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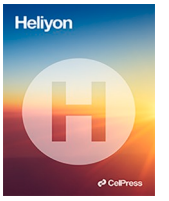

Cooperatives and sustainability: The case of maize producers in the plateaux region of Togo

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ABSTRACT

This study analyzed the influence of the producer's organizational form (individual or cooperative) on the three dimensions (economic, social and environmental) of sustainability in the Plateaux Region of Togo. An innovative approach called Deep Participatory Indicator-Based (DPIB) was used to target the analysis at the producer local level. The environmental sustainability score was above average for individual producers compared to cooperatives. Economic sustainability score is not related to the producer's organization form. Social sustainability was not dependent on the form of organization. The analyses led to participatory planning and actions based on three cooperative principles. Actions based on the seventh cooperative principle – Concern for Community - raise awareness among cooperators producers on the importance of carrying out social works, agro-ecological practices and sustainable agriculture for community members. The actions related to the fifth and sixth cooperative principles – Education, Training & Information and Cooperation among Cooperatives, strengthen the capacities of cooperatives on the need to seek higher quality markets and inform coops in the region about opportunities for combined marketing actions.

1. Introduction

The International Cooperative Alliance (ICA) defines sustainability as the capacity to support, maintain or endure (International Cooperative Alliance, 2013) [1]. Ref. [2] suggests that cooperatives have significant potential to address sustainability issues in the dimensions of economics, environment and society. The very definition of a cooperative suggests that this organizational form should focus their operations toward economic, social and cultural sustainable through joint, democratic actions following the seven cooperative principles [3]. It has been suggested that following the seven coop principles it is possible to attaining different outcomes

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related to sustainability dimensions [4–6].

Literature that examines the African coop environment suggests that cooperatives are not living up to their sustainability potential. Ref. [7] found that cooperatives in South Africa did not address sustainability issues such as poverty, unemployment or inequality due to the lack of understanding of the cooperative principles and minimal support from other cooperatives. In an article by Ref. [8] the cooperative organizational form is shown as a means to intensify agriculture and increase market orientation for the smallholder farm sector, rather than address social, environmental or cultural sustainability. In the Uganda example, Ref. [9] argue that the cooperative revival was strongly influenced by neoliberalism putting aside sustainability issues and joint, democratic engagement in favour of increased productivity for individual producers. reference [9] suggest that the neoliberal influence maintains the status quo of large scale producers focusing on export oriented production.

Examining the Togo case, the Togolese government in its National Development Plan (NDP) 2018–2022, intends to set up a network of small producers to support what are known as agropoles [10]. Agropoles are agricultural growth poles and corridors of land that assist small producers in accessing resources for increased agricultural production. Agropoles are coordinated investments covering in agriculture to support autonomous industrialization of the sector. They usually combine public and private investments and are built around existing, local resources such as food crops, processing infrastructure and research along with a focus on land reform to encourage economic development [11]. The NDP seeks to develop Togo's agricultural sector through these agropoles that encourage the development of large-scale producer cooperatives with an emphasis on building economic capacity over environmental or social sustainability. At present, however, only a small percentage (8%) of Togo's farmers are active members in 2500 small producer coops across Togo. The Togolese Government sees these small producer coops as inefficient in delivering economic sustainability. Through the NDP the Togolese Government seeks to create larger, economically focused cooperatives to bring producers together to focus on export production to grow the Togolese economy [10].

These 2500 small producer cooperatives, however, are seen by local communities as a method to enhance food security, combat climate change, address unemployment along with other actions to address all three dimensions of sustainability, economic, environmental and social. reference [12] outline two cases in Togo that took very different paths for the outcomes of their cooperatives. Near the town of Atakpame' in the Plateaux Region of Togo the authors found that the Lonlon cooperative implemented less costly, local methods to combat climate change while in the village of Okougnohou in the Plateaux Region put up opposition to the Konto cooperative's climate change initiatives in favour of individual self-sufficiency and a focus on poverty reduction. The focus on sustainability measures beyond simply economic sustainability by these small producer cooperatives suggest they adhere to their cooperative identity as outlined by the ICA definition and principles and emphasize a local approach to community development through cooperative action.

Co-operative action in maize production in sub-Saharan Africa, which is conducted mostly on small-scale farms, could produce significant benefits for communities in all three dimensions of sustainability [13]. Economically, agriculture represents the backbone of Togo's economy with 60% of the working population engaged in agricultural production generating 45% of Togo's GDP [14]. The small-scale farmer relies mainly on human labour rather than mechanical "green revolution" approaches that include fertilizer, modified seeds and pesticides enhancing employment opportunities at the community level [15]. Unfortunately this results in low agricultural productivity with the rural population, especially farmers, among the poorest in the country [16]. Poverty makes accessing production resources difficult for small-scale farmers limiting their ability to focus on optimal production and attain high production efficiencies [17,18]. Most small-scale agriculture production in Togo is done on family farms where cash crops (cotton, coffee and cocoa) and food crops (cereals and legumes) are grown together along with animal breeding in a diversified farm system emphasizing food security speaking to the social and environmental dimensions of sustainability rather than the economic [19,20]. The mixed methods of production utilized by small producers compared to large scale "green revolution" production practices decreases the emphasis on export oriented agricultural production in favour of food security, local employment and environmentally friendly production practices.

Togo's small, local agricultural production practices means that any measure of sustainability must incorporate the regional or even village level variances. This project utilized the Deep Participatory Indicator-Based (DPIB) approach [21,22] to turn the focus away from a generalizable (broad-based) approaches to sustainability measurement to a localized, facilitated approach to capture the local variations in agricultural production practices. The DPIB approach is participatory and non-rigid in the choice of sustainability indicators based on the paradigm of SDG 17 – Partnership for the Goals. Utilizing the DPIB approach this research completed a comparative study of the economic, environmental, and social sustainability of farms in the Plateaux Region of Togo isolating whether producers were organized as cooperatives or as individual producers. The objective was to determine if the cooperative organizational form affects the definition and uptake of sustainable production activities. To address the three dimensions of sustainability the research utilizes three separate hypotheses.

1. The economic sustainability of the maize producers in the Plateaux region of Togo is negatively affected by an individual form of organization,
2. The form of organization of the maize producer as a cooperative positively affects the environmental sustainability of the farm within the Togo Plateaux region,
3. The social sustainability score of the maize producing farms in the Togo Plateaux region is negatively affected by an individual organization form.

To discuss these three hypotheses the paper will at first outline the materials and methods utilized in the study presenting the Plateaux Region's environment for context. A discussion on the data collection and analysis process will inform the reader of the novel

DPIB approach which captures local sustainability issues used in this study. The results from the data collection and analysis section will highlight the similarities and differences between the individual and cooperative organizational forms of maize producers. Results will then be presented followed by discussion and conclusion sections for each of the three dimensions of sustainability, economic, environmental and social. These individual discussion and conclusion sections will provide a comparison between the individual producer and cooperative form related to each sustainability dimension in the Plateaux Region of Togo. A final discussion and conclusion will round out the paper to outline the overall findings of our research.

2. Materials and methods

The materials and methods section has been organized to outline the study environment to ground the research in its geographic setting. Following the description of the study environment a descirption of the methods utilized will be presented in a step-by-step manner as outlined in the Deep Participatory Indicator-Based (DPIB) approach. The choice of the DPIB approach for this study was based on the need to localize the measurement of sustainability due to the large proportion of producers that are small-scale and local. A generalizable or broad based approach to sustainability measurement that focuses on green revolution approaches to production does not fit the broader population of Togo's agricultural sector. Nor can a generalizable approach represent the complex agricultural environment created by the small-scale producers of Togo who focus on social and environmental needs as well as economic. The DPIB approach takes the following steps to focus the analysis toward local sustainability, (1) Characterization of target group, (2) Group discussions with stakeholders - survey Development, (3) Survey Implementation, (4) Estimation of sustainability level and (5) Action oriented outcomes.

2.1. Study environment

The study environment covered the prefectures of Haho and Ogou both located centrally in the Plateaux Region of Togo. The centralized nature of Haho and Ogou allowed for efficient of sampling of small-scale producers. The Plateaux Region of Togo is subdivided into 12 prefectures and is bordered to the North by the Central Region, to the South by the Maritime Region, to the East by the Republic of Benin and to the West by the Republic of Ghana. The overall population of the Plateaux Region is just over 1.375 million with an even split of 50.7% women and 49.3% men. The majority, 80.3%, of the Plateaux Region's population resides in rural areas leaving only 19.7% in urban centers such as Atakpame (85,000 pop.), Kpalime (75,000 pop.) and Badou (24,000 pop.). The age distribution for the Plateaux Region's population sees the largest age group in the 0–9 years old group followed closely by 10–19 year olds and then 20–29 year olds indicating a young population [23].

Haho maintains a population of 248,160 based on 2010 Census [21]. Much like the Plateaux Region, Haho's population is evenly split between male and female with only a slightly higher male population percentage, 51.2% and 48.8% respectively [23]. The population of Haho is predominantly rural with 85.9% residing in rural areas [23]. The age distribution of Haho does skew toward a younger population demographic much like the Plateaux Region with the largest population age groups being 0–9, 10–19 and 20–29 listed in order of magnitude [23].

The Ogou prefecture's population base of 196,470 is split between males and females at 51.1% and 48.9% respectively. The Ogou population, unlike Haho's, is not as rural with 64.7% residing in rural areas. The major urban center of Atakpame maintains the 35.3% of Ogou's population that resides in an urban area. The age demographics of Ogou, like the overall Plateaux Region, skew young with the larges age group being 0–9 year olds followed closely by 10–19 and 20–29 year olds [23].

The Haho and Ogou prefectures were chosen from the 12 prefectures in Togo as representative sample sites of the Plateaux Region as Haho represents a predominantly rural area and Ogou a rural area with urban center. Both prefectures are centrally located allowing for efficient sampling of small-scale producers.

2.2. Characterization of target group

The first step in the DPIB approach is a characterization of the target group. The characterization of the target group for this study focused on the decision factors of maize producer to join, or not join, a cooperative. This characterization allows us to conduct a sustainability assessment focused on the producer's organizational form (coop or individual producer). Understanding the basic elements (decision criteria) that make it possible to define two groups under study: 1) producers who chose the individual form and 2) producers who chose the cooperative form.

Producers from both groups were contacted via partner organizations, Gebana and the *Institut de Conseil et D'appui Technique (ICAT) Plateaux*. Both of these organizations have close ties with primary producers in both Haho and Ogou prefectures. Each producer was asked to participate in the research project through an introduction from the two partner organizations.

2.2.1. Analytical framework of the characterization

With the individual participants invited to participate an analytical framework to characterize the participants was developed. This study builds on previous work making use of the following explanatory variables: Age (AGE), gender (SEX), marital status (SM), educational level (NIVSCO), number of household dependents (NPERCH), primary activity by income size (ACTIP), secondary activities by income size (ACTIS), number of years of experience (ExpA), area planted (SUPEMB), amount of maize harvested per ha each year (R), and contact with extension services (SVUL), to explain the maize producer's membership in a cooperative.

The following relationship was established:

MEMCOOP = f (AGE, SEX, SM, NIVSCO, NPERCH, ACTIP, ACTIS, ExpA, SUPEMB, R, SVUL) (0).

Where MEMCOOP = Membership in a cooperative.

Age has a positive influence on the decision to join a cooperative in some literature [24–26] but was not significant in others [27]. In terms of the gender characterization, reference [27] showed a negative influence of gender. Ref. [26] showed that gender had no influence on the decision to belong to a cooperative. Education level has been found to be significant in many studies [26,28,29], as well as farm size and contact with the extension service. Household size, types of activities (primary or secondary), seniority, and yield were rarely considered among the factors determining cooperative membership.

Yield was considered in this research because it is recognized in previous work [29] that smallholder farmers in developing countries are often encouraged to organize into cooperatives primarily to overcome production and marketing constraints. The focus on green revolution approaches to production are captured in the yield characterization of the analytical framework.

2.2.2. Model selection for characterization

The literature offers several models for estimating technology or system adoption rates and their determinants. Linear probability, Tobit, Logit and Probit models are often used. The first model is increasingly discarded because the probability can often exceed 1. The latter two models are the most commonly used to specify the relationships between the probability of choice and the determinants of choice [30,31]. Recent work that is quite similar to the present in terms of the logic of the mathematical relationships between variables has made use of the Probit model to analyze the determinants of farmers' choice to adopt or reject a new rice variety [32]. The Probit model was thus favored over others in this study.

Assuming that farmers make adoption decisions based on a utility maximization objective and assuming that the fundamental utility function, which classifies the preference of the i th farmer, is a function of the evaluation variables - "X"- (e.g., age, gender, farm size, etc.). We have:

$$\begin{cases} U_{i1}(X) = b_1 X_i + e_{i1}, \text{for adoption} \\ U_{i0}(X) = b_0 X_i + e_{i0}, \text{for non} - \text{adoption} \end{cases} \quad (1)$$

Since the utilities are random, the i th farmer will choose the alternative "technology adoption" if and only if:

$$U_{i1} > U_{i0} \quad (2)$$

Thus, for farmer 'i', the probability of adoption is given by:

$$P_i = P(U_{i1} > U_{i0})$$

$$P_i = P(b_1 X_i + e_{i1} > b_0 X_i + e_{i0})$$

$$P_i = P(e_{i0} - e_{i1} < b_1 X_i - b_0 X_i)$$

$$P_i = P(e_i < bX_i)$$

$$P_i = F(X_i)$$

Where F is the cumulative distribution function for e. The type of model will depend on the claim made about F. A Probit model assumes the normal distribution of the data. Thus, for an operator 'i', the probability of technology adoption is given by:

$$P_i = \frac{1}{\sqrt{2\pi}} \oint_{-\infty}^{Z_i} e^{-\frac{Z}{2}} dZ \ (M)$$

Table 1
The explicative variables introduced in the model.

Variables	Description	Modalities	Expected Signs
AGE	Age of the producer	_	+
SEXE	Gender of producer	0 = Female, 1 = Male	+/−
NIVSCO	Operator's level of education	1 = Not Enrolled in School, 2 = Primary, 3 = Middle school, 4 = High school, 5 = University	+
NPERCH	Number of dependents	_	+
ACTIP	Main activity	0 = Other, 1 = Agriculture	+
ACTIS	Secondary activity	0 = Other, 1 = Elevage	+
ExpA	Number of years of farming experience	_	+
SUPEMB	Farm size	_	+
R	Maize yield	_	+
SVUL	Contact with extension service	0 = Non, 1 = Yes	+

(+) = Positive influence; (−) = Negative influence; (±) = Significant without precision.
Source: preliminary analysis of survey data, 2019.

For the Probit model, P_i is the probability that the i th producer adopts the technology. Z_i is a vector of explanatory variables related to the i th maize farmer.

The main objective is to determine the socio-economic factors that motivate the maize farmer to join a cooperative. The dependent variable (Y) for the model is the adoption or non-adoption of the cooperative organization form.

Y takes the value of 0 if the maize farmer is not a member of any cooperative and 1 otherwise.

Model (M) aims to determine the probability of adopting a technology. Since Y can only take two values: 1 when the producer adopts the cooperative organization form and 0 otherwise, it was a binomial Probit.

The following logistic regression equation was used:

$$Y_i = b_0 + b_1 AGE_i + b_2 SEXE_i + b_4 NIVSCO_i + b_5 NPERCH_i + b_6 ACTIP_i + b_7 ACTIS_i + b_8 ExpA_i + b_9 SUPEMB_i + b_{10} R_i + b_{11} SVUL_i + e_i$$

Where Y is the dependent variable, i is the maize producer and e_i is the logistic error of the distribution. The variables introduced into the model are detailed in Table 1. After the collection phase, we realized that there was no variation in the Marital Status (SM) to explain our outcome variable of interest. Thus, to avoid the problem of collinearity, this variable was removed from the model.

2.3. Data collection

Determination of sample size is based on a sample calculation formula, with 95% confidence and 50% maximum variability:

$$n = \frac{N}{1 + N \times e^2}$$

Source [33]:

"N" is the target population size (all maize producers in the Plateaux region of Togo), n is the sample size and e is the level of precision.

Based on the maize producers common characteristics with nearly 65% of Togo's population actively engaged in agricultural production engaged in agricultural production [34] there is a high degree of homogenetiy wihtin the popoulaiton. As a result, the level of precision when calculating the sample was ±8%.

The size of Togo's agricultural population was determined to be 164,766 maize producers according to the 2012 National Agricultural Census [35].

The calculation above provides a minimum sample size of 156 maize producers:

n = 164,766/(1 + 164,766 × (0.08 × 0.08)) = 156 maize producers.

This study was able to connect with 176 maize produceers through two parnter organizations Gebana and the *Institut de Conseil et D'appui Technique (ICAT) Plateaux*. Gebana is an organization with a mission to develop supply chains for primary producers by acting as a global farmers' market that producers can access to sell their products. ICAT-Plateaux provides technical support through consulting services as part of the Republique of Togo's Ministry of Agriculture, Animal and Fisheries Production. Both of these partner organizations provided documentation on primary producers they engage with allow this study to randomly select villages from the two prefectures of Haho and Ogou with active primary producers.

Itchiri and Madjamakou are the two villages from the Ogou prefecture which were randomly selected. From the Haho prefecture the study was able to randomly select three villages, Tsrouvita, Latho and Kloegname. An interviewer was able to conduct a semi-structured survey as well as focus groups in each of the five villages with self-identified maize producers. Key informants within each of the villages were also engaged with the study through interviews to provide context for the study. The details of the participation numbers and rate of survey return can be found in Table 2.

Steps 2 and 3 of the DPIB approach are implemented as follows.

The semi-structured surveys and focus groups were on the most relevant components and indicators of sustainability.

Each focus group consisted of, on average, 7 people per group. In total, 6 focus groups were conducted, 3 per selected prefectures. Research at the prefectural level made it possible to better define the research area, i.e. the sample size, to better specify the data to be

Table 2
Breakdown of respondents by village.

Prefectures	Villages	Number of producers	Percentage per prefecture (%)
		Surveyed	
Haho		**88**	**50.0**
	Kloegname	33	18.8
	Tsrouvita	30	17.0
	Latho	25	14.2
Ogou		**88**	**50.0**
	Itchiri	76	43.2
	Madjamakou	12	6.8
Total		**176**	**100.0**

Source: Survey results, November 2019.

collected and to refine the questionnaire used for the survey.

Key informant interviews were conducted with self-identified maize producer community leaders. Utilization of key informants allowed for more in-depth discussions on the current status of maize production in the villages along with future expectations. The key informant interviews were conducted individually with the researcher keeping detailed notes of the discussion. The interviews were conducted in an informal setting allowing the interviewee to freely express their views on the three dimensions of sustainability.

This study also utilized secondary data on the maize production area and distribution within the Haho and Ogou prefectures. The secondary data collected included government reports from the Agricultural Extension Service of the Republic of Togo's Ministry of Agriculture, Animal and Fisheries Production (part of the ICAT).

2.4. Data analysis

2.4.1. Comprehensive approach

The DPIB approach presented in Fig. 1 was adopted throughout the study.

Upon completion of the semi-structured surveys and focus groups, the selected sustainability indicators were organized as follows:

Economic dimensions - available capital per hectare, yield and the number of hectares of land under production, net income, and technical efficiency. A modification in the net result reported for economic indicators was required compared to reference [36]. The modification was required due to the difference in Togo's minimum guaranteed inter-occupational wage (SMIG) used in our study when compared to reference [36]. Ref [36] used a SMIG of 30,000 FCFA (Franc of the African Financial Community; FCFA 650 ≈ Euro 1). Our study utilized Togo's current (2022) SMIG of 35,000 FCFA.

Environmental dimensions - duration of exploitation, fertilizer dose, herbicide dose, the level of soil erosion, trees density, seed renewal cycle, crop diversity and rotation cycle.

Social dimension - the rate of self-consumption, share of expenditures, level of prosperity, diversity of social organizations and the share of revenues distributed for social causes are used.

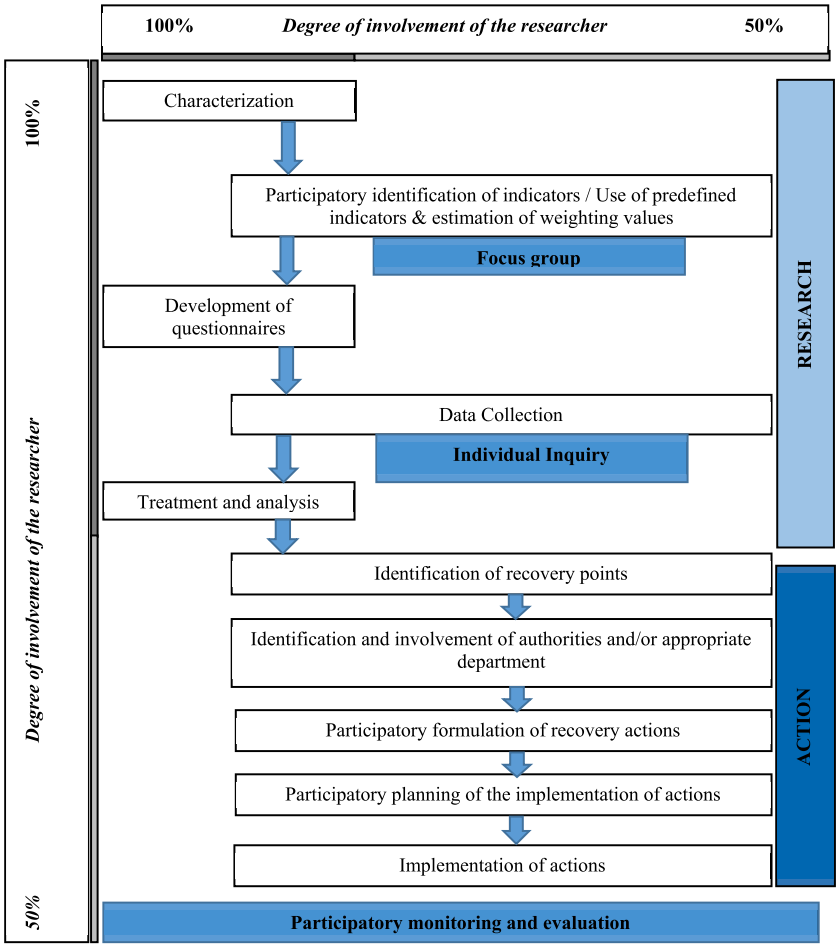

Fig. 1. Deep Participatory Indicator-Based (DPIB) Approach. As one moves to the right and downwards, the degree of involvement of the researcher decreases. *Source: Result of analysis of survey data, 2020; proposed by Ref.* [22].

During the course of the study focus groups in the study areas outlined the need to measure the level of prosperity a two stage process. Stage 1 was a measurement through self-rating by community members of level of prosperity in the classroom. Then Stage 2 was an interview defining the high-value assets owned by the respondent. The high value assets included livestock, arable land, buildings and other luxuries. An average of the two scores from the two stages provided the final prosperity score.

Once the indicators were defined, producers in collaboration with researchers, defined the weight of each indicator in a

Table 3
Meaning of components and indicators.

Components	Indicators	References of related previous works	Meaning provided by stakeholders in Benin (Yegbemey et al., 2014) and confirmed in this study context	Clarifications provided by stakeholders in Plateaux region of Togo
Economic dimension				
Financial autonomy	Available capital (FCFA/ha)	[36,37]	Agriculture needs investments that farmers have to use as capital	–
Corn Productivity	Yield (kg/ha)	[36,38]	As long as the average productivity level is reached before major disturbances, farmers are willing to invest in production over time	The average yield from 2017 to 2019
	Size of land under production	[36,37]	The success of production depends much on farmers' capability to have a consistent budget from the beginning of production	
Profitability	Net income (FCFA)	[36,39–41]	The activity should provide income that will help farmers to take care of their own needs and the needs of their family, including both food and nonfood needs	The minimum wage in Togo is 35,000 FCFA
Efficiency	Technical efficiency (%).	[36,41]	Agricultural production takes place in a context of limited natural resources (land, labor, capital, etc.). Farmers have to be efficient (operate at the optimum level) to not overuse or misuse resources	The level of yield achieved compare to the average yield of the Plateaux region of Togo, taking into account the average production costs
			Environmental dimension	
Soil fertility	Duration of activity (years)	[36]	A prerequisite for sustaining agricultural production because, if soil fertility decreases, the viability of agriculture is in danger	–
	Fertilizer dose (kg/ha)	[36]		
	Pesticide rate (l/ha)	[36,39]		
Land degradation	Level of soil erosion (%).	[36,37,40,41]	Excessive pressure, erosion, organic matter loss, and salinization are the major sources of arable land degradation	–
	Trees density (trees/ha)	[36]	Good practices protecting arable land are crucial for agricultural production over time	–
Seed quality	Yearly seed renewal cycle	[36]	Old seeds are likely to have lower quality. Indeed, these seeds are mainly provided from many rounds of previous harvests whereas their germination potential becomes lower with time	–
Crop rotation	Diversity of Cultures (Culture)	[36,38,40]	Good practices for soil management with numerous positive advantages. A good system of crop rotation enables farmers to not depend too much on external inputs	–
	Rotation cycle (year)	[36]		–
			Social dimension	–
Food safety	Level of self-consumption (kg/member of the household)	[36]	The preliminary role of agriculture is to ensure household food security	–
Contribution to household expenses	The share of income spent (%)	[36]	Besides the household's food needs, there are needs for cash for expenditures on food or nonfood goods (children's schooling, health, etc.) Production should be enough for consumption and sales in order to contribute to household expenditures	–
Quality of life	Level of prosperity	[36,37,41]	Being prosperous in society is fundamental for farmers	–
Social Involvement	Diversity of organizations (%)	[36,37,41]	Farmers use to be involved themselves in social networks Agriculture should allow farmers to participate in the social life of their community	–
	Share of revenue distributed for social causes (%)	[36]		

Source: Field data, 2019.

participatory manner [36].

The indicators were then group in to homogenous components (Table 3). Producers then assessed the importance of each modality of each criterion through a five-point scale (1-very weak, 2-weak, 3-medium, 4-strong, 5-very strong).

When it came to defining the indicators for sustainability it was found that there were no significant differences between focus groups. A medium score of 3 on the 5-point scale when measuring sustainability was determined to define a sustainable production of maize.

Table 3 gives the meanings of indicators and some references of related previous works.

2.4.2. Estimation of values of indicators, components and dimensions

According to the work of reference [36] the scores for each indicator, component and dimension of sustainability will be calculated (aggregated) using the linear aggregation technique of the participatory method. Note, however, that the aggregation method used here is based on equal weighting due to the lack of information on the weight of each indicator and component defined.

Sustainability indicators are identified and presented in Table 4 – Score Scales Used. Based on the raw data collected the indicators are presented by components and scores from the 5-point scale of sustainability.

An identical weighting method for each dimension and component was used involving a linear aggregation technique. The value of a component is equal to the average score related to the indicator. The value (Vc) of a component (C) with i indicators (I) is calculated using the following equation:

$$V_C N^{-1}. \sum_i V_{Ii} \quad (3)$$

N represents the number of indicators within component C. V_{Ii} represents the value (or score) of the i-th indicator. With a maximum value of a component being 5 and the minimum 1, the value of each dimension (V_D) is calculated by the sum of the value of its components. Thus, the maximum value of each dimension is 100 and the minimum is 20. The V_D of a given dimension with j component can be represented by:

$$V_D = 20. J^{-1}. \sum_j V_{Cj} \quad (4)$$

Table 4 shows the rating scales applied to each indicator.

Each of the hypotheses under consideration is accepted when the difference in average sustainability scores (environmental, economic or social) between producers belonging to a cooperative and those not belonging to any cooperative is significant. Otherwise, it is rejected.

Table 4
Score scales used.

Components	Indicators	Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
Economic dimension						
Financial autonomy	Available capital (FCFA/ha)	≤20,000	]20,000–80,000]	]80,000–150,000]	] 150,000–300,000]	>300,000
Corn Productivity	Yield (kg/ha)	≤1000	]1000–2000]	]2000–3000]	]3000–4000]	>4000
Profitability	Net income (FCFA)	≤100,000	] 100,000–300,000]	] 300,000–400,000]	] 400,000–600,000]	>600,000
Efficiency	Technical efficiency (%).	≤10	]10–30]	]30–50]	]50–70]	>70
Environmental dimension						
Soil fertility	Duration of activity (years)	≥16	[12–16 [	[8–12 [	[4–8 [	<4
	Fertilizer dose (kg/ha)	≥400	[300–400 [	[200–300 [	[100–200 [	<100
	Pesticide rate (l/ha)	≥5	[4–5 [	[3–4 [	[2–3 [	<2
Land degradation	Level of soil erosion (%).	≥20	[15–20 [	[10–15 [	[5–10 [	<5
	Trees density (trees/ha)	≤4	]4–8]	]8–12]	]12–16]	>16
Seed quality	Yearly seed renewal cycle	≥4	[3–4 [	[2–3 [	[1–2 [	<1
Crop rotation	Diversity of Cultures (Culture)	≤2	]2–3]	]3–4]	]4–5]	>5
	Rotation cycle (year)	≤1	]1–2]	]2–3]	]3–4]	>4
Social dimension						
Food safety	Level of self-consumption (kg/ member of the household)	≤200	]200–400]	]400–600]	]600–800]	>800
Contribution to household expenses	The share of income spent (%)	≤10	]10–30]	]30–50]	]50–70]	>70
Quality of life	Level of prosperity	1	2	3	4	5
Social Involvement	Diversity of organizations (%)	≤10	]10–20]	]20–30]	]30–40]	>40
	Output share for social networks in %.	≤5	]5–10]	]10–15]	]15–20]	> 20

Source: Field data, 2019. Used in Ref. [21].

3. Results

3.1. Assessment of environmental sustainability

Step 4 of the DPIB approach is the estimation of the sustainability levels for the economic, environmental and social dimensions of sustainability which will be presented in the results section.

3.1.1. Descriptive statistics on environmental sustainability

Table 5 presents the descriptive statistics which show that the maize cultivation in the Plateaux Region of Togo was environmentally sustainable (DurEnv = **62.47** ± 8.74). The high environmental sustainability score was driven by the maize producer's respect for the environment through the use of quality seeds providing a score of 3.31 ± 1.77 along with use of crop rotation producing a score of 3.81 ± 1.3. Crop rotation cycles produce the highest score of all indicators within the dimension of environmental sustainability with a score of 4.03 ± 1.56. The environmental sustainability is graphically represented in Fig. 2 that shows a radar's attraction to the crop rotation and seed quality scores.

3.1.2. Effects of organization form on environmental sustainability

The organizational form taken by maize producers of the Plateaux Region, as seen in Table 6, had a significant effect on environmental sustainabiltity ($p < 0.05$). Cooperatives showed a lower environmental sustainability score compared to individually organized producers. Measurements such as farm duration scored better when producers organized as individual producers ($p < 0.01$). Pesticide dose and soil erosion levels scored higher when producers formed as non-cooperatives ($p < 0.05$ and $p < 0.01$). It was only in the seed renewal cycle score where producers functioning in a cooperative form scored better than non-cooperative organizational forms (3.776 versus 2.960 with $p < 0.01$).

3.2. Assessment of economic sustainability

3.2.1. Descriptive statistics on economic sustainability

Table 7 shows that maize cultivation in the Plateaux Region of Togo was economically sustainable (DurEco = 71.90 ± 16.07). This economic sustainability, which is much higher than the average score (50), is supported, in order of importance, by the technical efficiency of producers (score = **4.39)**, maize productivity (score = **3.72)** and the financial autonomy acquired (score = **3.51**). A graphical representation of the three main components of economic sustainability can be seen in Fig. 3. These three components form the basis of the economic sustainability of maize producers in the Plateaux Region.

3.2.2. Effects of organization form on economic sustainability

The way maize producers are organized had no effect on economic sustainability as seen in Table 8. A significant effect ($P < 0.05$) was observed on the "available capital" indicator with cooperatives scoring higher than non-cooperative organizational forms (3.67 vs. 3.39, respectively).

3.3. Assessment of social sustainability

3.3.1. Descriptive statistics on social sustainability

Cultivation of maize on the Plateaux Region of Togo was found to be socially unsustainable (DurSoc = 40.66 ± 9.49) (see Table 9). Social involvement scored 1.05 out of the 5-point scale and food security scored 1.9. These two components of social sustainability pulled down the overall score for social sustainability in the region. A radar depiction of social sustainability seen in Fig. 4 shows centripetal image driven by the social involvement and food security scores. There is a slight contribution toward sustainability by the household expenditure score (3.15 out of 5) and the quality of life sore (3.00 out of 5).

Table 5
Descriptive statistics on the environmental sustainability of maize producers in the Plateaux Region in Togo.

Components (C)	Indicators (I)	Average Score	Std. Dev.
Soil fertility (C1 = 2,890,152)	Duration of operation (years)	3.02	1.46
	Fertilizer dose (kg/ha)	2.90	0.88
	Pesticide rate (l/ha)	2.73	1.62
Land degradation (C2 = 2,6,960,225)	Level of soil erosion (%).	3.13	0.66
	Tree density (trees/ha)	2.27	1.22
Seed quality (C3 = 3.3125)	Yearly seed renewal cycle	3.31	1.77
Rotation (C4 = 3,806,818)	Diversity of cultures (Culture)	3.58	1.03
	Rotation cycle (year)	4.03	1.56
Dimension			
Environmental sustainability (DurEnv)		**DurEnv = 62.47**	8.74
With: $V_C = N^{-1}.\sum_i V_{Ii}$ & $V_D = 20.J^{-1}.\sum_j V_{Cj}$			

Source: Result of analysis of survey data, 2020. Used in Ref. [21].

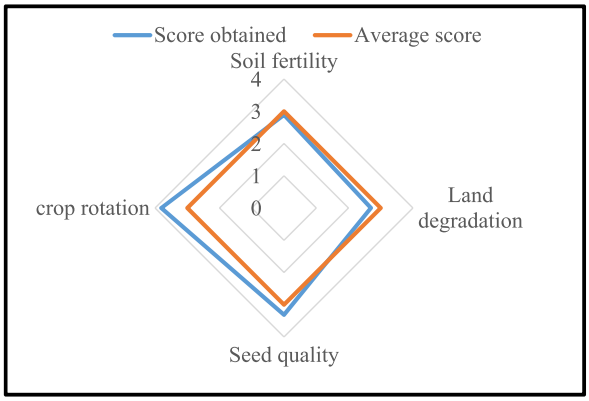

Fig. 2. Scores of the components of environmental sustainability of maize producers in the Togolese Plateaux Region. The red line shows the average threshold of environmental sustainability. The blue line represents the current level. If maize farming is environmentally sustainable as in this case, the blue line is expected to be on the red line or above it. Otherwise, maize farming in Togolese Plateaux Region is not environmentally sustainable. *Source: Result of analysis of survey data, 2020. Used in Ref.* [21]

Table 6
Results of the estimation of the effect of the organization form of the maize producer in the Plateaux region of Togo on environmental sustainability.

Indicators	Non-cooperators	Co-operators	Pr (|T|>|t|)
Duration of operation (years)	3.360	2.592	0.0005***
Fertilizer dose (kg/ha)	2.970	2.829	0.2918
Pesticide rate (l/ha)	2.960	2.434	0.0324**
Level of soil erosion (%).	3.350	2.829	0.0000***
Tree density (trees/ha)	2.210	2.342	0.4783
Yearly seed renewal cycle	2.960	3.776	0.0022***
Diversity of Cultures (Culture)	3.540	3.632	0.5618
Rotation cycle (year)	4.170	3.855	0.1846
Dimension			
Environmental Sustainability	63.8	60.72	0.0203**

***p < 0.01; **p < 0.05; *p < 0.1.
Source: Result of analysis of survey data, 2020. Used in Ref. [21].

Table 7
Descriptive statistics on the economic sustainability of maize producers in the Plateaux Region of Togo.

Components (C)	Indicators (I)	Average Score	Std. Dev.
Financial autonomy (C1 = 3.511364)	Capital available per hectare (Fcfa/ha)	3.51	0.83
Corn Productivity (C2 = 3.715909)	Yield (kg/ha)	3.72	1.19
Profitability (C3 = 2.767045)	Net income (Fcfa)	2.77	1.46
Efficiency (C4 = 4.386364)	Technical efficiency (%)	4.39	0.60
Dimension			
Economic sustainability (DurEco)		DurEco = 71.90	16.07
WITH: $V_C = N^{-1}.\sum_i V_{Ii}$ & $V_D = 20.J^{-1}.\sum_j V_{Cj}$			

Source: Result of analysis of survey data, 2020. Used in Ref. [21].

3.3.2. Effects of the organization form on social sustainability

The farmer's organizational form had no significant effect on social sustainability (Table 10). Nevertheless, a significant effect (P < 0.01) was observed on the level of prosperity. Producers organized in cooperatives had a higher prosperity level score (score = 3.41) than those not belonging to any cooperative (score = 2.7).

As well as other variables, experience in maize farming and educational level had a positive influence on the producer's decision to join a cooperative (Table 11).

4. Discussion

4.1. Discussion of environmental sustainability outcomes

The results highlight the scores (dimension, components and indicators scores) of environmental sustainability of maize production

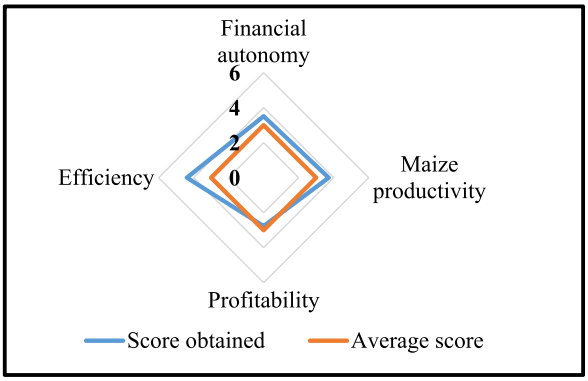

Fig. 3. Scores of the components of the economic sustainability of maize producers in the Togolese Plateaux Region. The red line shows the average threshold of economic sustainability. The blue line represents the current. If maize farming is economically sustainable as in this case, the blue line is expected to be above or on the red line. Otherwise maize farming in Togolese Plateaux Region is not economically sustainable. *Source: Result of analysis of survey data, 2020. Used in Ref.* [21]

Table 8
Results of the estimation of the effect of the organization form of the maize producer in the Plateaux Region of Togo on economic sustainability.

Indicators	No Cooperators	Co-operators	Pr (|T|>|t|)
Available Capital (FCFA/ha)	3.39	3.67	**0.0265****
Yield (kg/ha)	3.71	3.72	0.9403
Net Income (FCFA)	2.65	2.92	0.2237
Technical Efficiency (%).	4.37	4.41	0.6811
Dimension			
Economic Sustainability	70.6	73.62	0.2183

***P < 0.01; **P < 0.05; *P < 0.1.
Source: Result of analysis of survey data, 2020. Used in Ref. [21].

Table 9
Descriptive statistics on the social sustainability of maize producers in the Plateaux Region of Togo.

Components	Indicators	Average Score	Std. Dev.
Food safety (C1 = 1.903409)	Level of self-consumption (kg/Household Member)	1.90	1.06
Contribution to household expenses (C2 = 3.153409)	Share of Income Spent (%)	3.15	1.46
Quality of life (C3 = 3.005682)	Classroom Prosperity Level	3.01	1.54
Social Involvement (C4 = 1,051,136)	Diversity of Organizations (%)	1	0
	Percentage of Revenue Distributed for Social Causes	1.10	0.48
Dimension			
(DurSoc)	Social Sustainability **DurSoc = 40.66**		9.49
WITH: $V_C = N^{-1}.\sum_i V_{fi}$ & $V_D = 20.J^{-1}.\sum_j V_{Cj}$			

Source: Result of analysis of survey data, 2020. Used in Ref. [21].

in the Plateaux Region of Togo related to the choice of form, individual producers or cooperative. Similarly, the results verify the plausible link between the producer's organization form and the sustainability scores (environmental, economic and social). For example, the environmental sustainability score of maize production in the Plateaux region of Togo was above average representing a focus on environmental production practices across all producer groups. However, this environmental score was better for individual producers. This result is in line with that highlighted by Ref. [42] on coffee farmers in Ethiopia showing that farmers' environmental performance is negatively associated with membership in a cooperative. Like Ethiopian coffee farmers, individual maize producers may consider themselves as environmental stewards for their own property unlike group or co-operative producers where ownership is ambiguous [42]. This environmental focus could relate to the individual's connection to their land as a result of their sense of ownership of the land and their years of farming experience on the land.

Producer's farming experience has a significant effect on decision to belong to a cooperative (as shown in Table 11). The more experience a producer has on the land the more likely they are to choose the cooperative organizational form. The cooperative organizational form, however, focuses less on environmental stewardship and more on economic outputs. Within a cooperative form a producer has easy access to credit and therefore has enough resources at the beginning of the season to obtain chemical inputs that are favourable to yield but destructive to the environment. Within a group the producer saves through increased purchasing power, but at

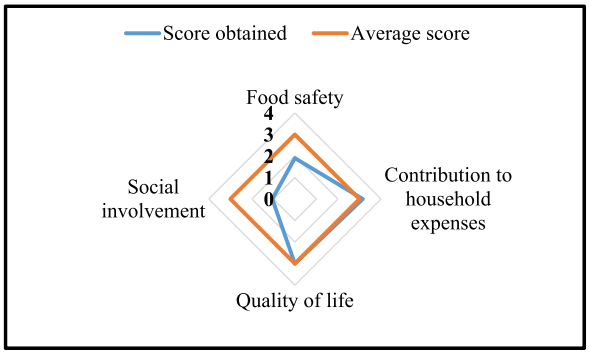

Fig. 4. Scores of the components of social sustainability of maize producers in the Togolese Plateaux Region. The red line shows the average threshold of social sustainability. The blue line represents the current level. If maize farming is socially sustainable, the blue line is expected to be above or on the red line. Otherwise as in the present case, maize farming in Plateaux Region of Togo is not socially sustainable. *Source: Result of analysis of survey data, 2020. Used in Ref.* [21]

Table 10
Results of the estimation of the effect of the organization form of the maize producer in the Plateaux Region of Togo on social sustainability.

Indicators	No Cooperators	Co-operators	Pr (|T|>|t|)
Level of self-consumption (kg/Household Member)	1.94	1.86	0.6015
Share Of Income Spent (%)	3.21	3.08	0.5567
Diversity of Organizations (%)	1.00	1.00	.
Classroom Prosperity Level	2.70	3.41	**0.0024*****
Percentage of Revenue Distributed for Social Causes	1.10	1.11	0.9427
Dimension			
Social Sustainability	39.8	41.78	0.1693

***P < 0.01; **P < 0.05; *P < 0.1.
Source: Result of analysis of survey data, 2020. Used in Ref. [21].

the cost of environmental sustainability of their land.

The results of this study also show that extension agents do not orient their exchanges with producers in Togo's Plateaux region towards agro-ecological requirements. As the fifth cooperative principle indicates, cooperators need to be trained, informed and educated in the cooperative model not simply on green revolution production practices if they wish to produce in an environmentally sustainable way. The agro-ecological requirements that should be systematically disseminated are not part of the educational focus of extension agents. The NDP produced by the Togolese Government is following the traditional agricultural approach toward export markets for economic growth at the expense of environmental sustainability.

4.2. Conclusion – environmental sustainabilty

The analyses show a significant difference ($p < 0.05$) in environmental sustainability scores between individual and cooperative maize producers. The availability of economic resources accessed through cooperative action allows for environmentally unsustainable production practices through the use of fertilizer, pesticides and herbicides. It is therefore necessary to emphasize sustainable agro-ecological education within maize producers' cooperatives in the Plateaux Region of Togo. If possible, an environmental commitment should precede the granting of any credit or subsidy to producers at the beginning of the season to avoid the adoption of environmentally unfriendly production practices.

Following the DPIB approach, a focus group was organized with producers and extension agents to formulate the actions to be carried out in view of the results of environmental sustainability in relation to the organization form (see Fig. 5).

4.3. Discussion of economic sustainability outcomes

The results show the scores of economic sustainability and verify a link between the organizational form and the economic sustainability score. This link, as discussed in the environmentally sustainability section 4.1 and 4.2, shows a clear relationship between economic drivers for sustainability and environmental outcomes as producers seek yield over environmental sustainability.

The results show that the economic sustainability score of maize producers in the Plateaux region of Togo is above average, however, the score is not related to the way maize producers are organized either individually or through cooperatives. These results differ from the findings of Sultana, Ahmed, and Shiratake (2020) that show cooperative members enjoyed more economic benefits than non-member farmers [43]. Our results do show that capital access for a cooperative producer (score = 3.67) is higher than that of a producer who organizes individually (score = 3.39). This significant difference can be explained by the fact that access to credit is

Table 11
Model for the determinants of cooperative membership in the plateau region of Togo.

VARIABLES		Probit (OR)	Marginal effect (dF/dx)	*P*-value
		(1)	(2)	
		MEMCOOP	MEMCOOP	
AGE	Years	0.00112	0.000412	0.9274
		(0.0122)	(0.00451)	
SEXE	0, Female	−0.273	−0.102	0.3684
	1, Male	(0.303)	(0.112)	
NIVSCO	1, Out of school	**0.302**** (0.142)	**0.111**** (0.0526)	0.0333
	2, Primary			
	3, College			
	4, High School			
	5, Academic			
NPERCH	People	**−0.0574***	**−0.0212***	0.0788
		(0.0327)	(0.0121)	
ACTIP	0, Other	−0.607	−0.237	0.6736
	1, Agriculture	(1.442)	(0.563)	
ACTIS	0, Other	0.231	0.0830	0.4787
	1, Breeding	(0.326)	(0.113)	
EXPAM	Years	**0.0283****	**0.0104****	0.0442
		(0.0141)	(0.00526)	
SUPEMBM	Hectares	**0.0844*****	**0.0311*****	0.0009
		(0.0253)	(0.00897)	
R	kg/ha	**0.636****	**0.235****	0.0264
		(0.286)	(0.104)	
SVUL	0, No	**2.463***** (0.328)	**0.721***** (0.0545)	0.0000
	1, Yes			
Constant		−2.688* (1.573)		
Observations		176	176	
Pseudo R2		0.485		
Wald chi2		77.83		
Prob > chi2		0.00000		
Equation (A binomial probit estimated to explain the maize farmer's membership in a cooperative in the plateau region of Togo.) Area under ROC curve = 0.9179			$Y_i = b_0 + b_1 AGE_i + b_2 SEXE_i + b_4 NIVSCO_i + b_5 NPERCH_i + b_6 ACTIP_i + b_7 ACTIS_i + b_8 ExpA_i + b_9 SUPEMB_i + b_{10} R_i + b_{11} SVUL_i + e_i$	

AGE = age; SEX = sex; NIVSCO = educational level; NPERCH = household size; ACTIP = main activity according to the importance of income; ACTIS = secondary activities according to the importance of income; EXPAM = number of years of experience in maize production; SUPEMBM = the area of land used for maize; R = the yield of maize; SVUL = the contact with technical extension services.
Using a law of $\chi 2$ with 17° of freedom, we obtain chi2 (10) = 77.83 with a p-value of 0.0000. At a 1% risk, we can reject the hypothesis of the simultaneous nullity of the coefficients. The model is globally significant.
The values in bracket are the robust standard errors. ***p < 0.01; **p < 0.05; *p < 0.1.
Source: Result of analysis of survey data, 2020. Used in Ref. [21].

easier for cooperatives and affects the production practices of producers based on organizational affiliation.

Net income remains the only indicator with a below-average economic sustainability score within the region. The below average income focuses producers on the profitability component of economic sustainability. Unfortunately, producers are less informed, trained and educated on marketing techniques to improve income than they are on chemical input production practices that require cash outflows. Producers often limited themselves to the intermediate grain traders who come with offers to purchase. Producers are thus market limited where price debates are dominated by an intermediate trader and yield is the primary method used to improve income levels.

Education offered by extension agents is not orient toward higher value market trading i.e. organic production with higher price points or value added processing. This shortcoming in marketing and environmental production education should be mitigated by the cooperative organizational form, given the fifth principle involving training, information and education, however this does not appear to the case as extension education focuses the cooperatives toward high yield production practices.

4.4. Conclusion – economic sustainability

Being part of a cooperative or working individually did not detract from a farm's economic sustainability but changed decisions on production practices toward increased yields and away from environmentally sustainable production practices.

Education, information and training of producers on techniques for optimizing profits, e.g. organic production practices, product marketing, decrease input production practices, must be emphasized. Within the maize producers' cooperatives, there is also a need to raise awareness of inter-cooperative cooperation to access more diversified, profitable markets. Focusing on high yield production practices will result in lower crop prices for individual farms and a reliance on environmentally unsustainable production practices. Cooperation among cooperatives, the sixth co-operative principle, provides for the marketing of higher price point outputs steering

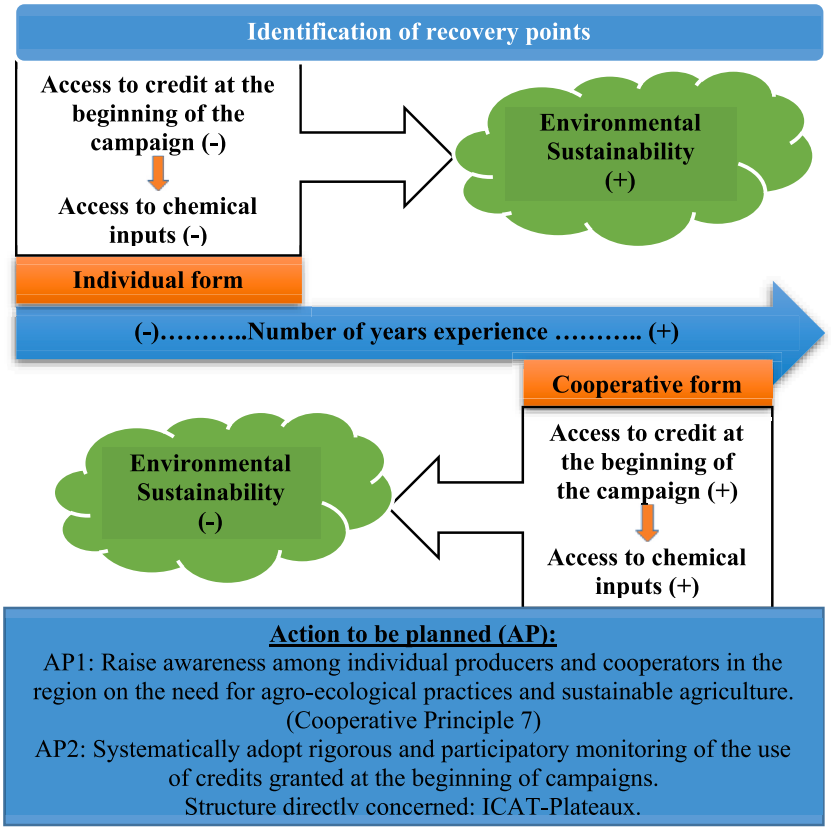

Fig. 5. Participative redress of environmental sustainability. Source: Result of analysis of survey data, 2020.

producers away from poor environmental production practices while addressing their need for higher incomes.

In line with the logic of the DPIB approach, a focus group was organized with producers and extension agents to formulate the actions to be carried out in view of the results of economic sustainability in relation to the organization form. Fig. 6 shows the situation schematically as DPIB seeks to address the issue of low income for maize producers.

4.5. Discussion of social sustainability outcomes

The social sustainability score of maize producers in the Plateaux Region of Togo is below average. However, the score does not depend on the form of organization (individual or cooperative) of the maize producer. The difference is significant when looking at the level of prosperity in the classroom, which represents the quality of life of the maize producer according to participants in the study. The quality of life score of the producer who is a member of a cooperative (C3 = 3.41) is higher than that of the producer who organizes individually (C3 = 2.70). This significant difference is associated with a few variables, i.e., the school level of the producer, the maize production area and the yield.

The key variable of school level of the producer is conducive to good information management around the functions of supply, production and disposal. The results of references [26,28,29]concluded that education provides positive incentives for rural people to join cooperatives as it increases awareness and understanding of the model. Thus, when the producer's ability to understand information is high, he/she better grasps the opportunities in his environment. It then becomes a question of what curriculum is being taught within the schools that encourages high yield, environmentally unsustainable production practices. The Western approach to production practices focus on higher yields per acre and encourages the development of large producers that utilize chemical inputs at the expense of environmental sustainability. Large producers also supplant small, family farms decreasing the social sustainability of the local community.

Access to additional maize production area [25,26] and yield values [29], have a positive effect on the probability of rural people deciding to join a cooperative. Cooperative producers have more land capital for greater production. The sale of this level of production is facilitated by the cooperative organization form and the more the farmer can produce the higher their income level. As a result, the farmer focuses on yield rather than environmental or social sustainability. This represents the "go big or go home approach to production currently used in developed nations that is leading to rural out-migration and lose of the family farm that provides for family food security.

Food security and social involvement are the other main components that have driven the social sustainability downwards. Indeed,

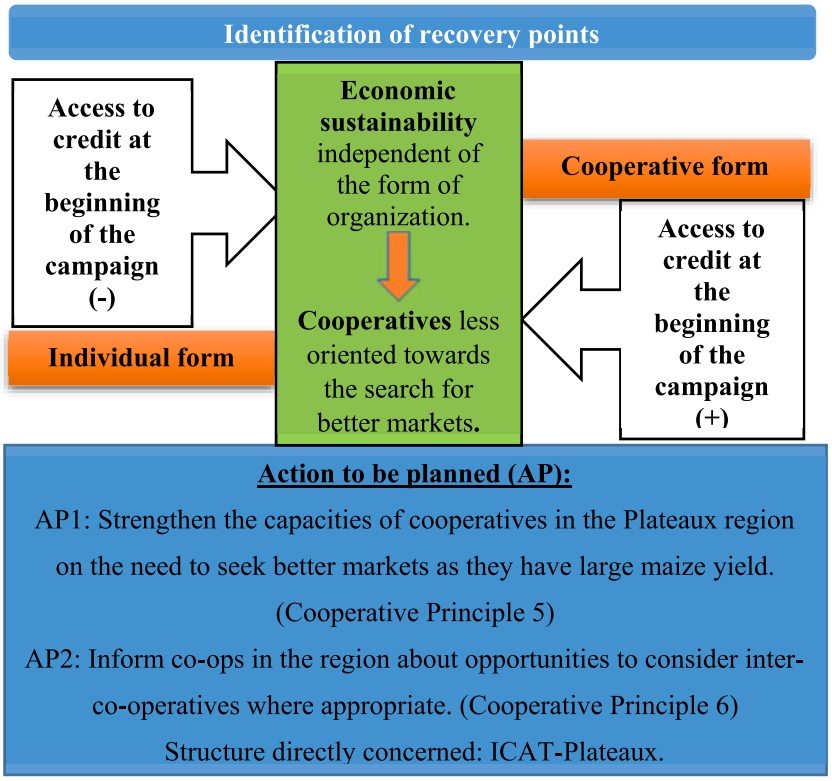

Fig. 6. Participatory adjustment of economic sustainability. Source: Result of analysis of survey data, 2020.

the scores of these components have remained very low both at the level of cooperatives and individual producers. Through the seventh cooperative principle of concern for community, cooperatives are encouraged to work for their communities, but this principle is far from being applied in cooperatives in the Plateaux region of Togo. Cooperatives are focused on yield for higher income which overwhelms social and environmental concerns.

4.6. Conclusion – social sustainability

Overall, the analyses revealed that the difference in social sustainability scores between individual maize producers and those in cooperatives is not significant. Farmers appear to be struggling with social indicators such as food security, social involvement and education attainment regardless of organizational form. It is therefore necessary to increase awareness of the fifth and sixth cooperative principle (5th Education, Information and Training; 6th Cooperation amongst Cooperatives) to encourage social development through education and cooperative social action. Educational attainment would inform producers of the various opportunities to produce, market and manage their incomes the value chain development rather than relying on inputs for improve yields. Cooperation among cooperatives would help improve the social involvement of cooperative member maize producers through collective action at the local and global levels. Cooperative members could work locally to address large community issues such as food security while utilizing surplus for export markets.

Following the DPIB approach, a focus group was organized with producers and extension agents to formulate the actions to be carried out in view of the results of economic sustainability in relation to the organization form. Fig. 7 shows the situation schematically.

5. General conclusion

Comparing individual and cooperative organization forms, this study's aim was to answer the question - How do maize producer cooperatives in the Plateaux Region of Togo contribute to sustainability? The individual production practices appear to be focused on sustainable production to ensure on-going, i.e. future, production for the next generation farmers, rather than immediate income improvements. The cooperative form appears to focus production practices on increasing yield through environmentally unsustainable production practices to access export markets.

Production of maize in Togo is economically sustainable, but not dependent on the producer's organizational form. Even with the cooperative focus on increased yield compared to the individual's focus on decreased inputs to improve income levels, the two forms are comparable when it comes to economic sustainability. The need for education on the negative effects of chemical inputs compared

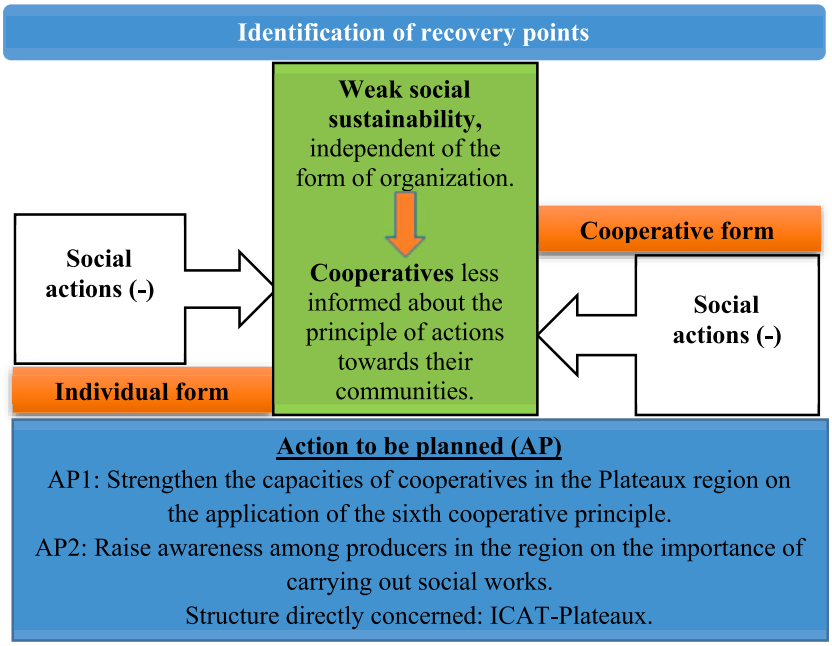

Fig. 7. Participatory redress of social sustainability. Source: Result of analysis of survey data, 2020.

to added value processing should be considered as a method to improve environmental and economic sustainability.

In social terms, the Plateaux region's scores is below average with a need to address food security, social involvement and education attainment. The cooperative principle of Education, Training and Information (Cooperative Principle 5) is a clear call to action to inform cooperative members of social issues. The educational actions by co-operatives, however, have been and continue to be focused on improving production yields (economic dimensions of sustainability) and not social concerns such as food insecurity, poverty or other community development indicators. Engaging in cooperation among cooperatives could also assist in improving the regions social inclusion issues through coordinated action to involve stakeholders in the collective management of maize production in the region, but again focused action on increased income rather than social improvement was noted.

These results lead to the conclusion that even if producers are members of cooperatives, the current application, or lack thereof, of the cooperative principles compromises the expected added value of the cooperative form. The Western style approach to production practices emphasized by the cooperative form will lead to similar economic, environmental and social issues currently being faced by farmers in the West such as producing outputs below costs, desertification of lands and loss of rural communities due to out-migration. Producers in the Plateaux Region of Togo need to define their own production practices to assist in the development economically, socially and environmentally sustainable production that address issues such as food insecurity, unemployment and education levels.

In view of the results highlighted in this study, the Togolese Plateaux Region, through its ICAT-Plateaux support service, should focus on the application of cooperative principles 5, 6 and 7 (5th – Education, Information and Training; 6th – Co-operation amongst Cooperatives and 7th – Concern for Community). A willingness to revitalize the cooperative movement requires, a diagnosis, then an upgrading to the existing relationship between cooperatives and external support services that expands the focus beyond simply economic to include social and environmental measures of sustainability.

Author contribution statement

Koudima Bokoumbo: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Kuawo Assan Johnson: Jacob Afouda Yabi: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Simon Berge: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Rosaine Nerice Yegbemey: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data included in article/supp. Material/referenced in article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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