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Analysis of Smallholder Farmers' Practices and Needs in Maize Harvesting in Benin Republic

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ABSTRACT

To investigate maize harvesting practices and the needs of smallholder farmers for a maize harvester, a survey was conducted using Open Data Kit (ODK) application for data collection. The sample was selected using ranked set sampling method thereby carrying out the first three municipalities in maize production in terms of quantity through the seven (7) Agricultural Development Poles (PDA) of the country. The interviews were carried out in the three municipalities of Kandi, Ouesse and Ketou, which belong respectively to agro-ecological areas 2, 4 and 6 in Benin Republic. In the regions covered by the survey, maize harvesting remained manual and was mainly conducted by women even though they were assisted by men and children. The number of labours mobilized during harvesting for marginal, small, and medium are in that order of 6, 7 and 11 persons with an average labour requirement of 6.66 labours·day^{-1}·ha^{-1}. Also, it was observed that the small and semi-medium farmers mobilized the same average labours as well as the medium and large farmers. More so, high (85%) unavailability of labour was noted during harvesting period. Farmers usually harvest maize ears (63.3%) than maize cobs (36.7%). The harvesting maize ears were snapped basically by bending, twisting or pulling ear shanks by 88.1%, 54.2% and 8.5% of respondents, respectively. The proposed maize harvesting machine performance, by farmers, must have an hourly capacity of 0.19 ha.hr^{-1}, harvesting loss less than 122.98 kg·ha^{-1}, requiring less than 5 operators with the overall cost less than 14.16 USD·ha^{-1}.

Keywords: Maize harvesting, smallholder farmers, agro-ecological areas, Benin Republic.

INTRODUCTION

Grains, especially cereals and legumes form a significant food source in the sub-Saharan region. [1] In the particular case of Benin, maize (*Zea mays*) is the most produced up to 74.81% followed by rice with 16.71% of the whole national cereal production. [2] In fact, the maize production increased from 725.62 thousand tons in 2000 and 1.37 million tons in 2017 to 1.46 million tons in 2019. [2-4] Improvement of maize productivity was related to the progress obtained in maize production, storage and conservation, processing, and especially in mechanisation, [5] which provides technologies to other agricultural fields. In fact, some ameliorated varieties of maize were developed, introduced and adopted by maize farmers to improve the productivity to 9.77 kg·ha^{-1} and the revenue to 4.23 dollars·ha^{-1}. [6] Likewise, new technologies and practices in storage and conservation were introduced. [7] These were adopted according to the sociological practices and helped to reduce post-harvest losses and to preserve the quality of the maize produced. [8]

Several post-harvest equipment sets of maize were developed, while pre-harvest

machines were imported to increase the performance of the sector. Among those equipment sets there are threshers, winnowers, calibrators and huskers were introduced throughout the territory to increase the quantity and the quality of products and by-products of maize. [9, 10] In fact, the efforts deployed by research institutions, universities, and by private and public agencies helped to improve the importation and the development of locally fabricated machines of maize processing. Nevertheless, the harvesting operation of maize stays manual not by the disinterestedness of those actors but may due to the lack of information on the actual needs and practices in maize harvesting. Indeed, the former Development Agency of Agricultural Mechanization (DAAM) has imported several row types combine harvesters for maize between 2008 and 2016 which have not been adopted by the maize farmers. This illustrates the gap between the politic actions and the actual needs and practices of maize harvesting which are mainly done by small-scale farmers. It is estimated that more than 75% of the local cereal production is provided by small-scale farmers. [1]

As it has been argued by AgriSETA, hand harvesting usually reduces the crop damages than mechanical harvesting. [11] However, manual maize harvesting is labour and time-consuming activity, and as reported by [12] the crop quality and yield is affected by the harvesting timing. They may decrease due to microbial infection. [13] The labour requirement increases the cost of the activity and other corollary in terms of labour availability and harvesting capacity. In fact, the harvesting method affect the area (size of the field) to be harvested. A farmer might easily be able to harvest half a hectare of maize by hand, but it is not possible hundreds or even thousands of hectares are to be harvested. [11] As recorded by [14] mechanical harvesting reduces the labour and time requirement to 95.47% and 54.67 %, respectively. From this point of view, it would have been better to integrate traditional and improved harvesting techniques. [15]

Taking into consideration these consequences of hand harvesting in maize production value chain and the lack of recent data practices related to the maize harvesting in developing countries such as Benin, there is a need to assess smallholder farmers' practices and needs in maize harvesting. Thus, the aim of this research is to investigate difficulties, constraints and performances of actual harvesting methods of maize in order to provide data about the situation of this activity.

MATERIALS AND METHODS

Research Methods

Survey design was adopted as a method of study. A personal face-to-face survey was done, and a sample size of 60 farmers was used. The sample was selected using ranked set sampling method thereby carrying out the first three municipalities producing maize in terms of quantity. The selected samples were separated by varying the agro-ecological area using Agricultural Development Poles (ADP) as factors.

Methods of Sampling

The surveys were conducted in an area of high potential production of maize in Benin Republic. Based on the data from the Ministry of Agriculture, Livestock and Fisheries (MAEP) during the decade from 2006 to 2016, the first three municipalities producing maize in terms of quantity are Ketou, Kandi and Banikoara, respectively, for an average of 80.98, 60.04 and 41.43 thousand tons per year. [16] However, during the second sorting, Banikoara was replaced by the fourth one Ouesse, which scored 40.64 thousand tons per year. This is because Banikoara and Kandi are both in the ADP 2, while Ketou and Ouesse are in the ADP 4 and ADP 6, respectively. In each municipality, the sample members were randomly selected from the list of maize farmers provided by the Territory Agency of Agricultural Development (TAAD). However, some farmers were unavailable and have been replaced by others from the

same list. The sample size is 15, 15 and 30 respectively for Ketou, Ouesse and Kandi.

Method of Data Collection

Primary data were collected using Open Data Kit (ODK) application which is an open-source set of tools used to carry out Mobile Data Collection (MDC). The use of ODK uploaded on Android mobile devices involves form building, testing, validation, training, data collection, collation (aggregate and briefcase), and data analysis. [17] The original questionnaire was constructed based on the objectives of this study. The built form of ODK included 27 items in 3 subsections: Characterization of farmers; technology and practices in the maize crop harvesting and characteristics of an appropriate machine for maize harvesting. Thus, the questions were very much focused on issues such as production capacity, methods of harvesting, performance of the methods, difficulties and requirements of the expected small-scale maize harvester features. However, the characterization of farmers was based on farm size classes following the Food and Agriculture Organization of the United Nations (FAO) recommendations. [18]

Survey Location

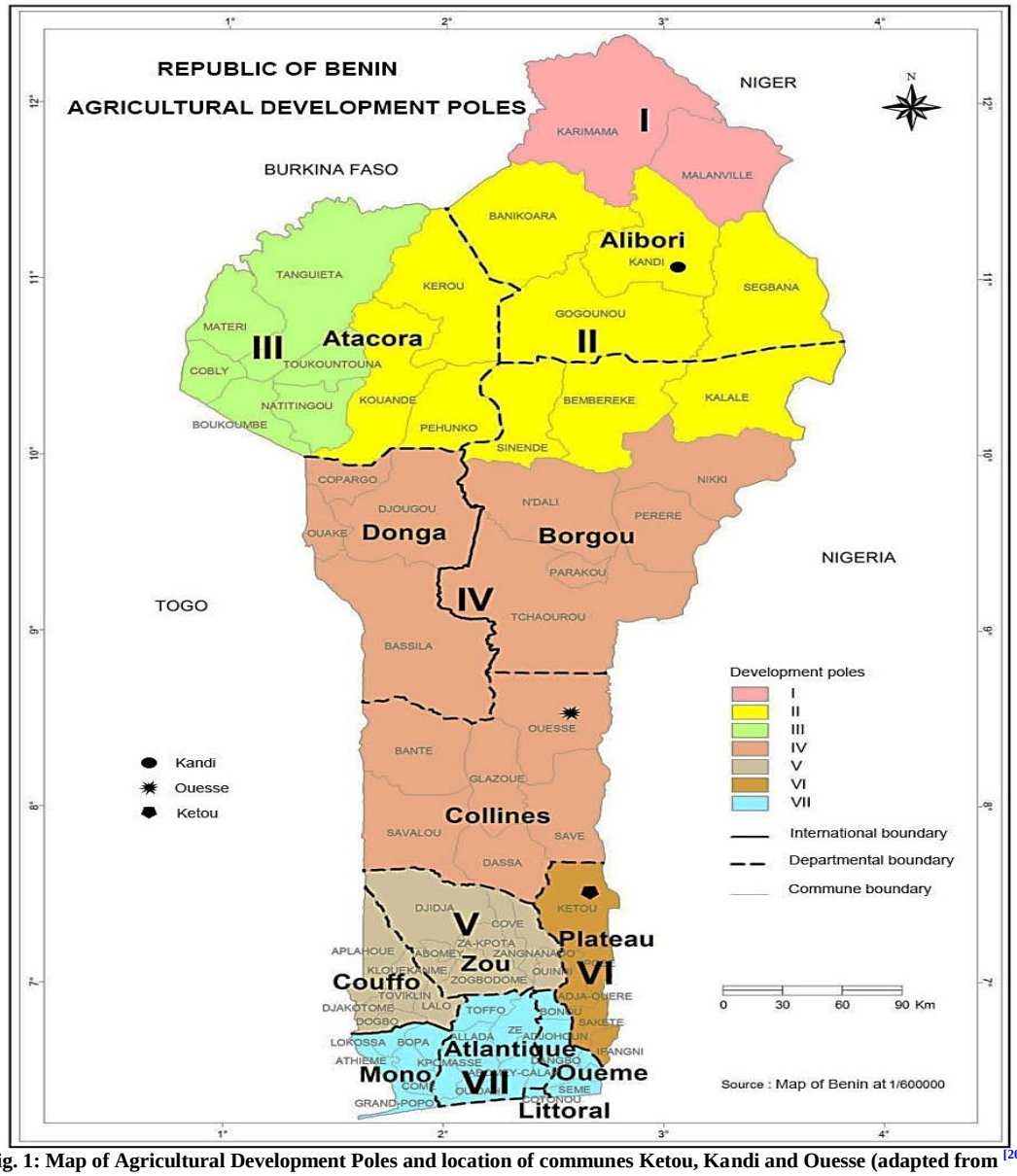

Fig. 1: Map of Agricultural Development Poles and location of communes Ketou, Kandi and Ouesse (adapted from [20]).

The survey was carried out in three municipalities Kandi, Ouesse and Ketou, from ADP 2, ADP 4 and ADP 6, respectively. Each ADP refers to a specific agro-ecological area and covers, in that order, a part of North, Centre and South of Benin. The ADP 2 named 'Cotton Pool Area' is dominated by cotton production followed by the maize crop, while the ADP 4 named 'Cotton, Food Crops and Cashew Trees Area' is dominated by cashew trees and cotton production followed by the maize crop, whereas, oil palm trees followed by the maize crop prevailed in the ADP 6 which is named 'Palm trees and Food Crops Area'. [19] Kandi is located at latitude 11°8'3.01"N and longitude 2°56'19"E, Ouesse at latitude 8°28'59.99"N and longitude 2°25'59.99"E and Ketou at latitude 7°21'47.95"N and longitude 2°35'59.21"E. They are indicated in Fig. 1.

Statistical Methods

Descriptive statistics such as mean value, frequency distribution and percentages were computed to visualize and analyse the distribution of field data using histograms and bar charts. The data were analysed with the Statistical Package for the Social Sciences (SPSS) software version 25.

RESULTS AND DISCUSSION

Characterization of Farmers

In the process of investigating the practices and needs of smallholder farmers, 60 farmers who were interviewed and 93.3% were found to be men. Similar results, 94.2% of men amongst maize farmers, were found by [21] which is more than 73.1% recorded by. [22] The predominance of men amongst maize farmers is due to the lack of land, financial and human resources assessment by women to conduct appropriately their farming operations as reported by. [21] In fact, this can be related to the fact that men have a right to land as a productive resource than females like it was observed by [23] in the case of Nigeria.

Using the farm size classification, the large set of respondents were medium farmers (40%), semi-medium farmers (31.7%), small farmers (13.3%), large farmers (11.7%) and marginal farmers (3.3%) as shown in the pie chart of Fig. 2. Medium scale farmers are the main set of maize farms in Benin and may due to the emergent of small-scale farmers who are growing from the ranks of the small-scale farm sector. Similar trend was observed by [24-26] in some countries in Africa and is explained by the growth of the number of medium-scale farmers, who now control more farmland than small-scale farmers.

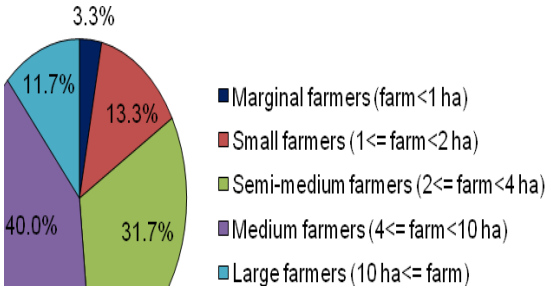

Fig. 2: Density of respondents as related to their farm size.

Results show that the annual maize production capacity range from 12.30 to 52.50 tons for large farmers, from 3.60 to 22.50 tons for medium farmers, from 1.20 to 11 tons for semi-medium farmers, from 0.55 to 3.75 tons for small farmers and from 0.48 to 1.40 tons for marginal farmers, while their means (SD) were 30.45 (12.49) tons, 11.03 (5.07) tons, 4.79 (2.81) tons, 1.84 (1.26) tons, and 0.94 (0.65) tons, respectively.

Practices in Maize Crop Harvesting

Results revealed that in all regions covered by the survey, the maize harvesting remained manual (100%) and the crop was harvested few weeks after its maturity (100%). Commonly, the late harvesting timing was explained by crop fields drying (98.3%) and unavailability of labour (53.3%) which was highly required in Kandi (93.8%). More so, the results showed that seeding rows was largely practised (95%) throughout the territory against low broadcast sowing (5%). This revealed the rate of adoption of the seeding practice of maize which is vulgarized by extension

services and other extension documents. [27, 28] In fact, seeding rows is an advantage in a mechanized harvesting system.

Regarding the harvest products, maize ears were greatly harvested (63.3%) compared to maize cobs (36.7%). In fact, maize ears husking was done mainly on the field (41.7%) and during shelling (25%). This can be explained by the fact that maize is mainly stored in its form of ears by farmers than its form of cob. Actually, maize ears husking was done sometime before (21.7%) and after (11.7%) storage. More so, husking maize ears before shelling in machine is less practiced by farmers in general except a large part of seeds growers.

Results showed that only 25% of farmers cut the maize stalks during harvesting while the abandoned maize stalk in the field, which were used as animal feeds by 79.7% of farmers. In fact, 57.6% of farmers used maize stalks as fire sources on the field and 41.1% left them on the field to maintain soil fertility. The use of maize crops residues for animal feeds is widely appreciated in developing countries. [29-31] In fact, as studied [32] in Nigeria, the available field residues are left to maintain soil fertility, reduce soil erosion and for livestock grazing and the remaining part is removed from fields for animal feed and bedding. However, poor nutritive value of agricultural crop residues with low digestibility, low crude protein and low mineral content is a major constraint which limits their value as an animal feed. Thus, a potential maize harvesting technology must take taking into consideration the importance and the use of maize plants residues.

Concerning the harvesting principles practised, maize ears were snapped basically by bending ear shank (88.1%), while twisting (54.2%) and pulling (8.5%) were used as options. These results contrast with the principles used in harvesting machines whether they are combine harvesters or snappers. In fact, removing maize ears from maize plants is basically done by pulling action. [33] On the other hand, for all the respondents (100%), harvesting was mainly women activity though they were assisted by men (65%) and children (61.7%). In fact, in many economies in sub-Saharan Africa, women provide most of the labour force for agricultural production. [34] Furthermore, in respect of harvesting and threshing, women invest substantially more labour than men in their households. [35, 36] This is in contradiction with the findings of [37] who reported that women were typically involved in all other activities (except for ploughing) but did not provide the majority of labour. Indeed, family labour is mainly mobilized for the harvest. However, it was noted that expatriate labours from Burkina Faso and Niger were used by medium- and large-scale farmers at Kandi for all the step of maize production.

Challenges Faced by Farmers

When asked about difficulties met in harvesting process, 93.3% of respondent agreed that this activity is high time consuming. 88.3% of farmers supported that the late harvesting induced high maize loss in terms of quantity, while 35% in terms of quality at harvest. This is in contrast with previous findings which showed the negative impact of the delay harvesting with the quality of the crop. Indeed, as reported by, [38] long-term exposure of the crop to field infestations and damage by birds, rodents, wild animals, insects and fungi beyond maturity, while infestations and damage that start in the field account for up to 80% of insect infestations at the beginning of storage.

An average of 85% stated that unavailability of labour and losses due to livestock transhumance were factors which affect their maize productivity.

However, all the respondents (100%) had come to the fact that mechanization of the maize crop harvesting of the maize crop and protection of the field against animals (18.3%) were recommended solutions to manage the difficulties mentioned above.

According to the scale of the farming system, the mean (SD) of labours mobilized

during harvesting period was estimated at 6 (6) for marginal farms, 7 (3) for small farms, 7 (2) for semi-medium farms, 11 (7) for medium and 11 (5) for large farms. However, as presented in Fig. 3, the average labour required to harvest 1 hectare of maize crops per day were 6.66 (3.06) which is far better than 25-30 men per hectare day recorded in 1994 by. [39] The average daily cost of labour was 1,308 (315) XOF per man. Therefore, the average cost of manual maize harvesting per hectare was 8,330 (3,365) XOF·ha^{-1}. Furthermore, the mean (SD) maize harvest loss per hectare was estimated as 122.98 (66.84) kg·ha^{-1}.

Characteristics of Appropriate Technology for Maize Harvesting

Results showed that most respondents (95%) strongly recommended that appropriate harvesting equipment should be self-propelled with maize ears snapping devices. About 81.7% proposed that a stalk chopper device must be installed on the machine, while 76.7% suggested maize ears huskers. However, three quarters of respondents strongly disagreed with the use of a power take-off as a power source of the machine. Besides, the respondents suggested a machine capacity of 0.19 hectares per hour for a working day of 10 hours, while mobilizing 5 workers to achieve packaging and transport.

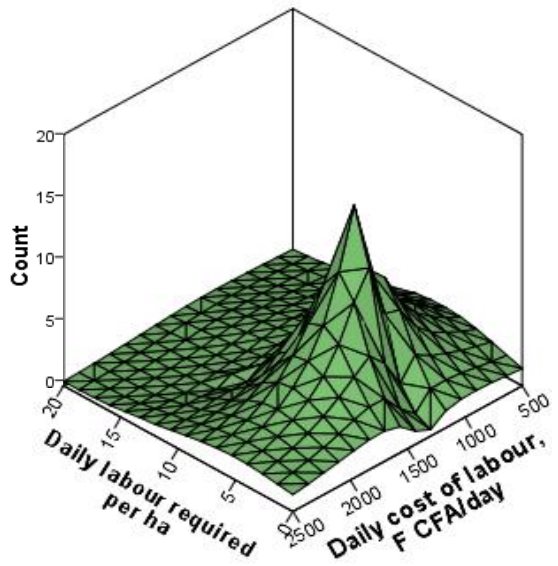

Fig. 3: Surface plot of the density of daily labour requirements per hectare as related to the daily cost of labour.

CONCLUSION

The results of the survey showed that the harvesting was totally a manual activity and done mainly by women, even though they were assisted by men and children. The labours mobilized during harvesting period for marginal, small and semi-medium, and medium and large farmers were 6, 7 and 11 persons, respectively. However, a high unavailability of labour in harvesting period with an average of labour requirements of 6.66 labour·day^{-1}·ha^{-1} was observed. In practices, maize ears are usually harvested than maize cobs (36.7%) itself. The harvesting maize ears were snapped basically by bending, twisting and pulling ear shanks by 88.1%, 54.2% and 8.5% of respondents, respectively. About an appropriate technological solution, farmers suggested a harvesting machine with average hourly capacity of 0.19 ha.hr^{-1} and harvesting loss less than 122.98 kg·ha^{-1}, requiring fewer than 5 operators with the overall cost less than 8,330 XOF·ha^{-1} | 14.16 USD·ha^{-1}.

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