climate of the region. Therefore, continuing with research and policy narrowly focused on few commercially or nutritionally relevant crops and varieties, neglecting the diversity of crops and landraces that West African farmers have co-developed over generations could have irreversible impacts for traditional crop diversity and agroecosystem's resilience. Inversely, alone, traditional crops and landraces cannot fulfil farmers' contemporary aspirations and needs.

With political and research support, political agroecology can provide locally feasible and economically viable alternatives to agro-industrial modes of production, helping to revitalize traditional crop diversity while improving farmers' access to new seeds in more democratic and horizontal ways, thereby supporting local agroecosystem's resilience. For example, in northern Malawi, research supporting farmers' experimentation and horizontal farmer-to-farmer knowledge sharing helped diversify crop and varietal diversity while improving food security, nutrition, health, and decision-making power of household members (Bezner Kerr et al., 2019; Nyantakyi-Frimpong et al., 2016). In western Guatemala, participatory plant breeding boosted the cultivation of traditional crops and landraces through the development of new (climate adapted) varieties that met farmers' multiple needs (Vernooy et al., 2014). All around the world, farmers' groups and movements are creating alternatives against agro-industrial models of farming and the loss of traditional crop diversity – i.e., through the resistance to genetically modified seeds and the support to farmers' seed systems (Bottazzi and Boillat, 2021; Toledo and Barrera-Bassols, 2017). Crucial to these approaches is considering the complexity of local realities with the inherent contradictions that agrobiodiversity-based methods can pose for gender, labour, and market relations (Bezner Kerr et al., 2019; Marfurt et al., 2023a), as well as the risk that local crops are co-opted by international markets, with unexpected local impacts, as it has been the case of quinoa (Kerssen, 2015; Skarbø, 2015).

In sum, policies or interventions aiming at enhancing Bassari resilience should both, halt (or revere) the decreasing trend of Bassari traditional crops and enable Bassari farmers' access to climate change adapted varieties. To be successful, this process needs to embrace the complexity of social and politically contested processes, paying attention to whose knowledge is considered legitimate, and putting local communities and their ways of knowing at the center. By documenting not only how agrobiodiversity choices are being transformed, but also the traditional ways of managing this diversity and local resistances, our research contributes to describe alternative ways to manage agrobiodiversity within a political agroecology framework. This entails that farmers re-gain sovereignty, knowledge, and control over their own agroecologies, which can only be done by addressing historical agrarian injustices.

We claim for a reconsideration of research priorities in favour of under-researched crops, like fonio and Bambara groundnut, which have an untapped potential in the light of climate change. Alongside these new research priorities, there should be a shift from top-down centralized agrobiodiversity governance systems towards more inclusive processes, participatory actions and shared decision-making (Girard and Frison, 2018; Méndez et al., 2013).

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CRediT authorship contribution statement

Anna Porcuna-Ferrer: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Laura Calvet-Mir:** Conceptualization, Methodology, Validation, Writing - review & editing, Supervision. **Ndeye Fatou Faye:** Conceptualization, Methodology, Validation, Resources, Supervision, Writing - review & editing. **Benjamin Klappoth:** Investigation, Data curation, Methodology, Writing - review & editing. **Victoria Reyes-García:** Conceptualization, Methodology, Validation, Resources, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Vanesse Labeyrie:** Conceptualization, Methodology, Validation, Resources, Writing - review & editing, Supervision.

Declaration of competing interest

The authors declare that there is no conflict of interest.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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