Net Journal of Agricultural Science
Vol. 7(4), pp. 112-124, November 2019
DOI: 10.30918/NJAS.74.19.032
ISSN: 2315-9766
Full Length Research Paper

Adoption and impact of improved cassava (*Manihot esculenta* Grantz*)* production technology on farmers' welfare in Mezam Division of the North West Region of Cameroon

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Accepted 25 October, 2019

EXECUTIVE SUMMARY

This research sample, one of a series of adoption case studies championed by the ongoing Programme for the Improvement of Competitiveness of Family Agro-pastoral farms, examines the adoption by Mezam farmers of improved cassava production technologies (ICPT) diffused through ACEFA programme. The latter is a programme jointly managed by the French government and the Cameroon government (through the ministry of Agriculture and Rural Development - MINADER and the ministry of Livestock, Fishery and Animal industries - MINEPIA) to support Family Agropastoral Farm enterprises (FAFs) in Cameroon as to what concerns supportive counseling and financing in the form of investments. This research work was carried out during the second phase of ACEFA's programme which started in 2012 and ran up to 31st of September 2018, and has progressively covered the 58 Divisions that make up the 10 Regions of Cameroon. The objective of the evaluation was to assess the success of adoption and impact of improved cassava production technology (ICPT) at the farm level, and by implication the success of ACEFA's programme in facilitating the transfer of those technologies. The evaluation design combines elements of theory-based and case-based approaches. These stem from a *realist perspective*; that is, a recognition that outcomes are affected positively and negatively by the real world context in which they occur. Realist evaluation recognizes the complexity of interventions in the social world and the difficulty of isolating the impact of a single intervention, seeking instead to explore what works, for whom, in what circumstances and why. In line with realist, theory-based approaches, the evaluation methodology tested an ex-post theory of change (TOC) developed with ACEFA. The evaluation used mixed qualitative and quantitative methods, combining desk-based secondary data with field-based primary data collection and analysis. The evaluation methodology for primary data collection on the adoption of ICPT was done through a survey of cassava growers conducted between January and July 2018. A four-stage, clustered, randomized procedure was used to select a representative sample of 180 cassava farmers. These farmers were administered semi-structured questionnaires about their cassava production, consumption, marketing practices, preferences for different cassava cultivar characteristics, and their knowledge of, and access to improved seed and fertilizer. Data were analyzed using SPSS and the quasi-experimental method.

The survey revealed that adoption of improved cassava production technology has been extensive. Close to two-third of the farmers (63.90 %) planted improved cassava variety (ICV) on their cassava fields with most cultivated variety being 96/1414 (66.1%). A similar proportion (62.2%) practices the planting configuration techniques. Socio-economic analysis results showed that majority of the farmers were females (65.56%) and over 46 years of age with over 4 members per household. Majority of the respondents were married (75 %) having primary level of education (66.1%). Most of the respondents reported not to be novice in cassava production. Majority of respondents (67.8%) own the land they use for production. However, the rate of fertilizer use on cassava was relatively low as less than one-third of sample farmers (30.60%) reported

having applied fertilizers in their cassava fields. Adoption rates were higher among female farmers than male farmers, and 77.39% of the respondents revealed that they adopted because the variety is high yielding and profitable. 55.38% of those who did not adopt revealed that disadoption is influenced by the degree of availability and accessibility of local cuttings compared to improved cuttings.

What have been the impacts of the ICPT?

In the absence of reliable baseline data, it was not possible to calculate quantitative measures of project impact. Based on farmers' qualitative judgments, however, it is clear that adoption of ICPT has been associated with significant farm-level productivity gains (cassava yields after adoption: 9084.10 kg) and noticeable increases in the income earned (87.78%) from sales of cassava (76.67%). 63.30% of the respondents experience an increase in their consumption. Furthermore, harnessing on social capital and access to counseling the farmers have been able to improve on their associative life while gaining new skills. Also, impacts on the nutritional status of rural households appear to have been improved. Results from focus group discussion revealed that the average number of meals per day had changed since the adoption of ICPT, and the frequency of "luxury food" consumption (meat and/or fish) had increased from one to two or three times per week.

In addition to documenting the uptake and diffusion of ICPT, this case study provides valuable insights about the many factors that can affect the adoption of agricultural innovations in general. The survey results show that adoption of improved cassava production technology is directly influenced by three sets of factors: (i) *characteristics of the technology* (e.g. complexity, profitability, riskiness, compatibility with other technologies); (ii) *characteristics of the farming systems* (e.g. agro-climatic conditions, prevailing cropping systems, access to credit, age and farm size, and availability of physical inputs); and (iii) *characteristics of the farmer* (e.g. ethnicity and culture, wealth, education, gender). Most challenges faced in production were poor road infrastructure (47.8 percent) and fast decay of tubers (43.9 percent), which call for getting down decentralized rural infrastructures along with quality and efficiency of related services. For instance, storage facilities will require roads and transport services to get crops to collection points as well as reliable energy services to keep perishables in proper condition.

Keywords: Rate of adoption, impact, technology, cassava producers, logit model.

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INTRODUCTION

In order to ensure political stability, economic growth and eradicate poverty, one of the four pillars of Cameroon's Vision 2035 is to address food crisis and make Cameroon the breadbasket of the Central African Region (Manu et al., 2014). Increasing agricultural productivity is critical to meeting expected rising demand and, as such, it is instructive to examine recent performance in cases of modern agricultural technologies (Challa, 2013). Agriculture generates the highest number of employments (more than 60% of both skilled and unskilled), ensures national food security, and shares a percent contribution of 15.33% to Cameroon 's Gross Domestic Product (GDP), foreign earnings and, above all, provides raw materials to the industrial sector (24.49%), which is still in its infant stage (Mouafor et al., 2016). Cassava and its derivatives are in first place, with a value of 43percent of market share for roots and tubers: 26% for processed products and 17% of fresh roots (PNDRT, 2003). Cassava also provides higher income to growers well over rice and maize, its two major competitors in Cameroon (Mvodo and Liang, 2012a). Cassava mainly consists of starch, and it is a source of energy for humans and animals due its high carbohydrate content (Sangian et al., 2019). For agricultural households, roots and tubers, most often are cultivated in combination with other crops. Cassava has carbohydrate content approximately forty-times higher than rice and twenty-times higher than maize.

Cassava lends itself to polyculture; it withstands drought and infertile soils (Ceballos et al., 2006). Cassava (*Manihot esculenta Grantz*) is the main food crop of Cameroonians, having less agronomic requirements, and is cultivated in numerous regions of the country (Ngome et al., 2013; Temegne et al., 2016). Cassava is, together with maize, common beans, cocoyam, yam, plantain and rice, among the most important staple food crops of the North-West Region (NWR) of Cameroon. Cassava serves this function as it can be consumed raw upon maturity, processed into garri, water fufu, cassava flour mainly produced for home consumption after its introduction to the NWR around 1920 (Ohadike 1981; Warnier 1984). Its processed

products are very popular with the growing urban population because they are easier to prepare and can be kept longer than the other staple crops. For instance, garri is made from cassava storage roots, grated, fermented, and fried with or without palm oil (Zundel et al., 2010). In the N.W.R, as everywhere in Cameroon, cassava producers maintained that cassava performs five main roles including: famine reserve crop, rural food staple, cash crop for urban consumption, industrial raw materials and foreign exchange earner (Nweke et al., 2002). In the humid savannas of Cameroon (to which the NWR belongs) most of the farmers growing cassava for home consumption also plant it as a commercial crop. In view of the changing role of cassava and the changing environment, new cassava varieties are required (Zundel et al., 2010).

Besides, funding for research in general and agricultural research in particular in Cameroon and many developing countries becomes increasingly scarce. For this reason, research administrators have come under heightened pressure to ensure that available resources are used efficiently. The need to illustrate accountability has generated increased interest in research impacts assessment methods and motivated a large number of empirical studies designed to determine whether agricultural research programme are having their intended effects. A number of these studies have used some type of benefit-cost analysis to calculate return to research investments. Such approach typically involves measuring the diffusion of innovations generated by a research programme and calculating the economic and financial margins resulting from their appropriation. Despite the fact that the findings of a number of recent research impacts studies back the view that investments in agricultural research continue to generate attractive rates of return, some scholars instead argue that economic framework type of analysis is borne with limitations. The latter contend that economic rate-of-returns calculation is, in some ways, relatively suited for evaluating agricultural research type of activities whose primary outputs (technological innovations) are essentially a means of achieving broader welfare goals that cannot always easily be measured. The realization that traditional economic approaches are not always well-suited for dealing with changes in the quality of human lives has fueled interest in alternative research impacts assessment methods that are less dependent on tangible calculus of monetary costs and benefits.

One such alternative approach to understanding the impacts of agricultural research involves adoption case studies. Well-conceived, intelligently planned, and carefully executed studies of a case can generate valuable insights into understanding how rural households adopt agricultural innovations and are affected by them (Stern et al., 2012; Sechrest et al., 1998). Such insights are useful in devising ways to maximize the appropriation of agricultural innovations, hopefully with favourable effects on sustainable food production, poverty reduction, and environmental protection. Case studies are not necessarily inexpensive to conduct, but they are easier to execute than controlled experimentation involving large groups of test subjects and are sufficiently flexible to accommodate a wide range of research or evaluation questions.

This research sample summarizes the findings of a recent case study that focused on the adoption rate and impact of improved cassava varieties on farmer's welfare through ACEFA programme. ACEFA is a programme jointly managed by the French government and the Cameroon government (through MINADER and MINEPIA) to support family farm enterprises (FAFs) in Cameroon as to what concerns supportive counseling and financing in the form of investments. The ACEFA programme has as vision to improve the competitiveness of the family Agro pastoral farms by improving on the incomes of the family agro pastoral farm enterprise (FAFs) and to professionalize producer organizations. The overall objective of the case study was to assess the success of adoption and impact of ICPT at the farm level, and by implication the success of ACEFA's programme in facilitating the transfer of those technologies in order to improve the welfare of ICPT producers (and consumers). Specific sub-objectives of the case study were as follows:

- document adoption at the farm level of ICPT and shed light on the factors affecting adoption;
- assess qualitatively and, where possible, quantitatively the impacts of ICPT on the welfare of cassava-producing households; and
- draw lessons from the ACEFA programme and ICPT and, accordingly, make recommendations that may be useful in the design and implementation of future projects of a similar nature.

Cassava economy of Cameroon

In Cameroon, cassava ranks first amongst root and tubers crops in terms of total production and consumption with yearly production estimated at 5 Mt (Agristat, 2010) with the Centre, East and South regions being the most productive areas (PNDRT, 2005). It is the main starchy staple with 80percent of rural and urban households consuming cassava and cassava derived products on a daily basis (Essono et al., 2008). Currently, however, there is a growing awareness of the potential of cassava as a source of food and of income but the majority of cultivated varieties are susceptible to pests and diseases causing significant yield losses (Hahn et al., 1987; Njukwe et al., 2012). Cassava and its products for example "baton", paste, flour, "fufu", "garri", and starch are being sold both in Cameroon and elsewhere in Central Africa for the rapidly growing urban populations. This increase in demand for cassava has led to increased

prices in Cameroon and an increase in production beyond the previous traditional subsistence systems. Its ability to grow and produce reliable yields in areas where cereals and other crops do not perform well has also contributed to its popularity. Cassava is consumed in many forms particularly, fresh, boiled or processed but also for its leaves which serve as vegetables and is largely grown by smallholder farmers, with the main production system being intercropping.

Smallholder farmers in Cameroon grow various cassava cultivars and there are marked producer and consumer preferences as to the type of variety grown and these determine the uptake of new varieties (Zundel et al., 2010). Cassava also has gained industrial importance to produce ethanol, glucose and amino-acid, high-quality cassava flour is use in bread production both for domestic consumption and export purposes (Sanni et al., 2007). Cassava products are components of basic food intake for seven (7) to eight (8) million people in Cameroon living in the eight (8) southern regions and cover around eight (8) percent of daily nutritional needs, just below plantain (9.8%) in the group of starchy food crops (SNI, 2009).

Production trends

According to official statistics, the area annually harvested to cassava in 2016 averagely is about 374,655 ha. As areas devoted to its cultivation was estimated at 204,548 ha with an annual production of 2.3 million tons (PNDRT, 2005). Most of the cassava grown in Cameroon is cultivated in association with other crops, particularly in the Western Highland zones and humid forest zone with bimodal rainfall; this implies that the planting densities are generally low. Average cassava cuttings planted per hectare is 10,000 cuttings. Total annual cassava production is currently estimated at 5,501,749 tons. Both of the two key determinants of production (area harvested and yield) increase yearly.

Consumption trends

Among all the major energy-providing crops (cassava, yam, cocoyam, colocasia, sweet potato, plantain, Irish potato) that are grown in Cameroon, it ranks first in per capita consumption. According to FAOSTAT (2008), the per capita consumption of cassava in 2005 in Cameroon was 90.13 kg/year, where cassava provided an average of 270.87 kcal/capita/day, which is higher than was estimated in 2002, at 75 kg/person (MINADER, 2003b). Of the two million tons produced that year, it was estimated that 1.13 million tons were consumed in total: 360 tons in urban and 770 tons in rural areas. Cassava offers an affordable source of calories and contributes to household food security; while it is a key dietary staple. Cassava has remained a subsistence crop because of its rapid spoilage after harvest, caused by an inadequate/irregular supply to feed the few processing facilities and inefficient processing methods for the market (Njukwe et al., 2013). Cassava is consumed in many forms. It is consumed raw, in the form of water “fufu”, “garri”, “kum-kum” (cassava flour). The leaves are prepared and eaten as vegetables. Cassava is eaten either fresh (boiled, raw) or processed. The quantity of each cassava product consumed varies by region, level of urbanization, and ethnic diversity of the dwellers and their diverse food habits.

METHODOLOGY

Study area

Mezam Division is located in the North West Region of Cameroon with its capital called Bamenda. It is located 366 km north-west of Yaoundé. The area covers an approximate area of 200 km² and is situated between latitude 5°58′42.6″N, and longitude 10°08′52.0″E. It is bounded to the North, East, and West by Menchum, Boyo and Momo Divisions and to the South by the Western Region. Mezam Division in the North West Region of Cameroon is divided into seven sub Divisions namely the Bali, Bafut, Bamenda I, Bamenda II, Bamenda III, Santa, and Tubahas seen in the map of Mezam Division (Figure 1).

The soils of Mezam are mostly Oxisoils. But there are still some dark and fertile soils around river banks for example River Mezam and other streams. Some valleys have dark alluvial depositions carried from hills and other areas. Mezam has a sub-equatorial climate which is a climate that is greatly modified by altitudes. This type of climate is shown by nine months of Rainy Season with an annual rainfall of about 2400 mm. Rainfall pattern in the Mezam Division is at peak in the month of July to August. Mezam Division is characterized by a cool-like climate influenced mainly by mountainous terrain. The average temperature is 23°C with the minimum and maximum ranging from 15 to 32°C. Also, the temperature is greatly modified by the altitude such that the high mountain areas experience cold climatic condition. There are two main seasons; wet seasons which corresponds to the forceful penetration of the monsoon winds from the Atlantic Ocean and a Dry Season which sets around the month of November to February, reducing most agricultural activities in most parts of Mezam except gardening in the Santa work area. There is also the Rainy Season, which starts from March and continue till October, giving the signal for almost all agricultural activities in the area. The Dry Season is characterized by the Hamattan with dry air. Practically because of climate change, this area (Mezam) experiences some rains in January and no rains by mid-March. During the Dry Season, temperatures exceed 23°C in the day and drops to 18°C in the night and early mornings. During the peak period of rainy season, the rainfall is often estimated to 2900mm on an average, accompanied by lightning and thunder storms leading to landslide (common in the Bafut work area) especially in the months of August and September.

Study setting, sampling techniques and data analysis

The impact evaluation design combines elements of theory-based and case-based approaches. These stem from a realist perspective; that is, recognition that outcomes are affected positively and negatively by the real world context in which they occur (Stern et al., 2012). In this perspective, realist evaluation recognizes the complexity of interventions in the social world and

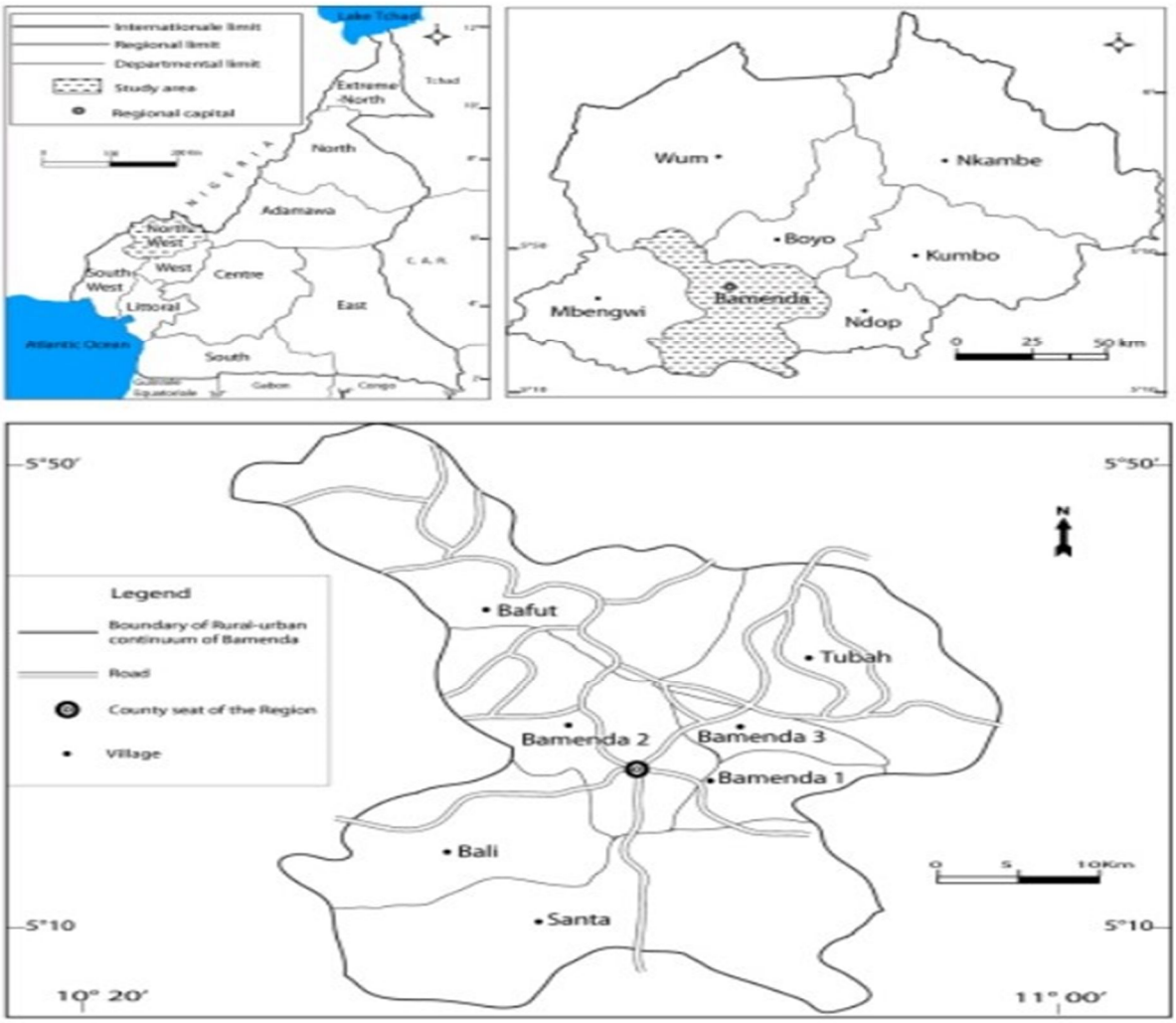

Figure 1. Map of North West Region showing Mezam Division.

the difficulty of isolating the impact of a single intervention, seeking instead to explore what works, for whom, in what circumstances and why. In line with realist, theory-based approaches, the evaluation design employed in this study case seeks to test a theory of change for ACEFA intervention via ICPT.

Furthermore, a multistage sampling technique was used for this study with four stages. In the Division, Sub-divisions were selected through simple random sampling technique. Five of the sub-divisions in the Mezam Division were selected. Stage two involved selection of villages in the Sub-Divisions selected in stage one giving a total of 12 villages, the third stage involved the selection of common initiative group of farmers into cassava production from each of the 12 villages selected in stage two giving a total of 85 cassava producer groups interviewed for the study (Table 1).

While the fourth and last stage involved an average selection of seven Family agro pastoral farms (FAFs) from each selected group given a total sample size of 180 FAFs interviewed (Table 2).

For primary data collection, a semi-structured questionnaire was used to collect data from the cassava producers. 180 questionnaires were elaborated around a list of precise points that were related to the theme or topic of the study. Firstly, the questionnaire had a section on socioeconomic characteristics of the farmers: Sex, age group, family size, household size and level of education. Secondly, the questionnaire assessed the level of adoption by asking questions on cassava varieties cultivated and source of these varieties. Finally, farmers were asked information on the, credits/loans, off-farm income, farming experience and land tenure system. The collected data were analyzed with the help of statistical packages such as Statistical Package for Social Sciences (SPSS) and impact evaluation was done qualitatively by using the quasi experimental and participatory approach. The analyses process consisted of coding the questionnaires and variables so as to ease their insertion in the statistical package. Descriptive statistics such as frequencies, means, percentages, etc, were used to bring out the socio-economic characteristics of the cassava producers and the extent of improved cassava variety adoption. The logit model was used to analyse the factors influencing the adoption of improved cassava varieties.

RESULTS AND DISCUSSION

Socio-economic characteristics of the cassava farmers

The socio-economic characteristics of the farmers retained for this study included gender, age, marital

Table 1. Classification of farming groups involved in cassava production in Meza.

Sub-division	Villages	Cassava producing groups
Bafut	Mundum	
	Njinteh	
	Mforya	46
	Achenie	
	Mbebeli	
Bali	Wosing	15
Santa	Awing	
	Baligham	9
Bamenda II	Ntahbeng	8
	Alahbukam	
Tubah	Bambui	7
	Bambili	
Total		85

Table 2. Sample size of family agro-pastoral farms selected for interview.

Sub-division	Cassava producing groups	Average FAFs/group	Total number of FAFs	30 percent of FAFs sampled/group
Bafut	46	7	322	97
Bali	15	7	105	32
Santa	9	7	63	19
Bamenda II	8	7	56	17
Tubah	7	7	49	15
Total	85		595	180

Source: Field survey (2018).

status, family size, farming experience and educational level (Table 3).

It was observed that 65.60% of the respondents were females and 34.40% were males. This implies that females dominated in cassava production. This was probably because women are the main food provider in rural Cameroon. According to Prakash (2006), it is estimated that in Cameroon rural women supply about 90 percent of the food needed for subsistence by the population making them more involved in agriculture than the males. Majority (56.1%) of the respondents were middle age adults ranging between 46 and 55 years old, while 32.8% of the respondents were 56 years of age and above. Also 9.4% of the respondents were between 36 and 45 years of age and only a few (1.7%) were between 20 and 35 years of age. This implies that most of the farmers engaged in cassava farming were adults (46 to 55 years old).

The results obtained showed that majority (75.0%) of the respondents who were engaged in cassava production were married, followed by respondents who are widows (10.6%), divorced (9.4%) and single who were 5.0% These results suggested that married respondents dominated in cassava production due to the fact that they had households' responsibilities. Hence, income obtained from cassava appears crucial for alleviating household income and improving household food security.

Household category with household size of [0 to 5] was the highest with a percentage of 51.7% followed by size of [6 to 10] with a percentage of 46.1% and only 2.2% was over 11. Large family size is an indicator for availability of labor provided that the majority of the family members are within the age range of active labor force.

With respect to farming experience, 42.2% of the respondents indicated that they have been into cassava production between 11 and 20 years. 37.7% of the respondents indicated to have been into cassava production for over 21 years and only 20% of the respondents had been into cassava production for less than or equal to 10 years. This shows that the respondents in this study are not novice in farming activities especially in cassava production. This equally indicated that the study sample was composed of experienced farmers including those who were reluctant to change towards the use of improved cassava

Table 3. Socio-economic characteristics of survey respondents.

Characteristics	Frequency	Percentages (%)
Gender		
Female	118	65.60
Male	62	34.40
Total	180	100.00
Age		
[20-35]	3	1.70
[36-45]	17	9.40
[46-55]	101	56.10
[56 and above]	58	32.80
Total	180	100.00
Marital status		
Single	9	5.00
Married	135	75.00
Divorce	17	9.40
Widow	19	10.60
Total	180	100.00
Household size		
[0-5]	93	51.70
[6-10]	83	46.10
[11 and above]	4	2.20
Total	180	100.00
Educational level		
No formal education	38	21.10
Primary	119	66.10
Secondary	22	12.20
University	1	0.60
Total	180	100.00
Land tenure		
Inheritance	34	18.90
Renting	24	13.30
Owner	122	67.80
Total	180	100.00

production technology.

In terms of educational background, majority (66.1%) of the respondents had primary education, followed by no formal education (21.1%), Secondary education (12.2%) and only 0.6% of the respondents attended university level.

Rate of adoption of improved cassava cuttings

In Mezam division, the most cultivated varieties are $EScaPP_{30,}$ 96/1414, TMs92/0057, EScaPP32, TMs92/0326, 8034, 8017, TMs0239 due to the fact that growth of these cassava are determined by the agro-ecological zones. Some of the adopters of improved cassava varieties used only one type while others made a combination of two varieties. Out of all these mentioned varieties, 96/1414 is the highest yielding variety with long tubers and it is very good for processing ("Garri", "water-fufu", "cassava flour"). Those are the more reasons why so many farmers cultivated it.

Results showed that 76 adopters (66.1%) used only 96/1414, 10 adopters (8.7%) used only the $EScaPP_{30}$ (Bitter purple). Also 4 adopters (3.5%) used only TMs92/0057 variety and 4 adopters (3.5%) used only $EScaPP_{32}$ variety. Furthermore 21 adopters (18.3%) jointly used 96/1414+$EScaPP_{30}$.

Over half of the sampled farmers planted improved cassava varieties 63.90%. 100% of these farmers practiced the slanting planting configuration (Table 4). The rate of use of chemical fertilizer was much lower (30.60%). This is because most of these farmers preferred organic manure over fertilizer. Most common combination involved adoption of improved cassava cuttings and slanting planting without fertilizer application.

The findings as shown in Table 5 revealed that the majority (77.39%) of the farmers who adopted said high yield and profitability is the reason that made them grew the variety. Whereas 18.36% and 4.35% respectively argued that the resistance to pest and diseases, and the early maturity of the variety are the reasons why they grew the varieties.

For non-adopters of improved cassava varieties, majority (55.38%) of the interviewed said it is because of the availability of local cuttings compared to improved cuttings that made them grew the local variety. 44.62% of these non-adopters said it is lack of capital that drives them from cultivating the improved variety. This shows that varieties characteristics, to a large extent, play a vital role in influencing farmer's adoption behavior. If the characteristics satisfy the need and interest of the farmers the likelihood that they will adopt will be maximized (Tadesse, 2008).

Factors affecting improve cassava production technology adoption

Different socio-economic characteristics of the respondents were analyzed including gender, age, marital status, family size, farming experience and educational level. This was done using a regression analysis. In this analysis, the model output shows that the probability of obtaining a chi-square value is 23.248, and a P-value of 0.016 therefore indicates an existing significant relationship between the independent variables and the dependent variable (adoption of improved cassava varieties). The Nagelkerke R Square (R^2) value obtained was 0.231. This indicates that 23.1% of the explanatory variables can accurately predict the dependent variable and explain farmer's adoption of

Table 4. Rate of adoption of cassava production technology.

	Improved cassava varieties (%)	Use of fertilizer (%)	Slanting planting (%)
Yes	63.90	30.60	100.00
No	36.10	69.40	0.00

Table 5. Farmer's reasons for the cassava varieties grown.

Category	Frequency	Percentages (%)
Adoption (ICV)		
High yielding and profitable	89	77.39
Resistant to pest and diseases	21	18.36
Early maturity	5	4.35
Total	115	100
Non-adoption (local varieties)		
Availability of cuttings	36	55.38
Lack of capital	29	44.62
Total	65	100
Total	180	

improved cassava varieties. The logit model results are presented in Table 6.

The adoption of Improved cassava production technology was dependent on two of the factors at 5% (**) and 1% (***) levels of significance. Farm size, farming experience, educational level, household size, main income source, land tenure system and level of importance of cassava had no significant relationship with adoption. They were therefore not considered as factors influencing the adoption of improved cassava varieties in Mezam Division of the North West Region of Cameroon. At the 5% level of significance, adoption was found to have a significant relationship with age. At the 1% level of significance, adoption was found to be dependent on access to credit. Therefore, age and access to credit were considered the main factors influencing adoption.

Impact of improve cassava production technology on the farmers

Here, the impact of cassava production technology on farmers was assessed using five indicators of welfare. These include productivity, Social impact, income, health status and skills.

Productivity

From Table 7, we can see that the cassava yields are averagely higher after the adoption of the improved cassava varieties as compared to the situation before adoption (9084.1031 ± 5345.68275 and 5345.68275 ± 3489.77632, respectively). It is however worth mentioning that some farmers who have adopted the improved cassava varieties can harvest up to 14167.80 kg of cassava per hectare.

Yet, the annual cassava production per hectare is less than the national average which was estimated at 13.3 tons/hectare (Njukwe et al., 2014). This finding is in line with the latter which postulated that, the NWR of Cameroon is among the least producing cassava antennas in the country.

Farmer incomes

In this study, 87.8% mentioned a general increase in farm and household income after adopting the improved cassava production technology, either directly through increased sales of cassava or indirectly.

How can income gains be measured?

In the absence of baseline data on farmers' cassava marketing activities prior to the initiation of this study, there was no reliable way to measure income gains directly. Indirect methods based on farmers' recollections must be ruled out as too unreliable. When questioned about the distant past, few farmers are able to recall detailed information about amounts of cassava they sold and the prices they received. Lacking any approach to measure income gains directly, we instead asked farmers whether during the previous five years they had noticed any changes in (i) the quantity of cassava they produced each year, (ii) the quantity of cassava they sold each

Table 6. Logistic results of factors influencing adoption of improved cassava varieties.

Variable	B	Exp(B)
Age (0 = less than 40, 1 = more than 40)	.856**	2.355
Access to credit (0 = No, 1 = Yes)	1.513***	4.540
Farm size (Hectares)	.030	1.030
Years of farming (0 = less than 20 years, 1 = More than 20 years)	-.524	.592
Educational level (0 = No formal education, 1 = Formal education)	.111	1.117
Sex (0 = Female, 1 = Male)	-.520	.595
Household size (in numbers)	.588	1.801
Main income source (0 = Non agriculture, 1 = Agriculture)	.089	1.093
Marital status (0 = Single, 1 = Married)	.096	1.101
Land tenure system	-.009	.991
Level of importance of cassava (0 = consumption, 1 = Commercialization)	-1.126	.324
Constant	1.238	3.448

Note: ** = significant at 5 percent and *** = Significant at 1 percent. Percent correct = 87.8percent, and number of observations = 180.

Table 7. Estimated yields of cassava per kilogram from 1 ha of land.

Variables	Minimum	Maximum	Mean	Std. Deviation
Yields before adoption/weight in kg of bags.	11.69	13076.40	5345.68275	3489.77632
Yields after adoption/weight in kg of bags	11.34	14167.80	9084.1031	5345.68275

year, and (iii) their total annual income from cassava sales. The distributions of responses are shown in Figure 2.

In response to all three questions, more than half of the respondents indicated that they had noticed increases. Interestingly, the proportion of farmers reporting an increase in the quantity of cassava sold was lower than the proportion of farmers reporting an increase in income from cassava sales. This discrepancy can be explained by the fact that cassava prices especially when it has been processed strengthened considerably during the past five years. Hence, the total income from cassava sales could indeed have increased even if the physical quantity of cassava sold remained the same or even decreased. Taken together, the responses to these three questions provide additional evidence that the improved cassava varieties with its associated technological package have had a positive effect on the incomes of many rural households throughout the study area in Mezam Division.

If rural incomes have increased because of the improved cassava production technology, how has the income gain benefited rural households?

Through focus group discussions, farmers who reported increased income from cassava sales were asked to describe how the additional income was spent. By far the most common reported uses were paying children's school fees, purchasing building materials to expand or renovate the farmer's house, investing in family-owned retail trading business, purchasing additional agricultural land, paying medical bills and buying new clothes.

The additional income earned through cassava cultivation (much of which presumably can be attributed to the adoption of improved cassava technologies) for the most part seems to have been invested productively, rather than spent on short term consumption.

Social capital

Here, it was examined whether the group membership to which the farmers belonged had increased over time. This is presented in Figure 3.

Results revealed that all the farmers belonged to a group as shown in Figure 3, 61.1% of the farmers acknowledge an increase in membership of their respective groups as a result more farmers adopt the improved cassava varieties. Analyses of outcomes from focus group discussions suggest that beneficiaries increased their social networks as a result of the ACEFA programme. Networks were important for the acquisition of new information and experience-sharing on the improved cassava varieties.

Health status

Here, the health status was captured using the

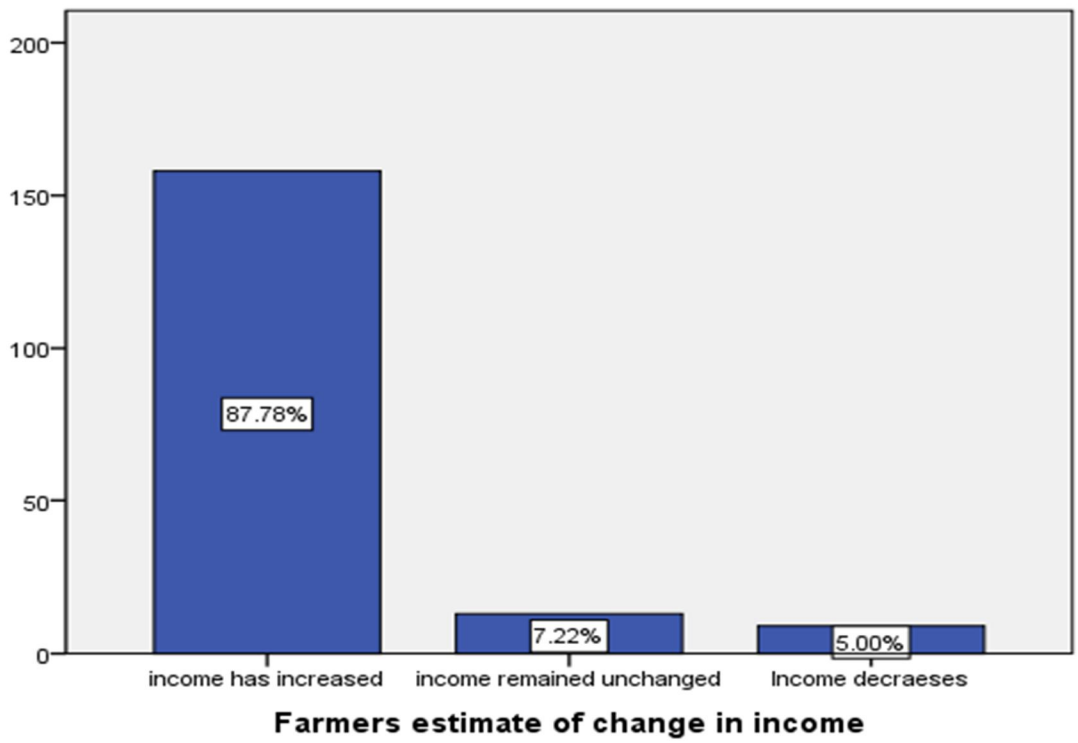

Figure 2. Farmers estimate of change in sales and income.

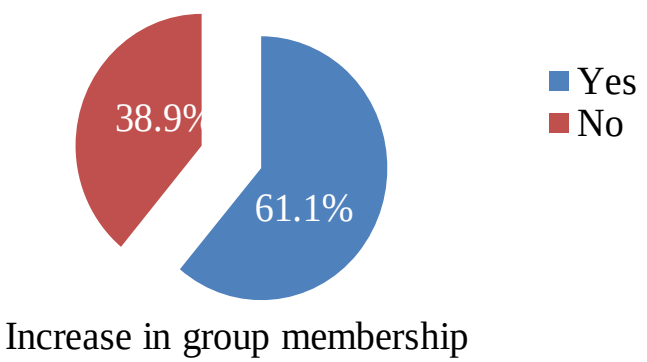

Figure 3. Increase in membership per group.

consumption pattern, the number of meals eaten per day and the frequency with which meat or fish was eaten by the household (Figure 4).

Looking at food consumption and nutrition dynamics, Figure 4 shows that 63.30% of respondents had a general increase in the consumption pattern, whereas the consumption pattern of 35.60% of respondents did not change and just 1.10% of the respondents noticed a decrease in consumption. Further, results from focus group discussion revealed that the average number of meals per day had changed since the adoption of ICPT. Also, the level of "*luxury food*" consumption (meat/fish) on a weekly basis had increased from one to two or three times per week.

Skills

Table 8 presents the different skills gained by the cassava producers. From Table 8, economically, 90% of the farmers explained they have witnessed a change in their farming skills in different ways. The skills include knowledge on how to do proper record keeping (69.4%), the use of improve planting materials (43.9%), farm maintenance (25.6%), post-harvest management (20.6%) and improved cropping system (10%). The percentages indicate the percent of farmers who acquired specific skills. This knowledge is backed by the trainings and formal test/assessment they received from the ACEFA project in Mezam division.

Challenges associated with the adoption of cassava production technology

The challenges faced by farmers which limit their abilities to reap the maximum benefits of the adopted improved cassava varieties are presented in Figure 5.

From Figure 5, it can be inferred that the most troubling issue of the farmers is the lack of feeder roads to transport their farm produce with limited or no damages incurred (close to 48%). This was closely followed by fast decay of the tubers of the improved varieties (close to 44%). Information from focus group discussions revealed that farmers harvest just few ridges of their cassava from farms weekly so as to meet up with market demand since

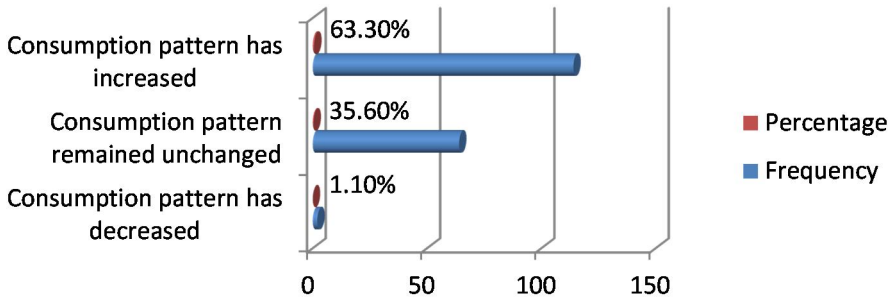

Figure 4. Consumption pattern.

Table 8. Skills acquired by the farmers.

Characteristics	Frequency	Percentages (%)
Post-harvest management	37	20.6
Improve cropping system	18	10
Farm maintenance	46	25.6
Use of improved planting materials	79	43.9
Record keeping	125	69.4

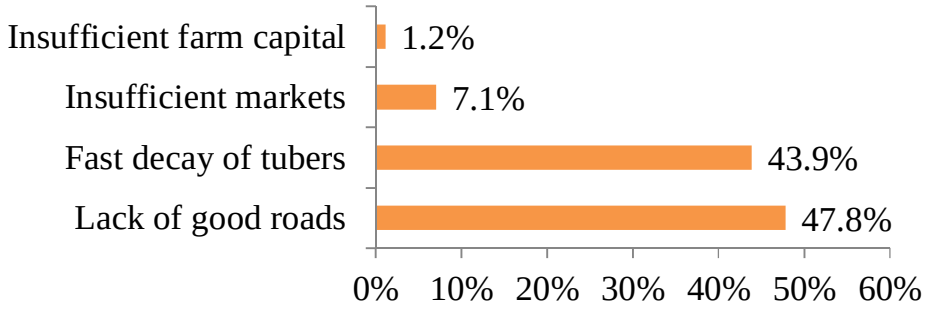

Figure 5. Challenges associated with cassava production technology.

most are being sold in their local markets. Other challenges such as insufficient markets (just over 7%) and insufficient agricultural capital (1.2%) were mentioned by the farmers.

CONCLUSION

The adoption rate of the improved cassava varieties by the farmers was reasonably high (63.90%). The reasons why the farmers adopted were because of high yield and profitability (77.39%), resistance to pest and diseases (18.36%) and early maturity of cuttings. Notwithstanding this level of success, non-adopters claimed that the local cuttings were more available (55.38%) than the improved cassava cuttings and that lack of capital (44.62%) was still acute. Moreover, the age of the farmer, access to credit, the farm size, household size, main source of household income, marital status of the farmer, and level of education of the farmers positively affects their decisions to adopt the improved cassava varieties. Besides, access to agricultural credits (B = 1.513, p = 0.009) and the age of the farmer (B = 0.856, p = 0.027) were of significant importance. Similarly, while the age of the farmer, sex of the farmer, educational level, access to credits, and farm size were positively correlated with the use of chemical fertilizers, it turned out that access to agricultural credits (B = 1.054, p = 0.038) and farm size (B = 0.440, p = 0.040) were also of significant importance. In the same vein, the adoption of the improved cassava varieties improved the welfare of the farming households in their social capital (membership in groups), human capital (improved skills) and financial capital (increase in yields and farm income).

The implications of the findings are straight forward. Ignoring for a moment the considerable practical

difficulties involved in carrying out conventional adoption impacts assessment studies based on standard economic approaches, it is important to recall that most of these studies tend to overlook many of the benefits generated by research projects simply because it is difficult to assign economic value to them. In the case of adoption and impact of improved cassava production technology, such benefits include the following:

1. Better-trained human capital: During the life of this phase of ACEFA programme, hundreds of Mezam cassava producers and extension officers received training. The effects of this training will long outlive the project

2. Improved information: The ACEFA programme generated a substantial amount of information that can and is being put to good use by many different end users in their day-to-day activities. Those households who adopted the improved cassava varieties were able to improve on their yields, sales, farm income and consumption patterns. Also, due to social impact and access to counseling, the cassava producing farmers have been able to improve on their associative life while gaining new skills.

Overall, 47.8% of the respondents complained of poor road infrastructure to transport their farm produce to the nearby market and 43.9% also complained of fast decay of their tubers on-farm. These were the major challenges faced by the farmers. This put into perspective the kinds of decentralized rural infrastructure investments that can have the most direct positive impact towards improving the welfare of rural households. For instance, the availability of feeder roads, storage facilities and reliable energy services can lower the transactions costs of market exchange for farming households, both by improving physical connections and also by reducing information asymmetries. Better physical market connections increase the availability of inputs (improved seeds, fertilizers) and agricultural extension services in addition to improving market access. All of which are likely to increase agricultural productivity and consequently welfare.

Lessons for adoption and impact evaluation

It seems appropriate to conclude with a few comments regarding the nature of the impacts evaluation process. One of the biggest challenges we faced in reviewing the success of adoption and impacts of improved cassava production technology of the ACEFA programme was the difficulty of identifying and quantifying intervention-generated impacts. These tasks were made considerably more difficult because measurable performance indicators were not clearly defined at the outset of the programme and baseline data on such indicators were not systematically collected. This implies that if interventions of a similar nature are to be undertaken in future, more consideration should be given during the project design phase to monitoring and evaluation issues, and resources should be invested accordingly in collecting baseline data that can be used later to measure the tangible achievements of the project.

We mention these “intangible” benefits in conclusion to emphasize once again the difficulty of carrying out applied impacts assessment work. Given the indirect nature of the link between investments made today in supportive counseling and financing in the form of investments and changes realized tomorrow in the welfare of farmers, any attempt to measure and quantify extension work impacts is bound to be incomplete in some respect. The results presented in this research sample provide compelling evidence that ACEFA programme has succeeded in meeting its primary objectives of raising productivity, increasing incomes, and improving nutrition for cassava farmers throughout the MEZAM Division in the North West Region of Cameroon. While this closing note will be welcomed by many of those who contributed to the success of the programme, others will be justified in feeling that certain parts of the story have been overlooked.

Acknowledgments

ACEFA Mezam and a number of individuals played a role in the preparation of this research sample, and although it is not possible to cite all of them, some deserve particular mention. Producer group councilors of ACEFA Mezam were instrumental throughout this study in mobilizing their time to participate in the survey. Mr. Chungong Divine Chenwi of the Divisional Technical unit of ACEFA Mezam embraced the proposal to carry out the study and equally provided, beyond helpful and insightful comments, valuable administrative and secretarial support.

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