

A multifunctional perspective to explain the survival of neglected plants: the case of the sweet potato in Benin

ABSTRACT

Neglected crops have great potential to improve agricultural diversity and contribute to food security. In Benin, sweet potato is one of these crops that is still not widely adopted. Although the benefits of sweet potato are widely known, it is only grown on small areas in Benin. This study aims to analyze the rationale behind farmers' decisions to allocate land for sweet potato production. 320 farmers were interviewed in *Gogounou* and *Boukoubé* in North Benin. Data were analyzed using χ^2 tests and a structural equation model. Quotations were used to illustrate the findings. Farmers' individual characteristics, perceptions of the crop, its production and the benefits they expect from it, have a significant influence on the decision to allocate land to sweet potato cultivation. Thus, farmers grow sweet potato because it fulfil a food and/or commercial function. However, due to the neglect of agricultural policies, the sector is plagued by challenges that their low level of knowledge does not allow them to meet. To deal with the uncertainties, farmers are implementing risk mitigation strategies that lead them to limit the area sown. The survival of a neglected plant can be explained by its importance as a food source for the communities. However, in order to increase acreage and scale up, the plant must also fulfil a commercial function.

Keywords: Neglected crops, orange fleshed sweet potato, decision making, structural equation model, risk management.

1. INTRODUCTION

Over the years, intensive farming, modernization and population growth have led to a loss of agricultural diversity (1–3) which has had a negative effect on food and nutritional security (4,5). To achieve the second goal of sustainable development, which is "to eradicate hunger, ensure food security, improve nutrition and promote sustainable agriculture" and to improve the living conditions of communities, it is important to reverse this trend.

Neglected crops have great nutritional potential and can contribute to food security. The terms neglected, orphaned or under-utilized crops refer to plants that receive little or no attention. They are neglected by agricultural policies and research and extension services. Therefore, farmers have no access to the agricultural services needed for their cultivation (6). The survival of a neglected plant generally depends on the functions or uses it fulfils for the populations that cultivate them (7). When the plant is very useful, stakeholders can even induce its scaling up (8). In this way, a plant may be heavily produced in one locality and neglected in another. In fact, in the absence of public aid and despite an unfavorable context, local players are preserving crops (9) that are of particular importance or use to them. Neglected plants often have a high socio-cultural value (10,11) which explains why they are often cultivated by groups sharing a common history and perceptions (12). The expected usefulness of growing a neglected plant is therefore a function of the stakeholders'

perceptions of the plant and its cultivation. In fact, awareness of the advantages of a neglected crop can lead to the development of its value chain (13,14). To this end, stakeholders' knowledge of a plant is essential. For the harmonious development of an agricultural sector, farmers should have access to both scientific and local knowledge (15). As far as neglected plants are concerned, knowledge is mostly local but generally just sufficient to ensure the survival of the crop.

The case of the sweet potato is all the more interesting in that the benefits of this crop are widely recognized around the world. It is the sixth most important food crop in the world and the fifth most important in underdeveloped countries (16). World production in 2020 was 89,487,835 tons, with a production area of 7,400,472 hectares (5). In Benin, sweet potatoes are a neglected crop, and the industry is struggling to develop (17). Orange-fleshed sweet potato varieties are particularly nutritious, but very few are produced in (17). They are rich in β -carotene (a precursor of vitamin A) and can play an important role in combating malnutrition. In fact, in East Africa, sweet potato is known as a food security crop (18) because it is an important source of energy in the human diet due to its high carbohydrate content. It also plays an important role in human and animal nutrition and is known to have the potential to survive climate change thanks to its ability to adapt to different environments and agricultural systems, its productivity and its short growth cycle (19). Despite these advantages, the sweet potato is not highly valued because it is grown in small quantities (10,20,21).

This study analyses farmers' choice to grow small quantities of sweet potatoes. The aim is to analyze farmers' logic of action for allocating land to sweet potato, based on the hypothesis that the sector's poor development is explained by the fact that sweet potato growers attach only symbolic importance to this crop, which is produced solely for self-consumption. The theories of expected utility and functionalism used to guide this study are presented below.

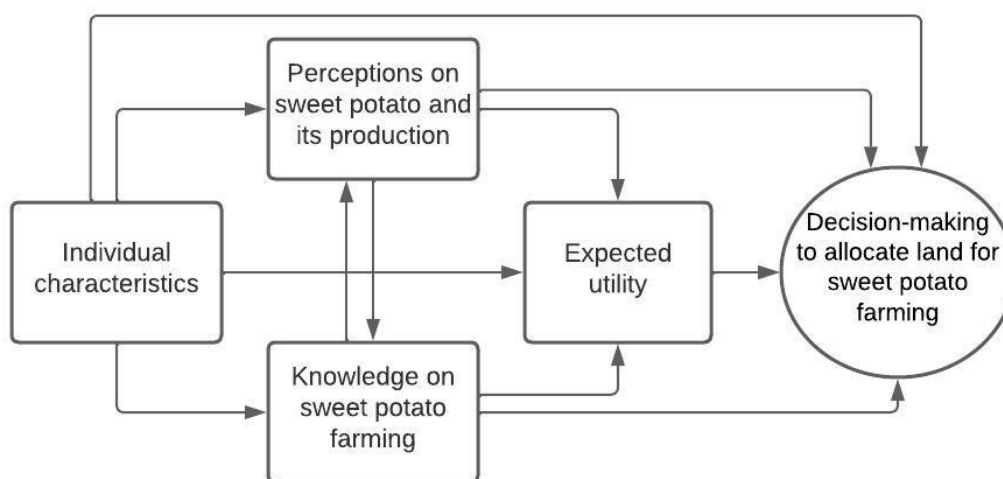


Fig 1: Framework for analyzing the decision-making process in sweet potato farming and value-adding systems

In the literature, the individual characteristics (socio-cultural and economic) of farmers and their effects are widely documented. These include age, gender, level of education, ethnic group, etc. They can facilitate or inhibit decision-making (22).

Knowledge can be traditional, local or scientific (23). This knowledge may be about a new technology's availability, its use and its potential outcomes (24). In the case of sweet potato, the lack of extension services limits producers' knowledge to local knowledge. This

knowledge includes farming techniques, management techniques, institutions, agricultural services and the plant's usages.

Farmers' perceptions of an innovation are very closely linked to their knowledge (22). While knowledge refers to factual information and understanding of how the new technology works and what it can achieve, perceptions refer to the opinions farmers have about it based on their needs and previous experiences. Perceptions play a key role in maintaining neglected crops (13). This importance is generally food-related, but can also be economic, medical, cultural and/or symbolic for populations (25). It may also involve beliefs. The expected utility of the innovation differs from one individual to another (26). It is the result of people's perceptions, knowledge and characteristics.

2. MATERIAL AND METHODS

2.1 STUDY AREA

The study was conducted in the North of Benin, in *Gogounou* and *Boukoubé*. These are mostly rural areas with farming households. They were chosen because they are known sweet potato growing areas in Benin.

Boukoubé is located in the *Atacora* department, on mountain chains. The climate is Sudanese. 4,967 tons of sweet potatoes were harvested from 841 hectares in 2021 (DSA, 2023). Farming and livestock rearing are the main activities, but they are practiced extensively. Farmers in *Boukoumbe* grow many food crops, including cereals (sorghum, millet, maize), pulses (cowpeas, groundnuts, sesame) and roots and tubers (yams, cassava, taro).

Gogounou, on the other hand, is a more urban district. It is one of the areas dedicated to cash crops such as cotton and soya. Farmers in this zone have access to more services (fertilizers, agricultural advice, subsidies). The climate is Sudanese-Guinean. In addition to cash crops, cereal crops (maize and sorghum) are also grown. Sweet potato is produced in smaller quantities here than in *Boukoumbe* (682 tons on 105 hectares in 2021) (DSA, 2023).

2.2 STUDY AREA

The sweet potato (*Ipomoea batatas*) is a perennial crawling plant in the *Convolvulaceae* family. It is native to Central America and north-west South America. It has been introduced into West Africa since the 16th century, and is now so well established that communities consider it a local plant.

In Benin, sweet potatoes are widely grown throughout the country at all times of the year. National production was 56,923 tons in 2021, with a sown area of 10,131 hectares. There are various local varieties with different colors, but the most widely consumed are the white-fleshed varieties. The most popular are : *Vobodouaho*, which in the local language means "Be confident and get into debt" (because of the good yield) and *Mèché*, which in the language means "my friend" (because of the very good yield) (19). They have a short cycle and a high yield, and produce long tubers. Orange-fleshed sweet potato varieties, rich in β -carotene and used to combat vitamin A deficiency, are also grown but in very small quantities. To this end, Benin's universities, with financial support from the African Union, have initiated a project to promote improved orange-fleshed sweet potato value chains in order to improve the nutrition of pregnant women and children.

In Benin, sweet potatoes are typically grown by small-scale producers over small areas as it requires little investment. It is known as an emergency crop and is therefore mainly grown for self-consumption. However, farmers often sell it to cover unforeseen expenses (illness, accidents, ceremonies, etc.). Some farmers choose to grow sweet potato with the intention of commercializing it. However, marketing is limited by the conservation issues.

2.3 DATA COLLECTION

A total of 320 sweet potato farmers were interviewed in semi-structured interviews, 160 per commune. The sampling technique used was the snowball technique. This is "a chain sampling method that uses the recommendations of initial subjects to generate other participants" (Johnston and Sabin, 2010). This technique was chosen due to the lack of information on sweet potato farmers in the selected areas. The initial respondents were identified with the help of the Territorial Agricultural Development Agencies.

Data collected were related to the expected usefulness and perceptions of sweet potato, as well as the knowledge, characteristics and decisions of farmers. The expected utility of sweet potato was defined by the uses that farmers make of their sweet potato harvest, while the decision taken by farmers was assessed by the area sown to this crop. Small areas were less than 0.125 hectares (ha), medium areas were between 0.125 ha and 0.25 ha and large areas were between 0.25 ha and 2 ha.

The variables used to describe farmers' personal characteristics were: area of residence (*Boukouloube*, *Gogounou*), origin (native or non-native) and level of education. Farmers' knowledge was assessed on: (1) sweet potato varieties, (2) cultivation techniques including pest management and (3) post-harvest methods. The aim was to determine whether the interviewee had any knowledge of these. For each type of knowledge, the respondent received either zero or one point. Each farmer therefore had the possibility of obtaining a score ranging from 0 to 3 points. 0 points indicated a very low level, 1 point a low level, 2 points an average level and 3 points a high level. No farmer obtained three points; the very low, low and average levels were maintained.

Finally, to identify farmers' perceptions, a question was asked: What do you think of the sweet potato and its cultivation in your village? The major themes were then identified in the responses. These were perceptions relating to the symbolic importance attached to the sweet potato, children's interest in its consumption, challenges linked to the production of cutting, tedious soil preparation, harvest conservation problems, and beliefs linked to diseases caused by the sweet potato (such as sexual weakness in men or stomach aches if it is eaten too often).

2.1 DATA ANALYSIS

The data were first explored using descriptive statistics in IBM Statistics SPSS 21. The factors influencing the decision to grow sweet potato were then analyzed using a structural equation model. To better explain these influences, the farmers' logic of action was determined.

Structural Equation Modelling (SEM) was used to analyze the factors influencing the decision to grow sweet potatoes. This type of analysis measures the relationships between observable and non-observable (latent) variables on one hand and effects (direct and indirect) on the other hand (Mueller and Hancock, 2018). The observable variables were nominal and the cause of the latent variables. The SEM used was thus a formative model and the Partial Least Square method was applied (Fernandes, 2012). In order to be validated (Ringle et al., 2018), the variables introduced into a formative measurement model must undergo three assessments (Table 1): redundancy analysis, multicollinearity analysis and analysis of the significance and relevance of external weights. As the coefficients obtained for the redundancy analysis were greater than 0.70 (Table 1), convergent validity was retained. Multicollinearity was assessed using the variance inflation factor (VIF). All variables were accepted because the VIF was less than 3. The statistical significance and relevance of the external weights of the relationships between the observable and latent variables were assessed using bootstrapping. The external weights were all found to be significant.

Table 1: Validity of measurement model

Latent variables	Observable variables	Outer weights	VIF	Coefficient
Decision-making to allocate land for sweet potato farming	Area sown: [0-0,125[	0,05	2,5	0,98
	Area sown: [0,125-0,25[	0,01	2,6	0,93
	Area sown: [0,25-2]	0,05	2,4	0,98
Expected utility	Uses of sweet potato harvest	0,00	1,5	0,88
	Sweet potato symbolic importance	0,02	2	0,89
	Children's interest in sweet potato	0,00	1,9	0,850
Perceptions on sweet potato and its production	Cuttings production challenges	0,01	1,5	0,9
	Tedious soil preparation	0,00	1,8	0,83
	Harvest conservation problems	0,00	2,3	0,92
	Beliefs linked to diseases caused by the sweet potato	0,00	2	0,93
Knowledge	Levels of knowledge	0,00	1,4	0,89
	Origine: native	0,01	1,7	0,9
Individual characteristics	Area :Boukoumbe	0,01	2	0,92
	Level of education : educated	0,01	1,3	0,83

The traditional adjustment indices (RMSEA, standard chi2, CFI, NFI) are not relevant for the PLS method. Endogenous latent variables are assessed by interpreting the values of probability, R^2 and Q^2 (Hair et al., 2019). The R^2 measures the explanatory power of the model. It provides an understanding of the explanatory contribution of each latent variable. After analyzing the index values (Table 2), the model is validated. It explained 61%, 51% and 92% of the variances of the "decision making", "expected utility" and "perceptions" variables. The latent variables are all validated in the model since their probability is less than 0.01. In addition, the Q^2 s are all greater than zero. The model therefore has predictive capacity, particularly for the "perceptions", "decision-making" and "expected utility" variables.

Table 2: Structural model validation parameters

Latent variables	P > F	R^2	R^2 adjusted	Q^2
Decision-making to allocate land for sweet potato farming	0,000	0,61	0,60	0,32
Expected utility	0,004	0,5	0,51	0,3

		1	0
Perceptions on sweet potato and its production	0,000	0,9 2	0,92 7
Knowledge	0,01	0,0 2	0,0 1

To generate the typology of sweet potato farmers, the "Uses of sweet potato harvest" variable measuring utility was compared with farmers' characteristics, perceptions and knowledge using chi-square tests. Finally, farmers' expressive and recurrent quotations were included to illustrate the results.

3. RESULTS AND DISCUSSION

3.1 CHARACTERISTICS OF THE FARMERS

The respondents had more or less the same characteristics in the two study areas (table 3). Most were men (96.5%) aged between 25 and 45 (51.6%). The majority were native (72.2%), illiterate (78.8%) and had a low level of knowledge of potato production techniques (55.6%). Farmers grow sweet potato on average areas (44.5%) ranging from 0.25 ha to 2 ha. They grow sweet potato for three reasons. The majority (49.1%) hope to use it for their own consumption. 31.9% of them grow sweet potato for sale in the hope of earning an income. Finally, 19% of farmers use sweet potato roots to feed the workers they employ during major crops harvest.

Table 3: Socio-professional characteristics of farmers

Variables		Gogounou (%)	Boukoumbe (%)	Total (%)
Gender	Men	96,9	96,3	96,5
Age	[14-25[	15	31,3	23,1
	[25-45[	61	43,1	51,6
	[45-65[	24	25,6	25,3
Education level	None	96,3	61,3	78,8
Origine	Native	69,4	75	72,2
Sweet potato sown area	Sown area : [0-0,125[	36,3	10,7	23,5
	Sown area : [0,125-0,25[	6,9	82,4	44,5
	Sown area: [0,25-2]	56,9	6,9	32
Knowledge level	Very low level	23,1	33,1	28,2
	Low level	57,5	53,8	55,6
	Average level	19,4	13,1	16,2
Usages	Consumption	12,5	85,6	49
	Sale	49,4	14,4	31,9
	Food for workers	38,1	0	19,1

3.2 FACTORS AFFECTING THE DECISION TO ALLOCATE LAND FOR SWEET POTATO FARMING

The SEM was used to identify the factors affecting the decision to allocate land for sweet potato farming. Table 4 shows the nature of the links between the manifest and latent variables.

Table 4 : Nature of the links between manifest and latent variables

Latent variables	Observable variables	Signs
Decision-making to allocate land for sweet potato farming	Area sown: [0-0,125[	+
	Area sown: [0,125-0,25[	-
	Area sown: [0,25-2]	+
Expected utility	Consumption	-
	Sale	+
	Food for workers	+
Perceptions on sweet potato and its production	Sweet potato symbolic importance	+
	Children's interest in sweet potato	+
	Cuttings production challenges	+
	Tedious soil preparation	+
	Harvest conservation problems	+
	Beliefs linked to diseases caused by the sweet potato	+
Knowledge level	Very low level	-
	Low level	-
	Average level	+
Individual characteristics	Origine: native	-
	Area :Boukoulombe	-
	Level of education : educated	-

The utility expected by farmers is positively influenced by their personal characteristics and their knowledge (Figure 1). It is negatively influenced by their perceptions. Thus, native farmers with no formal education living in *Boukoulombe* attach symbolic importance to sweet potato but perceive many challenges associated with growing it, especially the soil preparation and cuttings breeding. Because of their low level of knowledge, they choose to grow sweet potato for self-consumption.

Farmers' personal characteristics and their perceptions of the plant, its production and the utility they expect to obtain from it have a significant influence on the decision to allocate land to sweet potato cultivation. The 'Knowledge' variable was not discriminatory because most farmers had more or less the same level of knowledge.

In conclusion, the farmers most likely to grow sweet potato on medium-sized areas are the natives who live in *Boukoulombe* and are not educated. They attach symbolic importance to the plant and want to grow it for self-consumption in the interests of their children, but have negative perceptions of its cultivation. They also believe that sweet potatoes cause sexual weakness in men and stomach aches in adults if eaten more than once a week. On the other hand, educated non-natives living in *Gogounou* have a greater knowledge of sweet potato farming. They grow it for sale or to feed their workers on small or large areas. In order to gain a better understanding of the farmers' decisions, their logic of action were identified.

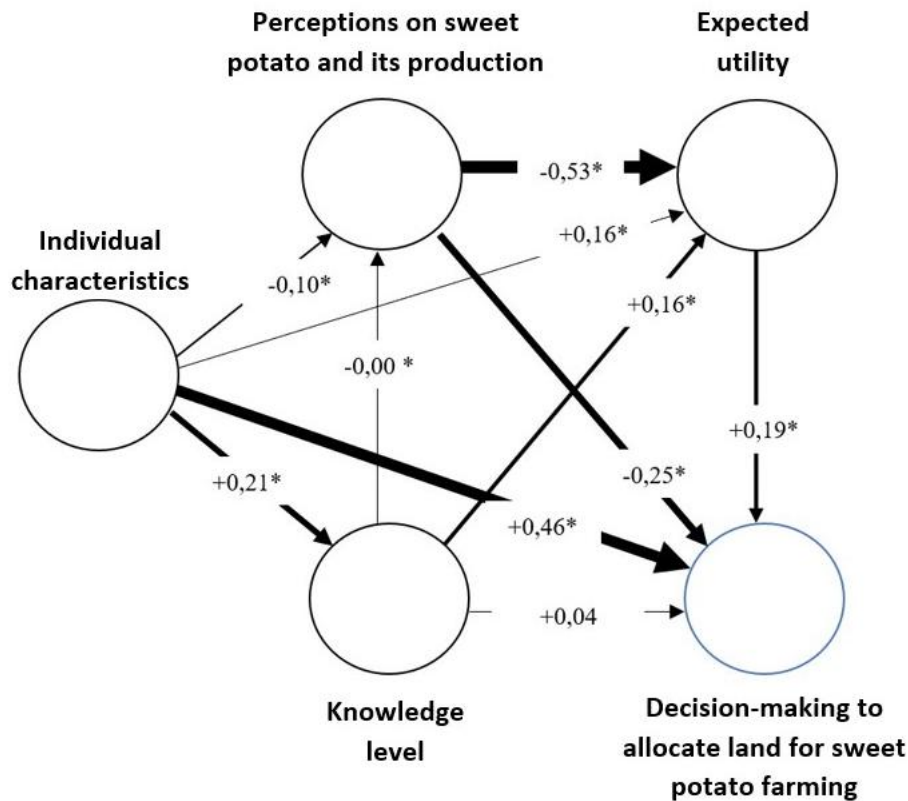


Figure 2 : Factors influencing the decision to allocate land for sweet potato farming

* : significant structural relationships

The thickness of the arrow depends on the importance of the structural relationship

3.3 FARMERS' LOGIC OF ACTION TO ALLOCATE LAND FOR SWEET POTATO FARMING

Farmers who grow sweet potatoes for self-consumption, for sale or to feed workers do not have the same logic of action (Table 5).

Table 5 : Farmers' logic of action by their use of sweet potato harvest

Latent variables	Variables	Consumption (%)	Sale (%)	Food for workers (%)	Khi ²
Decision-making to allocate land for sweet potato farming	Area sown: [0-0,125[	13,4	14,7	63,9	0,001
	Area sown: [0,125-0,25[	74,5	20,6	8,2	
	Area sown: [0,25-2]	12,1	64,7	27,9	
Perceptions on sweet potato and its production	Sweet potato symbolic importance	73,9	56,9	19,7	0,001
	Children's interest in sweet potato	28	20,6	9,8	0,010
	Cuttings production	86	21,6	0	0,001

Latent variables	Variables	Consumption (%)	Sale (%)	Food for workers (%)	Khi ²
Knowledge level	challenges				
	Tedious soil preparation	86	21,6	6,6	0,001
	Harvest conservation problems	73,9	56,9	19,7	0,001
	Beliefs linked to diseases caused by the sweet potato	80,9	42,2	39,3	0,001
	Very low level	36,3	24,5	14,7	0,003
	Low level	52,2	52	70,6	
	Average level	11,5	23,5	14,7	
Individual characteristics	Origine: native	83,4	22,5	100	0,001
	Area :Boukoumbe	87,3	77,5	0	0,001
	Level of education : educated	12,7	77,5	61,9	0,01

Three logics of action were identified. These were farmers with a cultural link to sweet potatoes, market-oriented farmers and cash crop farmers.

Farmers culturally linked to sweet potatoes

Farmers culturally linked to sweet potatoes grow them for self-consumption on areas ranging from 0.125 ha to 0.25 ha (74.5%). They are natives (83.4%) of *Boukoumbe* (87.3%) and for the most part uneducated. Most of them (73.9%) consider the sweet potato to have symbolic importance, as can be seen from their answers to the question : For what reason could you give up the sweet potato?

"It's the sweet potato that saves us, when sweet potato is in the house, famine comes out";

"The reason why you can't leave sweet potato is that when a stranger, an aunt for example, comes to visit you without having warned you beforehand, it's sweet potato that you serve to her.

"When a visitor leaves, you can give them a bag and explain: 'I haven't got much. Please take this for the children."

For these farmers, sweet potato is an emergency crop, ideally suited to feed children (28%). However, they believe that sweet potatoes can cause illness (80.9%), such as sexual weakness in men and stomach upsets in adults, if eaten too often (more than once a week). Overall, farmers have a low level of knowledge. However, 36.3% of farmers with a cultural attachment to sweet potatoes had an even lower level of knowledge. This could explain the fact that many of them experience technical complications in the production of cuttings, soil preparation (86%) and the conservation of the sweet potato harvest (73.9%).

Market-oriented farmers

Market-oriented farmers also have a symbolic attachment to the crop (56.9%) and believe that sweet potatoes cause sexual weakness in men or stomach aches in adults if eaten more than once a week (42.2%). However, they hope to sell their harvest and earn some income. To this end, 64.7% of them grow sweet potato on large areas ranging from 0.25 ha to 2 ha. Most of them are non-natives (77.5%) and educated (77.5%) living in *Boukoumbe*. 24.5%, 52% and 23.5% of them have respectively a very low, low and average level of knowledge about the crop. Regarding the storage of sweet potatoes, 56.9% of farmers in this category think that it's difficult to conserve the harvest:

"Sweet potato is a very good crop. But it rots very fast. We can only keep it for a month. If you don't find customers quickly, you end up with all sorts of troubles". A farmer's answer to the question : Would you like to increase your sweet potato production ?

Cash crop growers

To the question Why would you give up growing sweet potatoes?, a farmer replies: *"I can't give up growing sweet potatoes. With what am I going to feed the people who plough my field? Laughs."*

Cash crop farmers are mainly found in *Gogounou*, a more urban area than *Boukoubé*. They are natives (100%) and mostly well-educated (63.9%). The majority of cash crop farmers have small sweet potato fields (63.9%) with land areas of less than 0.125 ha. They cultivate cotton and/or soya on large areas, for which they need labor. However, feeding this labor is expensive. These farmers therefore plant small areas of sweet potato next to the cotton and/or soya fields in order to feed their employees. This is not a new practice, but one inherited from their parents. The sweet potato is chosen for this purpose because it is considered to be filling and a great source of energy.

"Sweet potatoes are quick and easy to cook and fill you up quickly. If I had to make rice, I wouldn't be able to eat it as it is... I'd have to buy tomatoes or something to add to it. With sweet potatoes, all I need is water (to boil them)".

"Some workers, when they're hungry, dig up a few roots, wipe them dry and eat them raw (traditional way of eating). All this without stopping work because the fields are next to each other. It suits me".

Despite their low level of knowledge (70.6%), the small areas under sweet potato no doubt explain why most farmers in this category do not perceive any particular problems with sweet potato farming. However, 39.3% of cash crop farmers believe that sweet potatoes cause sexual weakness in men or stomach aches in adults if eaten more than once a week.

4.DISCUSSION

This study assumed that the cultural importance of sweet potato to rural communities would influence farmers' decisions. This hypothesis was rejected because only farmers culturally linked to sweet potato are influenced by the importance of sweet potato.

4.1 THEN, WHY IS THE SWEET POTATO GROWN?

Although they receive no support from the government, farmers are committed to preserving and growing sweet potato. This confirms the theories that the survival of neglected plants depends on the local communities to which they belong (27). Sweet potato is valued because it is useful in different ways (28). It provides two functions for the community: a food function and a commercial function. These uses have been inherited because, failing to acquire new knowledge, people reproduce the practices of their parents. The cultivation of neglected plants is therefore linked to customs and traditions, as indicated by Giller (29). Perceptions of the plant are also a determining factor in farming choices (13). In several regions, sweet potato is considered to be an emergency crop (30). The small proportion of stakeholders who try a commercial vision are foreign individuals who have come to the area with different beliefs and perceptions. Farmers therefore keep sweet potato farming going because they use it for various functions depending on the needs of their households and farms. This multifunctionality provides a better understanding of the survival of the sweet potato and should be taken into account in agricultural development policies and actions, as suggested by Hervieu(31), Labarthe and Moumouni (32) and Cuissard .

4.2 HOW DO GROWERS DECIDE TO ALLOCATE LAND TO SWEET POTATO CULTIVATION?

Sweet potato farmers are rational in their decision-making. The neglect of extension services and agricultural policies does not make it easy for farmers to access production factors and knowledge (17). As a result, the sector has no real guarantee of outlets (33). It does not offer sufficient security or opportunities. Sweet potato farmers, while unable to influence decisions in multi-stakeholder areas (32), protect themselves from risk because of the difficulties and uncertainties associated with the crop (34). Their decision to allocate land to sweet potato farming therefore depends on the strategies they implement to manage these risks. In some areas, sweet potatoes are an established part of the diet and difficult to replace. Farmers recognize the benefits of the plant and may feel a strong symbolic attachment to it. However, assessing the risks arising from their perceptions of the sweet potato leads them to limit the area sown. The choice of risk management strategy in terms of production and value-adding methods depends on the characteristics of the farmer and his environment (35,36).

5.CONCLUSION

It is concluded that the survival of a neglected plant can be explained by its importance as a food source for the communities. However, in order to increase acreage and scale up, the plant must also fulfil a commercial function.

CONSENT

As per international standards or university standards, Participants have given their consent to participate in this study.

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