



Indigenous farming transitions, sociocultural hybridity and sustainability in rural Senegal

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ARTICLE INFO

Keywords:

Indigenous
Hybrid systems
Serer
Cultural ecology
Food security
Cultural change

ABSTRACT

For many centuries, the indigenous agricultural and cultural systems of the Serer people of Senegambia ensured soil fertility, crop rotation, tree preservation, mixed farming and herding, yielding one of the highest population densities in the pre-colonial Sahel. In the 20th century, as population grew, soil fertility declined and climate change produced regular droughts, Serer farming systems changed to creatively combine many indigenous techniques with some modern practices. The Serer hybrid farming system that emerged especially after the late 1960s is demonstrably more productive than modern or indigenous techniques practiced in pure form (Faye et al., 2020). Given the productivity of hybrid farming techniques, this article asks: Who adopts them? And under what circumstances? Building on years of participant observation supplemented with a survey of 742 Serer farmers, I tested several competing explanations from neo-liberal, feminist, and cultural ecological approaches to understand why and among whom hybrid farming occurs. Multiple regression analysis shows a strong relationship between cultural syncretism and hybrid farming. Farming techniques are not just a matter of isolated, individual choice, but also work through the social and cultural systems that support agriculture. The more these systems reflect established patterns of mixing cultural elements, borrowing from outside and blending into and transforming Serer tradition, the greater the likelihood that farmers will use hybrid techniques. These findings have implications both for agricultural sustainability and for recognizing the sociocultural embeddedness of seemingly individual choices.

1. Introduction

In Senegal, West Africa (Fig. 1), farming is the mainstay of the economy. About 77.5 % of the population (CIA World Factbook, 2017) are farmers who depend on rain-fed agriculture and cultivate peanuts (*Arachis hypogaea*), cotton (*Gossypium barbadense*), and vegetables as cash crops for export, as well as pearl millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), maize (*Zea mays*), and cowpea (*Vigna unguiculata*) as food crops. Senegal is in the Sahel region, where land degradation (or desertification) has occurred due to both human activities and climatic variations (Kusserow, 2017; Mirzabaev et al., 2019). Today, agriculture in Senegal primarily depends on limited June-to-October rains and faces formidable challenges, such as impoverished soils and land degradation, overgrazing, and frequent desert-like conditions. Climate change has reduced rainfall, and deleterious agricultural practices, such as deforestation for firewood and reduction of vegetative cover exert further negative impacts on farmers' livelihoods. As a farmer from Senegal, having lived up in Tukar from the early 1970s until the 1990s, I have witnessed these challenges firsthand.

Given that African soils are extremely denuded of essential nutrients, scores of scientists and development practitioners suggest that the continent needs significant increases in chemical fertilizers to restore soil fertility and agricultural productivity (Africa Union, 2006; Dumont, 1966; Montpellier Panel, 2014; Sanchez et al., 1996). In contrast, other agricultural experts believe turning to agroecological production systems is the best path to lift African agriculture and improve rural livelihoods (Altieri, 1995; De Schutter, 2010; Rouw and Rajot, 2004). Still others advocate for a hybrid or holistic strategy, such as Integrated Soil Fertility Management (ISFM), to alleviate land degradation in Africa (Bationo et al., 2007; Masse et al., 2004; Powell et al., 2004).

This study builds on prior work (Faye, 2018; Faye et al., 2020), which shows that selective mixing of modern agricultural techniques with the historic agroecological system of the Serer people Senegal's Peanut Basin has proven to boost soil fertility and agricultural productivity. Studies in South America (Peru, Columbia, Ecuador, Bolivia, etc.) have also highlighted the importance of hybrid knowledge systems in understanding the drivers of "agrobiodiversity" – the biological diversity of agriculture and food systems and human-environment interactions

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<https://doi.org/10.1016/j.njas.2020.100338>

Received 14 February 2020; Received in revised form 14 October 2020; Accepted 23 October 2020

Available online 4 November 2020

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(Zimmerer et al., 2019a, 2019b). This Serer hybrid farming system is demonstrably more productive than either modern techniques or maintaining the traditional system alone. This, in turn, raises a new set of questions: What accounts for farmers' likelihood to practice hybrid farming techniques? Under what conditions will they do so? Which general account of social, behavioral, and cultural change in developing societies helps best predict and explain the adoption of hybrid farming?

The more that is known about the contexts, conditions, and motivations behind the adoption of hybrid farming, the more this high-yield, effective form of agriculture can be promoted. Thus, we need to understand the sociology (the behavioral change, patterns of social interaction and culture) of those who practice hybrid farming today to conserve and preserve environmental systems, resources, and landscapes, while also fostering community sustainability and protecting livelihoods.

This study focuses on six villages (Fig. 2) in the Siin region of west-central Senegal: Toukar, Diohin, Ndokh, Pultok-Diohin, Mboyen, and Ngonin. These villages are mainly composed of the Serer ethnolinguistic group, with small minorities of Wolof and Toucouleur people. The total population of these villages was approximately 16,000, at the time of the study in 2016. Individuals were selected (using a non-probability sampling strategy) from six villages, in which 7412 were over 18 years old (because this population group dominates the agricultural workforce). A randomized selection of 10 % (742 informants who own farms) provided a representative sample of variations in agricultural practice, opinions about those practices, underlying values, socioeconomic background, and demographic characteristics of the population. Because men own most fields, I conducted slightly more interviews with men (60 %) than women. My personal experience in Toukar suggests that about 80 % of fields are owned by men. Villages and fields were chosen based on farmers' responses to the following two

questions asked to the farmers: Did you use *toss*? And did you use chemical fertilizer? Based on their responses, four types of farming systems were identified: mostly indigenous, mostly hybrid, mostly modern, and marginal or no-inputs. I constructed my sample of fields to include relatively equal numbers of fields under each type of farming system (Faye, 2018).

The climate is tropical semi-arid with high temperatures and two seasons, wet and dry. The wet season has an unpredictable annual rainfall ranging from 400 to 700 mm (ISRA, 2013). Farmers have integrated sedentary rain-fed farming with livestock (cattle, goats, and sheep) to form a highly complex and strategic land management system. Many have turned to more contemporary and imported farming techniques, with mixed results.

To understand how competing theories fare in determining the adoption of hybrid farming, I used a mixed method approach. I relied on decades of personal experience from growing up in these villages, which I combined with formal, open-ended interviews and participant observation as part of return visits as a researcher. Then, I supplemented these qualitative insights with a quantitative, 742-person survey conducted among randomly selected farmers in six villages (Fig. 2). The survey let me test general patterns and hypotheses, which emerged from the interviews, participant observation, and personal experiences. Together, these tools provide a comprehensive look at the conditions under which farmers take up hybrid techniques.

2. Why is this hybrid farming model important?

Hybrid agriculture emphasizes the selective or moderate use of chemical fertilizers and pesticides, combined with elements of traditional farming systems, such as intercropping, manuring, and rotating fallow systems (*toss*) with crop diversification and sustainable resource management practices. It is the mixing of historic indigenous

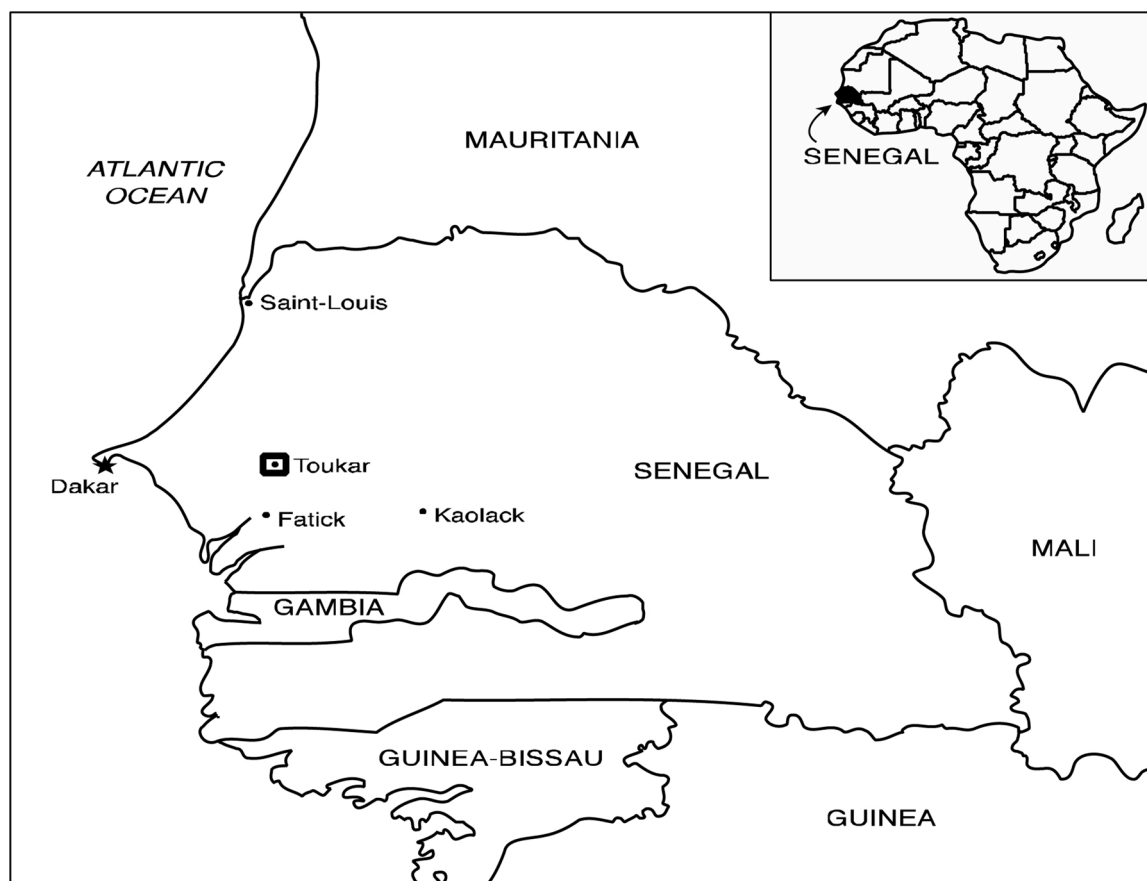


Fig. 1. Map of Senegal, and Senegal in Africa (inset).

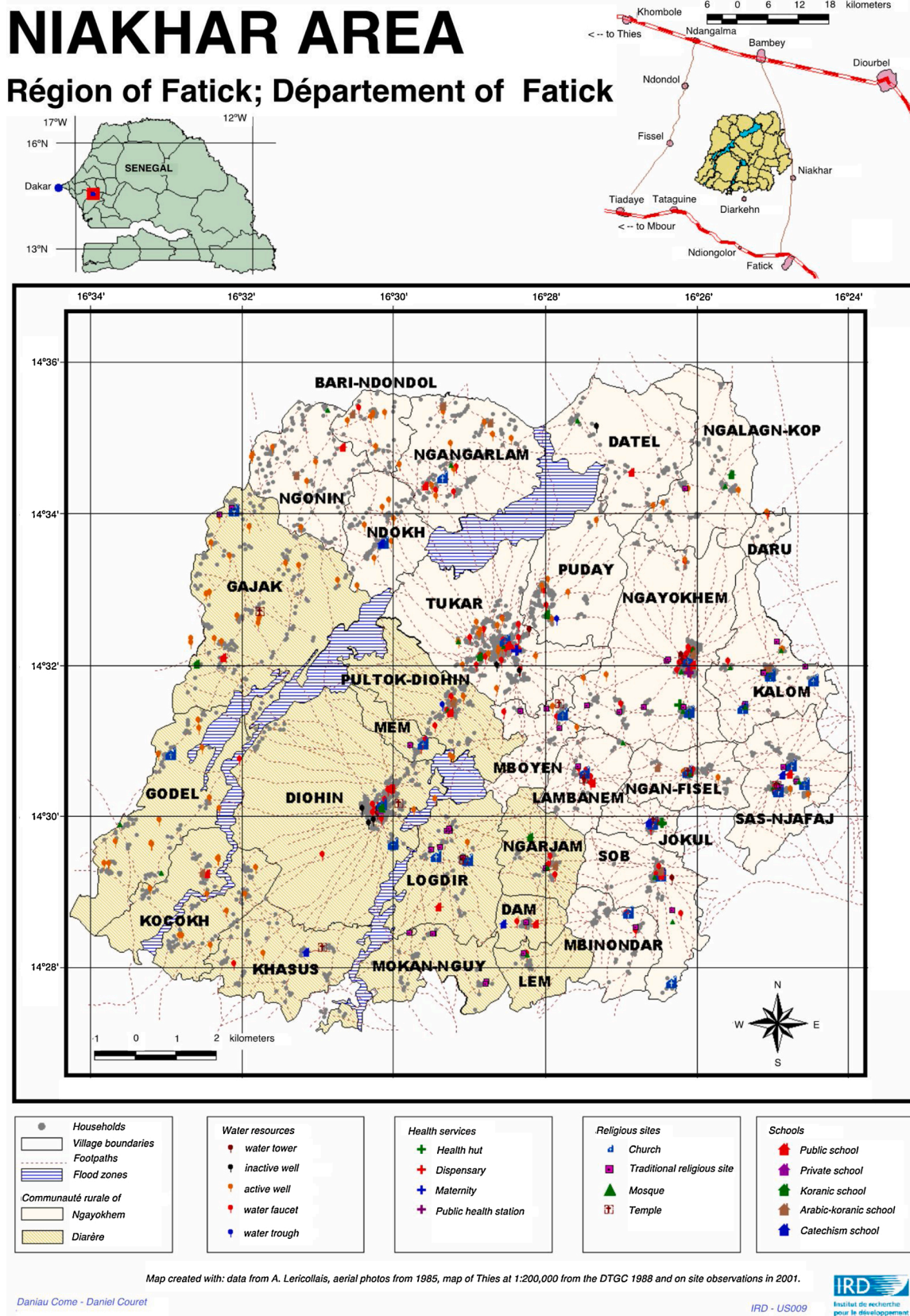


Fig. 2. Map of the study area, including the six villages (Ngonin, Tukar, Ndokh, Diohin, Poultok-Diohin, and Mboyen).

practices—the complex tradition of fallow, crop rotation, and maintenance of nitrogen-fixing trees—with modern techniques, knowledge, and tools imported from the West and elsewhere.

Modern farming focuses on the use of modern agricultural inputs such as chemical fertilizers, high-yielding plant varieties, pesticides (i.e., fungicides to protect peanut seeds from the nematodes and enhance crop yields), and equipment (i.e., small machines for millet and peanut planting and cultivation, fork, hoes for animal traction or plows, and horse-drawn carts) in order to refine Serer historic pastoral strategies. For instance, the introduction of the plow (a medium or heavy cultivator equipped with a lifter) for peanut cultivation in 1963 resulted in Serer farmers scrambling to cultivate more lands.

Indigenous farming refers to mostly precolonial, traditional farming techniques, a historic agroforestry system that is low cost because farmers are not required to purchase external inputs to improve production, but rather, relies on locally available resources. Indigenous farming systems are the complex tradition of fallow (*toss*), crop rotation, animal manure, maintenance of nitrogen-fixing trees to boost soil fertility, enhance crop yields, and maintain livestock production. This is done under authoritative management of the *lamans* and *yal bakh* who ensured their power and legitimacy were paramount through the success of this land management system (Faye, 2018).

Hybrid farming has the highest yields both per plant and per area when compared to traditional and modern farming techniques, as a result of improved soil fertility (Faye et al., 2020). In addition, according to Pretty et al., (2003) “new approaches and technologies involving application of blended modern agroecological science and indigenous knowledge systems spearheaded by thousands of farmers, NGOs, and some government and academic institutions have been shown to enhance food security while conserving natural resources, biodiversity, and soil and water throughout hundreds of rural communities in several regions” (2003, cited in Altieri, 2009, p. 103).” Given the productivity of hybrid farming, its promotion can be expected to contribute to better yields, richer soils, and increased food security as the climate changes. As a first step toward policies that expand this form of farming, it is worth exploring why and how it’s been adopted to date.

3. What contributes to the adoption of hybrid agriculture?

To explore patterns of adoption of hybrid farming, I draw from wider accounts of economic, social, and cultural change in international development. This vast literature ranges from expectations of systemic modernization toward Western standards and the insistence that individual cost-benefit analysis in markets is crucial, to a focus on gender differences and the interaction of culture and ecology (Bassett and Zimmerer, 2003; Brohman, 1995; Butzer, 1989; Leys, 1996; Rocheleau and Edmunds, 1997).

To best understand change in farming systems in a place like Senegal, I draw on three major theories of development and social change: 1) the conventional “Western-style sociocultural modernization theory,” widespread in its neoliberal form (Brohman, 1995; Harvey, 2005, 2007; Gershon, 2011), 2) feminist accounts of social change (Rocheleau and Edmunds, 1997; Akinola, 2018), and 3) cultural ecological approaches (Butzer, 1989; Zimmerer, 2007). For simplicity, I treat modernization and neoliberal theories as a single family of accounts, given their similarity in explaining behavioral change in development outcomes.

A modernization-neoliberal approach suggests that wealth, education, age, community, and family size should correlate well with the adoption of hybrid farming. In this view, if allowed to work freely, individual farmers are entrepreneurs who will make decisions that maximize their outcomes. Farmers who have material *wealth* (greater resource endowment) can afford expensive chemical fertilizers and pesticides that are indispensable for hybrid farming. Education can also be an expected correlate of hybrid farming because it facilitates the ability to read and understand Western tools and techniques, such as the adequate quantity of chemical fertilizers. The theory would also posit

that *younger* people would adopt hybrid farming because they tend to be more exposed to telecommunications, social media, and digital technologies than their elders. As one young farmer from the village of Ngonin stated, “Thanks to my mobile phone, I can reach vendors of seeds, chemical fertilizers, and pesticides in the city when the state’s stock runs out” (Faye, 2018).

Scale also matters within this account: Farmers who live in high-population density locales (i.e., larger rural communities) will be more likely to encounter new ideas and knowledge of hybrid farming because they tend to have better telecommunication, more mobile phone towers, and television sets (CIA World Fact, 2017), all of which facilitate contact with non-local, non-traditional ways of life, including farming¹. Likewise, farmers who have *smaller families* are more likely to be liberal, having broken with cultural norms of high fertility (either as a source of status or social insurance) in favor of material needs.

In contrast, feminist accounts of social change and development posit that one cannot really understand development-related social behaviors without taking into account socially constructed gender differences and the allocation of resources and power on the basis of gender (Doss, 2002; Sultana, 2011; Stock, 2013;). In the villages under study, women do retain some spaces of autonomy in terms of access to and management of certain fields, and they control some forms of wealth. But, by and large, control of land and monetary assets to purchase chemical fertilizer—the resources needed to practice hybrid farming—is confined to men. Male resource control, in this view, would translate into the ability to pick the best fields, take ownership of the manure stockpiled in the family compound, control cash needed to purchase chemical fertilizer, and in the process, a greater likelihood to deploy mixed farming systems.

Finally, from a cultural ecological point of view “All environments and landscapes are co-productions of nature-culture” (Demeritt, 1994, p.167). This perspective posits that social change is a function of how humans, by using appropriate agricultural technologies (material culture), adapt to the environment, and of how socio-cultural behaviors, norms, and rituals interact with and are informed by nature (Butzer, 1989; Zimmerer, 2007; Head, 2010). To situate the cultural-ecological approach in the Serer region, I draw on my own experience and ethnographic research to focus on incorporating new cultural elements.

Adaptation to changing ecological and economic contexts cannot be separated, especially in this region, from the dynamics of cultural change. The last thousand years of ecological and economic change have coincided with the infusion of new religions, values, languages, and practices from across the Sahel, across the Sahara, and across the Mediterranean (e.g., intra-African migration, arrival of Islam, European imperialism) (DeCorse, 1998). For example, Gelwaar kings of Siin and Saluum in precolonial Senegal originated from intermarriages between Mandinka women (of a matrilineal dynasty) from Mali and Serer patrilineal nobility (Sarr, 1987), resulting in today’s bilinear social structure. Similar borrowing occurred with the arrival of Islam in the 11th century and the spread of Christianity with European colonization in the 15th century, both of which were incorporated into local, animist belief systems. People in this region are accustomed to adopting new ideas and lifestyles without abandoning their preexisting cultures. They change, but change within the stability of an incremental, pragmatic syncretism (Berk and Galvan, 2009).

For instance, in the study area, interviews with peasants illustrated how Serer people have been adopting foreign religious beliefs, foreign arts (jewelry, music, crafts), lifestyles, languages, and habits. Some farmers use other cultures and knowledge such as ideas and behaviors of Lebanese, Mauritians, and other merchant groups as a remedy for personal and societal problems, including obtaining credit. Interviews

¹ This holds just as true in the internet era as it did during earlier times, analyzing how earlier technologies, including radios and telephones, were expected to seamlessly diffuse modern social behavior and norms (Deutsch, 1961).

with hybrid farmers reveal that when locals can communicate in merchants' languages, wear their clothes, and practice their religions, it makes them more open to doing business and receiving favors.

A cultural ecological lens on Serer farming systems must include a recognition of ongoing cultural hybridity because individuals' farming decisions are not made in isolation. They reflect how farming households are embedded in changing ecological contexts. They also reflect how these households respond to shifting cultural landscapes, with varying degrees of hybridity in the values that inform farming decisions. Indeed, my ethnographic research suggests a range of such responses, from those who see cultural mixing as normal and itself a kind of local tradition, to those who reject outside cultural influences from Europe, the Islamic world, or other West African ethnic communities and seek a more orthodox, less syncretic, set of organizing values. This is a natural fit with cultural ecology, because the degree of cultural mixing is an embedded adaption to shifting contexts whose scale far exceeds that of individual choice (Zimmerer and de Haan, 2019).

Cultural ecology theory places great emphasis on the role of environmental conditions in transforming human cultures. It provides an ecological framework to understand when and how people engage in pragmatic, syncretic borrowing and blending of cultural practices and values. Thinking as a cultural ecologist, I expect people who are already conversant and comfortable with mixing cultures to also be open to integrating their farming systems. Hybrid farming, in this view, is a practical response to environmental and economic conditions in ways that reflect culture-nature coevolution, historic cultural connections, and cultural hybridization. So, we should expect cultural mixing to correlate with the adoption of hybrid farming.

4. Regression results

To understand which of the three major theoretical frameworks informs Serer's behavioral change and explains the adoption of hybrid farming, I used a stepwise multiple linear regression analysis to correlate the degree to which farmers engage in hybrid farming against a group of independent variables that reflect each of the theories described above.

4.1. Findings

Among the variables that best represent modernization-neoliberalism theory, only wealth and education proved statistically significant (Table 1). Richer and more educated farmers engage in or support hybrid farming, providing partial confirmation of the modernization-neoliberal theorizing. However, age and family size—critical components of a full modernization-neoliberalism account—were not statistically significant. Results indicated an inverse relationship between village size and hybrid farming, suggesting that smaller villages were more likely to use blended techniques, both of which contradict the theory's hypothesis.

The variable that represents a feminist approach, gender, was also not significant. The data showed no correlation between gender and support for hybrid farming ($p = 0.169$, Table 1). This illustrates that men are no more likely than women to adopt these techniques.

To represent cultural ecological theory, I created a cultural mix index², which proved statistically significant. According to Table 1,

² Serer people use a complex cultural belief system (a variety of religious belief systems, such as Catholicism, Islam, and Pangolism), which is fundamental to everyday life. Some farmers exclusively practice Catholicism, Islam, or Pangolism, while others mix them. To produce an accurate and complete picture of this cultural mixing, I developed multiple questions about the degree of cultural mixing and then averaged the answers in a composite index. To measure the degree of cultural mixing in this society, I relied on significant indicators such as mixed-religious beliefs to construct a cultural mix index that describes the extent to which people support and use different cultural belief systems.

cultural mix was the second most significant correlate (cultural mix, $p < 0.001$) with the adoption of hybrid farming. This suggests that Serer farmers who are already involved in practices of cultural hybridity also support hybrid farming as a mechanism to build resilience and adjust to social and environmental challenges, providing support for the cultural ecological perspective.

4.2. Discussion

Wealth correlated positively with hybrid farming. Modernization-neoliberal theory suggested that, when farmers are exposed to commodified economic arrangements and the accumulation of material wealth, they become more individualistic and more willing to adopt or support hybrid farming. Richer farmers also seem to take full advantage of hybrid farming. They appear to make rational calculations to maximize their objectives, such as buying pesticides and chemical fertilizers to protect seeds and increase crop yields. Poor farmers, conversely, do less hybrid farming.

This regression analysis masked the social embeddedness of wealth and farming decisions. Farmers coded as wealthy often have large family obligations or need to maintain high social status through considerable expenditure on social gatherings. With wealth comes socio-cultural obligations. The labor intensiveness of hybrid farming practices (e.g., shifting herds to ensure their manure fertilize fallow lands), allows wealthy, high-status individuals to provide useful tasks for social dependents. The wealthy may be prone to adopt hybrid farming, but not necessarily for the individualistic reasons suggested by the modernization neo-liberal approach. One rich farmer's statements reinforce these ideas, "One who does not embrace modernization is likely to be left behind...They are better, more efficient, quicker, and less tiring...We use both systems because we are looking for all good means to provide the best for our families."

In addition, education correlated with hybrid farming. Modernization-neoliberal theory suggests this is because educated farmers are more open to change, better understand new technologies, and are more likely to integrate them with traditional techniques. An educated female farmer noted that "because she has been helping her relatives utilize new and useful technologies (use chemical fertilizers, pesticides), yields have increased." In modernization-neoliberal thinking, education should correlate with the adoption of modern farming techniques, less so with hybrid farming. As with wealth, if we consider the social meaning of being educated—this human capital asset increases status and draws social dependents, as confirmed by this farmer's statement, "My cousin went to the university in Dakar, and we all rely on him to provide for the whole family. He is our hope." Thus, the educated need to balance techniques that increase productivity (be they modern or traditional) with the traditional need to support dependents. A socially embedded view better explains why one's education level correlates with their likelihood to adopt hybrid farming than the standard modernization-neoliberal account.

It is worth noting that neither age, village size, nor family size correlated with hybrid farming, further demonstrating the limitations of the overly individualistic modernization/neoliberalism account. Given this approach's expectation that development occurs through change across all domains of life, the correlation of only two of five modernization/neoliberal variables undermines the applicability of this perspective.

Feminist theory suggested that gender should correlate with hybrid farming because men control most of the fields and agricultural decision making. I would argue that gender was not a significant variable because male-female dynamics in Serer agrarian systems follow a complex division of household responsibilities. Although men control most fields, decisions and land allocations are other matters of resource control that can be negotiated. Women stated that their husbands—heads of the household (*yal mbind*)—consult with them in family decisions, such as apportioning land to family members and sale of livestock. Thus, looking

Table 1

Regression and mean, max, min, and standard deviation of productions of hybrid farming practices and significance.

	Estimate	Std. Error	t value	Mean	Max	Min	Std	Pr(> t) or p-value
(Intercept)	76.4746	10.3984	7.354					5.14e-13***
Variables that best illustrate Modernization/Neoliberal account								
Wealth	0.2672	0.1049	2.546	13.63	49.45	0.05	7.36	0.011097 *
Education	0.0856	0.0354	2.416	11.19	100(*)	0	21.01	0.015947 *
Age	-0.0374	0.0468	-0.799	48	90	18	15.73	0.424571
Family size	0.1792	0.1072	1.671	15	52	1	7.14	0.095093.
Village size	-6.6109	0.8466	-7.809	2.36	3	1	0.84	2.00e-14 ***
Variables that best illustrate Feminist account								
Gender	-0.2450	0.1779	-1.377	-	456 (M)	286 (F)	3.8	0.168941
Variables that best illustrate Cultural Ecological account								
Cultural Mix Index	0.1233	0.0357	3.455	18.55	72.81	0	19.48	0.000583***

Notes: Significant codes: 0'***' 0.001'***' 0.01'***' 0.05'.' 0.1' ' 1.

Residual standard error: 18.3 on 734 degrees of freedom.

Multiple R-squared: 0.1227, Adjusted R-squared: 0.1144.

F-statistic: 14.67 on 7 and 734 DF, p-value: < 2.2e-16.

(*) the highest level of education is the completion of elementary school.

deeper, it's clear that women have some say in agrarian decisions that operate at the family level, not the individual level differentiated by gender. Women participate considerably in agricultural activities and are thus part of family system dynamics in agricultural decision making (Rocheleau and Edmunds, 1997). These dynamics involve complex negotiations over authority, resources, and access to rural spaces, which cannot be simply reduced to a gender dichotomy operationalized at the individual level.

Cultural mixing emerging as a strong correlate for the adoption of hybrid farming makes sense in three ways. First, it follows a long-standing dynamic of pragmatic, selective adaption of external ideas characteristic of Serer responses to economic and ecological change. The Serer, like others in Senegal, developed an open, tolerant version of Islam, not only based on the teachings of the Islamic prophet, Muhammad (Ps), but also embedded in larger African belief systems that include animism (Pangoolism in Serer), centered on the belief that all parts of the environment are animated, interrelated, and alive. Catholics in this region also blend many aspects of animist ritual and belief into their everyday practices.

Many people in the study region think of this kind of cultural mixing as mutually positive, as evidenced by one farmer's statement: "These mélanges are good for the Western world and good for the development of the Serer people." This comment points to the multifaceted and flexible nature of how many Serer people handle cultural change, matching my own experience³ and the comments of many informants.

As explained earlier, this openness to cultural mixing can also derive from the diversification of strategies and risk aversion. Given the disruption and uncertainty associated with the arrival of new belief systems, the Atlantic slave trade, capitalist incorporation, colonialism and postcolonialism, it makes sense to "hedge one's bets," by adopting multiple belief systems, remaining open to more than one explanation, cosmology, or guide to how to live. Who knows which will persist and prove to be right? Given generations of disruption and uncertainty, risk averse bet-hedging has become a cultural pattern (Scott, 1976; Zimmerer, 1996), applied to many domains of life and taught to children as a value. Those who are more open to cultural mixing in general are thus primed and open to hybrid farming.

³ I grew up in this region and speak Serer Siin. My own positionality helps explain the culture and value of this community that is based on the deep attachment of various cultural systems that support the historic *O'mbaaxSerer* farming of sacredness of trees, ancestral spirits in land, and sense of custodianship of land over many generations.

As this farmer who uses hybrid techniques noted: "We must not base ourselves on traditions and leave modernization, but we also must not modernize everything and leave the past."⁴ Or more directly, in the words of a farmer from the village of Diohin:

"The world is changing and our *cosaan* is changing with it. We (now) associate our *pangools* with other prayers and religious practices, like Islam and Catholic. We're using foreign ideas, knowledge and customs as never before, and this is reflecting on our farming techniques which helps in drought times. ... These changes are also good for us because the rainy season has become shorter and shorter, and the (new) crops can mature even if the rainfall is short and not abundant. ... These changes reduce the labor force and make farming more profitable. We also think that the changes are good because now, we do not spend the whole day in the fields like we used to."

Second, this tendency to hybridize culture amplifies and extends core ideas of cultural ecology. Cultural mixing is essentially a cultural ecology argument (Seeland, 1997), an approach that views human systems (like farming, and the behaviors and cultures that support it) as embedded in changing ecological and socio-economic contexts. Studies of cultural hybridity in indigenous-modern Andean agricultural systems further corroborate this account of cultural mixing (Zimmerer et al. 2020). Cultural ecology underscores that local culture adapts to the local environment the same way local plants and animals adapt to their environments. But this account of Serer farming systems enriches a standard cultural ecological account by highlighting transformation within the cultural side of cultural ecology. Cultural ecologists would do well to attend to the dynamics of cultural syncretism: how much mixing, of what, by whom, with what outcomes. Serer people who are more open to cultural hybridization seem to approach the possibilities of farming system adaptation to ecological change a little differently: They are more willing to adopt the hybrid farming techniques that produce high yields and fertile soils. Similar studies in the Andes have also shown indigenous farmers adopt "improved varieties" while still using diverse crop systems (or agrobiodiversity) to improve their earlier farming practices in the face of agricultural modernization (Zimmerer, 1996, p.7; Zimmerer et al., 2019a, 2019b).

Finally, attention to cultural mixing within a cultural ecological approach underscores the social situatedness (as opposed to individualistic nature) of hybrid farming. Both the modernization-neoliberal and the feminist approaches reduce the "choice" to adopt hybrid farming to the level of the autonomous individual. The methodological

⁴ According to this participant, modernization refers both to Western farming, culture, and values—including Christianity—and Arabic-Islamic values.

individualism unfortunately embedded in the survey tool I used would seem to reinforce this. But a careful look at the pattern of correlation, combined with my own observation and qualitative research, discount such individualistic accounts. A purely individualistic gender binary doesn't correlate with hybrid farming adoption because power relations and decision making in Serer family systems don't follow a simple gender binary; they entail ongoing negotiation and power-sharing patterns that vary by resource. Moreover, the two modernization-neoliberal variables that correlate with the adoption of hybrid farming make much more sense when understood through a lens of social embeddedness, social status, and networks of dependents than when they are interpreted as autonomous actor decisions. Which brings me back to cultural ecology: a variable like one's tendency to mix cultures weaves into the warp of cultural ecology because both share the weft of *situatedness*. Cultural ecology approaches contextualize decision making (like the adoption of hybrid farming) in an interplay of people and their production/livelihood systems with shifting ecological, economic, and cultural contexts. Cultural mixing shows the situated creativity at work when people like Serer farmers carefully and pragmatically rearrange new and old cultural elements, in so doing pre-figuring and modeling similar adaptive steps that go into the adoption of hybrid farming. This response to changing conditions makes no sense if individuals are treated as though they make autonomous choices. They behave based on their relationships with transformed landscapes, disrupted economies, and mixed, recombinant cultures.

5. Conclusion

This study focused on the following questions: What are the patterns of adoption of hybrid farming techniques, and which general accounts of social change best account for these patterns of adoption? Data analysis revealed that the cultural ecological account best explains hybrid farming adoption, especially if we deepen cultural ecology with a focus on cultural hybridization. Serer farmers who are more embedded in longstanding community dynamics of mixing indigenous and modern cultures (belief systems, values, ideas, practices, knowledge, etc.) are more likely to take up mixed farming. The cultural ecology of hybrid farming techniques is nested within one's adaptation to disruptive socio-cultural change and local strategies to manage such disruption through cultural mixing. People in this region are accustomed to adopting new ideas and lifestyles, at least since the 11th century arrival of Islam, without discarding their preexisting cultures.

The implications of cultural ecology's fit are far-reaching. They demonstrate that integrating technical and cultural components of the old farming system with new farming models can generate the most productive and ecologically sound farming techniques. They also underscore how openness to blending indigenous and nonindigenous techniques are indispensable for soil replenishment, crop yield, livelihood resilience, and rural agricultural sustainability.

One could read the positive correlation with wealth and education to suggest that boosting incomes and schooling will increase hybrid farming. But as explained above, these relationships have less to do with the individual emancipatory power of income and knowledge (as Western theorists often like to imagine). They are more a function of the social status and social network impacts of wealth and education, which both facilitate the adoption of modern inputs and necessitate labor-intensive traditional work to maintain expanded circles of dependents. Wealth expansion and educational investment, while desirable, have proven elusive and problematic in Senegal.

Serer society has been and is likely to remain poor (\$998 GDP per capita for Senegal as a whole in 2017, with rural incomes in places like the Serer zone lower).⁵ Widespread and stubborn poverty undermines

⁵ In 2011, 46.7 % of Senegal's population was below the poverty line, and 66 % of rural residents were considered poor (borgenproject.org).

the idea that boosting wealth can expand hybrid farming, the most viable and sustainable agricultural system in the region. If Senegal ever developed its hydrocarbon reserves⁶, and if it had the political leadership to engage in meaningful redistribution of oil-derived wealth (rare in oil producing developing countries) (Karl, 1999), Senegal could use a sovereign wealth fund to boost farmers' personal incomes and expand educational access. Indeed, since its independence Senegal has considered not only enhancing funding for schools, but also educating its people in native tongues—as opposed to the official French language—and adopting a curriculum focused on practical skills. These reforms have proven elusive, in part because any expansion of educational access is expensive and a function of wealth and political will. Perhaps it would be easier to implement these new policies by re-allocating national budgetary resources, which would also be difficult. Although wealth and education are significant predictors of hybrid farming, they are difficult to translate into practical solutions. This leaves cultural mixing as the most meaningful correlate, because it boosts hybrid farming without these costs.

This study makes an important contribution to cultural ecological theory, highlighting context and situatedness by drawing attention to the dynamics of cultural mixing as a social trope (the blending of values, beliefs, ideas, languages, and religions of indigenous and nonindigenous people, derived in part from risk aversion and bet-hedging). Cultural mixing explains how human systems respond to changing ecological contexts, adding attention to meaning and creativity alongside production and material conditions.

As this study shows, hybrid farming involves not just traditional or modern farming practices but embraces local values, beliefs, and culture. Neither tradition nor modernity dominate the practice. Serer farmers who adopt hybrid farming do not fear transgression; they avoid the hegemony of one farming model over the other. They are not reactionary about losing traditional practices or afraid of new techniques. They instead maintain local, effective techniques that ensure viable agricultural production, while avoiding the mistakes of high-input, industrial agriculture with its social and environmental costs. They chart out a compromise between traditional and modern farming techniques, taking the best from both to face adversity.

This study's findings overwhelmingly suggest that farmers who integrate modern practices with historic farming traditions generate a coherent fusion that produce positive implications for sustainability, climate change adaptation, soil replenishment, and crop yield. They strengthen their resilience and livelihoods, update elements of the well-adapted indigenous agroecosystems, and make room for new techniques and tools that make cultural sense to them.

Declaration of Competing Interest

The authors report no declarations of interest.

Acknowledgements

The author would like to thank the farmers of the Siin region for participating in this study, the research assistants at the Institut de Recherche pour le Développement for helping with data collection, and the anonymous reviewers who commented on this manuscript. This work was funded by the Mellon International Dissertation Research Fellowship (2016 IDRF) and the Global Oregon Graduate Research Award from the Global Studies Institute, University of Oregon (2016 GOGRA).

⁶ See Elimane Haby Kane, Oil Wealth in Senegal: For the Many or the Few? Income from recently discovered oil and gas deposits must go toward reducing poverty and precariousness. Research & Commentary, February 15, 2019. <https://inequality.org/research/oil-wealth-senegal/>.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.njas.2020.100338>.

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