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Building Resilience for Food and Nutrition Security in Africa: Focusing on Small-Scale Farmers

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Food and nutrition security has become an important policy agenda in the international community. Sustainable Development Goal 2 aims to end hunger, achieve food and nutrition security, and promote sustainable agriculture. However, this goal will likely be challenged by emerging risks such as climate change in many developing countries. The Six Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) predicts that climate change will affect food security, especially in Africa, since the majority in the rural areas are rainfed small-scale farmers who are directly affected by climate change. Thus, policy intervention is urgently required to build climate resilience in the agricultural sector. To envision nutrition-sensitive agricultural production and consumption system, we first need to understand i) how farmers manage climate risks? ii) What technical options enhance farmers' food and nutrition security? This paper tries to present some current evidence regarding those links in the literature, provide some empirical evidence on small-scale farmers in one of the drought-prone areas in southern Zambia, and envision the future direction of research.

Key words: climate risks, food security, nutrition, small-scale farmers, risk management, Zambia

1. Introduction

Food and nutrition security has become an important policy agenda in the international community. Sustainable Development Goal 2 aims to end hunger, achieve food and nutrition security, and promote sustainable agriculture. However, this goal will likely be challenged by emerging risks such as climate change in many developing countries. The Six Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) predicts climate change will affect food security, especially in rural Africa, since most are rainfed small-scale farmers directly affected by climate change (Umetsu et al., 2014). Thus, policy intervention is urgently required to build climate resilience in the agricultural sector.

To envision nutrition-sensitive agricultural production and consumption system, we first need to understand i) How farmers manage climate risks? ii) What technical options enhance farmers' food and nutrition security? This paper first overviews current evidence regarding the links between weather risks, crop diversification, and nutrition security in the literature. We then provide empirical evidence on small-scale farmers in one of the drought-prone areas in southern Zambia using preliminary results from our household survey data. Finally, we conclude by providing future research directions for policy intervention.

2. Literature review: Diversification as a strategy for nutrition and climate risk

(1) Agricultural diversity, diet diversity, and nutritional diversity

Food and nutrition security among small-scale farmers, especially children under the age of 5, has been a significant development agenda, as SDG Goal 2 envisions (Nkonde et al., 2021). Therefore, the critical issue of this policy agenda is to consider how agricul-

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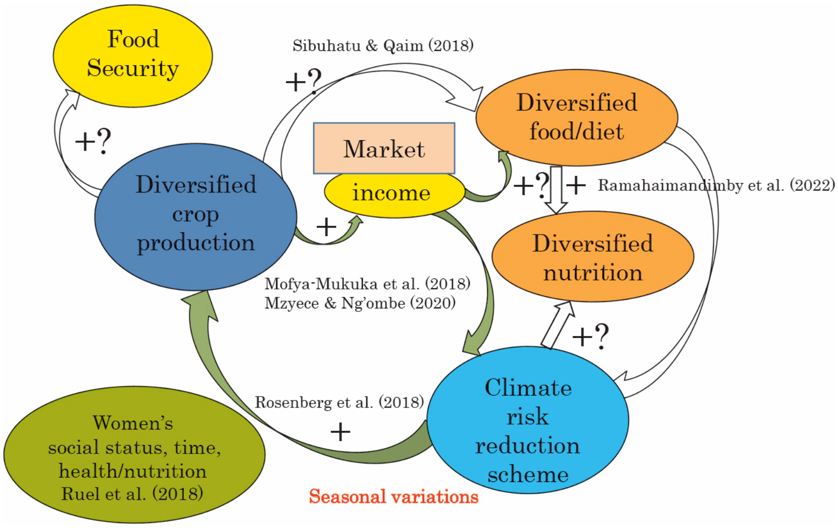

Fig. 1 Pathways linking production and dietary diversifications in nutrition-sensitive agriculture
Source: Authors' construction.

tural intervention, such as nutrition-sensitive agricultural programs, possibly affects food and nutritional diversity.

A systematic review by Sibhatu and Qaim (2018) concluded that crop diversity generally increased diversified diet and nutrition, but the results were mixed. Rosenberg et al. (2018) also concluded that nutrition-sensitive agricultural programs increased crop diversity, but the impact on access to nutritious food was not enough in Zambia.

On the other hand, Ramahaimandimby et al. (2022) asserted that production diversity is associated with dietary diversity and dietary diversity with the nutritional status of children. Mofya-Mukuka and Hichaambwa (2018) also found that crop diversification increased farm income and diet diversity in terms of Months of Household Adequate Food Provisions (MAHFP); however, the impact on improved access to nutritional food was less clear. Concerning income, Mzyece and Ng'ombe (2020) concluded that crop diversification increased farm income stability but reduced technical efficiency. Diversifying subsistence production often contributes less to dietary diversity than cash income (Sibhatsu and Qaim, 2018). As such, the literature revealed that the impact of crop diversity and its effect on diet and nutritional diversity is not straightforward, while diet diversity drive and income drive may exist to achieve nutritional diversity. Furthermore, Nkonde et al. (2021) indicate that other interventions, such as productivity improvement and communication for behavioral change regarding diets, are also required. Figure 1 summarizes the above links.

In addition to those links, under the climate variability and resulting agricultural production variability, production decisions also depend on market conditions, risk preferences, and the severity of production risk faced by farmers. The following section summarizes the literature in this line.

(2) Climate risk and farmers' mitigation strategy

Households in developing countries take *ex-ante* risk management strategies as a behavioral response to missing credit and insurance markets or their impaired functions (Morduch, 1995). The extensive literature has discussed production diversification among available means to mitigate income risks and achieve income smoothing. For example, Bezabih and Di Falco (2012) report that the measured riskiness of a crop portfolio at the household level responds negatively to annual rainfall variability in Ethiopia. As another piece of evidence from Zambia, Arslan et al. (2018) show that the historical variation in the rainy season rainfall can explain diversification measures regarding the following three dimensions: Crop production, livestock production, and income sources. As another type of ex-ante risk management, farmers diversify plots, especially when microclimates are salient (Morduch, 1995).

Risk mitigation through production decisions and adaptation strategies to climate risks can be costly. While variability-reducing inputs and techniques are favored, farmers may be reluctant to invest in riskier profitable inputs and technologies to circumvent investment losses in bad times. For example, Rosenzweig and Binswanger (1993) examine the sensitivity of asset portfolio choice to weather variability by wealth level using the ICRISAT data from India. Their findings show that weather risk motivates poor farmers to select a combination of assets less sensitive to rainfall variation with lower profit returns, with underinvestments in liquid assets and draught animals. Using household panel data from rural Ethiopia, Alem et al. (2010) also find that rainfall uncertainty measured by intra-year variations discourages investments in productivity-enhancing farm inputs like chemical fertilizer.

These previous findings are consistent with the idea that vulnerable households select more conservative but less profitable production modes in their crop choice and land allocation decisions under missing and incomplete financial markets. However, given the tradeoff between income stability and average return, whether agricultural diversification as a response to weather risk contributes to food and nutritional security is an empirical question to explore.

3. Household survey on food and nutrition security in Zambia

(1) Sorghum as an intervention crop

Our research project in the Southern Province of Zambia features sorghum as a potential crop to achieve the above-mentioned dual goals: Ensuring nutrition security and enhancing resilience to climate risk. As a significant benefit on the consumption side, sorghum is one of the cost-effective energy sources with rich micronutrients such as iron and zinc (Kiran et al., 2014). Given the recent increase in diabetes and overweight in urban areas, Zambian people have been gradually aware of the importance of healthy diets. Increased sorghum consumption would directly address micronutrient malnutrition among rural farmers.

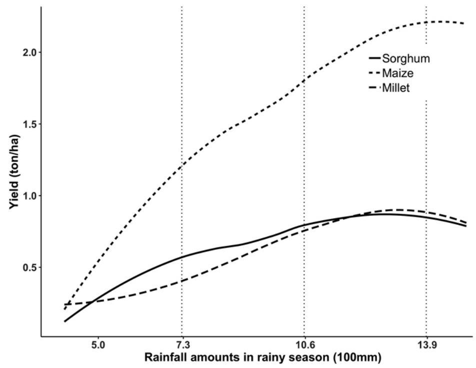

Fig. 2 Yield responses to annual rainfall by crop
Source: Yield data come from the annual Crop Forecast Survey by the ZamStats, 1990–2010. Rainfall data come from the WorldClim historical monthly weather data.
1) Locally weighted regression was used for the estimation.

As an advantage on the production side, sorghum is more drought-resistant than other major cereal crops like maize, the staple crop in the country. Historical data also confirms this salient feature of sorghum crops. Figure 2 illustrates yield responses to rainfall in the rainy season (November to next April) by crop. Yield data come from the district-level statistics between 1990 and 2010 based on the crop forecast survey conducted by the Zambia Statistics Agency (ZamStats, hereafter). For calculating rainfall amounts for the corresponding years, the WorldClim historical monthly weather data were aggregated from the grid cell levels to the district levels. Figure 2 shows that sorghum yields respond less to precipitation than maize, while its average yield is low. Thus, growing sorghum is a low-return but low-risk investment compared to growing moisture-sensitive crops like maize.

Despite these benefits, the government has not promoted sorghum compared to heavy input and output subsidies for maize. As a result, the maize monocropping farming system is dominant in Zambia, and sorghum cultivation is not common. For example, the crop forecast survey shows that only 3.8 (11.3) percent of agricultural households grow sorghum during the 2020/21 agricultural season in Zambia (Southern Province). Because many rural farmers engage in subsistence farming and limited output market participation, it is likely that agricultural diversification directly leads to dietary diversification (Mulenga et al., 2021). Especially market opportunities to sell sorghum harvests still need to be expanded in rural areas, while some brewery companies are interested in purchasing sorghum from local farmers (Hamukwala et al., 2012).

The primary hurdle to disseminating sorghum is the limited access to new seeds (Miyazaki et al., 2020). Local agro-input dealer shops rarely sell sorghum seeds, while farmers protect early mature local varieties in the community (Hamukwala et al., 2012). In addition to this fundamental constraint, bird-inflicted crop losses are expected to be substantial like other crops (e.g., De Mey et al., 2012). Thus, labor burdens for bird scaring may discourage sorghum cultivation.

The natural question is whether relaxing these impediments encourages farmers to take up sorghum and, in turn, fosters nutritional security and resilience to unpredictable climates. This question provides a fundamental motivation for the research project.

(2) April 2022 Census and preliminary results

Our research project answers this outstanding question by conducting a household survey followed by a field experiment with the free distribution of sorghum seeds to farmers in the Southern province. Southern Province provides a good setting for the empirical test for the following reasons. First, this region faces the highest rainfall variability in Zambia and often experiences severe droughts (e.g., Arslan et al., 2018). In addition, the local climate variability reflecting differences in elevation is salient in Southern Province (Kanno et al., 2015). Their available ex-post coping strategies against weather shocks (e.g., livestock sales) are often costly in terms of forgone future income and have a direct link with poverty dynamics (Miura et al., 2012). Thus, alternative risk management measures are warranted. Second, before the nation's independence in 1964 (after which the government started the intensive campaign to promote maize), local farmers had historically cultivated sorghum for a long time (Colson 1959). Given the local history, sorghum still plays a cultural role. Third, household interviews conducted by Miyazaki et al. (2021) in the same study area confirm a keen interest in sorghum cultivation among local farmers. They also find that while farmers consider drought tolerance the most critical factor when selecting indigenous varieties, high profitability is the most concern when choosing improved sorghum varieties.

To define the sampling frame for the field experiment, we randomly selected 12 enumeration areas (EAs) in 5 wards in the Sinazongwe district of Southern Province. Then, in April 2022, we conducted the intensive census survey with all households in the chosen EAs in collaboration with the ZamStats. As a result, we have successfully collected information from 996 households.

Preliminary results from the census provide interesting patterns. About 40% of the sample households have grown sorghum at least once in the last ten years. Average households self-reported having experienced drought for two years in the last decade. The simple regression confirmed a positive association between sorghum cultivation and drought experiences after accounting for time-invariant ward characteristics. In addition, more than 85 percent of the respondents acknowledge the advantage of sorghum over maize in drought tolerance. These patterns suggest that perceived drought risks motivate local farmers to grow sorghum.

We use the household dietary diversity score (HDDS) as an indicator to gauge dietary diversity at the household level. The HDDS is defined as the number of food groups consumed in the last 24 hours by any household member. Following FAO (2010), we designed the questionnaire with 16 coarse-grained food groupings, which in turn were aggregated into the following 12 food groups: (1) cereals, (2) tubers and roots, (3) vegetables, (4) fruits, (5) meat, (6) eggs, (7) fish and seafood, (8) legumes, nuts, and seeds, (9) milk and milk products, (10) oils and fats, (11) sweets, and (12) spices, condiments, and beverages. Our sample average of the HDDs is 7.89, with a standard deviation of 3.90. While the observed dietary diversity is better than expected since the HDDS scored 12 for about 40% of households, the data also show that another 40% consumed only 3–5 food categories on the previous date of the interview. Investigating these significant variations in the HDDS per se is a promising avenue for future research.

(3) Field experimental design

Our field experiment aims to investigate who prefers what sorghum variety for production and establish the empirical pathway from growing drought-resistant crops to food and nutrition security among small-scale farmers. For this purpose, we introduce random variations in access to improved sorghum seeds. In doing so, we randomly divide the sample households into two groups: A group of households freely given to the red sorghum variety (ZSV36R) and the other group of households freely given to the white sorghum variety (ZSV17). Thus, the unit of randomization is the household level.

While both varieties are suitable for food, bird-inflicted crop losses would be minimal for the red sorghum relative to the white sorghum since it contains bitter tannins in the seed coat. If bird scaring is a discouraging factor for the adoption of sorghum, the adoption rate will be higher among the households that received the red sorghum than those that received the white sorghum. As such, if one group has a higher take-up rate than the other, we can estimate the causal impacts of growing sorghum on outcomes of interest, such as household income and dietary diversity, by exploiting the difference in adaptation rates across the groups.

We conducted household interviews as a baseline survey and, in turn, distributed sorghum seeds to the sample households according to the experimental design in September 2022. We plan to conduct a follow-up survey after the end of the 2022/23 rainy season and collect information on agricultural practices during the season. By combining data from the follow-up survey with the random variations in access to new sorghum seeds at baseline, our experiment will explore the potential role of sorghum as insurance against climate risks and examine how sorghum self-production contributes to nutrition security among smallholder farmers in rural Zambia.

4. Conclusion

As a policy to achieve food and nutrition security while coping with the heightened climate risk due to recent climate change, policymakers and researchers have paid attention to nutrition-sensitive agricultural programs. Given the prevalence of subsistence farming and limited participation in output markets, promoting crop diversification can be a reasonable pathway to dietary diversification. However, diversification into less profitable but less risky crops is also a common self-insurance measure to hedge against climate risk in uncertain environments. The tradeoff between risk avoidance and expected profit maximization suggests that the proposed pathway from agricultural diversification to dietary diversification is not straightforward. Because market conditions farmers face and their available *ex-post* coping strategies differ across regions, site-specific evidence is warranted to design the effective agricultural intervention to achieve dual goals: Ensuring nutrition security and enhancing resilience to interannual climate variability in a rain-fed agricultural setting with missing and incomplete risk markets.

Our research project will contribute to this discussion by investigating the role of sorghum as a drought-tolerant crop in the Southern Province of Zambia. Despite its significant potential, sorghum has recently played a minor role as a cereal crop for the livelihoods of Zambian farmers. To explore farmers' responses after relaxing market constraints regarding access to sorghum seeds, we randomly distributed two types of sorghum to local farmers in September 2022. After collecting the data from the follow-up survey at the end of the 2022/23 rainy season, we will examine who adopts the drought-tolerant crop and test the effectiveness of sorghum adoption in food and nutrition security for smallholders in Zambia.

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