IMPACT ASSESSMENT REPORT

Chad

Programme d'Appui au Développement Rural dans le Guéra (PADER-G)

Authors:
Romina Cavatassi
Athur Mabiso
Mohamed Abouaziza
Eric Djimeu

IFAD
Investing in rural people

Cavatassi, R., Mabiso, A., Abouaziza, and M. Djimeu, E.2018. Impact Assessment of the Cereal Banks Intervention in the Programme d'Appui au Développement Rural dans le Guéra (PADER-G), Chad. IFAD: Rome, Italy.

Cover image: ©IFAD/Eric Djimeu

Acknowledgements

The authors would like to thank the Government of Chad and the IFAD Country team for the support provided in conducting this impact assessment. In particular, thanks are accorded to Valantine Achancho and Ibrahima Bamba, who were IFAD country program managers responsible for the PADER-G project at various points in time. We thank the PADER-G implementation team, especially El Hadj Abdoulaye Mahmoud along with Gabpobe Souapebe Aristide, André Boutna and Zoumrou Kalpelbe for their continued support and technical input provided over the course of the impact assessment. Our utmost appreciation goes to the CIBLE Études é Conseil team and their diligent enumerators who collected the data analyzed. Special thanks to Luc Billong and Michel Toukam of CIBLE Études é Conseil. For substantial research assistance and analytical collaboration we thank first and foremost Tim Balint who has been involved from scoping mission through design of the IA plan for his contribution and backstopping also during data collection, Pierre Marion, formerly with IFAD Research and Impact Assessment Division (RIA), Peter Brückmann of IFAD RIA, Deo-Gracias Houndolo and Marie-Eve G. Augier, both from the International Initiative for Impact Evaluation (3ie). Finally, we wish to thank our many other colleagues at 3ie and IFAD RIA who provided backstopping or technical input to the impact assessment at various points in time. This impact assessment was funded by IFAD as part of the IFAD10 Impact Assessment Agenda.

Table of contents

Executive summary

Smallholder farmers in developing countries often lack appropriate cereal storage facilities which can contribute to food insecurity and low cereal commercialization, particularly when they can only rely on one cropping season with no irrigation. Lack of quality storage can lead to post-harvest losses (Abass et al, 2014; Sheahan and Barrett, 2017) and often compels smallholder farmers to sell their crops soon after harvest, when crop prices are at their seasonal lowest, only for them to buy grain for consumption during the lean season, when prices are high (Kadjo et al, 2018; Aggarwal et al, 2018; Stephens and Barrett, 2011). In many instances, such farmers need food assistance to survive the lean season and in other cases, they may have to borrow money at usurious rates in order to purchase food. This was the case in Guéra Region of Chad, a semi-arid area that frequently experiences droughts and dry spells in ways that severely reduce crop production and rural households' food security.

To address these issues, the IFAD-funded Programme d'Appui au Développement Rural dans le Guéra (PADER-G) project was implemented with the main objective of supporting poor rural households and smallholder farmers in Guéra, Chad to improve their food security and livelihoods. One specific aim of PADER-G, designed to manage risks of food shortage, was to improve cereal storage among smallholder farmers through the construction of community cereal banks (*banque de céréales*). This main element of the project was complemented with the establishment of community committees (*Comité de gestion des banques de soudure* – COGES) which were trained on effective management of the cereal banks.

This report documents results of an ex post impact assessment of the cereal banks element of PADER-G. The impact assessment was conducted between November 2017 and September 2018 and employed both qualitative and quantitative research methods. The combination of qualitative and quantitative methods allow measuring impacts through the support of a narrative that both helps understand the meaning of results and yet it guides a more focused and cognizant IA design.

The analysis of quantitative data collected from 2198 households (1066 beneficiaries and 1132 non-beneficiaries) from 94 villages in 11 sous prefectures of Guéra was conducted by using a number of different approaches and propensity score matching methods which proved to provide robust estimates on the impacts of the PADER-G cereal banks intervention on several outcomes of interest, including food insecurity, resilience to drought and security shocks, dietary diversity, grain production (harvest), grain storage, post-harvest losses, and grain sales (market participation). Other areas of potential impact analyzed included social cohesions and women empowerment.

Findings revealed that PADER-G significantly reduced food insecurity, increased dietary diversity and increased the production and yields of major grains and oilseeds (sorghum, millet, berebere, groundnuts and sesame) among project beneficiaries in Guéra. As a result of IFAD cereal banks, food insecurity decreased by at least 37 percent while dietary diversity increased by 23 percent among beneficiary households. In addition, household consumption of sorghum and groundnuts increased by 34 percent and 54 percent, respectively thus explaining the sources of increased food security and dietary diversity. Quantities of sorghum and groundnuts stored also increased in corresponding fashion, with the amount of sorghum and groundnuts stored increasing by 77 percent and 110 percent, respectively. These results reveal that the major crops impacted by the PADER-G cereal banks were sorghum and groundnuts.

Another finding is that PADER-G helped households increase their asset holdings by about 14% overall. Productive assets as well as livestock assets increased by 17% while durable assets increased by about 9% for those households that benefited from PADER-G cereal banks. The improvement in assets is likely due to reduced liquidation of assets for the purposes of obtaining cash to purchase

food during the lean season. Thus, cereal banks appear to have protected households assets from sale during stress periods of the lean season.

In addition, results show that PADER-G beneficiaries were more resilient to violence/civil unrest incidences taking place in their communities. These impacts likely emanate from cooperation and cohesion among members of the COGES, who were reported to be supporting each other beyond food insecurity related strain. In addition, insights from the qualitative data suggest that some members of COGES were now able to provide local insurance support for those experiencing idiosyncratic shocks such as illnesses, theft and deaths. Results also show that thanks to the PADER-G intervention, households were more likely to participate in both agricultural and non-agricultural community groups. This suggests that PADER-G enhanced social cohesion among the beneficiaries in Guéra and is in line with the evidence on improved resilience to civil unrest and local social support system.

While PADER-G had a number of positive impacts, including on food production, consumption, food security and assets, it did not seem to have led to women's empowerment as originally planned. PAGER-G had initially designated twenty out of sixty-six cereal banks for women in an effort to empower women in the beneficiary communities. Although this is an indicator not straightforward and easy to measure, results of the analysis conducted suggest that this may not have been achieved. Future project designs may, thus, need to carefully consider the approach toward women's empowerment, perhaps by using alternative and combined interventions other than just the designation of community cereal banks for women. IFAD supervision mission reports also document challenges with women's empowerment in other areas of the PADER-G project, suggesting that the issue of women's empowerment in contexts similar to Guéra may require special attention and complementary interventions that carefully account for the cultural context (IFAD, 2014).

The results of the impact assessment provide valuable lessons, one of which is the importance of setting smart targets and goals that are not overambitious in contexts where basic needs such as food security and basic public services are lacking and where markets are nearly entirely missing. Thus, the positive impacts of PADER-G on food security and resilience to violence/unrest set a solid foundation for follow up interventions such as the PARSAT project on water for agriculture, which is currently ongoing. Another lesson that can be drawn from the impact assessment is the importance of ensuring sustainability of infrastructure investments. The impact assessment found that some of the non-beneficiary households resided in communities with older cereal banks that had been constructed before, by other development organizations. These older cereal banks were not as effective as the ones recently provided by PADER-G, and one explanation provided through qualitative interviews was that the older cereal banks were no longer well-managed and the infrastructure had deteriorated. Thus, for the PADER-G cereal banks to have sustainable impact, there will be need to put in place mechanisms that allow for continued maintenance and management of the infrastructure. A related lesson is that, by providing training to community cereal bank committees, PADER-G built capacity for the management of the infrastructure. This may have contributed to the higher impact of the PADER-G cereal banks compared to other cereal banks and it is likely that the training provided may enable sustainability of the PADER-G cereal banks' impacts. A separate lesson learned is the role of markets in influencing commercialization decisions of farmers, when they receive an intervention such as the cereal banks provided by PADER-G. Because there appeared to be limited markets linkages and profitability of sorghum, farmers mainly stored sorghum for home consumption while they were able to expand production of groundnuts for sale. Whereas this had positive implications on Food Security and dietary diversity, it was not reflected on income increases through profit and gross margins from selling to the market. As such, future interventions may consider deliberately supporting beneficiaries to access cereals and oilseeds

markets, if the impact of cereal banks is to go beyond food security and include profitable market participation.

Finally, it is encouraging to see that beyond the main objective of food security, cereal banks were able to achieve other impacts such as protecting household assets from distress sale, increased dietary diversity and resilience to civil unrest/violence. This implies that cereal banks can be an effective platform for generating impacts on a number of development outcomes in contexts where basic necessities are lacking for the majority of the people.

1. Introduction

Smallholder farmers in developing countries often lack appropriate cereal storage facilities which can contribute to food insecurity and low cereal commercialization (Jatta, 2016) particularly when they can only rely on one cropping season without irrigation. This is particularly the case in remote areas where rural farm households tend to use rudimentary storage facilities that fail to protect their crop output against a variety of biotic and abiotic stresses, in turn leading to post-harvest losses and reduced food availability (Abass et al, 2014; Sheahan and Barrett, 2017; Tefera, 2012). Smallholders that lack access to quality storage are often compelled to sell their crops soon after harvest, when crop prices are at their seasonal lowest, only to buy grain for consumption during the lean season (Kadjo et al, 2018; Stephens and Barrett, 2011; Aggarwal et al, 2018). In many cases, such farmers need food assistance to survive the lean season and in some cases they may have to sell off their assets to obtain cash for food purchases or send out household members to seek short-term employment elsewhere (seasonal labor migration) to earn income for food purchases (Hampshire and Randall, 2000). Evidence also suggests that high price volatility in rural cereals markets coupled with non-well-functioning or completely missing markets and with post-harvest losses, forces smallholders to grow just enough cereals for home consumption and not much for sale (Jatta, 2016; 2017). Thus, appropriate storage facilities such as community cereal banks can potentially ensure food security and yet mitigate the effects of high price volatility and encourage smallholders to increase cereal production and income from sale of surplus grain (Aggarwal et al, 2018; Tesfaye and Tirivayi, 2018; Chegere, 2018; Sarris and Morrison, 2010). Availability of local cereal storage facilities, such as cereal banks, can also prevent villagers from traveling long distances to buy grain, saving them time, which can be used in other productive economic activities (Rasmussen, 2018) when off-farm opportunities exists.

Cereal banks, among other village organizations, are also a potential platform for improved social cohesion and collective action, which can enhance the impacts of interventions designed to improve rural household welfare (Bernard et al., 2008). The same can be said about leveraging village-level organizations to empower women and address gender disparities. While there is no study showing the impacts of cereal banks on rural women empowerment, there is ample evidence suggesting that village-level organizations and participation of women in community leadership can be useful platforms for improving gender equality in rural settings (Chattopadhyay and Duflo, 2004; Narayan, 2005; Beaman et al., 2009).

To address some of these complex challenges prevalent in Chad, the Programme d'Appui au Développement Rural dans le Guéra (PADER-G) project was implemented with the main objective of building the foundation for a sustainable improvement of food security and income of poor rural households and smallholder farmers in Guéra, a region among the poorest and most food insecure of Chad, where over 87 per cent of the population rely mostly on subsistence smallholder agriculture (Boutna 2016). Yet, agricultural production lacks basic materials and equipment and is increasingly affected by unpredictable and scarce rainfalls. Yields of basic cereals rarely surpass one tonne per hectare and are not sufficient to cover food security needs throughout the year. In fact, during the lean season, men are often forced to leave their villages to work as day-talers to secure their family's basic food needs; but the wages they are paid are often so low that they are forced into taking out loans with usurious interest rates. In addition, farmers are forced to buy seeds right at the beginning of the planting season when prices are highest.

Against these extreme challenges of food insecurity and hunger, the PADER-G sought to address the basic needs of food security through access to safe drinking water, rural road construction, managing risks of food shortage, access to financial services and strengthening farmers' organizations (FOs). In addition it aimed at mobilizing local savings and creating a viable financial services supply system, adapted to the specific needs of the rural households and producers. Its intervention strategy was based on a community participatory approach and the commitment of the beneficiaries. One specific aim of PADER-G, which was designed to manage risks of food shortage, was to improve cereal storage among smallholder farmers through the construction of community cereal banks (*banque de céréales*). This element of the project also established community committees and trained them on effective management of the cereal banks and represent the major component of PADER-G's actual expenditures (IFAD 2016) and as such it is the main focus of the present Impact Assessment (IA)[1]

PADER-G was approved in December 2010 for a total amount of US$20.1 million, of which IFAD financed US$17.4 million. Project activities were completed in December 2016, with a disbursement rate close to 100% (IFAD 2016). The PADER-G project was implemented in line with the Government of Chad's rural and agricultural development agenda. PADER-G is consistent with IFAD's goal of economic mobility and the IFAD strategic objectives of enhancing productive capacity, beneficial market participation, and resilience among rural communities. Overall PADER-G contributed to Chad's development efforts toward the Sustainable Development Goal 1, to end poverty, and Sustainable Development Goal 2, to achieve zero hunger by 2030.

The objective of this report is to present results from an ex-post impact assessment of the PADER-G community cereal banks intervention. The impact assessment employed various methods, which proved robust across a number of estimated impacts. The inverse-probability-weighted matching techniques on household data collected from villages that benefited from the community cereal banks (the treatment) and villages that did not benefit from the PADER-G cereal banks (the control) were used for the main report, however additional results are available in the appendix. The inverse-probability-weighted regression-adjustment (IPWRA) and other variants of matching techniques were used to assess the impact of PADER-G cereal bank interventions on several outcome and impact indicators, including household income, assets, food security, dietary diversity and resilience indicators. Other similar estimators used to check for consistency of results include the augmented inverse-probability-weighting (AIPW) and entropy balancing methods.

The PADER-G cereal banks intervention was selected as an ex-post impact assessments to be part of the IFAD10 Impact Assessment Agenda (IFAD10 IAA) that consists of a broader set of impact assessments across the world. The aim of IFAD10 IAA is to generate evidence and provide lessons for better rural poverty reduction programmes and to measure the impact of IFAD-supported programmes on enhancing rural people's economic mobility, increased agricultural productive capacity, improved market participation and increased resilience. In undertaking this impact assessment, IFAD endeavours to fill key knowledge gaps on the impacts of community cereal banks in rural areas of developing countries, an intervention that has received less attention from impact evaluators.

[1] Activities related to Farmer Organizations and roads under PADER-G are almost entirely disconnected from other project activities and have only benefitted a few villages. Moreover, the Farmer Organizations component foresaw very heterogeneous services for its members, was focused on rather well-off and market-oriented farmers, and only disbursed 38% of its originally foreseen budget (IFAD 2016).

The rest of this report is structured as follows: the next section documents the theory of change and main research questions that the ex-post impact assessments sought to answer. In the third section, the data and methodology for the impact assessments are described, with an emphasis on the identification strategy employed to measure impact. The fourth section presents the results of the PADER-G ex-post impact assessment while the fifth and final section concludes with a summary discussion of the results and a set of key lessons learned from the impact assessment findings.

2. Theory of change and main research questions

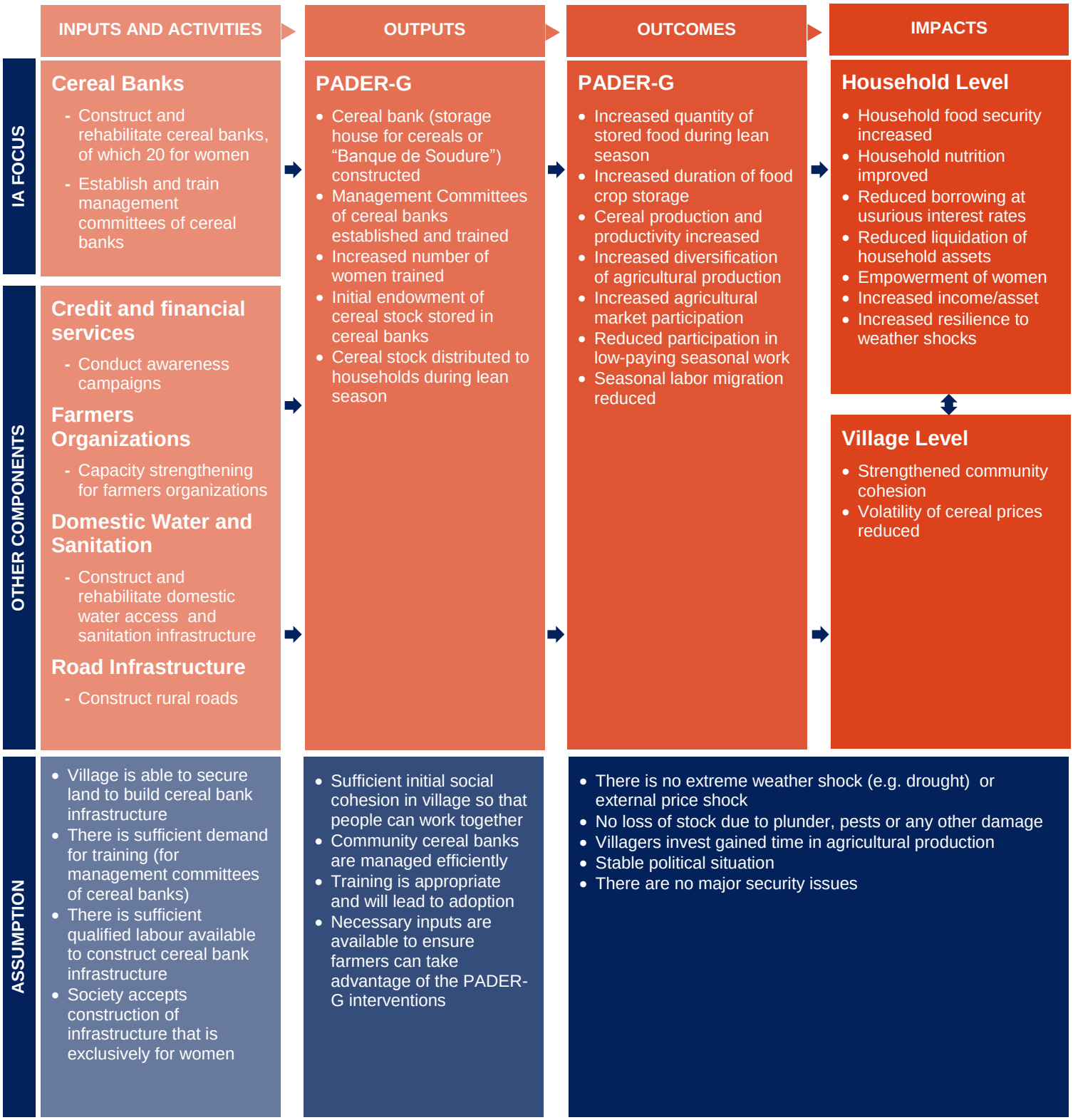
2.1 PADER-G theory of change

The theory of change for the cereal banks element of the PADER-G can be described as one that is relatively simplistic and somewhat linear. The main logic is that provision of cereal banks under PADER-G would smooth grain consumption and reduce food insecurity of beneficiary farm households by allowing them to borrow stored grain from the cereal bank, during the lean season, when grain availability is low and when food prices are highest. Thereafter, the beneficiary households would repay the borrowed grain (principal) plus nominal interest in the form of grain, during the following harvest season. The cereal banks intervention also included establishment and training of management committees, which, in theory, would ensure that the cereal banks were well-managed and in turn would be more effective in administering the grain loans and cereal bank operations in general. As a result of being able to borrow grain from the cereal banks, it was surmised that the beneficiary households would avert borrowing money at usurious interest rates for food purchases during the lean season and that they would also not need to sell off their assets to obtain cash for food purchases. Moreover, it was expected that borrowing grain from the cereal banks would allow beneficiary households to avoid sending off their men to look for wage labour during the lean season, which was a phenomenon previously observed in Guéra, prior to the implementation of PADER-G (IFAD, 2010).

At the community level, the introduction of cereal banks in the PADER-G villages could be expected to reduce grain market price volatility, since the market supply of grain during the harvest season would be reduced as more farmers would be able to store their output; and in the lean season there would be reduced market demand for grain, since cereal banks could cover some of the demand through distribution of stored grain to beneficiary households. Social cohesion and cooperation would also increase due to the introduction of cereal banks, as different households in the community would work together to manage the cereal banks. Also, they could use the cereal banks as a source of grain for local safety nets, e.g. for transferring grain to households particularly affected by disabilities, old age or idiosyncratic shocks such as illness and death (Gyau, et al. 2014).

Some of the outputs that were anticipated from the cereal banks interventions include the cereal bank infrastructure; establishment and training of cereal bank management committees that would ultimately function effectively; an initial endowment of cereal stock, which was to be stored in the cereal banks; and volumes of cereal stock distributed to beneficiary households during the lean season. These would lead to several outcomes and impacts, including increased stored food, increased duration of food storage, reduced participation in low-paying seasonal wage labour markets and reduced sale of household assets to obtain cash for food purchases, particularly in the lean season.

Figure 1: PADER-G Theory of Change



Because PADER-G purposively constructed 20 cereal banks exclusively for women, it was also expected that it would generate gender-differentiated benefits. Households of participating women were expected to exhibit higher food security and increased resilience compared to households that did not benefit from the cereal banks. Moreover, women who participated in the exclusively-women cereal banks were expected to be empowered, especially those women who participated in management committees of the cereal banks.

With respect to the outputs of PADER-G, it is assumed that sufficient social cohesion exists in the villages, so that people can work together on the community project and cooperate with their respective management committees. This assumption is likely to be met because one of the criteria for a village to be selected into the PADER-G project was its level of social cohesion. In addition, it was assumed that the trainings delivered by the project would be appropriate and would lead to adoption of best practices among the cereal bank management committees.

With respect to the outcomes and impacts, it is assumed that markets function well enough to enable supply responses as well as changes in demand that influence some of the impact indicators such as prices, crop diversification, income, assets and food security. It is also assumed that farmers do not face any additional binding constraints to improving their productivity, that their communities have sufficient ability to govern management committees and reasonable enough policy support and conducive environment that allows functioning of the management committees.

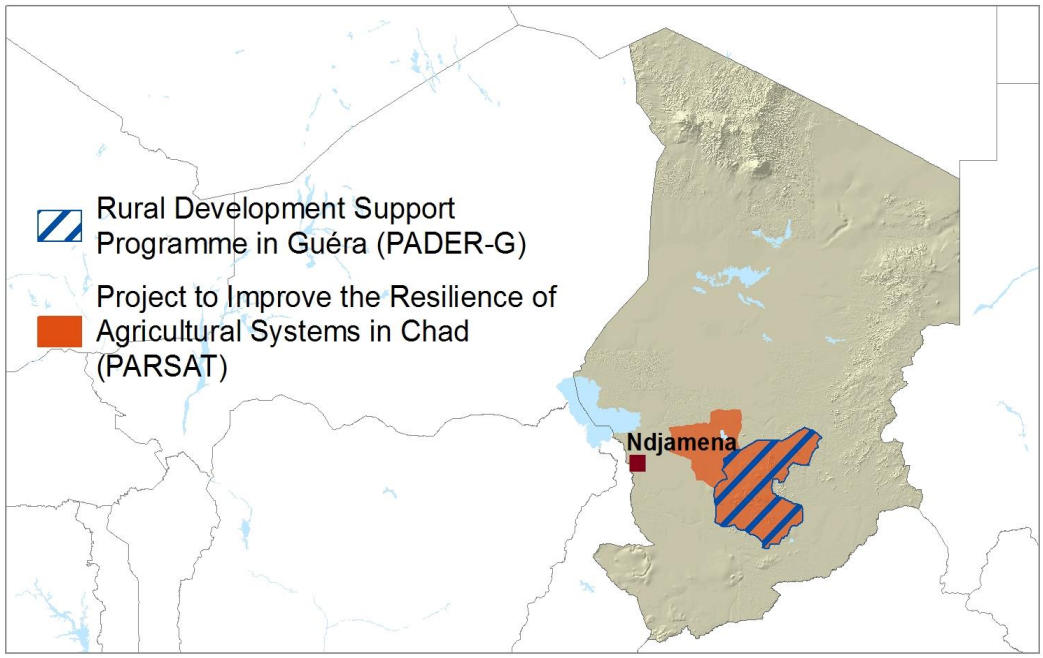
It is important to bear in mind that while the theory of change delineates the intended impact pathways, there may be unintended consequences from implementation of the PADER-G cereal banks. Moreover, there may be spill-over or indirect effects arising from the project, particularly on non-beneficiary households. A potential unintended effect of the PADER-G is unequitable distribution of grain during the lean season, if for example households that were better off borrowed more grain from the cereal banks only to sell it. This issue can be addressed in the impact assessment by assessing the quantities of grain borrowed by income quintiles.

Potential spill-over effects could include borrowing of grain from households that were not members of the cereal banks or investment in cereal banks in nearby non-beneficiary villages, as a result of other project interventions outside of PADER-G or due to imitation by non-beneficiary villages, after observing the benefits of cereal banks in the beneficiary villages. These potential issues could be addressed in the impact assessment by either controlling for the presence of cereal banks in non-beneficiary villages or dropping those households that received grain from the PADER-G cereal banks, even though they were not part of the list of beneficiaries.

2.2 Project coverage and targeting

PADER-G targeted the rural poor of Guéra region in Chad, who live in small, remote villages. Geographically, PADER-G's targeting approach centred on the rural poor in the department of Guéra (Figure 2). This overlapped with the geographic target of the on-going Projet d'amélioration de la résilience des systèmes agricoles au Tchad (PARSAT) project, which is a follow-on to PADER-G.

Figure 2: Geographic scope of the PADER-G and PARSAT projects in Chad



This geographic overlap between the PADER-G and PARSAT lent the two projects well for ex-post and ex-ante impact assessments as it allowed for the use of the same control or counterfactual farmers as a basis of the analysis, thus making the two impact assessments particularly cost-effective.

The main intended impacts of PADER-G were increased food security, through increased storage of grains by beneficiary households. However, the intervention was also likely to generate unintended impacts on households in the control group (spillover effects) such as reduced grain prices during the lean season due to reduced demand, as the beneficiaries of the PADER-G cereal banks were less likely to be demanding grain from the market, having stored grain or having the ability to borrow grain from the cereal bank. While this was likely, in reality it emerged that a large percentage of households in the control group also had other cereal banks, which had been established in the past. Thus, it is likely they too may have had access to some sort of grain storage facility in their community. In addition, markets for both grains and seeds turned out to be rather limited.

2.3 Research questions

While cereal banks have existed for many decades in different parts of the developing world the literature on their impacts is very limited. Beer (1990) is one of the earlier works that begins to investigate cereal banks in Niger, finding that households living in the drought-prone rural Sahel and participating in cereal banks appear more resilient. They are able to cope with low food availability in the lean season. The study is mostly descriptive and therefore unable to control for a number of confounding factors to estimate the actual impact of cereal banks. In a more recent study, Msaki et al (2015) find that cereal banks are often unsustainable and collapse once external support or subsidies are no longer available. While Msaki et al (2015) show some positive association between access to

cereal banks and food security among the participating households, the study uses a small sample of 80 households in one specific arid area in rural Tanzania, rendering the study ungeneralizable.

Using a randomized approach in 40 villages in Northern Burkina Faso, Gross et al (2016) demonstrate that cereal banks can have a positive impact on food and nutrition security. Their results reveal that cereal banks had a large and positive impact on body mass index for both adults and children (a proxy indicator for food and nutrition security improvement). It also appears that the effect was more significant for those households living in more remote areas. In a slightly older study of grain banks in 39 villages in India Meethal Reji (2013) concludes that grain banks had a significant impact on food security, especially for those who were excluded from the targeting of government programs. The success was attributed to the simplicity and transparency of the grain banks' operations, and the healthy relationships between local leaders and beneficiary families fostered by the grain bank platforms. This highlights the importance of social cohesion and effective management of the grain banks to achieve impact.

While there appears to be evidence of cereal banks' impacts on food security, Liu (2016), on the contrary, claims that the problem of food security cannot be solved by cereal banks alone. Instead, it is argued that a comprehensive strategy including food production, animal health, and livestock management is needed. Kent (1998) shows that the failure rate of cereal banks reached up to 90 percent in Niger within five years of the project's inception, and over 80 percent in Burkina Faso after the end of the external support due to miscalculation of potential costs (e.g. costs of physical losses), embezzlement, and poor management. Kent (1998) even claims that cereal banks could harm food security through breaking the traditional relationships between traders and villages. Also Bhattamishra (2012), Mariko et al (2012), and Mwamfupe Davis (2015) found that the lack of adequate storage facilities, delay and non-payment of loans, limited capital, lack of training, lack of business acumen among villagers and mismanagement are among the many obstacles to ensuring success and sustainability of cereal banks.

Given the mixed evidence on cereal banks and the dearth of impact assessment literature on cereal banks, the current study makes a contribution by analysing the impact of the PADER-G cereal banks. Given that most villages of the eligible list had other types of cereal banks that were previously installed, a comparison is also made between PADER-G and non-PADER-G cereal banks in Chad, using various types of propensity score matching approaches, which proved to be robust across several impact and outcome indicators. The specific research questions of this ex-post impact assessment are divided into those that focus on outcomes of the project as well as intermediate research questions that aim at understanding the mechanisms and barriers to achieving outputs and outcomes as outlined below.

Main research questions:

1. Does access to a community cereal bank increase household food security?
2. Does access to community cereal bank increase household dietary diversity?
3. Does access to a community cereal bank increase household economic mobility (crop income, assets and poverty reduction)?
4. Does access to a community cereal bank increase production of various types of crops and lead to crop diversification?
5. Does having access to a community cereal bank increase household resilience?
6. Does the cereal bank alter social dynamics in the village (gender; social cohesion)?

Intermediate research questions:

Are the main outcomes achieved through

a. increased volumes of grains stored?
b. increased duration (time) of household grain storage?

c. reduced post-harvest grain losses?
d. increased crop market access (the price of crops and value of crop sales)?
e. increased sourcing of seeds stored in cereal banks?
f. reduced borrowing from usurious lenders?

3. Impact assessment design: Data and methodology

3.1 Data

The design of the PADER-G impact assessment used a mixed-method approach. Both quantitative and qualitative data were collected, with the latter being collected prior to quantitative data collection to help inform the design of the quantitative survey. Moreover and equally important, the qualitative data were used to inform interpretation of the quantitative results. The qualitative data were collected using focus group discussions and key informant interviews, which were conducted in October 2017. A separate report documenting in detail the qualitative findings is available elsewhere (CIBLE, 2017), however relevant findings have been incorporated into the present document.

Qualitative data

The qualitative data analyzed in this report were collected from 20 to 31 October 2017 in seventeen villages in the Guéra region with 93 respondents, including 59 men 34 women and 19 young people (18-25 years). Five different survey instruments were used. These survey instruments are the following: one group discussion guide whose target was the populations living in the PADER-G villages; one group discussion guide whose target was the populations living in the control villages; an interview guide for members of the PADER-G Coordination and Management Unit; an interview guide for community leaders (village chiefs); and an interview guide for the managers of the cereal bank management committees (COGES). Thus, we conducted - seven focus group discussions in seven villages including: four PADER-G villages and three villages control. In addition, we conducted nine key informant interviews including three with COGES officers, three with community leaders, and three with members of the PADER-G Coordination and Management Unit. All the data collected for this qualitative survey were mainly collected in Chadian dialects. Also, the recordings made during the collection were transcribed in Arabic and translated into French. Analysis of the qualitative data entailed a manual synthesis of transcripts using thematic, content and narrative analyses to provide a robust picture on different aspects related to PADER-G. These aspects include the selection process of PADER-G villages, the management of COGES, the potential impact of PADER-G on food security, stock management of stored crop output, agricultural production, livelihoods, resilience, social cohesion and migration.

Quantitative data- community level

Community-level surveys were conducted in Guéra to collect quantitative data at the community level, including data on local market prices, availability of alternative grain storage at village level and pre-existing infrastructure characteristics, such as water collection points, public school buildings, healthcare facilities, access to financial services, transport, and agricultural extension centres among other facilities and services. In addition, the community survey collected data on the existence of agricultural cooperatives, farmer organizations, and other type of community organizations such as women's credit and support groups, which could all be used for matching villages through propensity score matching.

While data were collected at the community level, it is important to note that the unit of analysis for both the PADER-G impact assessment is the smallholder farm household. This is linked to the unit of intervention, which is at the community level, through the notion that farm households would participate as members of cereal banks and respective management committees and would ultimately receive direct benefits, as reflected on several outcomes identified and measured through this IA.

Quantitative data- household level

Given that the impact assessment of PADER-G used the same counterfactual as the one for PARSAT, a separate IFAD-funded project in the Guéra region, the quantitative data collection was coordinated to ensure that it catered for assessing impacts of both PADER-G and PARSAT interventions with adequate statistical power. The total sample size from the quantitative data collected for the PADER-G impact assessment was 2,198 households as shown in Table 1, which also presents the breakdown of the sample by intervention group and by Sous Préfecture.

Table 1: Geographic distribution of the PADER-G sample by treatment group

Sous Préfecture	Non-PADER-G	Treatment PADER-G	Total
Commune de Bitchotchi	31	32	63
Baro	222	128	350
Bitkine	127	127	254
Chinguil	0	64	64
Eref	126	190	316
Mangalme	32	51	83
Melfi	32	124	156
Mokofi	62	32	94
Niergui	347	191	538
Mongo	153	127	280
TOTAL	**1132**	**1066**	**2198**

Quantitative data were collected between November 2017 and January 2018 in the Guéra region. The household data collected consisted of variables on food consumption, the food insecurity experience scale, agricultural production, land parcel sizes and crop output, as well as socio-demographic characteristics, seasonal migration, off-farm labour participation, women's empowerment, asset ownership, storage practices, experience of shocks and subjective measures of resilience thereof, access to credit, and receipt of external support from various sources. Numerous other variables were included in the questionnaire to capture quantitative data on a number of relevant factors that were either used for matching or were controlled for in the analysis.

In each village, 30 households were surveyed. In PADER-G villages, with a random number table, 30 households were randomly selected from the list of households participating in the PADER-G cereal banks for interviewing. The populations in the Sahel region live in groups of 4 to 5 households and are distant from each other; we used a different approach to select the 30 households in non-PADER-G villages. Due to difficulties in obtaining the list of people living in selected villages, in non-PADER-G villages, we used random-walk technique to sample households surveyed. Based on the 2009 census data of all villages in the Guéra Region, we calculate the sampling interval (the number of households in the population divided by the number of households needed for the sample). We throw a pen in the air to randomly determine the direction where to start the sampling. From a random number table, we select a random start between 1 and sampling interval. We repeatedly added the sampling interval to select subsequent households.

Constructing the counterfactual villages for PADER-G

Prior to data collection project documents were reviewed and discussions held with the project management unit, during field visits conducted in eight PADER-G beneficiary villages. Through these documents and discussions, it was established that receipt of the PADER-G interventions was demand-driven and based on an assessment of needs and capacity to implement the project interventions. Based on this information, the first stage of the quantitative data collection was designed to identifying PADER-G and non-PADER-G villages that shared similar baseline characteristics related to both programme selection and outcomes. In order to achieve this, propensity score matching was performed using 2009 census data of all villages in the Guéra Region. The characteristics used to perform the propensity score are shown in **Table 2**.

Table 2: Variables used for PADER-G propensity score matching at village level

Variables	Definition	Unit of measurement
Ethnic_group	Dominant ethnic group in the village	Dummy variable
Water_point	Number of water collection points	Number
Population	Population size	Number
School	Number of schools built	Number
Health	Number of health centers	Number
Cereal bank	Number of cereal banks	Number
Microfinance	Number of microfinance	Number
Market	Weekly market	Dummy variable

Note: Data sourced from the 2009 census data

According to information obtained during discussions with the project management staff, the data collected for these variables are likely to be related to both programme selection and outcomes of this impact assessment. For each PADER-G village, at least two nearest matches from the non-PADER-G villages were identified. The trimmed list of matched villages was then shared with the project management staff who, based on their contextual knowledge of the Guéra Region, advised on non-PADER-G villages to exclude because of issues related to potential spill-over effects and contamination. A detailed description of the village-level matching and subsequent sampling of households is contained in the Impact Assessment Plan (Cavatassi et al, 2017).

To assess the balance of the distribution of characteristics before and after the matching, we use normalized difference. Normalized difference assesses balancedness of the distribution of characteristics from the matched sample as the result is invariant to sample size (Imbens, 2015). This approach is important when the sample size is small. The normalized difference is obtained by dividing the difference in means of the measured covariate by the average standard deviation in both groups. Ho et al. (2007) and Harder et al. (2010) considered that a normalized difference of less than 0.25 is considered satisfactory for balancedness. We find that the matched sample is not significantly different in characteristics.

Constructing the counterfactual households for PADER-G

Given that our ultimate interest is in assessing impacts of the PADER-G project at the household level, we implemented another level of matching at the household level within the matched level after data collection. Based on the quantitative data collection at the household level, we found that 727 out of 1104 households from the control villages have cereal banks that were built before the PADER-G project from a different type of intervention. As such, our strategy is to assess the impact of the IFAD-funded cereal banks (1,104 households) compared to households without any cereal

bank (337 households). We also compare non-IFAD cereal banks (727 households), versus households without any cereal banks. This double comparison would allow us to estimate the impacts of the IFAD-funded cereal banks versus other cereal banks, thus better attribute the impacts to the project IFAD funded as opposed to the generic intervention, namely cereal banks . Therefore, we ended up constructing counterfactuals for households in villages where IFAD-cereal banks exist as well as households in villages where there were other cereal banks. Our household-level matching procedure included variables at both the household and community levels shown in Table 4**Error! Reference source not found.**.

Table 3: Variables used for propensity score matching at household level

Variable	**Definition**	**Unit of measurement**	**Data source**
gender	Dummy variable that takes 1 if household head is male	Dummy variable	Household Survey
head_age	Age of household head	Years	Household Survey
head_attended_school	Dummy variable that takes 1 if household head attended school	Dummy variable	Household Survey
married	Dummy variable that takes 1 if household head is currently married	Dummy variable	Household Survey
hh_max_edlvl	Maximum level of education for household members	Categorical variable	Household Survey
departement3	Dummy variable that takes 1 if a household exists in Guéra	Dummy variable	Household Survey
village_p_market	Dummy variable that takes 1 if a village has a periodical market	Dummy variable	Community Survey
village_farmer_group	Dummy variable that takes 1 if a village has a farmer group organization	Dummy variable	Community Survey
village_assistance_nr	Number of assistances received by a village during the past 5 years	Number	Community Survey

The matching results are presented in

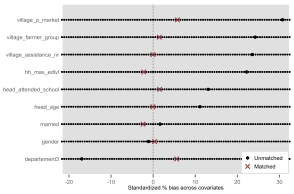
Figure 3 and show that all variables help in reducing the bias after matching in both IFAD-cereal banks and non-IFAD cereal banks. The matching results thus reveal that the standardized percent of bias is significantly reduced across all matching covariates. In addition, all observations are located within the common support, with different weights for each observation reflecting its importance in the matching procedure. That is reflected in a reduction in Rubin's Bias[2] from 57.8 % to 10% for IFAD cereal banks and from 62.8% to 10.8% for non-IFAD cereal banks. In addition, the Rubin's Ratio[3] is 1.37 for the former and 1.15 for the latter, both of which are within the recommended range of (0.5, 2) (Rosenbaum & Rubin, 1985; Rubin, 2001).

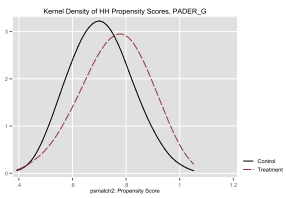
Figure 3: Matching results at the household level

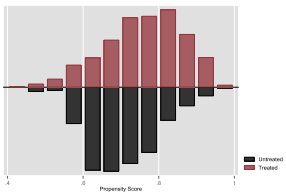
[2] Rubin's Bias is the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group.
[3] Rubin's Ratio is the ratio of treated to (matched) non-treated variances of the propensity score index.

Treatment: 1,097 observations (IFAD cereal banks)

Control: 377observations (without cereal banks)

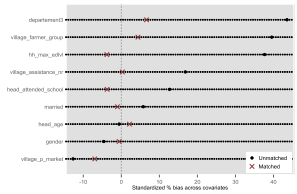


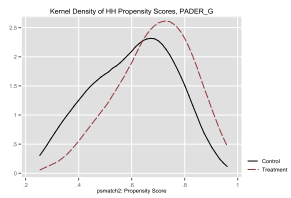




Treatment: 727observations (Non-IFAD cereal banks)

Control: 377observations (without cereal banks)





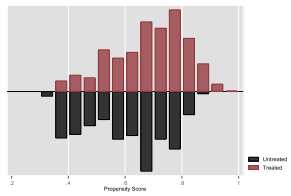


Table 4: Summary statistics before and after matching for IFAD cereal banks Vs pure control

IFAD cereal banks	Before matching				After matching				Reduction in Bias (%)
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat Mean/SE	Control Mean/SE	p-value	Bias	
gender	1.24	1.24	0.853	1.11	1.24	1.24	0.962	0.34	69.26
	(0.01)	(0.02)			(0.01)	(0.02)			
head_age	44.20	42.63	0.066*	11.10	44.20	44.21	0.991	0.08	99.28
	(0.43)	(0.72)			(0.43)	(0.73)			
head_attended_school	0.18	0.13	0.034**	13.06	0.18	0.17	0.856	1.52	88.39
	(0.01)	(0.02)			(0.01)	(0.02)			
married	0.64	0.63	0.785	1.63	0.64	0.65	0.735	2.42	-48.47
	(0.01)	(0.02)			(0.01)	(0.02)			
hh_max_edlvl	1.25	0.98	0.000***	22.20	1.25	1.28	0.770	2.25	89.88
	(0.04)	(0.06)			(0.04)	(0.06)			
departement3	0.41	0.49	0.003***	16.96	0.41	0.38	0.416	5.55	67.27
	(0.01)	(0.03)			(0.01)	(0.03)			
village_p_market	0.37	0.23	0.000***	30.75	0.37	0.35	0.489	5.77	81.25
	(0.01)	(0.02)			(0.01)	(0.02)			
village_farmer_group	0.62	0.50	0.000***	24.26	0.62	0.62	0.837	1.44	94.05
	(0.01)	(0.03)			(0.01)	(0.03)			
village_assistance_nr	1.04	0.78	0.000***	23.57	1.04	1.04	0.993	0.07	99.72
	(0.04)	(0.05)			(0.04)	(0.06)			
No. of observations	1 099	377			1 097	375			

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 5: Summary statistics before and after matching for non-IFAD cereal bank vs pure control

IFAD cereal banks	Before matching				After matching				Reduction in Bias (%)
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat Mean/SE	Control Mean/SE	p-value	Bias	
gender	1.22	1.24	0.466	4.62	1.22	1.23	0.937	0.59	87.30
	(0.02)	(0.02)			(0.02)	(0.02)			
head_age	42.55	42.63	0.925	0.59	42.55	42.26	0.814	2.12	-257.58
	(0.50)	(0.72)			(0.50)	(0.77)			
head_attended_school	0.18	0.13	0.051*	12.68	0.18	0.19	0.695	3.75	70.42
	(0.01)	(0.02)			(0.01)	(0.02)			
married	0.66	0.63	0.362	5.78	0.66	0.66	0.892	1.03	82.09
	(0.02)	(0.02)			(0.02)	(0.03)			
hh_max_edlvl	1.45	0.98	0.000***	37.64	1.45	1.50	0.688	3.80	89.90
	(0.05)	(0.06)			(0.05)	(0.07)			
departement3	0.70	0.49	0.000***	43.55	0.70	0.67	0.362	6.60	84.85
	(0.02)	(0.03)			(0.02)	(0.03)			
village_p_market	0.18	0.23	0.043**	12.67	0.18	0.21	0.327	6.99	44.87
	(0.01)	(0.02)			(0.01)	(0.02)			
village_farmer_group	0.69	0.50	0.000***	39.52	0.69	0.67	0.556	4.35	88.99
	(0.02)	(0.03)			(0.02)	(0.02)			
village_assistance_nr	0.95	0.78	0.010**	16.83	0.96	0.95	0.982	0.26	98.47
	(0.04)	(0.05)			(0.04)	(0.07)			
No. of observations	727	377			726	375			

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

3.2 Questionnaire and impact indicators

Quantitative data were collected using a household questionnaire between November 2017 and January 2018 in the Guéra region. The questionnaire consisted of questions on household food consumption, food insecurity experience scale, agricultural production, land parcel and plot areas and crop production related variables, as well as socio-demographic characteristics, seasonal migration, off-farm labour, women's empowerment, asset ownership, storage practices, experience of shocks, access to credit, and receipt of external support from various sources.

A community-level questionnaire was also used to conduct a community-level survey and collect data on local market prices, availability of alternative grain storage at village level and pre-existing infrastructure characteristics, such as water collection points, public school buildings, healthcare facilities, access to financial services, transport, and agricultural extension centers among other facilities and services. In addition, the community survey collected data on the existence of agricultural cooperatives, farmer organizations, and other type of community organizations such as women's credit and support groups, which could all be used for matching villages through propensity score matching. At the household level, from PADER-G and non-PADER-G villages and qualitative data from beneficiaries and financial service providers. The unit of analysis for both the PADER-G is the smallholder farm household.

The treatment variable is participation in a PADER-G cereal bank, which is a binary variable denoting whether a household is a PADER-G cereal bank beneficiary or not. There are several outcome variables of interest. The primary outcome variables include agricultural production, crop diversification, household income, food security, dietary diversity (nutrition) and resilience indicators. In addition, other variables were used in our analysis, some as matching variables and others as control variables. Overall the questionnaires have been built with the purpose or measuring the main indicators on which impacts are to be expected given the logic of the project and its theory of change as well as to comply with IFAD main strategic objectives as in accordance with the objectives formulated for the project with the Government of Chad. To this purpose the following main categories of indicators have been measured.

Agricultural production, productivity and uses of major crops

Given the focus of the project, the IA looked at agricultural production and productivity for the major crops that farmers cultivated during their major season during 2017 (Rainy Season 2017). These crops include millet, sorghum, groundnuts, sesame, berebere and penicilaire. We estimate the impact on the probability to cultivate these crops and check whether, thanks to the storage opportunity offered by the cereal back there is any substitution effect with different types of cereals or crops. In addition, the impact on productivity as measured by yields (harvest per hectare) as well as multiplication ration (kilograms harvested per kilograms of seeds planted) was assessed. We also check the impact on uses of the crops harvested, including home consumption, sales, animal feed and other uses. Finally, to test the effectiveness of cereal banks' storage capacity, we estimate the impact on the quantity stored, duration of storage and post-harvest losses of grains stored.

Food insecurity and diet diversity

Reducing food insecurity for farmers is the main objective of the cereal banks element of the PADER-G. We measured the Food Insecurity Experience Scale (FIES) following the FAO's guidelines, which is based on eight questions that reflect household's access to adequate food during 2017 (over the last 12 months before the data collection). These questions refer whether 1) a household worried that they would not have enough food to eat, 2) they were unable to eat healthy and nutritious food, 3) they ate only a few kinds of foods, 4) they had to skip a meal, 5) they ate less than you thought you should, 6) ran out of food, 7) they were hungry but did not eat, and 8) went without eating for a whole day. In addition, we estimate the effect of cereal banks on these eight components of the FIES to have a comprehensive picture of the impact.

Along with the FIES, dietary diversity is measured at household level following the FAO's guidelines, which measure household ability to access 18 food groups. We use the last week as a reference (FAO, 2010).

Economic mobility

The economic mobility include both income and assets indicators which are the main impact indicators at household level. The income indicators are the gross income from main grains and oilseeds farmers cultivate. These include sorghum, millet& penicilaire, berebere, groundnuts, sesame. Overall asset index that could be used as a solid measures for household economic status (Filmer and Scott, 2012). The overall asset index encompass four assets indices to give a comprehensive picture for household wealth. These indices include durable asset index, productive asset index, livestock asset index and housing asset index. While the first three indices are computed using the principal components analysis (PCA) as the questions used to compute them are continuous, the multiple correspondence analysis (MCA) was used to calculate the housing asset index given the categorical nature of their questions. For the overall asset index, the principal components analysis based on the polychoric correlation is implemented, which allows to combine both continuous-based indices with categorical-based ones (Kolenikov and Angeles, 2004).

Market access

Some proxy indicators in terms of amount of sales and prices were also used to ascertain whether having a well-functioning cereal bank allows for storing the grains and selling them in the first place, and if so selling them where prices are higher and more profitable. On the input side we also looked at the source of seeds and access to credit to check whether the cereal bank allows alleviating borrowing money for grains and seeds at usurious prices and improve the seed sourcing.

Resilience

As a proxy for resilience, we use household's ability to recover from the top three significant shocks encountered over the 12 months prior to the start of the data collection. The resilience index is adjusted by the severity of each shock to allocate different weight depending on shock severity. In addition to the overall resilience index for the top three significant shocks that was encountered by farmers in Chad during 2017, we calculated the index for each of these shocks to check whether farmers reacted differently for different shocks as a result of the intervention of interest. The top three significant shocks used for the overall resilience index might be different from one farmers to another, whereas for the one-shock resilience indices, we focused on the top three shocks that were encountered by most farmers in Chad. They are successively from top: drought, crop pests or disease and local unrest/violence.

Social Cohesion

Last but not least, to measure the impact on social cohesion, we used a set of proxy variables that asked the respondents whether they participated in certain agricultural as well as non-agricultural groups in their community combined with number of household members participating and frequency of meetings. The total number of community agricultural groups and the total non-agricultural groups were used, with higher numbers implying increased community-level participation by the household.

3.3 Impact estimation

We used non-experimental methods to assess the impact of cereal banks on different outcomes of interest. Specifically, we used several matching approaches, namely propensity score matching to the Inverse Probability-Weighted Regression-Adjustment (IPWRA), Augmented inverse-probability weighting (AIPW) and Entropy Balancing. These treatment effects models allow us to identify the impact of the cereal banks interventions in the PADER-G by matching the beneficiaries with the households in the control group (counterfactual) and comparing the two. The IPWRA estimators combine inverse probability weighting and

regression adjustment methods to achieve more efficiency in estimating the impact of cereal banks on our different outcomes of interest, while AIPW estimators are efficient and have relatively good properties when the conditional mean and conditional probability functions are misspecified.

The estimation of the propensity score requires, first, to choose the econometric model, and second the variables to be included in the model. As suggested by Smith (1997), when the purpose of the model is to estimate the probability of treatment, logit and probit models usually yield similar results. Thus, we use probit models. Regarding the inclusion (or exclusion) of variables in the propensity score model, conditional independence assumption requires that conditional on the explanatory variables, the outcomes must be independent of the treatment (intervention). Consequently, only variables that simultaneously influence the treatment decision and the outcome variables should be included in the model. In addition, the variables to be included in the model must be unaffected by the treatment or the anticipation of the treatment.

Specifically, for the estimation of the treatment equation, we include in the model, variables that are available, predict the probability to live in a village with a cereal bank, and influence our outcome variables. Specifically, we use simultaneously two approaches regarding the inclusion (or exclusion) of covariates in the propensity score model. We use statistical significance approach and existing evidence about the determinants of the probability to receive community-based social and economic infrastructures for the inclusion (or exclusion) of variables in the propensity score model. Statistical significance approach relies on statistical significance. We start with a parsimonious specification of the model, e.g. a constant, age of head of household, education of head of household and department dummy and then 'test up' by iteratively adding variables to the specification. A new variable is kept if it is statistically significant at conventional levels. This approach substantially increases the prediction rates (Heckman et al, 1998). In addition, variables used in existing evidence about the determinants of the probability to receive community-based social and economic infrastructures are used in the process of the inclusion (or exclusion) of variables in the propensity score model.

Estimation of the treatment effect under nonexperimental settings and specifically using propensity score matching (PSM) has recently become increasingly popular in social science research. There have been a number of reviews on the theoretical background related to PSM (Heckman et al., 1998; Dehejia and Wahba, 1999; Morgan and Harding, 2006), its practical applications (Becker and Ichino, 2002; Abadie et al., 2004; Imbens and Wooldridge, 2009) as well as some empirical studies in agricultural economics using PSM (Liu and Lynch, 2011; Mayen et al., 2010). The basic idea of PSM is to generate treatment and control groups that have similar characteristics such that comparisons can be made between these matched groups. The propensity score $P(X)$ is the estimated probability of receiving treatment given a set of background covariates. The difference in the average outcome of treatment and control groups can be attributed to the program under the assumption that selection into program participation is based on observable factors alone.

Let Y_{1h} and Y_{0h} be the outcome variables for a household that is a cereal bank member in a PADER-G village and a household in a non-PADER-G village, respectively, and $D \in \{0, 1\}$ be the indicator of treatment. The propensity score $P(X)$ is defined by Rosenbaum and Rubin (1983) as the conditional probability of receiving treatment given observed characteristics:

$$P(X) = Pr(D = 1|X) = E(D|X) \tag{2}$$

Where X is a multidimensional vector of observed characteristics.

Given the propensity score $P(X)$, the average effect of treatment on the treated (ATT) can be estimated as follows:

$$\begin{aligned} \widehat{\boldsymbol{ATT}} &= \boldsymbol{E}\{\boldsymbol{Y_{1i}} - \boldsymbol{Y_{0i}}|\boldsymbol{D_i} = \boldsymbol{1}\} \\ &= \boldsymbol{E}[\boldsymbol{E}\{\boldsymbol{Y_{1i}} - \boldsymbol{Y_{0i}}|\boldsymbol{D_i} = \boldsymbol{1}, \boldsymbol{p}(\boldsymbol{X})\}] \\ &= \boldsymbol{E}[\boldsymbol{E}\{\boldsymbol{Y_{1i}}|\boldsymbol{D_i} = \boldsymbol{1}, \boldsymbol{p}(\boldsymbol{X})\} - \boldsymbol{E}\{\boldsymbol{Y_{0i}}|\boldsymbol{D_i} = \boldsymbol{0}, \boldsymbol{p}(\boldsymbol{X})\}|\boldsymbol{D_i} = \boldsymbol{1}] \end{aligned} \tag{3}$$

Equation (3) gives the average program impact under the conditional independence (CIA) and overlap assumption.

Inverse probability of treatment weighting (IPTW)

The first and main approach used to assess the effect of the cereal bank on the outcome variables is the IPTW model. IPTW has been widely used in impact evaluation literature (see Lunceford and Davidian, 2004; Joffe and Stuart, 2015). It consists of estimating a multivariate regression model, using the propensity score as sampling weight. Several studies suggest that weighting the data with the propensity score balances the distribution of covariates and results in fully efficient estimates (Rosenbaum, 1987; Hirano and Imbens, 2001; Hirano et al., 2003). For ATT, the weight is defined as equal to 1 for households that live in a PADER-G village and are a member of the cereal bank and the inverse of one minus the propensity score $\hat{P}(X)/(1-\hat{P}(X))$ for households that live in non-PADER-G villages. For comparison and robustness, we implement this approach by estimating the following multivariate regression with propensity score as weights:

$$\boldsymbol{Y_{hv} = \beta_0 + \beta_1 PADERG_h + \beta_2 AP_v + \beta_3 VC_v + \delta X_h + \lambda_v + \epsilon_h} \quad (4)$$

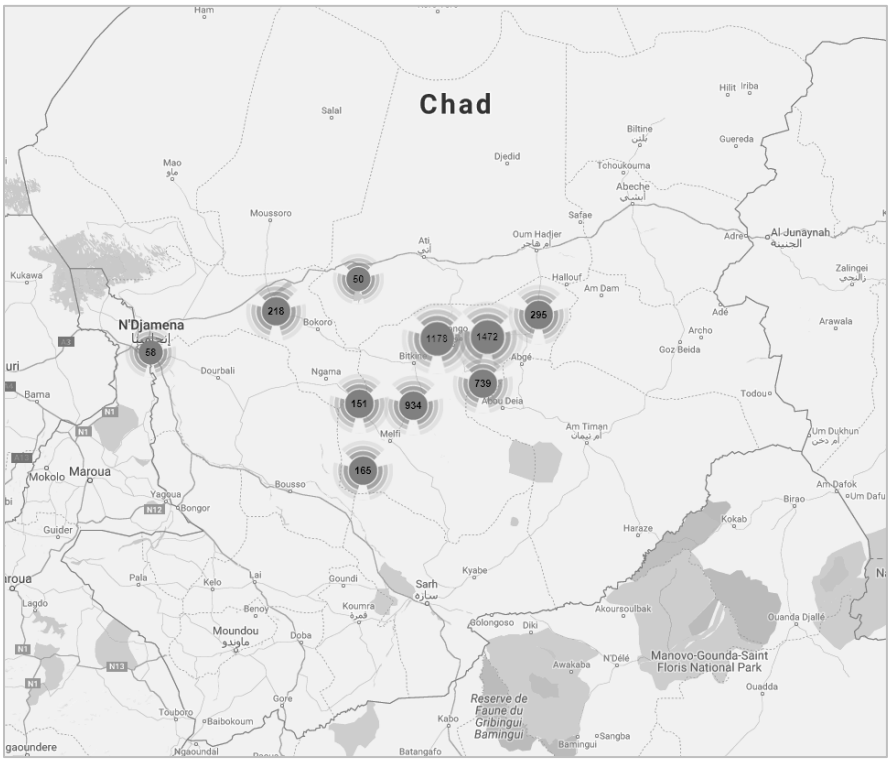
Where Y_{hv} is the outcome variable for household h in village v; $PADERG_h$ is an indicator variable that takes the value one if the household h is a member of the cereal bank in a PADER-G village and zero otherwise; AP_v includes variables for different assistance programs received by village v between 2012 and 2017; VC_v represents village characteristics (access to a primary health center, periodic market, etc.) that could affect the outcome variable; X_h includes household socio-demographic variables (age and education of head of household, household size, household composition, etc.); λ_v indicates village fixed effects that captures characteristics at village level that are time invariant; and ϵ_h is the error term.

4.Profile of the project area and sample

4.1 Project contexts

As alluded to earlier, PADER-G was implemented in Guéra, Chad. Geographically, Guéra region is situated in the central Sahel zone (Sahel belt of Chad), sitting at an altitude of about 450 meters above sea level, with a relatively flat topography and an area of about 53,000 square kilometers (UN STATS, 2009). With a population of about 553,795, Guéra experiences extremely high temperatures (between 40 and 50 degrees Celsius) and relatively low levels of rainfall (normally 50-250mm per year). Thus, the region is semi-arid in nature, though it has potential for irrigated crop and livestock farming, with a major agricultural market in semi-urban Mongo, which is situated about 500 kilometers east of the capital city, N'djamena. Guéra also has a long history of conflict (de Bruijn and van Dijk, 2007) and while in recent years there have been improvements in the security situation, sporadic incidences of violence and theft still occur. Figure 4 shows the geographic dispersion of the households that were sampled[4] as part of this impact assessment. A majority of the sampled households are located close to Mongo, with another sizable number located near Melfi, another small town in the Guéra region.

Figure 4: Location of households sampled for the PADER-G cereal banks impact assessment



This population lacks basic infrastructure and services such as safe drinking water, proper sanitation[5] facilities, health and education services. In addition, it has poor access to financial services and transportation (IFAD 2010). The main income source for the majority of the population (over 87 percent), is subsistence smallholder agriculture with the main crops grown being sorghum, millet, berebere,[6] groundnuts, sesame and maize (Boutna 2016). Agricultural production in Guéra is characterized by lack of basic farm inputs and equipment and the area is increasingly affected by unpredictable and low rainfall. Cereal yields rarely surpass

[4] The figure includes those households sampled as part of the PASART ex ante impact assessment, which is an on going assessment of the follow-up IFAD-funded project being implemented in Guéra

[5] Poor sanitation is one of the major challenges in Guéra as demonstrated by one of the worst cholera outbreaks in 2011, with 1,754 cases recorded for the region, and 1,181 in Mongo (UNICEF-Chad, 2018).

[6] Bere bere is a small grain which is a local variety of millet. It is considered a different crop in Guéra region.

one tonne per hectare and are insufficient to meet food security needs for most households. During the lean season, households often experience food insecurity with children exhibiting acute malnutrition (Tesfai et al, 2013). Men are often forced to leave their homes to find work elsewhere, to secure supplemental income needed to buy food. However, the wages they receive are so low that they often have to take out loans from usurious lenders. Some households also depend on food assistance, mainly in the form of cash-based transfers, which are distributed to food insecure households by the United Nations' World Food Programme and government agencies (WFP-Chad, 2018).

Against this harsh context, the PADER-G project sought to secure the basic needs of the affected population in Guéra through investments in basic infrastructure and related community capacity building. Well-functioning and organized community cereal banks combined with facilitated access to credit and financial services were provided to mitigate the impacts of the lean season. IFAD invested US$2.4 million in the construction of 66 community cereal banks – of which 20 were exclusively built for women. An additional US$0.6 million was invested in capacity building of the cereal banks management committees (COGES – *comité de gestion*). The main purpose of cereal banks was to smooth household grain consumption over the agricultural cycle. This was to be achieved by providing grains to member households during the lean season, which the beneficiary households would then repay during the harvest season with an in-kind interest rate that covered operational costs (Bhattamishra 2008). The community cereal banks of PADER-G were also supposed to provide a mechanism for social cohesion and cooperation among households, in the case of low harvests or temporary or permanent disability of villagers (Gyau, et al. 2014).

Unfortunately, because targeting of beneficiaries under PADER-G was fragmented, there was a disconnect between the various project elements and respective beneficiaries. This was particularly the case for the road construction, water and sanitation, and farmers' organization interventions. Nonetheless, the community cereal bank beneficiaries were clearly identifiable, hence this was selected as the only element of PADER-G for impact assessment. Financially, activities related to the community cereal banks represent a major component of PADER-G's actual expenditures further justifying its selection for impact assessment (IFAD 2016).

It is important to note that several other food security projects have previously been implemented in Guéra, including IFAD-funded projects such as the Food Security Project in Northern Guéra (PSANG II). In addition the World Bank's Emergency Agricultural Production Support Project (World Bank, 2017) as well as OXFAM Great Britain's Improving the Food Security Information System in Guéra Region (commonly referred to in its French acronym PASISAT) are among the numerous food security interventions that have previously been implemented in Guéra. PSANG II and PASISAT both supported the construction and management of cereal banks as well (Cardenas and Fuller, 2016).

5. Results

This section presents the results of the analyses of the impact of PADAER-G cereal banks. In addition, the analysis presents impacts of non-PADER-G cereal banks which were found to be present in villages that did not receive the PADER-G project. The presentation of results is complemented by a discussion of the results that combines insights from the qualitative analyses as well as the descriptive statistics from the previous section for a comprehensive understanding of project impacts.

5.1 Overall impacts of PADER-G Cereal Banks

Production and productivity

Looking at agricultural production disaggregated by type of crops for the main crops, results suggest that IFAD cereal banks had a positive impact on crop yields and were more successful compared to other cereal banks in making farmers more efficient, as demonstrated by the impact on yields of major grains and oilseeds as measured in terms of kilograms of output per hectare and kilograms of output per kilogram of seeds used (i.e. the multiplication ratio). Kilograms of output per hectare for sorghum, sesame and groundnuts increased by 67 percent, 47 percent and 87 percent, respectively (Table 6). Results on the output input ratio (output in kilograms per kilogram of seeds planted) show similar impacts, albeit with smaller magnitudes.

Results find that the IFAD-funded PADER-G cereal banks did not have any impact on the area of land cultivated for most grains. At the same time, cereal banks did not result in farmers diversifying the portfolio of crops grown – no change in the number of different crops grown. Given that PADER-G cereal banks were mostly a storage intervention and not a productive asset transfer intervention or promotion of crop diversification, it is perhaps not surprising that no impact was found on land area expansion for major grains or crop diversification, particularly considering that the area is rather dry and without irrigation facilities and farmers need to concentrate on staple crops. Nevertheless, there was evidence of increased land allocation to groundnuts production as a results of both IFAD and non-IFAD cereal banks. This may be a result of groundnuts, an oilseed, being the main commercial crop grown in Guéra. If household began to experience food security and increased productivity in grains they perhaps began to increase production of their main commercial crop (groundnuts) in an effort to also increase their incomes.

Table 6: The impact of cereal banks on yields and output-seed ratios of major crops

	PADER-G cereal banks					Non- PADER-G cereal banks			
	Harvest per hectare	Harvest per seeds ratio	Log (Land Use)	Obs		Harvest per hectare	Harvest per seeds ratio	Log (Land Use)	Obs
Grains	0.471***	0.322***	-0.00379	1,328		0.230	0.0124	-0.0587*	1,008
	(0.133)	(0.0690)	(0.0256)			(0.164)	(0.0896)	(0.0344)	
Sorghum	0.686***	0.294***	0.00825	1,096		0.308	0.0269	0.0114	818
	(0.178)	(0.0966)	(0.0262)			(0.196)	(0.115)	(0.0365)	
Millet-Penicilaire	0.436	0.197	-0.0687	409		0.649**	0.0624	-0.126*	273
	(0.278)	(0.130)	(0.0438)			(0.292)	(0.151)	(0.0652)	
Berebere	0.427	0.0499	-0.0390	240		-0.278	-0.461	-0.0410	128
	(0.431)	(0.221)	(0.0671)			(0.478)	(0.286)	(0.0951)	

	PADER-G cereal banks					Non- PADER-G cereal banks			
	Harvest per hectare	Harvest per seeds ratio	Log (Land Use)	Obs		Harvest per hectare	Harvest per seeds ratio	Log (Land Use)	Obs
Oilseeds	0.651***	0.286***	-0.0210	885		0.0900	0.115	0.0503	697
	(0.180)	(0.0938)	(0.0258)			(0.218)	(0.118)	(0.0364)	
Sesame	0.474**	0.307***	-0.0194	622		0.144	0.245*	0.0356	554
	(0.213)	(0.115)	(0.0251)			(0.268)	(0.139)	(0.0368)	
Groundnuts	0.869***	0.350***	0.0470*	572		0.163	0.152	0.0899***	442
	(0.243)	(0.116)	(0.0249)			(0.274)	(0.131)	(0.0299)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Storage and post-harvest losses

With PADER-G cereal banks, farmers were able to store more in terms of quantity as well as duration of storage for grain and oilseeds. In particular for sorghum and groundnuts amount increased significantly, the amount of sorghum increased by 85% while that of groundnuts increased by 112%. On the other hand duration of storage increased only for berebere by 36%. Non-PADER-G cereal banks did not show any impact on both the amount stored and storage duration of most cereals, though a 22% increase in the quantity of groundnuts stored was recorded.

Table 7: The impact of cereal banks on storage and post-harvest losses of major crops

	PADER-G cereal banks					Non-PADER-G cereal banks			
Log	Storage	Storage Duration (Months)	Post-harvest Loss	Observations		Storage	Storage Duration (Months)	Post-harvest Loss	Observations
Grains	0.878***	0.123***	-0.0161	1,328		0.0250	-0.0155	-0.111	1,008
	(0.153)	(0.0466)	(0.120)			(0.0730)	(0.0275)	(0.0750)	
Sorghum	0.845***	0.0416	0.159	1,096		0.0468	-0.0372*	-0.0798	818
	(0.187)	(0.0491)	(0.128)			(0.0880)	(0.0220)	(0.0898)	
Millet-Penicilaire	0.0598	0.0622	-0.127	409		-0.0303	-0.0206	-0.0509	273
	(0.224)	(0.0703)	(0.189)			(0.123)	(0.0426)	(0.102)	
Berebere	0.0349	0.360***	0.115	240		-0.288	0.0379	-0.125	128
	(0.495)	(0.0857)	(0.253)			(0.204)	(0.0632)	(0.146)	
Oilseeds	0.457***	0.0320	0.121	885		0.00637	0.0136	-0.121	697
	(0.158)	(0.0539)	(0.110)			(0.0797)	(0.0248)	(0.0809)	
Sesame	0.0887	0.156	-0.232**	622		-0.0233	0.0220	-0.150	554
	(0.144)	(0.272)	(0.106)			(0.0829)	(0.377)	(0.102)	
Groundnuts	1.120***	0.0408	0.426***	572		0.221**	0.00699	-0.0882	442
	(0.201)	(0.0602)	(0.144)			(0.100)	(0.0300)	(0.0861)	

Note: number of observations are less for storage duration and loss, as shown in appendix 1, because not all farmers stored their crop output.

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Although PADER-G cereal banks were successful in positively affecting the amount of sorghum and groundnuts stored as well as the storage duration for berebere, there seems to have been issues with the

storage as indicated by the increased post-harvest loss of groundnuts stored. Farmers benefiting from the PADER-G cereal banks are found to have experienced a 43% increase in the quantity of groundnuts lost while in storage. Nevertheless, results show that the quantity of sesame lost while in storage declined by 23 percent. These mixed results may be a function of the type of crop stored. Given these results it is difficult to come up with conclusive evidence on whether cereal banks were effective at reducing post-harvest losses. Nonetheless, results on storage generally point to increased quantities of sorghum and groundnuts stored.

Food insecurity and dietary diversity

Looking at the impact of cereal banks on food security –related variables, results reveal that PADER-G cereal banks reduced food insecurity (as measured by the food insecurity experience scale (FIES)) and had a positive impact on dietary diversity, whereas other cereal banks did not have any impact on both indicators. As a result of PADER-G cereal banks, food insecurity decreased by at least 37 percent while dietary diversity increased by 23 percent. The improvement in the food security status stems mainly from a reduction in the likelihood of households skipping meals due to insufficient money or other resource (7 percent), and the likelihood of households being hungry but not being able to eat (6 percent).

One explanation for the observed positive impact on food-related indicators by PADER-G cereal banks compared to insignificant impact by other cereal banks is that the former are more modern relative the latter. The majority of PADER-G cereal banks were established recently during the project implementation period (last 5 years), whereas around 50 percent of other cereal banks were built 6 years ago. This might reflect an issue of cereal banks sustainability in achieving food security.

Table 8: The impact of cereal banks on food-related variables

	PADER-G cereal banks		Non- PADER-G cereal banks	
Food-related variables	**IPWRA**	**Obs**	**IPWRA**	**Obs**
FIES	-0.383*	1,472	0.0756	1,101
	(0.210)		(0.303)	
Probability (SKIPPED)	-0.0766**	1,472	-0.0210	1,101
	(0.0328)		(0.0462)	
Probability (HUNGRY)	-0.0654**	1,472	0.00315	1,101
	(0.0315)		(0.0391)	
Dietary Diversity Index	0.229**	1,465	0.196	1,097
	(0.110)		(0.146)	
Log (Home Consumption of)				
Grains	0.247**	1,328	-0.0261	1,008
	(0.0969)		(0.0342)	
Sorghum	0.358***	1,096	0.00658	818
	(0.126)		(0.0433)	
Millet-Penicilaire	0.0274	409	0.00520	273
	(0.170)		(0.0518)	
Berebere	-0.185	240	-0.0728	128
	(0.267)		(0.0985)	
Oilseeds	0.166	885	0.00721	697
	(0.126)		(0.0526)	

	PADER-G cereal banks			Non- PADER-G cereal banks	
Food-related variables	**IPWRA**	**Obs**		**IPWRA**	**Obs**
Sesame	0.0570	622		0.000826	554
	(0.127)			(0.0570)	
Groundnuts	0.553***	572		0.143*	442
	(0.180)			(0.0774)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Another and additional explanation is that thanks to the establishment of committees to manage the cereal banks and to training provided, there may have been synergies that allowed for a better and more efficient use of the infrastructure and of its services. The improvement in both the food security and dietary diversity, as a result of IFAD cereal banks, is reflected in the increase in home consumptions of some grains (mainly sorghum) and oil seeds (mainly groundnuts) from farmer's own harvest. Home consumption of sorghum and groundnuts went up by 34 percent and 54 percent, respectively. It is worth noting that groundnuts home consumptions increased with other cereal banks, even though that didn't have any implications on food security and dietary diversity.

Economic mobility

While the PADER-G cereal banks were primarily designed to have an impact on food security, particularly during the lean season, the intervention could also have had an impact on economic mobility indicators (as measured by crop income and assets) as well as on poverty reduction in the beneficiary villages. Results shown in Table 9 reveal that neither the PADER-G nor non-PADER-G cereal banks had an impact on income from the major crops grown in Guéra. This finding is perhaps not so surprising, given that the farmers who benefited from the cereal banks were poor and barely managing to ensure food security for their households Moreover, this is consistent with the foregoing findings on market access and in particular crop sales, which did not significantly increase, suggesting again, a need for market access support for the beneficiaries of the cereal banks if they are to experience increased incomes from crop sales. Thus, if cereal banks are to be leveraged for improved income other complementary interventions may be needed, especially those designed to increase marketing of cash crops.

Table 9: The impact of cereal banks on income of major cereals and oilseeds

	PADER-G cereal banks			Non- PADER-G cereal banks	
Log	**Crop Income**	**Observations**		**Crop Income**	**Observations**
Grains	0.0723	1,328		0.345	1,008
	(0.253)			(0.409)	
Sorghum	0.117	1,096		0.534	818
	(0.314)			(0.502)	
Millet- Penicilaire	-0.523	409		0.453	273
	(0.435)			(0.597)	
Berebere	-0.449	240		-1.698*	128
	(0.608)			(0.918)	
Oilseeds	0.129	885		0.325	697
	(0.297)			(0.469)	
Sesame	0.0636	622		0.759	554

	PADER-G cereal banks			Non- PADER-G cereal banks	
Log	Crop Income	Observations		Crop Income	Observations
	(0.354)			(0.549)	
Groundnuts	0.828**	572		0.468	442
	(0.378)			(0.538)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Given the potential subjectivity of questions used to construct the FIES index, we use assets as a proxy for food security (Guo, 2011). Households that experience acute food insecurity are likely to sell off their assets in an effort to obtain cash, which they can then use to purchase food in the short-run, especially during the lean season. Thus, if cereal banks had a positive impact on food security, they would be expected to have a positive impact on assets as well by preventing distress sales of assets. Guo (2011) also suggested two mechanisms through which assets accumulation could affect food security: consumption smoothing and preventive effects. The latter could be achieved though households' behavior change with a goal of assets accumulation. Such behavior change may prevent the occurrence of negative income shocks and additional consumption needs which in turn help achieve food security.

The results of our analysis of the impact of cereal banks on assets (Table 10) confirms the impact observed on food security as households benefiting from the PADER-G experienced a 14% increase in overall assets relative to the control households who did not have access to any cereal bank. The positive impacts were also found for the non-PADER-G cereal banks, in terms of the productive assets, though impacts were more significant and stronger among beneficiaries of the PADER-G cereal banks, which is consistent with the results of stronger positive impacts on food security among PADER-G cereal bank beneficiaries. On the other hand, the increased productive assets of farmers benefiting from cereal banks is consistent with the results found on increased crop harvest, and again PADER-G cereal banks showing stronger impacts. The productive assets index increased by 17% and 13% as a result of PADER-G and non-PADER-G cereal banks, respectively. In addition, PADER-G cereal banks showed impacts on farmers' livestock (17%) and durable assets (10%).

These results also reflect the potential positive long-term impacts of effectively managed cereal banks in addressing food insecurity and general household welfare, given that assets accumulation might be a better economic mobility measure compared income, which also reflect improvements in sustained food security (Haveman, 1992).

Table 10: The impact of cereal banks on assets

	PADER-G cereal banks			Non-PADER-G	
Assets	IPWRA	Observations		IPWRA	Observations
Overall Assets Index	0.140***	1,472		0.0558	1,101
	(0.0363)			(0.0506)	
Productive Assets Index	0.172***	1,472		0.129**	1,101
	(0.0522)			(0.0581)	
Livestock Assets Index	0.171***	1,472		-0.0137	1,101
	(0.0631)			(0.0843)	
Durable Assets Index	0.0983**	1,472		0.0601	1,101
	(0.0461)			(0.0767)	
Housing Index	0.00905	1,472		-0.00762	1,101
	(0.0111)			(0.0159)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Looking at the likelihood of moving out of the poverty, based on the assets indicators, PADER-G cereal banks reduced poverty when measuring poverty using the overall assets index poverty thresholds of the fortieth and sixtieth percentile (see Table 11). This improvement mainly stems from impacts on productive assets (see Table 26 in the appendix for detailed results). Both threshold indicators show that PADER-G cereal banks reduced poverty headcount among the beneficiaries by about 7%.

Table 11: The impact of cereal banks on poverty

	PADER-G cereal banks		Non- PADER-G	
Poverty	**IPWRA**	**Observations**	**IPWRA**	**Observations**
Above 40th percentile (Overall Asset Index)	0.0742**	1,472	0.0230	1,101
	(0.0294)		(0.0409)	
Above 60th percentile (Overall Asset Index)	0.0721**	1,472	0.0117	1,101
	(0.0300)		(0.0375)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Market Access

Results show that, unfortunately, cereal banks were mostly not able to help farmers increase their market access, as measured by the value of their crop sales and the prices they received for the crops (see Table 12 below). Results on sales of sesame show that PADER-G cereal banks actually helped increase sales by about 51% for those farmers growing sesame. Similarly, non-PADER-G cereal banks appear to have helped increase sales of sesame by 49%. However, the impact on sales of berebere for the non-PADER-G cereal banks was negative (a decrease of about 92%).

These results do not necessarily imply that cereal banks failed to improve output market access, per se, but rather that cereal banks may have varying effects on different types of crops' market access. It appears that for staple cereal crops such as sorghum, millet and berebere, cereal banks alone cannot be expected to increase sales and prices. However, for more commercialized crops such as sesame, there may be scope for positive impacts on market access for the farmers that grow these crops.

Inherently, cereal banks alone are not designed to increase market access unless complementary interventions such as linking participants to crop output markets and supporting them with competitive price negotiation mechanisms, are also incorporated in the cereal banks intervention. Moreover, farmers who were targeted by the PADER-G cereal banks were mostly subsistence farmers, such that their primary objective, and perhaps motivation for participating in the intervention, was to ensure food security of their households during the lean season and not necessarily to increase market sales of their crops. Thus, if cereal banks are to go beyond ensuring food security in the lean season for their beneficiaries and play a role in crop commercialization, complementary market access interventions would be needed. The evidence points to this possibility, particularly for the crops that are market oriented such as oilseeds (sesame and may be groundnuts) in the case of Guéra. In this respect, cereal bank management committees could play a crucial role as a platform for linking farmers to markets and increasing market access for the cereal bank beneficiaries.

Table 12: Impact of cereal banks on market participation (crop sales and prices)

	PADER-G cereal banks				Non- PADER-G cereal banks		
Log	**Sales Price**	**Sales**	**Obs**		**Sales Price**	**Sales**	**Obs**
Sorghum	-0.246	0.207	1,096		-0.215	0.227	818
	(0.163)	(0.131)			(0.227)	(0.207)	
Millet	-0.633	0.203	248		-0.306	0.307	166
	(0.385)	(0.160)			(0.549)	(0.244)	
Penicilaire	0.0287	-0.0983	169		0.222	0.392	109
	(0.248)	(0.216)			(0.354)	(0.302)	
Berebere	-0.516	-0.135	240		-0.362	-0.925**	128
	(0.346)	(0.297)			(0.521)	(0.438)	
Sesame	-0.150	0.510***	622		0.121	0.492**	554
	(0.226)	(0.168)			(0.352)	(0.235)	
Groundnuts	0.0185	0.00668	572		-0.103	0.316*	442
	(0.224)	(0.140)			(0.254)	(0.188)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Sourcing of seeds

On the other hand, looking at market access for seeds, we found that PADER-G cereal banks significantly increased the likelihood of farmers sourcing seeds from a storage facility, other than their own storage at home (Table 13). This was the case for all major grains and oilseeds grown by the farmers. However, no significant impacts were found on the probability to source seeds from commercial sources, friends or neighbors in the community. This finding suggest that cereal banks do nothing to increase market access of seeds, further emphasizing the need to complement the cereal bank intervention with market-oriented interventions that enhance market access, including for inputs such as seeds. Generally, farmers in Guéra mostly source seeds from their previous harvest and other inputs are sourced from informal sources.

Table 13. The impact of cereal banks on source of seeds of major cereals

Probability of sourcing seeds from:	PADER-G Cereal banks						Non-PADER-G Cereal banks					
	own seeds	credit seeds	storage facility seeds	commercial/ friends seeds	recycled seeds	Observations	own seeds	credit seeds	storage facility seeds	commercial/ friends seeds	recycled seeds	Observations
Sorghum	-0.0526	0.0150	0.187***	-0.102***	0.00504	1,188	-0.140***	0.0670*	0.0546***	0.0619	-0.0212	868
	(0.0375)	(0.0294)	(0.0140)	(0.0364)	(0.0179)		(0.0419)	(0.0363)	(0.0115)	(0.0503)	(0.0140)	
Millet	0.0842	-0.0601	0.151***	-0.239***	-0.00877	433	0.104	-0.104*	0.0476*	-0.146**	-0.0229	291
	(0.0590)	(0.0563)	(0.0236)	(0.0576)	(0.0280)		(0.0683)	(0.0551)	(0.0263)	(0.0714)	(0.0263)	
Penicilaire	-0.0509	-0.0284	0.209***	-0.145	0.00727	246	-0.148	-0.0678	0.0754***	0.143	-0.00489	132
	(0.0981)	(0.0704)	(0.0290)	(0.0979)	(0.0184)		(0.112)	(0.0945)	(0.0273)	(0.117)	(0.0414)	
Berebere	0.0726	-0.110***	0.107***	-0.167***	0.00364	634	0.0145	0.0668	0.0506***	-0.0457	-0.0264*	487
	(0.0473)	(0.0418)	(0.0150)	(0.0475)	(0.0210)		(0.0576)	(0.0445)	(0.0156)	(0.0621)	(0.0151)	
Sesame	-0.00336	-0.0366	0.112***	-0.125***	-0.000983	688	-0.0344	0.00216	0.0373***	-0.0392	-0.0366***	597
	(0.0452)	(0.0368)	(0.0152)	(0.0445)	(0.0167)		(0.0651)	-0.0578	(0.0105)	(0.0611)	(0.0135)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 13 also shows that the non-PADER-G cereal banks also had a similar effect, though with lower magnitudes of impact, in the order of a third of the PADER-G impacts in most cases. Whereas for the use of recycle seeds, we find that cereal banks did nothing to affect the likelihood of reducing the use of recycled seed. Thus, while farmers changed their source of seeds they did not necessarily stop recycling seeds. Results also suggest that cereal banks did not have an impact on sourcing of seeds through credit, with the exception of berebere seeds, where the probability of sourcing seeds on credit was reduced. This suggest that the impacts are limited and once again reinforces the idea that complementary interventions would be needed to leverage the existence of cereal banks to have an impact on access to markets including input access through credit.

Turning to the findings on use of credit, Table 14 shows that farmers benefiting from PADER-G cereal banks were no different from those who did not have access to a cereal bank in terms of their access to credit.

Table 14. Impact of cereal banks of use of credit

Credit	IFAD Cereal banks			Non-IFAD Cereal banks	
	IPWRA	Observations		IPWRA	Observations
Loan (yes)	0.0656***	1,472		0.0526**	1,101
	(0.0223)			(0.0252)	
Number of loans	0.0810***	1,472		0.0677**	1,101
	(0.0251)			(0.0273)	
Usury interest rate	0.115	282		0.116	182
	(0.0722)			(0.114)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Moreover, for those who accessed credit they did not seem to be accessing credit from less usurious sources. Thus, the objective of reducing dependence on usurious lenders seems not to have been met. Similar findings were recorded for non-PADER-G cereal banks highlighting that cereal banks in general without complementary interventions appear to be ineffective at discouraging borrowing from usurious sources. Thus, while farmers who benefited from cereal banks were able to borrow grain during the lean season, this did not necessarily translate to reduced borrowing from usurious lenders.

Resilience

Looking at the three most frequent and significant shocks, namely drought, crop disease and local unrest/violence, cereal banks showed a positive impact on households' resilience toward local unrest/violence, suggesting their crucial role in improving social cohesion. The impact of both PADER-G cereal and other cereal banks are almost the same. Yet, unlike PADER-G cereal banks, other banks revealed positive impact on households' resilience toward drought as well. Finding insignificant impact of the PADER-G cereal banks on drought resilience is somewhat surprising but could be an artefact of the increased post-harvest loss from stored grain, which might have made households feel they were unable to effectively deal with droughts and associated challenges of food insecurity.

Table 15: The impact of cereal banks on resilience

	Resilience-related variables	PADER-G cereal banks		Non-PADER-G	
		IPWRA	Observations	IPWRA	Observations
Overall	Ability to recover	0.0576 (0.0576)	1,331	0.198*** (0.0637)	1,011
	Resilience Index1	0.0576 (0.0576)	1,331	0.198*** (0.0637)	1,011
	Resilience Index2	0.0567 (0.0578)	1,331	0.197*** (0.0636)	1,011
drought	Ability to recover	0.0563 (0.0584)	987	0.181*** (0.0620)	798
	Resilience Index1	0.0563 (0.0584)	987	0.181*** (0.0620)	798
	Resilience Index2	0.0553 (0.0587)	987	0.179*** (0.0617)	798
Crop disease/pest	Ability to recover	-0.205* (0.121)	514	0.0513 (0.120)	387
	Resilience Index1	-0.205* (0.121)	514	0.0514 (0.120)	387
	Resilience Index2	-0.190 (0.122)	514	0.0655 (0.122)	387
Local unrest/violence	Ability to recover	0.328** (0.141)	171	0.378*** (0.141)	153
	Resilience Index1	0.328** (0.141)	171	0.379*** (0.141)	153
	Resilience Index2	0.347** (0.136)	171	0.403*** (0.140)	153

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Given the subjective nature of the variable on resilience, we ventured to explore resilience using geo-referenced climate data. Here, we focused on the food insecurity indicator (FIES), which was the primary outcome of interest for the PADER-G project. To operationalize the assessment of impact on resilience, we estimate similar models as those estimated earlier on food insecurity, with the difference being that the specification includes precipitation or temperature variables interacted with the PADER-G treatment dummy variable. The precipitation variables used are shown in Table 16 and these include the total rainfall for the months during which the crops were grown (precipitation_total_2017) and the coefficient of variation (CV) for the same variable (precipitation_cv_2017). A separate version of the CV variables is computed for the period when the crops are in vegetative stage and not for the whole crop production season (precipitation_cv_2017_d). For temperature, the variable used is the mean of the maximum decadal temperatures recorded during the period that the crops were grown. CV variables for the temperature variable are also included, analogous to the precipitation version of the estimations.

If PADER-G cereal banks had a positive impact on resilience as it pertains to drought or dry spells, the coefficient on the precipitation-treatment interaction variable would be expected to be negative and significant (i.e. indicating that PADER-G reduced food insecurity emanating from less rainfall). Similarly, the coefficient of the interaction term between the PADER-G dummy and the temperature variable is expected to be negative and significant, implying a significant reduction in food insecurity during periods of higher temperature. Based on these estimations using precipitation and temperature variables, we found no impact of the PADER-G cereal bank intervention on resilience to drought or dry spells. This result is consistent with the result in Table 15, which was based on subjective self-reporting. What is even more notable is that there is also no impact of the non-PADER-G cereal banks on resilience to drought and dry spells (see columns 6 to 10 in Table 16).

Table 16 Impact of PADER-G Cereal banks on objective measure of resilience to drought or dry spells

	PADER-G cereal banks					Non-PADER-G cereal banks				
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
treatment_PADER_G	-6.626**	-2.797	-0.0907	-2.797	-4.014	-4.167	-1.885	0.0256	-1.885	-3.456
	(2.824)	(1.817)	(0.948)	(1.817)	(5.424)	(3.205)	(2.295)	(1.074)	(2.295)	(6.897)
precipitation_total_2017	-0.00745					-0.000766				
	(0.00458)					(0.00531)				
1.treatment_PADER_G#c.precipitation_total_2017	**0.0110****					**0.00679**				
	(0.00506)					**(0.00582)**				
precipitation_cv_2017		-2.042*					-0.786			
		(1.094)					(1.436)			
2.treatment_PADER_G#c.precipitation_cv_2017		**1.575**					**1.015**			
		(1.241)					**(1.599)**			
precipitation_cv_2017_d			-7.858***					-8.107***		
			(2.171)					(2.463)		
3.treatment_PADER_G#c.precipitation_cv_2017_d			**1.564**					**1.504**		
			(2.554)					**(2.874)**		
temperature_cv_2017				-2.042*					-0.786	
				(1.094)					(1.436)	
4.treatment_PADER_G#c.temperature_cv_2017				**1.575**					**1.015**	
				(1.241)					**(1.599)**	
temperature_cv_2017_d					1.033**					0.671

	PADER-G cereal banks					Non-PADER-G cereal banks				
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
					(0.426)					(0.562)
5.treatment_PADER_G#c.temperature_cv_2017_d					**-0.316**					**-0.274**
					(0.480)					**(0.614)**
Observations	1,472	1,472	1,472	1,472	1,472	1,331	1,331	1,331	1,331	1,331

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Social Cohesion

Consistent with the impacts on resilience towards local unrest/violence, results shown in Table 17 suggest that cereal banks had a positive impact on the number of agricultural and non-agricultural groups that beneficiaries participated in, as indicators for social cohesion. PADER-G cereal banks showed stronger impacts in terms of significance and magnitude. The number of agricultural groups increased by 55 percent with PADER-G cereal banks and 11 per cent with other cereal banks. Along the same lines, number of non- agricultural groups increased by 22 per cent with PADER-G cereal banks and 15 percent with other cereal banks. Although the number of groups in which farmers became members increased, the number of meetings attended by the farmers were not affected by cereal banks.

Table 17: The impact of cereal banks on social capital

		PADER-G cereal banks			Non-PADER-G	
Social Capital		**IPWRA**	**Obs**		**IPWRA**	**Obs**
Agricultural groups	Number of agricultural groups	0.557***	1,472		0.112*	1,101
		(0.0441)			(0.0605)	
	Number of meetings	-0.0775	679		-0.104	296
		(0.111)			(0.164)	
Non-Agricultural groups	Number of social groups	0.268***	1,472		0.195***	1,101
		(0.0582)			(0.0729)	
	Number of meetings	-0.448***	355		-0.298	216
		(0.147)			(0.197)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Women's Empowerment

Last but not least, we also look at women's empowerment. Our analysis suggests that the PADER-G cereal banks did not have an impact on women's empowerment regarding agency on both agricultural-related and non-agricultural-related issues. It seems that designating cereal banks to be managed by women is not enough to tackle gender issues in the community and empower women in the context of Guéra, Chad. Table 18 shows that for a number of decision-making areas (both agricultural and non-agricultural), agency among women was similar for those who benefited from the PADER-G cereal banks and those who did not. The results are the same for those who benefited from non-PADER-G cereal banks and those who did not benefit from any cereal bank, reinforcing the notion that cereal banks per se may not enhance agency of women.

Table 18: The impact of cereal banks on women's empowerment (agency)

	PADER-G cereal banks			Non-PADER-G	
Decision making (=1 if decision is made by a woman)	**IPWRA**	**Observations**		**IPWRA**	**Observations**
Gender Empowerment Index	-0.154	1,472		0.334	1,101
	(0.254)			(0.341)	
Planting of seeds	-1.66e-05	1,408		0.0172	1,032
	(0.0324)			(0.0432)	
Inputs application	-0.0635	828		0.0115	557
	(0.0414)			(0.0601)	
Crop harvest	-0.0415	1,432		0.0170	1,058

	PADER-G cereal banks			Non-PADER-G	
Decision making (=1 if decision is made by a woman)	**IPWRA**	**Observations**		**IPWRA**	**Observations**
	(0.0325)			(0.0477)	
Crops sales	-0.0273	1,409		0.0290	1,039
	(0.0292)			(0.0434)	
Credit	-0.00692	899		0.0379	597
	(0.0435)			(0.0559)	
Choice of crops	-0.0207	1,439		0.00185	1,064
	(0.0314)			(0.0460)	
Inputs choice	-0.00395	888		0.0562	627
	(0.0411)			(0.0563)	
Income from crop sales	-0.0406	1,417		0.0319	1,038
	(0.0313)			(0.0449)	
Non-agricultural activities	-0.0312	1,324		0.0470	993
	(0.0327)			(0.0436)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

5.2 Heterogeneous impacts of PADER-G Cereal Banks

One of the context-specific heterogeneities that was found in the project area is the existence of community cereal banks of differing ages. Since the impacts of cereal banks may very well vary by age of the cereal banks, we investigated how the ages of cereal banks affected a variety of outcome indicators of interest. A point to keep in mind is that most IFAD-funded PADER-G cereal banks had been installed relatively recently. Thus, to check whether the positive impacts of IFAD cereal banks compared to other cereal banks was not due to the age of the cereal banks but rather other properties of the cereal banks, we estimated the IPWRA model, interacting the cereal bank variable with the age of the cereal bank. Results reveal that cereal bank's age did not significantly affect food security, food diversity and assets-related variables. However, it negatively affected harvest- and storage- related variables for the 2017 agriculture season (Table 19). Older cereal banks generally led to lower levels of harvest and lower quantities of crop stored, as well as shorter duration of grain storage.

Table 19: The impact of cereal bank's age

Variable	PADER-G CB	PADER-G CB * CB age	Non-PADER-G CB	Non-PADER-G CB* CB age
Food_Insecurity_Index	-0.403	0.00710	0.0692	0.0531
	(0.293)	(0.0775)	(0.342)	(0.0704)
Dietary_Diversity_Index	0.103	0.0508	0.106	0.0348
	(0.175)	(0.0373)	(0.219)	(0.0366)
Overall_Assets_Index	-0.0109	0.0300*	0.0444	-0.00715
	(0.0675)	(0.0168)	(0.0837)	(0.0148)
Productive_Assets_Index	0.160*	-0.00592	0.0768	-0.0133
	(0.0821)	(0.0183)	(0.100)	(0.0164)
AL_Overall_Assets_Index	0.0191	0.0106	-0.0107	-0.000167
	(0.0421)	(0.00970)	(0.0499)	(0.00910)
AU_Overall_Assets_Index	0.0195	0.00294	-0.0306	-0.00856
	(0.0454)	(0.0106)	(0.0527)	(0.00968)
AL_Productive_Assets_Index	0.0864*	-0.00148	-0.0226	0.00308
	(0.0454)	(0.0104)	(0.0527)	(0.00931)
AU_Productive_Assets_Index	0.0544	-0.00301	-0.0281	-0.00126
	(0.0460)	(0.0110)	(0.0510)	(0.00968)
Log_Harvest_Grains_s	0.276***	0.0124	0.456***	-0.0574**
	(0.0921)	(0.0261)	(0.105)	(0.0258)
Log_Harvest_Oilseeds_h	0.198	0.105*	0.630*	-0.101*
	(0.279)	(0.0569)	(0.332)	(0.0516)
Log_Harvest_Oilseeds_s	0.0542	0.0657**	0.00330	0.0466
	(0.132)	(0.0325)	(0.152)	(0.0321)
harvest_stored_Grains	0.790***	-0.000556	0.614**	-0.102*
	(0.206)	(0.0546)	(0.275)	(0.0568)
storage_months_Grains	0.153**	-0.0133	0.0727	-0.0226*
	(0.0627)	(0.0136)	(0.0753)	(0.0132)
Log_Harvest_Grains_h	0.0294	0.0920*	0.566**	-0.0750*
	(0.229)	(0.0530)	(0.239)	(0.0450)

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

These findings imply that the impact observed on food security, food diversity and asset indexes was not an artefact of age of the cereal banks but rather was attributable to the way PADER-G cereal banks were operated, likely including the management thereof. This includes the role of community management committees established and the training they received. Results showing a significant negative impact of the age-cereal bank interaction variable on the log of harvest and log of storage quantities and storage duration imply that, to some extent, age of the cereal bank mattered with younger cereal banks generating greater impacts. This result points to issues of sustainability of cereal bank impacts, suggesting that there may still be a need to consider complementary interventions that sustain the positive impacts of cereal banks. The literature on cereal banks has previously highlighted the challenges of sustainability associated with cereal bank infrastructure and management thereof (Bhattamishra, 2012; World Bank et al, 2011; CRS, 1998).

Conclusion

This impact assessment was conducted to evaluate the kinds of impact that resulted from the implementation of the PADER-G project in Guéra, Chad. Findings show that PADER-G significantly reduced food insecurity, increased dietary diversity and increased the production and yields of major grains and oilseeds (sorghum, millet, berebere, groundnuts and sesame) among project beneficiaries in Guéra. As a result of IFAD cereal banks, food insecurity decreased by at least 37 percent while dietary diversity increased by 23 percent among beneficiary households. In addition, it was found that household consumption of sorghum and groundnuts increased by 34 percent and 54 percent, respectively thus explaining the sources of increased food security and dietary diversity. Quantities of sorghum and groundnuts stored also increased in similar fashion, with the amount of sorghum and groundnuts stored increasing by 77 percent and 110 percent, respectively. These results reveal that the major crops impacted by the PADER-G cereal banks were sorghum and groundnuts.

One key lesson learned from the results of this impact assessment is that setting smart targets and goals that are not overambitious in contexts where basic needs such as food security and basic public services are lacking is a practical approach that can lead to real impact on poor farm households as well as set a firm foundation for future interventions. Thus, the positive impact of PADER-G on food security and resilience to violence/unrest set a solid foundation for follow up interventions such as the PARSAT project on water for agriculture, which is currently ongoing.

Another lesson that can be drawn from the impact assessment is the importance of sustainability of infrastructure investments as well as of good management. The impact assessment found that some of the non-beneficiary households resided in communities with older cereal banks that had been constructed previously by other development organizations. These older cereal banks were not as effective as the ones recently provided by PADER-G, and one explanation for this is that older cereal banks were no well-managed and the infrastructure had deteriorated over time. Thus, for the PADER-G cereal banks to have sustainable impact, there will be need to put in place mechanisms that allow for continued maintenance but also for a good management and capacity of the group to use and provide the services of a cereal bank. A related lesson is that, by providing training to community cereal bank committees, PADER-G was able to build capacity for sustainable management of the infrastructure and thus created positive synergies between the infrastructure itself and its use and management. This may have also contributed to the higher impact of the PADER-G cereal banks compared to other cereal.

A separate lesson learned is the role of markets in influencing decisions of farmers and in potentially determining a positive impact on their income thus going beyond food security., when they receive an intervention such as the cereal banks provided by PADER-G. Because there appeared to be limited markets linkages and profitability of sorghum, farmers mainly stored sorghum for home consumption while they were able to expand production and sale of groundnuts. Future interventions may consider deliberately supporting beneficiaries to access both cereals and oilseeds markets, if the impact of cereal banks is to go beyond food security and include market participation.

Another important consideration is that PADER-G had other components not evaluated in this study, which may have potentially generated further positive synergies such as access to sanitation and road construction. These could have potentially facilitated access to markets and generated synergies, had they not been somewhat dispersed due to the scattered targeting of interventions under PADER-G. Whereas in this case these other components of PADER-G represented minor financial expenditures of the project, it is worth considering how to better integrated every project component within its logic and theory of change so as to have stronger positive impact.

Finally, it is encouraging to see that beyond the main objective of food security, cereal banks were able to achieve other impacts such as increased resilience to violence as well as increased dietary diversity. This implies that cereal banks can be an effective intervention on food consumption as well as specific elements of resilience.

References

Abadie, A., Drukker, D. M., Herr, J. L. and Imbens, G. W. 2004. Implementing matching estimators for average treatment effects in Stata. *The Stata Journal* 4(3): 290–311.

Abass, A. B., Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N. and Bekunda, M. 2014. Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. *Journal of Stored Products Research*. 57: 49-57.

Aggarwal, S., Francis, E. and Robinson, J. 2018. *Grain today, gain tomorrow: evidence from a storage experiment with savings clubs in Kenya.* NBER Working paper no. 24391.

Barrett, C. B. Smallholder market participation: concepts and evidence from Eastern and Southern Africa. *Food Policy*. 33: 299-317.

Beaman, L., Chattopadhyay, R., Duflo, E., Pande, R. and Topalova, P. 2009. Powerful women: does exposure reduce bias? *The Quarterly Journal of Economics*. 124(4): 1497-1540.

Becker, S. O. and Ichino, A. 2002. Estimation of average treatment effects based on propensity scores. *The Stata Journal*, 2(4): 358-377.

Beer, F. 1990. *Cereal banks in Niger*. The Center for Research on Economic Development. University of Michigan: Ann Arbor, Michigan.

Bernard, T., Collion, M., de Janvry, A., Rondot, P., and Sadoulet, E. 2008. Do village organizations make a difference in African rural development? A study for Senegal and Burkina Faso. *World Development*. 36(11): 2188-2204.

Bhattamishra, R. 2008. *Grain Banks: An Institutional and Impact Evaluation*. Doctoral Dissertation. Cornell University, Ithaca, NY.

Bhattamishra, R. 2012. Grain Bank Survival and Longevity: Evidence from Orissa. *The Journal of Applied Economic Research*, 311–336.

Bhattamishra, R., and Barrett, C. B. 2010. Community-Based Risk Management Arrangements: A Review. *World Development* 38(7): 923-932.

Boutna, A. 2016. Etude des effets socio-économique des banques de soudure muse en place par le PADER-G. Working Paper

Cardenas, A. and Fuller, R. 2016. Resilience in Chad: Impact evaluation of reinforcing resilience capacity and food security in Bahr el Gazal and Guéra. Effectiveness Review Series 2014/15. OXFAM GB: Oxford, UK.

Cavatassi, R., Balint, T., Djimeu, E., Abouaziza, M., and Marion, P. 2017. Impact Assessment Plan Chad. Programme d'Appui au Développement Rural dans le Guéra (PADER-G) et Projet d'amélioration de la Résilience des Systèmes Agricoles au Tchad (PARSAT). Rome: IFAD.

Chattopadhyay, R. and Duflo, E. 2004. Women as policy makers: evidence from a randomized policy experiment in India. *Econometrica*. 72(5): 1409-1443.

Chegere, M. J. 2018. Post-harvest losses reduction by small-scale farmers: the role of handling practices. *Food Policy*. 77: 103-115.

CIBLE. 2017. Livrable Nr 4. Rapport Narratif. CIBLE. N'djamena, Chad.

CRS (Catholic Relief Services). 1998. *Notes from the workshop on community-level grain storage projects (Cereal Banks): Why do they rarely work and what are the alternatives?* January 19–22. https://lasdanaides.files.wordpress.com/2009/02/1998-crs.pdf Retrieved September 17, 2018.

de Bruijn, M and van Dijk, H. 2007. The multiple experiences of civil war in the Guéra region of Chad, 1965-1990. *Sociologus* 57(1): 61-98.

Dehejia, R. H. and Wahba, S. 1999. Causal effects in nonexperimental studies: reevaluating the evaluation of training programs. *Journal of American Statistical Association*, 94(488): 1053-1062.

Duflo, E. 2012. Women empowerment and economic development. *Journal of Economic Literature*. 50(4): 1051-1079.

Gross, J., Guirkinger , C., and Platteau, J.-P. 2016. Activation of Food Markets and Food Security: Impact of Cereal Banks in Northern Burkina Faso. Working Paper.

Gyau, A., Franzel, S., Chiatoh, M., Nimino, G. and Owusu, K. 2014. Collective action to improve market access for smallholder producers of agroforestry products: key lessons learned with insights from Cameroon's experience. *Current Opinion in Environmental Sustainability*,: 68–72.

Hampshire, K., and Randall, S. 2000. Seasonal labour migration strategies in the Sahel: coping with poverty or optimising security? International Journal of Population Geography, 5(5): 367–385.

Harder, V. S., Stuart, E. A., and Anthony, J. C. 2010. Propensity score techniques and the assessment of measured covariate balance to test causal associations in psychological research. *Psychological Methods*, 15(3): 234-249.

Hirano, K. and Imbens, G. W. 2001. Estimation of causal effects using propensity score weighting: an application to data on right heart catheterization. *Health Services and Outcomes Research Methodology*, 2(3-4): 259-278.

Hirano, K., Imbens, G. W., and Ridder, G. 2003. Efficient estimation of average treatment effects using the estimated propensity score. *Econometrica*, 71(4): 1161-1189.

Ho, D. E., Imai K., King, G., Stuart, E. A. 2007. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis*, 15(3): 199-236.

IFAD. 2010: *PADER-G. Document de conception de projet. Rapport de conception finale. Volume I: Rapport principal et Annexes (Octobre 2010)*. IFAD: Rome, Italy.

IFAD. 2014. *Programme d'Appui Au Développement Rural dans le Guéra (PADER-G) : Rapport de Revue à Mi-Parcours – 2014*. IFAD: Rome, Italy.

IFAD. 2016: *PADER-G. Rapport d'appui à l'achèvement (28/09/2016)*. IFAD: Rome, Italy.

Imbens, G. W. and Wooldridge, J. M. 2009. Recent developments in the econometrics of program evaluation. *Journal of Economic Literature*, 47(1): 5-86. DOI: 10.1257/jel.47.1.5

Imbens, G. W. 2015. Matching methods in practice: three examples. *Journal of Human Resources* 50(2): 373-419. Doi: 10.3368/jhr.50.2.373

Jatta, R. 2016. Hedging seasonal food price risks: The impact of cereal banking in the Gambia. In Kalkuhl, M., von Braun, J. and Torero, M. (eds.), *Food Price Volatility and Its Implications for Food Security and Policy*, pp 583-601. Springer DOI 10.1007/978-3-319-28201-5_22

Jatta, R. 2017. How viable are community cereal banking schemes in the face of climate change and food price dispersion? *International Journal of Agriculture and Environmental Research*. 3(2): 2825-2844.

Kadjo, D., Ricker-Gilbert, J., Abdoulaye, T., Shively, G., and Baco, M. N. 2018. Storage losses, liquidity constraints, and maize storage decisions in Benin. *Agricultural Economics*. 49(4): 435-454. https://doi.org/10.1111/agec.12427

Liu, X. and Lynch, L. 2011. Do agricultural land preservation programs reduce farmland loss? Evidence from propensity score matching estimator. *Land Economics*, 87(2): 183-201.

Lunceford, J. K. and Davidian, M. 2004. Stratification and weighting via the propensity score in estimation of causal treatment effects: a comparative study. *Statistics in Medicine*, 23(19): 2937-2960. https://doi.org/10.1002/sim.1903

Mariko, D., Malik, S., and Mohamoud, O. 2012. *Building resilience in the Sahel through cereal banks.* Food for Peace West Africa Working Paper, Issue Number 9.

Mayen, C. D., Balagtas, J. V. and Alexander, C. E. 2010. Technology adoption and technical efficiency: organic and conventional dairy farms in the United States. *American Journal of Agricultural Economics*, 92(1): 181-195. https://doi.org/10.1093/ajae/aap018

Msaki, M. M., Regnard, I., and Mwenda, M. 2015. Cereal banks or seed banks? An experience from Majoka arid village, Dodoma, Tanzania. *Developing Country Studies*. 5(9): 18-26.

Mwampfupe Davis, G. 2015. The experience of community cereal banks in food-deficit areas of semi-arid Tanzania. *International Journal of Scientific and Research Publications*, 5(6): 1-7. Retrieved from www.ijsrp.com August 7, 2018.

Narayan, D. (ed). 2005. *Measuring empowerment: cross-disciplinary perspectives*. World Bank: Washington DC.

Rasmussen, L. V. 2018. Re-defining Sahelian 'Adaptive Agriculture' when implemented locally: Beyond Techno-fix Solutions. *World Development* 108: 274-282.

Rosenbaum, P. R. and Rubin, D. B. 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika* 70(1): 41-55. https://doi.org/10.1093/biomet/70.1.41

Sarris, A. and Morrison, J. (eds.). 2010. *Food Security in Africa: Market and Trade Policy for Staple Foods in Eastern and Southern Africa*. Food and Agriculture Organization of the United Nations (FAO) and Edward Elgar: Cheltenham, UK.

Sheahan, M. and Barrett, C. B. 2017. Review: Food loss and waste in Sub-Saharan Africa. *Food Policy*. 70: 1-12.

Stephens, E. and Barrett, C. B. 2011. Incomplete credit markets and commodity marketing behaviour. *Journal of Agricultural Economics*. 62(1): 1-24.

Tefera, T. 2012. Post-harvest losses in African maize in the face of increasing food shortage. *Food Security: The Science, Sociology and Economics of Food Production and Access to Food* 4: 267-277, DOI 10.1007/s12571-012-0182-3

Tesfai, C., Ratnayake, R., & Myatt, M. 2013. Measuring local determinants of acute malnutrition in Chad: a case-control study. *The Lancet, 381*, S144. https://doi.org/https://doi.org/10.1016/S0140-6736(13)61398-7

Tesfaye, W. and Tirivayi, N. 2018. The impacts of postharvest storage innovations on food security and welfare in Ethiopia. *Food Policy* 75: 52-67.

UNICEF-Chad, 2018. Water, Sanitation and Hygiene. N'djamena, Chad. https://www.unicef.org/chad/survival_development_7267.html Retrieved September 17, 2018.

WFP-Chad (World Food Programme – Chad). 2018. WFP Chad Country Brief. WFP: N'djamena, Chad. https://reliefweb.int/sites/reliefweb.int/files/resources/WFP%20CHAD%20COUNTRY%20BRIEF%20JUNE%20%202018.pdf Retrieved September 24, 2018.

World Bank. 2017. *Implementation Completion and Results Report: Agriculture Production Support Project.* World Bank: Washington DC. http://documents.worldbank.org/curated/en/189061515169116579/Chad-Agriculture-Production-Support-Project Retrieved September 24, 2018.

World Bank, Natural Resources Institute, and Food and Agriculture Organization of the United Nations. 2011. *Missing food: The case of postharvest grain losses in Sub-Saharan Africa.* Economic and Sector Work Report No. 60371-AFR. World Bank: Washington DC.

Appendix:

Table 20: The impact of cereal banks on food-related variables

	PADER-G Cereal banks				Non-PADER-G Cereal banks			
Food-related variables	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
FIES	**-0.383***	**-0.373***	**-0.507****	**1,472**	**0.0756**	**0.0873**	**-0.0764**	**1,101**
	(0.210)	**(0.209)**	**(0.225)**		**(0.303)**	**(0.284)**	**(0.300)**	
Probability (SKIPPED)	-0.0766**	-0.0746**	-0.0934***	1,472	-0.0210	-0.0177	-0.0585	1,101
	(0.0328)	(0.0329)	(0.0354)		(0.0462)	(0.0439)	(0.0459)	
Probability (HUNGRY)	-0.0654**	-0.0626**	-0.0795**	1,472	0.00315	0.00417	-0.0165	1,101
	(0.0315)	(0.0315)	(0.0341)		(0.0391)	(0.0400)	(0.0407)	
Dietary Diversity Index	**0.229****	**0.228****	**0.287****	**1,465**	**0.196**	**0.214**	**0.231**	**1,097**
	(0.110)	**(0.113)**	**(0.125)**		**(0.146)**	**(0.144)**	**(0.159)**	
Log (Consumption)	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Grains	0.247**	0.230**	0.192*	1,328	-0.0261	-0.0132	0.00267	1,008
	(0.0969)	(0.0963)	(0.106)		(0.0342)	(0.0362)	(0.0399)	
Sorghum	0.358***	0.352***	0.338**	1,096	0.00658	0.0308	0.0434	818
	(0.126)	(0.127)	(0.136)		(0.0433)	(0.0477)	(0.0518)	
Millet& Penicilaire	0.0274	-0.00843	-0.167	409	0.00520	-0.0110	0.0354	273
	(0.170)	(0.168)	(0.153)		(0.0518)	(0.0557)	(0.0571)	
Berebere	-0.185	-0.210	0.0338	240	-0.0728	-0.0835	-0.126	128
	(0.267)	(0.280)	(0.320)		(0.0985)	(0.102)	(0.107)	
Oil seeds	0.166	0.166	0.127	885	0.00721	0.0264	0.0525	697
	(0.126)	(0.127)	(0.127)		(0.0526)	(0.0542)	(0.0580)	
Sesame	0.0570	0.0486	0.0431	622	0.000826	0.0367	0.0202	554
	(0.127)	(0.127)	(0.137)		(0.0570)	(0.0608)	(0.0621)	
Groundnuts	0.553***	0.538***	0.579***	572	0.143*	0.178**	0.161**	442
	(0.180)	(0.180)	(0.179)		(0.0774)	(0.0900)	(0.0807)	

Table 21: The impact of cereal banks on yields and output-seed ratios of major crops

Harvest per hectare	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Grains	0.471***	0.461***	0.432***	1,328	0.230	0.294*	0.265	1,008
	(0.133)	(0.133)	(0.151)		(0.164)	(0.162)	(0.195)	
Sorghum	0.686***	0.674***	0.687***	1,096	0.308	0.435**	0.323	818
	(0.178)	(0.177)	(0.185)		(0.196)	(0.206)	(0.236)	
Millet& Penicilaire	0.436	0.370	0.292	409	0.649**	0.543*	0.760**	273
	(0.278)	(0.268)	(0.277)		(0.292)	(0.286)	(0.360)	
Berebere	0.427	0.455	0.882*	240	-0.278	-0.329	-0.434	128
	(0.431)	(0.459)	(0.491)		(0.478)	(0.501)	(0.559)	
Oil seeds	0.651***	0.660***	0.675***	885	0.0900	0.174	0.275	697
	(0.180)	(0.181)	(0.190)		(0.218)	(0.218)	(0.216)	
Sesame	0.474**	0.465**	0.532**	622	0.144	0.260	0.287	554
	(0.213)	(0.211)	(0.229)		(0.268)	(0.273)	(0.224)	
Groundnuts	0.869***	0.865***	1.051***	572	0.163	0.233	0.243	442
	(0.243)	(0.243)	(0.272)		(0.274)	(0.277)	(0.272)	
Harvest per seeds								
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Grains	0.322***	0.317***	0.298***	1,328	0.0124	0.0556	0.116	1,008
	(0.0690)	(0.0680)	(0.0799)		(0.0896)	(0.0908)	(0.107)	
Sorghum	0.294***	0.278***	0.259**	1,096	0.0269	0.0805	0.115	818
	(0.0966)	(0.0945)	(0.105)		(0.115)	(0.119)	(0.143)	
Millet& Penicilaire	0.197	0.194	0.266**	409	0.0624	0.0324	0.166	273
	(0.130)	(0.128)	(0.124)		(0.151)	(0.154)	(0.180)	
Berebere	0.0499	0.0396	0.244	240	-0.461	-0.473	-0.426	128
	(0.221)	(0.233)	(0.277)		(0.286)	(0.316)	(0.317)	
Oil seeds	0.286***	0.282***	0.232**	885	0.115	0.188	0.123	697
	(0.0938)	(0.0947)	(0.105)		(0.118)	(0.122)	(0.106)	
Sesame	0.307***	0.304***	0.299**	622	0.245*	0.329**	0.173	554
	(0.115)	(0.115)	(0.125)		(0.139)	(0.147)	(0.127)	
Groundnuts	0.350***	0.345***	0.446***	572	0.152	0.169	0.297**	442
	(0.116)	(0.119)	(0.126)		(0.131)	(0.132)	(0.128)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 22 The impact of cereal banks on land use for crop production

Log (Land Use)	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Grains	-0.00379	-0.00420	-0.0129	1,328	-0.0587*	-0.0638*	-0.0337	1,008
	(0.0256)	(0.0259)	(0.0271)		(0.0344)	(0.0341)	(0.0336)	
Sorghum	0.00825	0.00891	-0.00494	1,096	0.0114	0.00659	0.0257	818
	(0.0262)	(0.0266)	(0.0290)		(0.0365)	(0.0358)	(0.0371)	
Millet& Penicilaire	-0.0687	-0.0542	-0.0620	409	-0.126*	-0.108*	-0.103	273
	(0.0438)	(0.0434)	(0.0447)		(0.0652)	(0.0594)	(0.0634)	
Berebere	-0.0390	-0.0546	-0.0978	240	-0.0410	-0.0377	-0.0440	128
	(0.0671)	(0.0769)	(0.0717)		(0.0951)	(0.0958)	(0.130)	
Oil seeds	-0.0210	-0.0207	-0.0168	885	0.0503	0.0467	0.0582	697
	(0.0258)	(0.0257)	(0.0286)		(0.0364)	(0.0351)	(0.0419)	
Sesame	-0.0194	-0.0198	-0.00951	622	0.0356	0.0357	0.0105	554
	(0.0251)	(0.0253)	(0.0261)		(0.0368)	(0.0345)	(0.0338)	
Groundnuts	0.0470*	0.0485**	0.0451*	572	0.0899***	0.0976***	0.110***	442
	(0.0249)	(0.0245)	(0.0258)		(0.0299)	(0.0314)	(0.0321)	
Crop Diversity	0.0229	0.0337	0.0138	1,471	0.113	0.0844	0.153*	1,101
	(0.0663)	(0.0659)	(0.0767)		(0.0803)	(0.0821)	(0.0812)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 23: The impact of cereal banks on storage of major crops

Log (Storage)	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Grains	0.878***	0.873***	0.819***	1,328	0.0250	0.0310	0.0460	1,008
	(0.153)	(0.152)	(0.175)		(0.0730)	(0.0735)	(0.0768)	
Sorghum	0.845***	0.844***	0.767***	1,096	0.0468	0.0742	0.0249	818
	(0.187)	(0.183)	(0.206)		(0.0880)	(0.0885)	(0.0911)	
Millet& Penicilaire	0.0598	0.186	0.380	409	-0.0303	-0.0730	0.0939	273
	(0.224)	(0.229)	(0.233)		(0.123)	(0.124)	(0.130)	
Berebere	0.0349	0.0701	0.534	240	-0.288	-0.288	-0.178	128
	(0.495)	(0.542)	(0.472)		(0.204)	(0.213)	(0.219)	
Oil seeds	0.457***	0.457***	0.343**	885	0.00637	0.0343	0.0410	697
	(0.158)	(0.159)	(0.172)		(0.0797)	(0.0791)	(0.0868)	
Sesame	0.0887	0.0825	0.0464	622	-0.0233	-0.00252	-0.0589	554
	(0.144)	(0.144)	(0.164)		(0.0829)	(0.0782)	(0.0854)	

Groundnuts	1.120***	1.135***	1.098***	572		0.221**	0.267**	0.241**	442
	(0.201)	(0.201)	(0.207)			(0.100)	(0.104)	(0.106)	
Log (Storage Duration in Months)	**PADER-G Cereal banks**					**Non-PADER-G Cereal banks**			
	IPWRA	AIPW	Entropy Balancing	Observations		IPWRA	AIPW	Entropy Balancing	Observations
Grains	0.123***	0.124***	0.111**	817		-0.0155	-0.0198	-0.0173	485
	(0.0466)	(0.0471)	(0.0519)			(0.0275)	(0.0251)	(0.0264)	
Sorghum	0.0416	0.0416	0.0504	605		-0.0372*	-0.0333	-0.0346	348
	(0.0491)	(0.0486)	(0.0551)			(0.0220)	(0.0251)	(0.0235)	
Millet& Penicilaire	0.0622	0.0586	0.0734	267		-0.0206	-0.0315	-0.0237	160
	(0.0703)	(0.0682)	(0.0689)			(0.0426)	(0.0421)	(0.0408)	
Berebere	0.360***	0.359***	0.312***	141		0.0379	0.0355	0.0277	48
	(0.0857)	(0.0869)	(0.0962)			(0.0632)	(0.0618)	(0.0696)	
Oil seeds	0.0320	0.0346	0.0126	497		0.0136	0.0189	0.0208	327
	(0.0539)	(0.0541)	(0.0645)			(0.0248)	(0.0257)	(0.0248)	
Sesame	0.156	0.168	-0.0532	278		0.0220	-0.0237	0.0429	208
	(0.272)	(0.273)	(0.293)			(0.377)	(0.390)	(0.378)	
Groundnuts	0.0408	0.0364	-0.0262	318		0.00699	0.0186	-0.00144	199
	(0.0602)	(0.0593)	(0.0712)			(0.0300)	(0.0353)	(0.0329)	
Log (Storage Loss)	**PADER-G Cereal banks**					**Non-PADER-G Cereal banks**			
	IPWRA	AIPW	Entropy Balancing	Observations		IPWRA	AIPW	Entropy Balancing	Observations
Grains	-0.0161	-0.0311	0.00598	817		-0.111	-0.115	-0.104	485
	(0.120)	(0.124)	(0.132)			(0.0750)	(0.0741)	(0.0721)	
Sorghum	0.159	0.127	0.130	605		-0.0798	-0.0688	-0.0211	348
	(0.128)	(0.136)	(0.149)			(0.0898)	(0.0922)	(0.0914)	
Millet& Penicilaire	-0.127	-0.0980	-0.0919	267		-0.0509	-0.0856	-0.100	160
	(0.189)	(0.182)	(0.195)			(0.102)	(0.108)	(0.0916)	
Berebere	0.115	0.133	0.305	141		-0.125	-0.0755	-0.288	48
	(0.253)	(0.276)	(0.314)			(0.146)	(0.184)	(0.193)	
Oil seeds	0.121	0.119	0.131	497		-0.121	-0.0977	-0.0836	327
	(0.110)	(0.111)	(0.117)			(0.0809)	(0.0771)	(0.0757)	
Sesame	-0.232**	-0.221**	-0.195*	278		-0.150	-0.0891	-0.122	208
	(0.106)	(0.105)	(0.117)			(0.102)	(0.0941)	(0.0968)	
Groundnuts	0.426***	0.428***	0.381**	318		-0.0882	-0.0605	-0.0431	199
	(0.144)	(0.145)	(0.159)			(0.0861)	(0.0907)	(0.0835)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 24: The impact of cereal banks on income and price of major crops

Log (Income)	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Grains	0.0723	0.0676	-0.0321	1,328	0.345	0.159	0.342	1,008
	(0.253)	(0.253)	(0.284)		(0.409)	(0.376)	(0.414)	
Sorghum	0.117	0.127	0.0139	1,096	0.534	0.417	0.543	818
	(0.314)	(0.314)	(0.353)		(0.502)	(0.466)	(0.519)	
Millet& Penicilaire	-0.523	-0.458	-0.960**	409	0.453	0.00853	0.307	273
	(0.435)	(0.431)	(0.397)		(0.597)	(0.586)	(0.589)	
Berebere	-0.449	-0.435	0.109	240	-1.698*	-1.888*	-1.849*	128
	(0.608)	(0.647)	(0.775)		(0.918)	(1.073)	(1.043)	
Oil seeds	0.129	0.112	-0.0198	885	0.325	0.255	0.321	697
	(0.297)	(0.296)	(0.305)		(0.469)	(0.432)	(0.456)	
Sesame	0.0636	0.0465	-0.0348	622	0.759	0.624	0.622	554
	(0.354)	(0.355)	(0.376)		(0.549)	(0.526)	(0.531)	
Groundnuts	0.828**	0.863**	0.771**	572	0.468	0.502	0.650	442
	(0.378)	(0.379)	(0.380)		(0.538)	(0.514)	(0.584)	
Log (Sales Price)	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Sorghum	-0.246	-0.261	-0.332*	1,096	-0.215	-0.215	-0.314	818
	(0.163)	(0.160)	(0.175)		(0.227)	(0.218)	(0.209)	
Millet	-0.633	-0.495	-0.777**	248	-0.306	-0.552	-0.528	166
	(0.385)	(0.392)	(0.371)		(0.549)	(0.559)	(0.510)	
Penicilaire	0.0287	-0.0439	0.155	169	0.222	0.186	0.439	109
	(0.248)	(0.262)	(0.315)		(0.354)	(0.399)	(0.454)	
Berebere	-0.516	-0.462	-0.256	240	-0.362	-0.423	-0.192	128
	(0.346)	(0.356)	(0.407)		(0.521)	(0.551)	(0.574)	
Sesame	-0.150	-0.167	-0.241	622	0.121	0.0932	0.0669	554
	(0.226)	(0.226)	(0.243)		(0.352)	(0.328)	(0.288)	
Groundnuts	0.0185	0.0221	-0.0613	572	-0.103	-0.0972	-0.148	442
	(0.224)	(0.223)	(0.231)		(0.254)	(0.262)	(0.262)	
Log (Sales)	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Grains	0.207	0.201	0.137	1,328	0.227	0.142	0.241	1,008
	(0.131)	(0.132)	(0.153)		(0.207)	(0.188)	(0.213)	
Sorghum	0.203	0.203	0.166	1,096	0.307	0.250	0.332	818
	(0.160)	(0.162)	(0.180)		(0.244)	(0.230)	(0.251)	

Millet& Penicilaire	-0.0983	-0.0792	-0.344	409		0.392	0.178	0.353	273
	(0.216)	(0.218)	(0.220)			(0.302)	(0.290)	(0.320)	
Berebere	-0.135	-0.111	0.163	240		-0.925**	-0.962**	-1.032**	128
	(0.297)	(0.304)	(0.352)			(0.438)	(0.486)	(0.492)	
Oil seeds	0.510***	0.507***	0.368**	730		0.492**	0.469**	0.459*	545
	(0.168)	(0.170)	(0.182)			(0.235)	(0.222)	(0.242)	
Sesame	0.00668	0.00590	0.00611	622		0.316*	0.286	0.185	554
	(0.140)	(0.140)	(0.153)			(0.188)	(0.184)	(0.201)	
Groundnuts	0.788***	0.803***	0.791***	572		0.491*	0.557**	0.673**	442
	(0.181)	(0.183)	(0.194)			(0.250)	(0.240)	(0.282)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 25: The impact of cereal banks on assets

	PADER-G Cereal banks					Non-PADER-G Cereal banks			
Assets	IPWRA	AIPW	Entropy Balancing	Observations		IPWRA	AIPW	Entropy Balancing	Observations
Overall Assets Index	0.140***	0.141***	0.103**	1,472		0.0558	0.0677	0.0662	1,101
	(0.0363)	(0.0363)	(0.0425)			(0.0506)	(0.0451)	(0.0486)	
Productive Assets Index	0.172***	0.181***	0.158***	1,472		0.129**	0.114*	0.144***	1,101
	(0.0522)	(0.0521)	(0.0553)			(0.0581)	(0.0614)	(0.0554)	
Livestock Assets Index	0.171***	0.170***	0.0968	1,472		-0.0137	0.0322	-0.00502	1,101
	(0.0631)	(0.0628)	(0.0771)			(0.0843)	(0.0763)	(0.0815)	
Durable Assets Index	0.0983**	0.0918**	0.0731	1,472		0.0601	0.0703	0.0743	1,101
	(0.0461)	(0.0468)	(0.0582)			(0.0767)	(0.0691)	(0.0807)	
Housing Index	0.00905	0.0103	0.0189	1,472		-0.00762	-0.00440	0.00194	1,101
	(0.0111)	(0.0111)	(0.0132)			(0.0159)	(0.0148)	(0.0161)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 26: The impact of cereal banks on poverty

Poverty	PADER-G Cereal banks (N = 1,472)			Non-PADER-G Cereal banks (N = 1,101)		
	IPWRA	AIPW	Entropy Balancing	IPWRA	AIPW	Entropy Balancing
Above 40th percentile (Overall Asset Index)	0.0742**	0.0739**	0.0551*	0.0230	0.0214	0.0326
	(0.0294)	(0.0297)	(0.0308)	(0.0409)	(0.0405)	(0.0404)
Above 60th percentile (Overall Asset Index)	0.0721**	0.0747**	0.0474	0.0117	0.00143	0.0211
	(0.0300)	(0.0300)	(0.0326)	(0.0375)	(0.0379)	(0.0362)
Above 40th percentile (Durable Asset Index)	0.0443	0.0396	0.0466	-0.0354	-0.0232	0.0291
	(0.0312)	(0.0312)	(0.0339)	(0.0396)	(0.0406)	(0.0429)
Above 60th percentile (Durable Asset Index)	0.0533*	0.0505	0.0392	0.0229	0.0287	0.0682
	(0.0309)	(0.0310)	(0.0339)	(0.0426)	(0.0414)	(0.0421)
Above 40th percentile (Productive Asset Index)	0.0924***	0.0986***	0.0756**	0.0450	0.0411	0.0208
	(0.0307)	(0.0313)	(0.0317)	(0.0422)	(0.0411)	(0.0412)
Above 60th percentile (Productive Asset Index)	0.0692**	0.0742**	0.0518	0.0550	0.0462	0.0400
	(0.0299)	(0.0299)	(0.0323)	(0.0364)	(0.0371)	(0.0356)
Above 40th percentile (Livestock Asset Index)	0.0250	0.0200	0.00946	0.0165	0.0120	0.0301
	(0.0298)	(0.0297)	(0.0331)	(0.0405)	(0.0403)	(0.0412)
Above 60th percentile (Livestock Asset Index)	-0.00299	-0.00306	-0.0173	-0.00486	0.00169	0.0151
	(0.0311)	(0.0311)	(0.0347)	(0.0401)	(0.0402)	(0.0391)
Above 40th percentile (Housing Asset Index)	0.00777	0.0113	0.0240	-0.0255	-0.0204	-0.00356
	(0.0309)	(0.0308)	(0.0346)	(0.0440)	(0.0416)	(0.0466)
Above 60th percentile (Housing Asset Index)	0.00777	0.0113	0.0240	-0.0255	-0.0204	-0.00356
	(0.0309)	(0.0308)	(0.0346)	(0.0440)	(0.0416)	(0.0466)

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 27: The impact of cereal banks on resilience

	PADER-G Cereal banks				Non-PADER-G Cereal banks			
Resilience-related variables	**IPWRA**	**AIPW**	**Entropy Balancing**	**Observations**	**IPWRA**	**AIPW**	**Entropy Balancing**	**Observations**
Overall								
Ability to recover	0.0576	0.0522	0.0541	1,331	0.198***	0.176***	0.213***	1,011
	(0.0576)	(0.0582)	(0.0652)		(0.0637)	(0.0674)	(0.0699)	
Resilience Index1	0.0576	0.0522	0.0541	1,331	0.198***	0.176***	0.213***	1,011
	(0.0576)	(0.0582)	(0.0652)		(0.0637)	(0.0674)	(0.0699)	
Resilience Index2	0.0567	0.0518	0.0549	1,331	0.197***	0.176***	0.211***	1,011
	(0.0578)	(0.0583)	(0.0654)		(0.0636)	(0.0675)	(0.0693)	
drought								
Ability to recover	0.0563	0.0496	0.0950	987	0.181***	0.155**	0.216***	798
	(0.0584)	(0.0590)	(0.0589)		(0.0620)	(0.0663)	(0.0686)	
Resilience Index1	0.0563	0.0496	0.0950	987	0.181***	0.155**	0.216***	798
	(0.0584)	(0.0590)	(0.0589)		(0.0620)	(0.0663)	(0.0686)	
Resilience Index2	0.0553	0.0500	0.0983*	987	0.179***	0.156**	0.211***	798
	(0.0587)	(0.0592)	(0.0589)		(0.0617)	(0.0662)	(0.0673)	
Crop disease/pest								
Ability to recover	-0.205*	-0.172	-0.195	514	0.0513	-0.0106	0.0735	387
	(0.121)	(0.121)	(0.132)		(0.120)	(0.135)	(0.107)	
Resilience Index1	-0.205*	-0.172	-0.195	514	0.0514	-0.0105	0.0738	387
	(0.121)	(0.121)	(0.132)		(0.120)	(0.135)	(0.107)	
Resilience Index2	-0.190	-0.156	-0.176	514	0.0655	0.00371	0.105	387
	(0.122)	(0.122)	(0.134)		(0.122)	(0.137)	(0.109)	
Local unrest/violence								
Ability to recover	0.328**	0.281*	0.264	171	0.378***	0.241	0.281**	153
	(0.141)	(0.151)	(0.161)		(0.141)	(0.169)	(0.138)	
Resilience Index1	0.328**	0.281*	0.264	171	0.379***	0.241	0.282**	153
	(0.141)	(0.151)	(0.161)		(0.141)	(0.169)	(0.138)	
Resilience Index2	0.347**	0.302**	0.285*	171	0.403***	0.264	0.328**	153
	(0.136)	(0.147)	(0.156)		(0.140)	(0.165)	(0.141)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 28: The impact of cereal banks on social capital

		PADER-G Cereal banks					Non-PADER-G Cereal banks			
Social Capital (Participationn in:)		**IPWRA**	**AIPW**	**Entropy Balancing**	**Observations**		**IPWRA**	**AIPW**	**Entropy Balancing**	**Observations**
Agricultural groups	Number of agricultural groups	0.557***	0.563***	0.564***	1,472		0.112*	0.119**	0.0998	1,101
		(0.0441)	(0.0434)	(0.0502)			(0.0605)	(0.0576)	(0.0675)	
	Number of meetings	-0.0775	-0.0375	-0.0765	679		-0.104	-0.101	-0.0918	296
		(0.111)	(0.124)	(0.122)			(0.164)	(0.167)	(0.139)	
Non-Agricultural groups	Number of social groups	0.268***	0.256***	0.220***	1,472		0.195***	0.203***	0.147*	1,101
		(0.0582)	(0.0599)	(0.0680)			(0.0729)	(0.0731)	(0.0773)	
	Number of meetings	-0.448***	-0.439***	-0.399**	355		-0.298	-0.215	-0.292	216
		(0.147)	(0.149)	(0.191)			(0.197)	(0.208)	(0.178)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 29: The impact of cereal banks on women's empowerment (agency)

Decision making (=1 if a woman)	PADER-G Cereal banks					Non-PADER-G Cereal banks			
	IPWRA	**AIPW**	**Entropy Balancing**	**Observations**		**IPWRA**	**AIPW**	**Entropy Balancing**	**Observations**
Seeds plantation	-1.66e-05	-0.00565	-0.00525	1,408		0.0172	0.0125	-0.0162	1,032
	(0.0324)	(0.0329)	(0.0341)			(0.0432)	(0.0440)	(0.0503)	
Inputs application	-0.0635	-0.0644	-0.0827*	828		0.0115	0.00696	0.0116	557
	(0.0414)	(0.0419)	(0.0442)			(0.0601)	(0.0574)	(0.0632)	
Crop harvest	-0.0415	-0.0408	-0.0605*	1,432		0.0170	0.0295	0.00253	1,058
	(0.0325)	(0.0322)	(0.0356)			(0.0477)	(0.0453)	(0.0451)	
Crops sales	-0.0273	-0.0259	-0.0343	1,409		0.0290	0.0269	0.0158	1,039
	(0.0292)	(0.0295)	(0.0301)			(0.0434)	(0.0410)	(0.0439)	
Credit	-0.00692	-0.00517	-0.0193	899		0.0379	0.0421	-0.0166	597
	(0.0435)	(0.0434)	(0.0456)			(0.0559)	(0.0579)	(0.0637)	
Choice of crops	-0.0207	-0.0234	-0.0320	1,439		0.00185	-0.00537	0.00787	1,064
	(0.0314)	(0.0313)	(0.0349)			(0.0460)	(0.0426)	(0.0462)	
Inputs choice	-0.00395	-0.00522	-0.0353	888		0.0562	0.0609	0.0531	627
	(0.0411)	(0.0410)	(0.0427)			(0.0563)	(0.0545)	(0.0583)	
Income from crop sales	-0.0406	-0.0400	-0.0496	1,417		0.0319	0.0420	0.0242	1,038
	(0.0313)	(0.0314)	(0.0345)			(0.0449)	(0.0429)	(0.0457)	
Non-agricultural activities	-0.0312	-0.0319	-0.0467	1,324		0.0470	0.0353	0.0588	993
	(0.0327)	(0.0325)	(0.0353)			(0.0436)	(0.0442)	(0.0471)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 30. The impact of cereal banks on sources of seeds of major cereals

Seed source:	PADER-G Cereal banks				Non-PADER-G Cereal banks			
Own storage seeds	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Sorghum	-0.0526	-0.0584	-0.0298	1,188	-0.140***	-0.135***	-0.0886*	868
	(0.0375)	(0.0370)	(0.0402)		(0.0419)	(0.0441)	(0.0499)	
Millet & Penicilaire	0.0842	0.0923	0.0214	433	0.104	0.129*	0.0820	291
	(0.0590)	(0.0595)	(0.0590)		(0.0683)	(0.0712)	(0.0729)	
Berebere	-0.0509	-0.0468	0.000218	246	-0.148	-0.121	-0.191	132
	(0.0981)	(0.100)	(0.0945)		(0.112)	(0.118)	(0.116)	
Sesame	0.0726	0.0744	0.0834*	634	0.0145	0.0475	-0.00418	487
	(0.0473)	(0.0475)	(0.0501)		(0.0576)	(0.0620)	(0.0621)	
Groundnuts	-0.00336	-0.00445	-0.0249	688	-0.0344	-0.0358	0.00392	597
	(0.0452)	(0.0452)	(0.0487)		(0.0651)	(0.0626)	(0.0612)	
Credit seeds	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Sorghum	0.0150	0.0143	0.00551	1,188	0.0670*	0.0698*	0.0378	868
	(0.0294)	(0.0300)	(0.0328)		(0.0363)	(0.0374)	(0.0473)	
Millet & Penicilaire	-0.0601	-0.0634	0.0159	433	-0.104*	-0.131**	-0.0916	291
	(0.0563)	(0.0558)	(0.0503)		(0.0551)	(0.0618)	(0.0576)	
Berebere	-0.0284	-0.0208	0.0527	246	-0.0678	-0.0345	0.00880	132
	(0.0704)	(0.0710)	(0.0548)		(0.0945)	(0.0914)	(0.0949)	
Sesame	-0.110***	-0.108***	-0.104**	634	0.0668	0.0592	0.0389	487
	(0.0418)	(0.0415)	(0.0432)		(0.0445)	(0.0506)	(0.0489)	
Groundnuts	-0.0366	-0.0370	-0.0451	688	0.00216	0.00772	-0.0305	597
	(0.0368)	(0.0369)	(0.0399)		-0.0578	(0.0535)	(0.0532)	
External storage facility seeds	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Sorghum	0.187***	0.186***	0.193***	1,188	0.0546***	0.0545***	0.0561***	868
	(0.0140)	(0.0142)	(0.0138)		(0.0115)	(0.0122)	(0.0130)	
Millet & Penicilaire	0.151***	0.153***	0.152***	433	0.0476*	0.0497*	0.0198	291
	(0.0236)	(0.0233)	(0.0232)		(0.0263)	(0.0271)	(0.0183)	
Berebere	0.209***	0.209***	0.205***	246	0.0754***	0.0768***	0.0739**	132
	(0.0290)	(0.0291)	(0.0296)		(0.0273)	(0.0278)	(0.0287)	
Sesame	0.107***	0.108***	0.113***	634	0.0506***	0.0478***	0.0555***	487
	(0.0150)	(0.0152)	(0.0161)		(0.0156)	(0.0162)	(0.0161)	
Groundnuts	0.112***	0.112***	0.113***	688	0.0373***	0.0393***	0.0395***	597
	(0.0152)	(0.0152)	(0.0153)		(0.0105)	(0.0108)	(0.0122)	

Commercial/ friend/ neighbor seeds	PADER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Sorghum	-0.102***	-0.0992***	-0.127***	1,188	0.125***	0.114**	0.0619	868
	(0.0364)	(0.0360)	(0.0395)		(0.0418)	(0.0442)	(0.0503)	
Millet & Penicilaire	-0.239***	-0.249***	-0.162***	433	-0.186***	-0.225***	-0.146**	291
	(0.0576)	(0.0590)	(0.0596)		(0.0669)	(0.0715)	(0.0714)	
Berebere	-0.145	-0.149	-0.195**	246	0.0975	0.0678	0.143	132
	(0.0979)	(0.100)	(0.0929)		(0.113)	(0.118)	(0.117)	
Sesame	-0.167***	-0.169***	-0.179***	634	-0.0538	-0.0843	-0.0457	487
	(0.0475)	(0.0473)	(0.0502)		(0.0591)	(0.0626)	(0.0621)	
Groundnuts	-0.125***	-0.124***	-0.109**	688	-0.00184	-0.00190	-0.0392	597
	(0.0445)	(0.0445)	(0.0480)		(0.0646)	(0.0622)	(0.0611)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 31. Impact on use of recycled seeds

Recycled seeds of:	PAGER-G Cereal banks				Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations	IPWRA	AIPW	Entropy Balancing	Observations
Sorghum	0.00504	0.00583	0.0174	1,188	-0.0212	-0.0248	-0.0325**	868
	(0.0179)	(0.0181)	(0.0208)		(0.0140)	(0.0152)	(0.0143)	
Millet & Penicilaire	-0.00877	-0.0101	-0.0138	433	-0.0229	-0.0272	-0.0160	291
	(0.0280)	(0.0264)	(0.0218)		(0.0263)	(0.0289)	(0.0250)	
Berebere	0.00727	0.0155	0.0324	246	-0.00489	0.0112	0.00983	132
	(0.0184)	(0.0257)	(0.0377)		(0.0414)	(0.0470)	(0.0495)	
Sesame	0.00364	0.00526	0.0276	634	-0.0264*	-0.0277*	-0.0256*	487
	(0.0210)	(0.0215)	(0.0294)		(0.0151)	(0.0155)	(0.0144)	
Groundnuts	-0.000983	-0.000424	0.0245	688	-0.0366***	-0.0396***	-0.0260	597
	(0.0167)	(0.0170)	(0.0239)		(0.0135)	(0.0139)	(0.0160)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 32. The impact of cereal banks on credit/borrowing

Credit	PADER-G Cereal banks					Non-PADER-G Cereal banks			
	IPWRA	AIPW	Entropy Balancing	Observations		IPWRA	AIPW	Entropy Balancing	Observations
Loan=1	0.0656***	0.0683***	0.0933***	1,472		0.0526**	0.0424	0.0426	1,101
	(0.0223)	(0.0220)	(0.0221)			(0.0252)	(0.0274)	(0.0364)	
Number of loans	0.0810***	0.0825***	0.111***	1,472		0.0677**	0.0556*	0.0582	1,101
	(0.0251)	(0.0253)	(0.0245)			(0.0273)	(0.0309)	(0.0374)	
Usury interest rate	0.115	0.104	0.125*	282		0.116	0.0892	0.146	182
	(0.0722)	(0.0841)	(0.0709)			(0.114)	(0.115)	(0.105)	

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 33: Impact of PADER-G cereal banks on objective measure of resilience to drought and dry spells (decline in food insecurity experience scale index)

	PADER-G cereal banks					Non-PADER-G cereal banks				
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
treatment_PADER_G	-6.626**	-2.797	-0.0907	-2.797	-4.014	-4.167	-1.885	0.0256	-1.885	-3.456
	(2.824)	(1.817)	(0.948)	(1.817)	(5.424)	(3.205)	(2.295)	(1.074)	(2.295)	(6.897)
prec_total_2017	-0.00745					-0.000766				
	(0.00458)					(0.00531)				
1.treatment_PADER_G#c.prec_total_2017	**0.0110****					**0.00679**				
	(0.00506)					**(0.00582)**				
precipitation_cv_2017		-2.042*					-0.786			
		(1.094)					(1.436)			
1.treatment_PADER_G#c.precipitation_cv_2017		**1.575**					**1.015**			
		(1.241)					**(1.599)**			
precipitation_cv_2017_d			-7.858***					-8.107***		
			(2.171)					(2.463)		
1.treatment_PADER_G#c.precipitation_cv_2017_d			**1.564**					**1.504**		
			(2.554)					**(2.874)**		
temperature_cv_2017				-2.042*					-0.786	
				(1.094)					(1.436)	
1.treatment_PADER_G#c.temperature_cv_2017				**1.575**					**1.015**	
				(1.241)					**(1.599)**	
temperature_cv_2017_d					1.033**					0.671

	PADER-G cereal banks					Non-PADER-G cereal banks				
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
					(0.426)					(0.562)
1.treatment_PADER_G#c.temperature_cv_2017_d					**-0.316**					**-0.274**
					(0.480)					**(0.614)**
Observations	1,472	1,472	1,472	1,472	1,472	1,331	1,331	1,331	1,331	1,331

Standard errors are shown in parentheses. Significance levels: *** p<0.01, **p<0.05, *p<0.1

International Fund for Agricultural Development
Via Paolo di Dono, 44 - 00142 Rome, Italy
Tel: +39 06 54591 - Fax: +39 06 5043463
Email: ifad@ifad.org
www.ifad.org
ifad-un.blogspot.com
www.facebook.com/ifad
instagram.com/ifadnews
www.twitter.com/ifadnews
www.youtube.com/user/ifadTV