Under-utilized crops and rural livelihoods: Bambara groundnut in Tanzania

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Abstract:

Indigenous crops are often neglected in development research, largely because they are grown in particular localities and only account for modest shares of agricultural production at a national level. This article aims to rectify this neglect with respect to the Bambara groundnut using a mixed methods study of farmers in Mtwara, Tanzania. The interest is in determining the importance of the crop in local production patterns and livelihoods, as well as potential levers for improved utilisation. Using the Sustainable Rural Livelihoods framework, we show that the crop is popular and recognised for its agronomic and nutritional properties. They are grown as an additional (or marginal) rather than main crop, with most growers reporting meeting consumption and food security needs as their primary motivation. The absence of markets constitutes a strong barrier towards sales of Bambara, and many farmers report being deterred from growing it because of that.

Keywords: Tanzania, Bambara nut, under-utilised crops, rural livelihoods

JEL classifications: Q12, Q13, Q18, O13, O55

1. Introduction

Social science research on food crops in developing countries focuses on the major crops (such as maize or paddy rice) as these are the most important for production and consumption. An unfortunate consequence is a lack of research on under-utilised food crops, also referred to as marginal or indigenous crops, so we have little knowledge of their contribution to local food security and livelihoods.[1] These indigenous crops are often grown widely in areas where they are particularly suited to local agro-climatic conditions and have attracted attention from crop scientists who recognise the potential for increased production (hence the term under-utilised). Under-utilised crops have features to help achieve Sustainable Development Goals (Bioversity International, 2017; Mabhaudhi et al., 2016): (i) they tend to be resilient and suit local conditions; (ii) they contribute to dietary diversity;[2] (iii) they represent a large pool of genetic resources thereby naturally maintaining biodiversity; and (iv) they contribute to income given the stable local demand in many countries.

In a context of globally stagnating yields for major crops, a greater focus on marginal crops could increase yields and food security, while promoting environmental sustainability. The lack of studies on such crops constitutes a gap in the literature on agricultural development in the African context. Studies recognise that agricultural diversity supports conservation policies (Bellon et al., 2015), risk management and coping with poverty (Di Falco and Perrings, 2005; Michler and Josephson, 2017), but do not investigate socioeconomic conditions associated with specific marginal crops. This study contributes by conducting a mixed-methods socioeconomic analysis of a marginal crop for which new higher yield varieties are being developed, the Bambara groundnut.

Bambara groundnut (henceforth BG) has received more attention in crop science recently than other under-utilised crops because of attractive agronomic and nutritional features (Ani et al., 2013; Azam-Ali et al., 2001; Hillcoks et al., 2012). The crop is widely grown throughout sub-Saharan Africa and is attracting attention in the policy community (Bioversity International and IER, 2017). The seed is considered a 'completely balanced' food with high nutritional potential (Halimi et al., 2019): it is rich in protein, iron and carbohydrates and contains fibre (Mkandawire, 2007; Mayes et al., 2019); the 16-25% protein content is higher

[1] These labels refer to groups of crops which are 'marginal' at the national or regional level, in aggregate terms, even though they may be important to individual farmers who cultivate them.
[2] Bioversity International (2017) notes that only three crops (maize, wheat and rice) account for half of plant-derived calories consumed globally; van der Merwe et al. (2016) show that under-utilised crops constitute an important part of household diets in South Africa.

than that of other legumes (Azam-Ali et al., 2001); it provides fatty acids, phosphorus and potassium (Olayide et al., 2018). Socioeconomic literature on the crop is scarce, an issue that crop scientists promoting the potential of Bambara recognise as a limitation. Greenhalgh (2000) explored the market potential of BG and stressed the need to generate more knowledge as governments and other public bodies do not collect data on Bambara regularly. Forsythe et al. (2015) for Malawi report that production is significantly hindered by some traditional beliefs, such as Bambara only being grown by specific segments of the population (such as older women who lost a child), although the influence of such beliefs is declining.

This study is based on quantitative and qualitative primary data collected in the Mtwara region of south-east Tanzania between September and November 2016, where Bambara is commonly cultivated. As little is known about the crop and why it is grown, exploratory research constitutes an important step. The interest is in determining the extent to which Bambara contributes to local livelihoods; perceptions of the crop by growers, non-growers and consumers; and understanding what prevents increased utilisation. The analysis shows that BG is grown primarily for consumption, valued as a crop by growers and valued as a food by almost all survey respondents. Relatively few growers sell a significant proportion of the crop, and the decision to grow is supplementary to the main agricultural strategy: even in this major growing region, a relatively small share of cultivated land is allocated to BG and it accounts for a relatively small proportion of total farm output. The absence of markets constitutes a strong barrier towards sales of Bambara, and many farmers report being deterred from growing it because of that. Although our case study is limited to the Mtwara region, small-scale studies with quantitative analysis are an important addition to the emerging literature on marginal crops that are under-represented in national level surveys.

2. Study site and survey methodology

2.1 Description of study site

Data was collected in the Mtwara rural district in Southern Tanzania between September and November 2016, in partnership with the Naliendele Agricultural Research Institute (henceforth ARI). The district is part of the Mtwara region, located along the Indian Ocean coast, which shares borders with the Lindi region in the North, the Ruvuma region to the West and Mozambique to the South. This region was chosen as a survey site because of the widespread cultivation of BG, and the involvement of the ARI in research and extension services relating

to the crop.[3] The representative 2011/12 Tanzania National Panel Survey illustrates the prevalence of BG growing in the region: only two per cent of farm households in Tanzania grew BG during the long rainy season but this rose to 11 per cent in Mtwara (the region with the highest proportion).

As the aim was to explore the features of BG growing, the survey focused on the 16 wards where BG can be grown (omitted wards had unsuitable soil types). There is a reasonable degree of heterogeneity in the wards surveyed, in terms of being coastal or inland and proximity to Mtwara city (the regional capital) and most are not connected to major infrastructure by tarmac or paved roads (see the Map in the Online Appendix). There is a high degree of religious and ethnic homogeneity in the district, with 98% of our sample being Muslim and 94% of the Makonde ethnicity.

Farming is predominantly small-scale, with average farm size of 4.37 acres,[4] the same as the national average farm size reported in Carletto et al. (2015) for 2010/11. On average, households farm just over two plots and grow a total of 3.6 crops. Most households entirely rely on family labour for their production (only 34% hired any labour). The main crops (Figure 1) are cashew, cassava, maize, paddy rice and three legumes - cowpeas, groundnut, and BG (the least commercial, see Figure 4).[5] For many farmers, cashew is the main source of income, being an established export crop. Cassava and maize are subsistence crops. Cassava is grown by almost three quarters of households and constitutes the backbone of diets as it is processed into *ugali*, a staple food in local diets together with rice.

****Figure 1 here****

2.2 Survey methodology

For the household and farm surveys, the agricultural extension officer of each ward was commissioned to select farmers in two villages within their ward. Eight farmers were selected per village, five of whom grew BG and three who did not.[6] Due to the oversampling of growers,

[3] The fieldwork was facilitated by the Crops for the Future Research Centre (CFFRC, www.cffresearch.org) who had a project with the ARI to develop new varieties of BG with enhanced yield that are easier to cook.

[4] Farm size is the total size of land farmed during the 2014/2015 season (does not include fallow land). Similarly, we only consider plots that were farmed.

[5] These account for almost 90% of production in the sample; the rest is made of vegetables (such as tomatoes and okra), sorghum, simsim and pigeon peas, all of which represent negligible shares individually.

[6] In the few instances where a farmer failed to show up to the meeting, the officer and the head of village found a farmer with similar characteristics. In one village we failed to find a replacement farmer and therefore had one less observation. In another three villages an additional farmer was present and could not be turned away.

the data is not representative of the overall district population. No register of farmers for the whole district was available, so we relied on the combined knowledge of the ARI team and the extension officers to select a set of farmers within villages.[7] Efforts were made at ensuring an equal split between male and female respondents in each village[8]. In rare occurrences where this was not possible in a village, the balance was maintained at the ward level. In total, 258 households were surveyed, with an almost equal split between respondents in terms of gender (49.6% of female respondents in our final sample). Although there is potential for bias in the sample if extension officers nominated farmers using extension services there is no significant difference between growers and non-growers in our sample: 22% of growers and 24% of non-growers received farming advice in the previous year.

The surveys collected data on household structure, village characteristics, and agricultural data for the 2014/15 long season - which crops were planted, on what area, how much was harvested/sold/stored, information on intercropping practices and storage methods, and inputs (family and hired labour, fertiliser and use of improved seeds). We included statements on BG adapted from Adzawla et al. (2016) with which farmers had to agree, disagree or be undecided (see Table 2). We then asked growers why they started growing the crop, presenting them with a list of options to choose from, such as consumption, income generation or agronomic features. Farmers who were not growing BG at the time of interview were first asked whether they had previously grown the crop or not. Subsequently, those who had grown in the past were asked why they stopped, while those who had never grown were asked to explain why. In the remainder of the text, whenever mention is made of 'non-growers' as a category, it therefore refers to both these sub-groups.

****Table 1 here****

The survey questionnaires were complemented with qualitative data collected in four focus groups in different villages, reflecting the variety of environments found in this area (see Table 1). In each village, we aimed at focus groups with six farmers with an equal gender split.[9] After

[7] We had a very limited budget and three months to complete the fieldwork. In the absence of a sampling frame we relied on local knowledge. Hence the limited number surveyed in each village and the over-sampling of BG growers.

[8] All respondents were either the head or the spouse of the head of household.

[9] This could not be fully enforced. In Nanguni, only one female farmer was present. In Mnazi, the group size could not be kept to six as three additional farmers decided to join and did not leave. In both Mtama and Mwindi the target composition was achieved. Even though focus groups were not sex-segregated, efforts were made at ensuring everyone could speak and express their opinion. Those participants who had not already expressed their opinion were asked to comment on what has previously been said, while those who had contributed repeatedly

questions on general issues faced by farmers, we asked why BG was grown (or not), in what ways was it an important crop, and how it compared with other crops in terms of sales and seasonal availability, storing and cooking.

Finally, we conducted a short semi-structured interview with three agricultural traders at the Mtwara city central market to get background information on BG trade at the wholesale level. All respondents were male, in their late 40s or early 50s at the time of interview. One of the respondents was also the chairman of the local traders' association. We asked traders about the positive and negative aspects of the crop from a wholesale perspective, and about the fluctuation in supply and demand across the year, compared to competing legumes such as groundnuts, cowpeas and pigeon peas.

3. Conceptual Framework and methodology

3.1 Conceptual Framework for Livelihood Analysis

We use the Sustainable Rural Livelihoods (SRL) framework (Ellis, 1999; Winters et al., 2001; Nielsen et al., 2013) to investigate the choice of BG production and sales by smallholders. The framework emphasises the use of crop and income source diversification by smallholders to mitigate the risks associated with increasingly extreme climatic conditions, uncertain agricultural production, and unexpected shocks (Asfaw et al., 2019, Barrett et al., 2001, Reardon, 1997; see Loison, 2015 for a review of the literature). The choice of on-farm (crop and animal production) and off-farm activities of households are shaped by their asset endowments; in particular their natural (e.g. farm land), physical (e.g. machinery, equipment), human (e.g. household workers, education), social (e.g. networks), and financial (e.g. access to liquidity) capital. Limitations may be imposed on the activities and the use of assets by households given their economic, political, and socio-cultural context. Crop production choices take place in a context of multi-input (land, household and hired labour, fertiliser) and multi-output (a variety of cash and food crops) production system, with 94% of households surveyed growing at least two crops and more than half growing at least four. Thus, the separate decisions to grow and sell Bambara need to be understood within the context of the household's overall livelihood strategy, specifically its income and risk profiles as well as the barriers to engaging in potential activities.

were politely asked to let others speak. Issues regarding the participation of women were generally not an issue, except in Mtama, where women initially spoke less.

3.2 Marketing analysis

Within the SRL framework, production and sales of different crops within a multi-input multi-output system are a way to mitigate risks and cope with unexpected household shocks. With respect to BG, the interest is therefore in determining the purpose of sales, and the potential barriers towards greater market participation.

To assess the importance of the presence of a physical market on sales, we estimate models of market participation for BG, cassava and other legumes. Comparing BG with other legumes is important as they share common agronomic features. Market participation is measured as a binary variable equalling one if the household sold any portion of their harvest. Although this only captures the decision to enter the market and ignores the choice of how much to sell, the dataset is too limited to model the latter. Figure 4 (section 4.3) supports marketing as a binary choice as farmers either retain the whole harvest or sell the majority. Studies of market participation for smallholders generally emphasise the role of household assets, geographic factors, and transaction costs (see Barrett, 2008). Our specification incorporates these factors using an expansive set of controls to limit the impact of confounding factors on the key variable of interest, the presence of a village market. About two-thirds of villages surveyed have a general market where all crops can be traded. We exploit this variation to investigate whether it has any effect on the household's decision to sell BG and compare this to the sales of other crops. If selling of BG has a higher dependence on the existence of a village market this would indicate a lack of alternative marketing opportunities.

Denoting market participation for crop c in household j by $Part_{cj}$, we estimate the following specification:

$$Part_{cj} = \alpha + \boldsymbol{\beta_1 Market_j} + \boldsymbol{\beta_2 Female_j} + \beta_3 HH_j + \beta_4 Farm_j + \beta_5 Assets_j + \theta_w + \varepsilon_{cj} \quad (1)$$

We focus in the main text on discussing the effects on participation for two key binary variables: the market dummy (=1 if there is a physical marketplace in household j's village), as absence of market is a key constraint, and the gender dummy (= 1 if the head of household is female). Full output is available in the Appendix together with description of variables (Tables A2 and A3). We include ward fixed effects (denoted by θ_w) to account for unobserved local variation such as geography and agroecology. We present results for estimations with and without ward fixed-effects as some of the variation for market may still be picked up by ward-

level effects (only two villages are observed for each ward). Of the 161 households who grew BG, 148 had a non-negligible harvest of whom 56 (38%) sold some proportion.

4. Results

4.1 Importance of BG

Consistent with the underutilised status and regional nature, farmers tend to grow landraces (traditional varieties that are specifically suited to local agro-ecology) of the crop rather than established varieties. As such, precise yields or agronomic features vary depending on the exact landrace and agroecology considered. However, there are some general features established in the literature: BG is a nitrogen fixer and can enhance the yield of other crops if intercropped; it is highly drought tolerant, with some landraces able to extract water down to a meter (Steduto et al., 2012); and requires little or no chemical fertiliser (Hillocks et al., 2012), an attractive property in the sub-Saharan case where access to fertiliser is often constrained. BG possesses all three properties through which a plant's drought tolerance manifests (Mayes et al., 2019): *avoidance* (maintaining usual physiological activity under mild to moderate stress), *escape* (speeding-up life-cycle in anticipation of water shortage), and *tolerance* (maintaining some physiological activity under drought terminal stress). This resistance to climatic stress makes BG an important crop in a context of globally stagnating yields and climatic uncertainty, particularly so in low-input agricultural systems (Olayide et al., 2018).

Bambara is important for consumption. Within Mtwara BG is commonly eaten on its own (*futari*) before working in the fields, due to its heartiness. It is very popular during the month of Ramadan, due to softness once cooked and the ease with which it is digested. During that time, it is usually eaten with *tambi* (sort of noodles) and *andazi* (local doughnuts). When eaten as part of a full meal, it provides a useful protein-rich side-dish to *ugali* or rice. Focus groups and informal chats with farmers indicate a relationship between landraces and how BG is prepared. When the crop is consumed and sold dried, locals have a strong preference for the creamy type, while when the crop is consumed freshly boiled, red beans tend to be more popular.

****Table 2 here****

Table 2 reports farmers' responses to the eight statements regarding BG, disaggregated by sex of respondent and whether BG is grown in the household or not. Farmers' perceptions are consistent with the benefits highlighted in the scientific literature: there is strong agreement

that BG is nutritious and requires little rainfall and chemical fertiliser, for both men and women as well as growers and non-growers, although agreement rates are higher among growers. There was also strong agreement that BG has good yield (in terms of output compared to other legumes), again with higher support among growers, especially males. Almost all respondents agreed it had good taste, showing the popularity of the crop in the area.[10]

Responses to statements regarding whether BG requires little labour and the availability of markets (understood as a place to sell the crop with a dedicated marketing area) were more mixed. Mixed views on labour requirements could reflect whether and how farmers follow agronomic recommendations (as mentioned above, only 22% of growers engage with extension services). In the focus groups, several farmers highlighted issues related to workload. For example, in Mtama, three farmers expressed the view that ploughing for BG is heavy and one respondent further explained that to get the ploughing done wage labourers would need to be hired. Similarly, responses to the statement 'BG has a good market to sell' are very mixed, especially for females in growing households. Note that the proportion of respondents for *non*-growing households disagreeing with the statement is also high, suggesting that lack of sales opportunity for BG is common knowledge among the population. This was corroborated in the focus groups, in which lack of permanent market to sell was systematically highlighted as an issue, as the following quotes illustrate:

> '*Bambara is a good crop, but we do not have a good market for it, and some farmers stop growing because of that'* Male participant, Nangumi focus group

4.2 Growing BG with the SRL framework

Figure 1 showed that Bambara has the smallest average cultivated area among the most frequently grown crops, at about 0.7 acres and representing just 15% of the total farm size of growing households. Cashew and cassava have the highest average planted areas, and are major sources of cash and food, respectively. Given the oversampling of BG growers we cannot comment on how widespread BG farming is in Mtwara but can see whether crop selection differs between growers and non-growers. Figure 2 shows that Bambara producers are more likely to also grow other legumes and cashews while non-growers are more likely to grow

[10] We also checked if perceptions of BG for female respondents differed based on whether they lived in a male or female-headed household (See Table A1 in appendix). Perceptions between the two subgroups are very similar to results shown in Table 2. The only exceptions are that female respondents from female headed households are slightly more likely to think it is nutritious and laborious to grow.

staple crops (although only the difference for cashews is statistically significant). However, average cultivated areas for these crops are very similar for BG growing and non-growing households, indicating that the main difference is in crop selection rather than farming scale.

****Figure 2 here****

****Table 3 here****

Table 3 compares the characteristics of BG growers and non-growers and shows that there are very few significant differences in the two samples. Growers and non-growers have similar human capital endowments. Growing households do have slightly older heads and a few more years of farming experience on average, but the differences are not statistically significant. Similar results are found for physical and social capital and infrastructure (a proxy for access).[11] For natural capital only there are some significant differences: Bambara growing households have significantly larger farms and more plots (both cultivated and owned): growers on average have around 0.8 additional acres of land (about 17% of their average total farm size) and about 0.3 additional plots of land. However, these differences do not translate to significantly different harvests (measured in kilograms) or farm revenues, so overall income from farming activities is similar. They do, however, appear to affect the types of farm activities households engage in with BG growers being significantly more likely to also grow a wider variety of crops. Off-farm activities are not significantly different for our limited data.

In terms of BG farming practice, it is the least intercropped of all the most frequently grown crops with three-quarters of households growing it as a monocrop (missing out on the benefit of nitrogen fixing).[12] An anecdotal explanation for this was given by a farmer from the Lipwidi ward during the focus group, stating that BG is difficult to intercrop as it needs dense planting and leaves little space for other crops. When monocropped, BG is generally grown on relatively small plots, with 76% of growers planting on 0.5 acres or less. Of the 41 households who intercrop, 38 (93%) intercropped it with either or both cashew and cassava. This is consistent with BG's status as a marginal crop where households either have a small additional plot of land that can be devoted to monocropping BG or where BG can be intercropped alongside the household's main crops.

[11] Housing conditions (types of flooring, walls, roofs, access to water) are similar between growers and non-growers as other indications of wealth. Social capital is more difficult to capture empirically, and we lack data on networks.

[12] About 25% of Bambara plots are intercropped, slightly less than for cashews or paddy, compared to 50% or more of maize, cowpeas and cassava.

4.3 Risk mitigation and accessibility

Bambara groundnut can be important to livelihoods for income or consumption shortfalls and to reduce risk, despite being typically grown on small areas. There may be barriers to entry or expansion that restrict growing.

****Figures 3 & 4 here****

Figure 3 shows the main reason respondents gave when asked why they grow BG. Meeting consumption or food security requirements was the most common reason both male and female respondents gave for growing BG, although women placed much more emphasis on this with 74% putting it as the main reason in contrast to 46% of men. Income generation was the second most common reason, especially for men (21% vs 11% for females). This is confirmed by how Bambara harvests are used by households. The 'other' category is largely made of responses relating to habits, family or community traditions, representing 15% of answers for male respondents and 10% for female respondents.

Figure 4 reports the distribution of households who either fully consume, mainly consume (sell less than half of harvest), or mainly sell their crop harvest (sell more than half) for all the main crops grown in the survey area.[13] Cashew, the main export crop, is almost exclusively grown for selling, while full consumption prevails for subsistence crops like cassava and maize. For Bambara, over 60% of households grow it purely for consumption purposes but around 25% grow it mainly for income generation. Far less of BG is marketed than cash crops and other legumes but more than for staple crops. Consumption is the dominant reason for growing BG and it plays a secondary role in contributing to household income.

The scientific literature emphasises the drought resistance qualities of BG, which may help mitigate the overall risk profile of a household's cropping mix. While farmers did agree that BG growing required little rainfall and chemical fertiliser, very few farmers cited these agronomic features as the main reason for growing BG. Another indication that risk reduction may only play a minor role is that risk of pests and diseases was the third most common reason farmers gave for stopping BG growing (left panel of Table 4). Although similar risks were also associated with growing other crops, especially other legumes, several farmers stressed that they were particularly ill-informed on how to deal with diseases associated with BG. This is

[13] Virtually all unsold produce retained in storage is used for home consumption. Farmers explained in focus groups and informal chats that they kept a few kilograms of seeds in plastic containers to be used for the next planting season, but this represents a negligible quantity relative to harvest.

corroborated by a lack of training/knowledge of BG growing being jointly the most common reason respondents gave for having never grown it (right panel of Table 4).

****Table 4 here****

This knowledge deficit is one example of barriers to entry or expansion which pushes crops such as BG to marginal positions in overall livelihoods, but there are others. The main reason given for stopping BG growing (and joint third for never growing) was requiring a lot of labour time and/or energy to grow (31%). A third of these respondents stopped growing due to illness within the household and another third could not afford the time given other farming commitments. This seems more of an issue for certain households given mixed perceptions of labour requirements for BG (Table 1) and similar mixed responses in focus groups. Lack of access to seeds is another important constraint and was the second most common reason given for having stopped growing BG (18%). All four focus groups also emphasised seeds became scarce and prices rose sharply near planting season. Marketing issues were also commonly cited as a reason for both stopping to grow and never growing in the first place. Interestingly, land constraints were hardly ever cited as one of the main reasons why famers were not growing BG: just 8% said they stopped growing due to a lack of farming area and only one farmer (out of 31) give that reason for never growing.

The focus groups highlighted other problems constraining BG farming such as traditional beliefs specific to BG. In several villages it is believed planting BG too early delays the rainfall for everyone in the village, resulting in BG being planted late in the season which can reduce its yield. However, such taboos are confined to a few wards within the district.

The barriers to entering BG farming do not appear to be binding as seen from the large movement in and out of BG growing; the majority (68%) of non-growers had grown Bambara in the past and 92% of all non-growers stated they intend to grow it in future. While there may be some concerns regarding BG, most farmers appear optimistic that they can grow BG in future. Nonetheless, the decision to plant BG is marginal, being grown on small parcels of land to supplement food security and consumption requirements; BG is of secondary importance compared to other crops.

4.4 Marketing of BG

Focus groups in all villages revealed that the lack of market, understood as a physical marketplace, was an important barrier towards greater commercialisation of the crop. BG is

marketed in low volumes and is not a major source of income: for selling households, mean BG sales were 126 kg (median 75 kg) compared to groundnut with mean sales of 204 kg (median 150 kg), for example. In Mwindi and Mnazi, farmers explained that the sales of fresh BG and dried BG are different in nature. Selling fresh produce is easy and does not require a market: pods can be sold in the field straight after harvest, or in the village to fellow farmers. Such sales, however, tend to be in very low volumes and constitute a marginal source of cash used to cover unexpected expenses, such as health bills. On the other hand, sales of dry BG require a marketplace and is part of a more long-term commercial strategy (planting with the aim to sell). As a result, farmers interested in turning BG sales into a long term viable activity repeatedly complain of absence of market.

Table 5 here

Table 5 presents the average marginal effects from Probit estimates of equation (1) above for BG, cassava and the other legumes combined. The main result is that the presence of a market has a strong positive and significant effect on market entry only for BG: it increases the probability of farmers selling some of their produce by 25 percentage points, a large effect given the average participation rate for Bambara across the whole sample is 38%, and much greater than the largely insignificant effect for other crops. These results confirm that the commercial environment is particularly limited for Bambara: producers may wish to grow or sell more but are deterred by the absence of a market.

Whenever a village market is present Bambara trade increases significantly, potentially because alternative marketing channels are not available for the crop (the negative coefficient for other legumes suggests they have alternative channels).[14] As the market discussed here is a general village market for all crops, we can rule out potential endogeneity as the presence of a general market is unlikely to be affected by households' desire to sell BG especially given its marginal status.

Table 5 also shows that female-headed households are significantly less likely to sell BG than their male-headed counterparts, with likelihood of selling being around 27 percentage points lower, similar in size to the effect of having a market in the village. The importance of this effect needs to be interpreted with caution due to the small sample, with only 18 female-headed households growing Bambara of whom three sold some portion of their harvest.

[14] Alternative marketing channels include commercial networks with city traders (through arrangements with farmers to come and pick up their harvest), some commercial deal with exporters, or even a well-functioning inter-village trade operated through intermediary traders, which does not exist for BG.

Nonetheless, this may indicate that BG is consumed more in poorer households, given that female-headed households are headed by widows[15], or that women tend to give priority to more nutritious crops.

5. Discussion and Conclusion

The previous section established that BG is positively perceived by respondents for its taste and nutritional value and many farmers, not only growers, are aware of its agronomic benefits. It is mostly grown for meeting consumption requirements and is popularly consumed as *futari*, a nutritious early meal for farmers, and during Ramadan. Similar attitudes towards the crop have been observed elsewhere in sub-Saharan Africa, for example in Zimbabwe (Mubaiwa et al. 2018) and Mali (Mbosso et al. 2020), where consumers reported its satiating effect and good nutritional properties as important attributes, and in Ghana where producers emphasized low manure and fertiliser requirements (Adzawla et al. 2016).

Movement in and out of BG farming is fluid, suggesting no specific assets are required to grow the crop, and the survey found no significant difference between growers and non-growers in terms of human, physical or social capital. Limited knowledge or preferences for other crops were the main reasons why some farmers never grew BG, whereas the labour effort and access to seeds were the main reasons why farmers stopped growing. According to its staff members, the ARI has developed improved seeds that can easily be bought by farmers, but most of them are not aware of their availability. Furthermore, strong price variation in seeds also affected the decision to plant with prices peaking around November and December, just before planting season. This issue is not specific to our case study. Berchie et al. (2010), looking at BG farming in the Ghanaian context, stress for example that more than two-thirds of farmers surveyed had to rely on their own seeds of local landraces to plant BG. Seed systems for marginal crops are generally poor (low monitoring of landraces and varieties, high heterogeneity etc.), an aspect now recognised as a limitation towards their greater production and sales (Mabhaudhi et al. 2019). The evidence that many farmers complained of a lack of knowledge (being the joint most common reason for never growing BG) and were not aware of best agronomic practices[16], such as effective use of labour, or how to deal with pests and

[15] The average farm size in female-headed households in our sample is 2.6 acres, as opposed to 4.6 acres for male-headed ones.

[16] Note that awareness of *agronomic benefits* and awareness of *best agronomic practices* need not be aligned. Very often farmers were aware of BG's agronomic benefits (for example, that it requires little fertiliser) but did not know the techniques to be implemented in order to realise these benefits (optimal planting methods).

diseases, is consistent with BG being an underutilised or marginal crop. Farmers were not aware of sowing patterns to maximise production (for example, the optimal space between seeds and across rows of seeds). In Nangumi, the ward agricultural extension officer confirmed this, by explaining that the farming community received frequent information about mainstream crops, but not for BG.

Despite its local popularity, BG is not a key component of livelihood strategies. Rather, it is planted as a useful additional crop by growers of cashew and other legumes. Commercial intent is limited by poor marketing opportunities for BG, an aspect repeatedly emphasized in the focus groups. Limited marketing opportunities for BG in several African countries was stressed in Greenhalgh (2000). Hillocks et al. (2012) emphasize that the absence of well-functioning markets for the crop in sub-Saharan Africa is partly due to lack of promotion and investment in value chains, thus relating to more general findings about marginal crops as a category. These tend to have limited commercial features, be strongly associated with home-consumption and existing trading networks are usually very local (Mabhaudhi et al. 2016). There have been, however, examples of improvements in the commercial potential of underutilised crops. In Tanzania, marketing opportunities for amaranth – another important underutilised crop in the sub-Saharan context - have greatly improved, and a regional trade has now been established providing regular income to farmers (Ebert, 2014).

Similar issues in terms of marketing are observed at a higher level along the value chain too. Our group interview with traders at the regional market centre (Mtwara town) reveals how erratic Bambara trade can be. Despite identifying advantages of Bambara compared to other legumes (such as the nut staying clean for a longer time than other legumes), traders thought of Bambara as a secondary crop from a commercial point of view because bulk buyers are not regular enough for domestic or international markets. There is some trade occurring nationally with traders coming from the neighbouring Lindi region and Dar Es Salaam but these visits are too irregular to be a dependable source of demand. The only regular international trade occurs with traders from Mozambique but this is not large enough for traders to treat Bambara as a priority crop.

Predictions of climatic trends for sub-Saharan Africa, with changing patterns of temperature and rainfall, implies that agricultural strategies based on the intensive farming of a restricted set of crops will be increasingly risky in the future. Resilient locally suitable crops could form

an important part of a defensive agricultural production strategy, especially stress (drought) tolerant crops. Bambara groundnut is one such crop; new varieties are being developed that increase yields and offer potential in many parts of Africa. However, lack of data on the factors discouraging farmers from increasing production limits the ability of crop scientists and extension officers to promote adoption of new varieties. This study addresses the gap by analysing quantitative and qualitative primary data collected in Mtwara (Tanzania).

The analysis shows that BG is widely appreciated throughout the study area, embedded in traditional ceremonies as well as for its nutritional content. However, even among growers, it remains a marginal crop. The majority of growers plant BG for consumption and food security, with income generation a secondary factor. Constraints to production are varied, but labour effort, access to seeds and pests/disease are the main reasons farmers stopped growing, (but almost all expressed a willingness to grow BG in the future). Off-farm sales are low, primarily because of the absence of marketing opportunities at the village level, a constraint that is not observed for competing and more commercial legumes. Improving farmers' agronomic knowledge (such as optimal planting) and access to seeds, especially higher yield varieties, may encourage increased production but to be effective this should be accompanied by expanding local market opportunities. There appears to be a pool of non-growers who could be encouraged (back in many cases) into BG production if made aware of improved opportunities.

The case study covers a small geographical area and a modest sample, so there is only limited statistical variation in important variables such as sales price; sample sizes are not large enough to conduct more advanced econometric analysis. It is one of the first studies to devote attention to a marginal crop and demonstrate the relevance to local livelihoods and production, highlighting that marketing is a major constraint. Attitudes towards underutilised crops cannot be investigated with nationally representative surveys, such as the World Bank LSMS, because marginal crops are not grown with enough frequency at the national level. Local studies are the way to provide research evidence on these crops: 'It is axiomatic that underutilized crops are also under-researched crops' (Azam-Ali et al., 2001:434).

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Table 1: Focus group details

Village (ward)	Village characteristics	Participants
Nangumi (Mayanga)	-Good road access (unpaved road) -Relatively far from urban centre	6 farmers (1 female, 5 male)
Mtama (Lipwidi)	-Poor road access -Far from urban centre	6 farmers (3 female, 3 male)
Mwindi (Mbawala)	-Good road access (unpaved road) -Close to urban centre	6 farmers (3 female, 3 male)
Mnazi (Nalingu)	-Poor road access -Relatively isolated from urban centre -Strong reliance on fishing (coastal)	9 farmers (3 female, 6 male)

Table 2: Perceptions about Bambara

Statements about Bambara	Response (%)	Male Respondent		Female Respondent	
		Non-grower N=47	Grower N=83	Non-grower N=50	Grower N=78
It is nutritious	Agree	57	72	68	68
	Undecided	43	28	30	31
	Disagree	0	0	2	1
It does not require a lot of rainfall	Agree	60	80	67	68
	Undecided	19	4	22	5
	Disagree	21	17	10	27
It does not require a lot of chemical fertiliser	Agree	70	83	60	77
	Undecided	23	12	36	19
	Disagree	6	5	4	4
It has good yields	Agree	70	92	66	78
	Undecided	19	4	28	5
	Disagree	11	3	3	17
It tastes good	Agree	100	98	94	96
	Undecided	0	1	6	1
	Disagree	0	1	0	3
It does not require a lot of labour	Agree	49	42	36	47
	Undecided	15	1	14	0
	Disagree	36	57	50	53
It has a good market to sell	Agree	34	43	44	38
	Undecided	26	18	36	23
	Disagree	40	39	20	38
It can be sold in different forms	Agree	94	99	94	96
	Undecided	6	1	4	3
	Disagree	0	0	2	1

Table 3: Characteristics of Growers and non-Growers of Bambara

	Non-growers N=97				Growers N=161				P-value
	mean	sd	min	max	mean	sd	min	max	
Human Capital									
No. members in household	5.17	1.88	1	11	5.43	2.66	1	28	0.36
No. adults aged 16-65	2.53	1.26	1	9	2.58	1.41	0	14	0.74
Dependency Ratio	1.30	1.04	0	7	1.31	1.09	0	8	0.93
Age of household head	48.01	12.93	22	72	50.80	13.32	23	86	0.10
Gender of head (1 = Female)	0.14	N=14	0	1	0.12	N=19	0	1	0.56
Head has primary education or higher (1 = Yes)	0.60	N=58	0	1	0.62	N=101	0	1	0.64
Had farming training (1=Yes)	0.24	N=23	0	1	0.28	N=44	0	1	0.50
Years spent farming	21.24	12.54	2	50	23.85	14.90	2	68	0.13
No. family workers on farm	2.07	0.74	1	5	2.11	0.70	1	4	0.72
No. hired workers on farm	1.79	3.19	0	16	1.56	2.88	0	15	0.55
Physical and social capital									
Owns means of transport (1=Yes)	0.64	N=62	0	1	0.61	N=98	0	1	0.67
Owns oxen (1=Yes)	0.02	N=2	0	1	0.01	N=2	0	1	0.62
Owns a phone (1=Yes)	0.67	N=65	0	1	0.67	N=108	0	1	0.99
Village/community cooperative (1=Yes)	0.88	N=85	0	1	0.85	N=137	0	1	0.56
Natural Capital									
Farm size (acres)	3.88	3.15	0.25	19	4.66	3.66	0.25	20	0.07*
Number of plots	1.93	0.93	1	5	2.25	1.16	1	9	0.002**
Number of plots owned	1.67	1.06	0	5	2.04	1.23	0	9	0.01***
Rents land (1=Yes)	0.21	N=20	0	1	0.21	N=33	0	1	0.98
Income Activities									
No. of crops grown on farm	3.05	1.41	1	7	3.88	1.26	1	8	0.00***
Grows cashew (1=Yes)	0.44	N=43	0	1	0.58	N=94	0	1	0.03**
Farm revenue (Tshs 000)	532	816	0	4720	648	902	0	6819	0.29
Harvest (total over farm, kg)	833	790	0	4270	890	728	0	3960	0.56
HH has formal job (1=Yes)	0.04	N=4	0	1	0.02	N=3	0	1	0.32
HH has seasonal job (1=Yes)	0.31	N=30	0	1	0.33	N=52	0	1	0.79
HH has any other job (1=Yes)	0.40	N=39	0	1	0.40	N=64	0	1	0.97
Infrastructure									
Grains/legumes market in village? (1=Yes)	0.63	N=61	0	1	0.61	N=98	0	1	0.75
Ward has a main road (1=Yes)	0.29	N=28	0	1	0.23	N=37	0	1	0.30

Table 4: Reasons for not growing Bambara

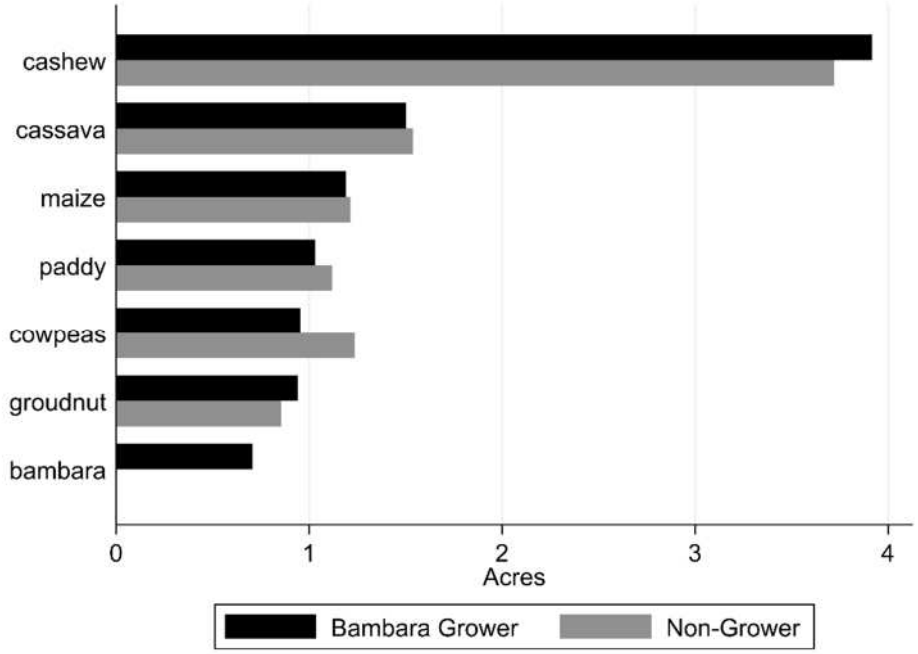
Why stopped growing Bambara		Why never grew Bambara	
Main reason given	%	Main reason given	%
Laborious	31	Lacks training/knowledge	19
Access to seeds	18	Preferences for other crops	19
Pests/Diseases	15	Farming conditions/Weather	13
Farming conditions/Weather	9	Laborious	13
Lack of area	8	Marketability	13
Marketability	8	Taboos	10
Low yield	5	Access to seeds	6
Preference for other crops	5	Lack of area	3
Taboos	2	No specific reason	3
N=65		N=31	

Table 5: Probit Estimates of Market Participation Model

	Bambara		Cassava		Other Legumes	
Market	0.259***	0.248***	-0.015	-0.029	-0.073	-0.159*
	(0.073)	(0.073)	(0.077)	(0.077)	(0.067)	(0.087)
Female HH head	-0.277***	-0.265***	-0.066	0.017	-0.144	-0.082
	(0.089)	(0.090)	(0.097)	(0.121)	(0.127)	(0.091)
Ward fixed effects	No	Yes	No	Yes	No	Yes
Pseudo-R^2	0.36	0.44	0.25	0.41	0.41	0.56
Observations	141	133	168	161	147	141

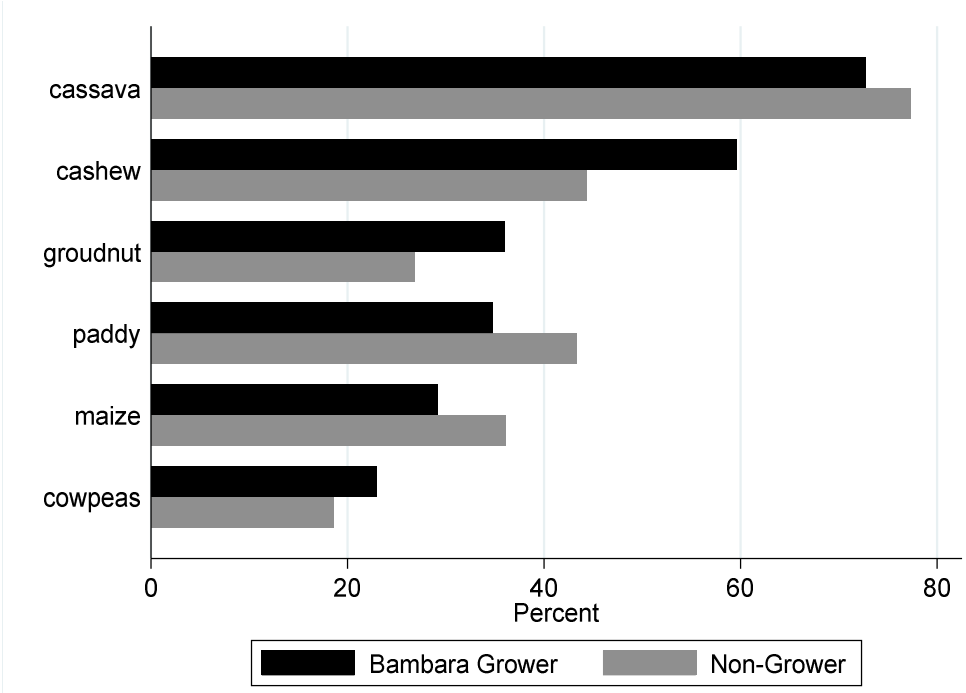
Notes: Full results with all variables in Appendix Table A2, variables as defined in Appendix Table A3. Estimates shown are the average marginal effects. Standard errors (shown in parenthesis) are clustered at the village level and are calculated using the Delta method. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Average Planted Area by Crops, per Household



Notes: Data for the 2014/2015 season

Figure 2: Proportion of farmers growing the common crops



Notes: Data for the 2014/2015 season. Note the BG growers were over-represented in our sample, but national data indicate that about a tenth of farmers in Mtwara grow Bambara.

Figure 3: Main reason for growing Bambara

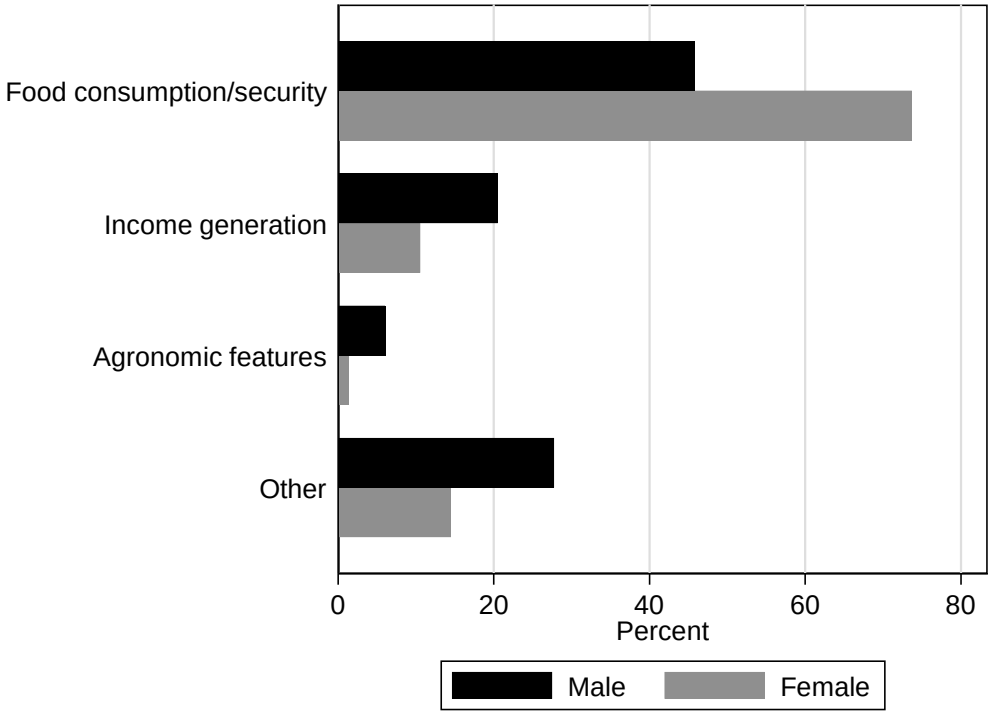
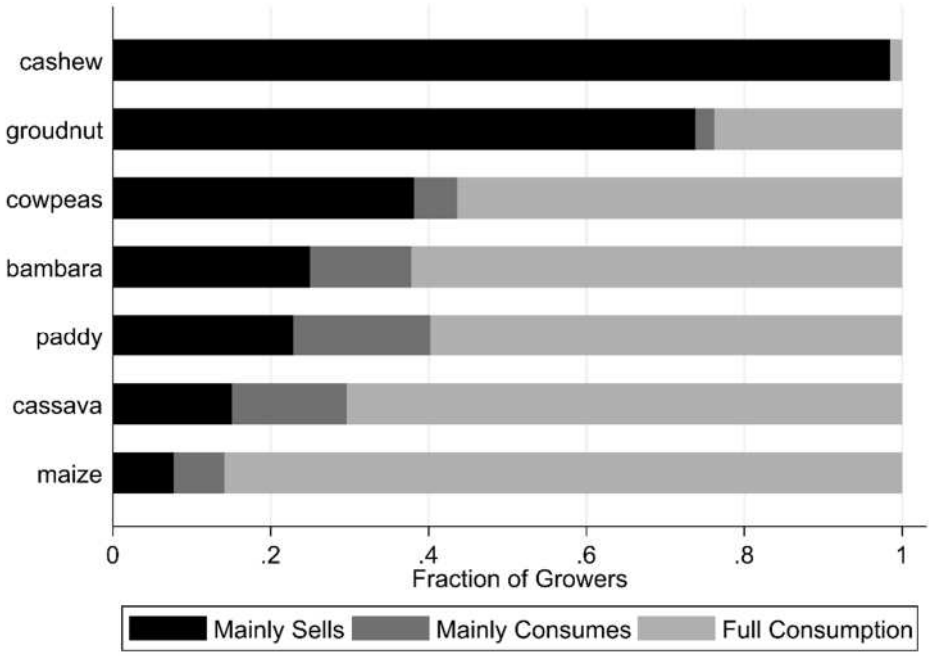


Figure 4: Degree of Commercialisation by Crop



Notes: 'Mainly sells' refers to households who sell more than half of their harvest and 'mainly consumes' refers to those who sell less than half.

Appendix (Online/available on request)

Table A1: Perceptions of Female Respondents by Gender of Household Head

Household grows Bambara	Yes	62	59
It is nutritious	Agree	63	82
	Undecided	35	18
	Disagree	2	0
It does not require a lot of rainfall	Agree	68	68
	Undecided	12	12
	Disagree	20	21
It does not require a lot of chemical fertiliser	Agree	71	68
	Undecided	24	29
	Disagree	4	3
It has good yields	Agree	73	74
	Undecided	14	15
	Disagree	13	12
It tastes good	Agree	94	100
	Undecided	4	0
	Disagree	2	0
It does not require a lot of labour	Agree	49	26
	Undecided	6	3
	Disagree	45	71
It has a good market to sell	Agree	41	38
	Undecided	28	29
	Disagree	31	32
It can be sold in different forms	Agree	97	91
	Undecided	2	6
	Disagree	1	3

As mentioned in the paper, the inclusion of controls in Table A2 is based on the literature on market participation for smallholders which emphasises the role of household assets, geographic factors, and transaction costs. Asset holdings refers to both productive agricultural assets, which directly increases farm output, and private asset holdings, which can indirectly affect output by easing access to credit for productive investments. The former is accounted for in our regressions by farm size, use of chemical fertiliser, and labour input. For private asset holdings, variables in the vector Assets can be used alongside the dummy for being a cashew grower, which proxies access to liquidity as cashew is mainly grown for sale. Owning a mobile phone or a mode of transport can be seen as reducing transaction costs as they facilitate access to information and markets, as suggested in Key et al. (2000). The education of the household head could be used for a similar purpose with search costs being lower for more educated heads (Heltberg and Tarp, 2002). Given the study area, geographic characteristics are generally less important than for national level studies and most variation is accounted for by using ward fixed effects.

Table A2: Estimation of Market Participation Model

	Bambara		Cassava		Other Legumes	
Market	0.259***	0.248***	-0.015	-0.029	-0.073	-0.159*
	(0.073)	(0.073)	(0.077)	(0.077)	(0.067)	(0.087)
Female HH head	-0.277***	-0.265***	-0.066	0.017	-0.144	-0.082
	(0.089)	(0.090)	(0.097)	(0.121)	(0.127)	(0.091)
Dependency ratio	0.040	0.011	-0.006	-0.008	0.056*	0.058**
	(0.048)	(0.049)	(0.034)	(0.032)	(0.029)	(0.028)
HH size	-0.002	-0.006	-0.020	-0.018	0.003	-0.006
	(0.010)	(0.010)	(0.019)	(0.015)	(0.007)	(0.010)
Age of HH head	-0.003	-0.001	-0.002	0.002	-0.001	-0.004**
	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
Primary education	-0.162**	-0.141**	0.109*	0.087	-0.131*	-0.047
	(0.067)	(0.060)	(0.060)	(0.057)	(0.070)	(0.072)
Log harvest	0.150***	0.122***	0.169***	0.142***	0.212***	0.220***
	(0.036)	(0.044)	(0.035)	(0.034)	(0.018)	(0.018)
Cashew grower	-0.215***	-0.207***	-0.022	-0.072	-0.232***	-0.192*
	(0.073)	(0.074)	(0.084)	(0.069)	(0.087)	(0.109)
Crops	0.065**	0.063**	0.027	0.013	0.020	0.006
	(0.032)	(0.027)	(0.023)	(0.024)	(0.028)	(0.026)
Farm size	0.031***	0.028**	-0.001	0.017	0.007	-0.000
	(0.012)	(0.012)	(0.011)	(0.014)	(0.009)	(0.008)
Rent land	0.131	0.025	0.041	0.184**	0.103	0.136**
	(0.080)	(0.086)	(0.088)	(0.081)	(0.072)	(0.064)
Chemical use	0.130	0.204**	-0.054	0.004	0.301***	0.339***
	(0.083)	(0.091)	(0.072)	(0.080)	(0.072)	(0.059)
Family workers	-0.018	0.011	0.082	0.057	-0.127**	-0.057
	(0.039)	(0.040)	(0.052)	(0.063)	(0.062)	(0.050)
Hired workers	-0.016*	-0.033***	0.019**	0.026***	0.003	0.013
	(0.009)	(0.009)	(0.008)	(0.006)	(0.010)	(0.011)
Farm training	0.076	0.115*	-0.168***	-0.165***	0.132**	0.165***
	(0.070)	(0.065)	(0.060)	(0.049)	(0.059)	(0.062)
Transport	-0.159**	-0.114	0.012	-0.022	-0.153**	-0.102*
	(0.070)	(0.091)	(0.080)	(0.093)	(0.065)	(0.059)
Phone	-0.170***	-0.125	-0.021	-0.012	-0.060	0.024
	(0.063)	(0.077)	(0.074)	(0.072)	(0.080)	(0.096)
Mosquito net	-0.027	-0.107	0.156**	0.156*	0.231	0.274***
	(0.128)	(0.149)	(0.077)	(0.083)	(0.141)	(0.083)
Formal job	-0.139	-0.146	-0.039	0.626***	0.286***	0.350***
	(0.087)	(0.154)	(0.173)	(0.023)	(0.096)	(0.071)
Seasonal job	-0.154**	-0.142*	0.009	0.050	-0.005	0.042
	(0.063)	(0.077)	(0.048)	(0.039)	(0.082)	(0.065)
Iron roof	-0.036	0.008	0.075	0.013	-0.069	-0.109
	(0.063)	(0.077)	(0.074)	(0.058)	(0.073)	(0.077)
Ward fixed effects	No	Yes	No	Yes	No	Yes
Pseudo-R^2	0.36	0.44	0.25	0.41	0.41	0.56
Observations	141	133	168	161	147	141

Notes: Variables as defined in Table A2. Estimates shown are the average marginal effects. Standard errors (shown in parenthesis) are clustered at the village level and are calculated using the Delta method. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Definition of variables

Variable	Definition
Household Variables	
Dependency ratio	Ratio of persons between 0-16 and above 65 to the number of persons of working age (16-65)
HH size	Number of persons normally resident in the household
Age of HH head	Age of the head of household
Female HH head	Gender of the head of household (0=male, 1=female)
Primary education	Education of household head (0=less than primary, 1=completed primary or more)
Farm Variables	
Market	Whether there is a physical marketplace in the village (0=no, 1=yes)
Log harvest	Log of crop harvest in the 2014/15 season (in kilograms)
Cashew grower	Did the household grow cashew in the 2014/15 season (0=no, 1=yes)
Crops	Total number of crops grown on the farm in the 2014/2015 season
Farm size	Farm size in acres, understood as total area farmed in the 2014/2015 season
Rent land	Did the household rent any plots of land in the 2014/2015 season (0=no, 1=yes)
Chemical use	Did the household use any chemical fertiliser to farm in the 2014/2015 season (0=no, 1=yes)
Family workers	Number of family workers who worked on the farm in the 2014/2015 season
Hired workers	Number of hired workers who worked on the farm in the 2014/2015 season
Farm training	Has anyone in the household received farming training (0=no, 1=yes)
Assets and Employment	
Transport	Does the household own a means of transport (0=no, 1=yes)
Phone	Does the household own a mobile phone (0=no, 1=yes)
Mosquito net	Does the household own one a mosquito net (0=no, 1=yes)
Formal job	Does anyone in household engage in a formal job (0=no, 1=yes)
Seasonal job	Does anyone in household engage in a seasonal agricultural job (0=no, 1=yes)
Iron roof	Is the roof of the household's dwelling made of iron sheets (0=no, 1=yes)

Map 1: Study site