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EPIC | Economics and Policy Innovations for Climate-Smart Agriculture

Food security impact of agricultural technology adoption under climate change: Micro-evidence from Niger

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Executive summary

This brief summarizes the results of a comprehensive national representative plot-level survey with a wealth of socio-economic information[1] merged with geo-referenced climatic information[2]. We assess factors affecting the adoption of agricultural technologies under climate risk and evaluate the impact of adoption on food security in Niger. Specifically, we look at how bio-physical and climatic factors affect a set of agricultural practices known to increase resilience and productivity. We analyse the relationship between type of practice and crop productivity for a range of different farmer types, and under a range of biophysical and climate conditions.

Introduction

Climate variability is already reducing agricultural productivity and is a clear threat to the ability of the agricultural sector to feed the world's growing population.

According to the Intergovernmental Panel on Climate Change (IPCC), increased variability in climate patterns, including the increased intensity and frequency of extreme events (mainly drought and floods). This is already occurring in some regions, with particularly negative impacts on rain-fed agriculture and the populations that depend upon it for food security.

This issue is of considerable importance in Niger, where the agriculture sector is characterized by high dependence on rain-fed agriculture, a scarcity of arable land and unstable rainfall. A mapping of vulnerability and poverty in Africa listed Niger as one of the countries that is both most vulnerable to climate change and least capable of responding to it.

Given that agricultural production remains the main source of income for most rural communities in Niger[3], the growing risk of crop failure associated with the increased frequency of

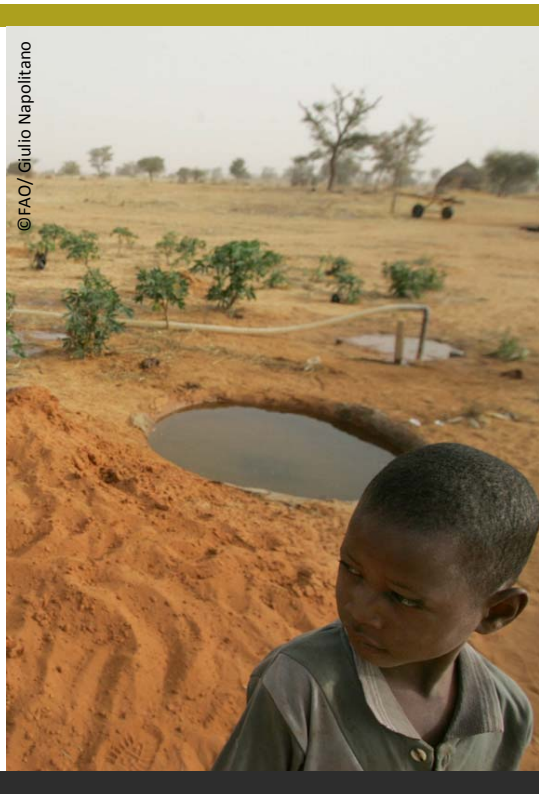
HIGHLIGHTS – KEY RESULTS

- Climate variability is one of the strongest determinants of type of practice adopted.
- Erosion problems are reported on about 15 percent of the plots.
- Use of inorganic fertilizer is higher than overall adoption rate of modern crop varieties.
- Use of crop residuals for incorporation into soils is more widespread compared with other practices.
- Households with higher levels of wealth, education and labour are the most likely to adopt modern inputs.
- Adoption of both modern inputs and organic fertilizer boosts the value of harvest per acre.
- Households with delayed onset of rainy season show consistent negative impact on harvested value of the crop.
- Farm plots with a nutrient availability constraint have lower harvest value per acre.
- Presence of cooperative and proximity to markets are strong positive determinants of harvested value per acre.
- Crop productivity from plots managed by women tends to be lower than male-managed plots.

[1] Niger National Survey of Household Living Conditions and Agriculture (ECVM/A, 2011).
[2] National Oceanic and Atmospheric Administration (NOAA) and the European Centre for Medium Range Weather Forecasts (ECMWF).

extreme events poses a major threat to food security and poverty reduction. Understanding the impacts of climate variability on smallholder production, and developing strategies that support farmers by improving their capacity to cope with the challenge, is thus an increasingly critical concern for the country's agricultural policy-makers.

Adaptation strategies may include diversification into off-farm activities (working as agricultural labourers, engaging in petty trading or migrating for wage work, etc.) as well as a range of on-farm actions (new cultivars, changing planting dates, sustainable land management or diversifying production activities, etc.). There is growing policy interest in building effective capacity to adapt to climate risk, and increasing resources dedicated to promoting a range of sustainable land management and productivity enhancing practices in many regions of Niger. Nevertheless, the level of use of these practices remains generally quite low, which could lead to stagnant or worsening yields and continuing land degradation.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[3] In 2001, agro-sylvo-pastoral production accounted for 38.1 percent of the national GDP (INS, 2005). The rural sector is also the most important source of employment, with 83.7 percent of the total population employed in activities related to the agriculture, livestock breeding, exploitation of forest resources, and wildlife and fisheries sectors (SDR, 2008).

Climate variability and adoption of farming practices in Niger

We analysed climate variability trends in Niger, using time series indicators of historical rainfall and temperature at the highest resolution and for the longest time period available.

Variables used to measure exposure to climate-related stress included average long-term rainfall and temperatures (1983–2011), the coefficient of variation in rainfall (1983–2011), average rainfall shortfall (1983–2011), the coefficient of variation temperature and number of dekads in which the maximum temperature was greater than 35 degrees.

The time series for rainfall data analysis clearly showed that the amount of rainfall is increasing over time (1983-2012) with minor differences among land use types. This trend is confirmed by 2006 forecasts from the National Environment Council for Sustainable Development of Niger, which predicted that rainfall would increase in the Sahel region due to climate change.

Our analysis of the distribution of the coefficient of variation of rainfall showed that pastoral areas experience relatively low levels of rainfall and higher variability compared with agricultural and agro-pastoral areas. We also observed significant differences in the distribution of current and long-run average rainfall across the different land use types.


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Such high temporal and spatial rainfall variability makes Nigerien farms more vulnerable to serious production losses, making it increasingly difficult for national agricultural production to satisfy the demand for food from the growing population. In examining the Niger dataset, we considered the adoption of potentially risk-reducing agricultural farm practices, such as the use of organic fertilizers, crop residues, legume intercropping, and soil and water conservation practices. These important elements of the Nigerien National Agriculture Plan are considered effective ways to increase the resilience of agricultural systems by improving their ability to withstand a climate shock such as drought or intense rainfall and remain productive.

Essentially these practices build ecosystem services such as soil quality, water retention capacity and nutrient cycling capacity, which are important in terms of maintaining productive capacity under climate stresses. We also examine the use of improved crop varieties and inorganic fertilizers, two practices that are aimed primarily at improving average yields and ultimately farm income, although their benefits in terms of reducing the risks of current climate stresses are uncertain.

[4] The shortfall variable has been computed as the average distance between the yearly precipitations during the rainy season and their long-term mean. Years reporting a level of rainfall higher than the long-run average have not been considered for the computation of the variable.

Key results

Adoption patterns and determinants

- We found that climate variability is indeed one of the strongest determinants of type of practice adopted. In regions with greater rainfall and temperature variability, crop residue incorporation into soils is more widely adopted. The probability of using modern inputs and organic fertilizer is negatively correlated with variability in rainfall and temperature.
- Erosion problems are reported on about 15 percent of the plots in the sample. The problem is particularly acute in the pastoral areas, where 27 percent of the plots are affected by erosion. Despite these high rates, adoption of anti-erosion measures is very low (3 percent at national level); the most frequent strategy for offsetting the effects of land degradation was found to be the establishment of tree belts (2 percent).
- Interestingly, the use of inorganic fertilizer is higher (11 percent) than the overall adoption rate of modern crop varieties (2 percent). The adoption rate of inorganic fertilizers is quite heterogeneous throughout the country and is concentrated in the agricultural areas of the Maradi and Zinder regions. Organic fertilizer was the most common strategy, with 33 percent of farmers reporting its use; whereas legume intercropping (6 percent) was not widely adopted.
- On the other hand, the use of crop residuals for incorporation into soils, is more widespread (40 percent) than the other practices, and this is particularly true in the agro-pastoral zones of Maradi, Zinder and Diffa. Since crop residuals are valuable for livestock feed and fuel use, the fact that farmers use them to incorporate into soils suggests that there is a strong benefit to productivity or resilience. Farmers with soils with high nutrient availability (or low constraints) were significantly less likely to use organic fertilizer or crop residue incorporation. Surprisingly, nutrient availability had no significant effect on inorganic fertilizer use.
- Households with higher levels of wealth, education and labour are most likely to adopt modern inputs. Distance to the nearest market and extension service also plays a strong role in adoption: the greater the distance, the less likely they are to have modern inputs. The converse holds true for organic fertilizer use: the further away the farm household is from the market and extension centre, the more likely it is to use organic fertilizer. Ownership of the plot is an important determinant of the likelihood of using organic fertilizer and residue incorporation into soils; both of which take time to realize their full benefits.


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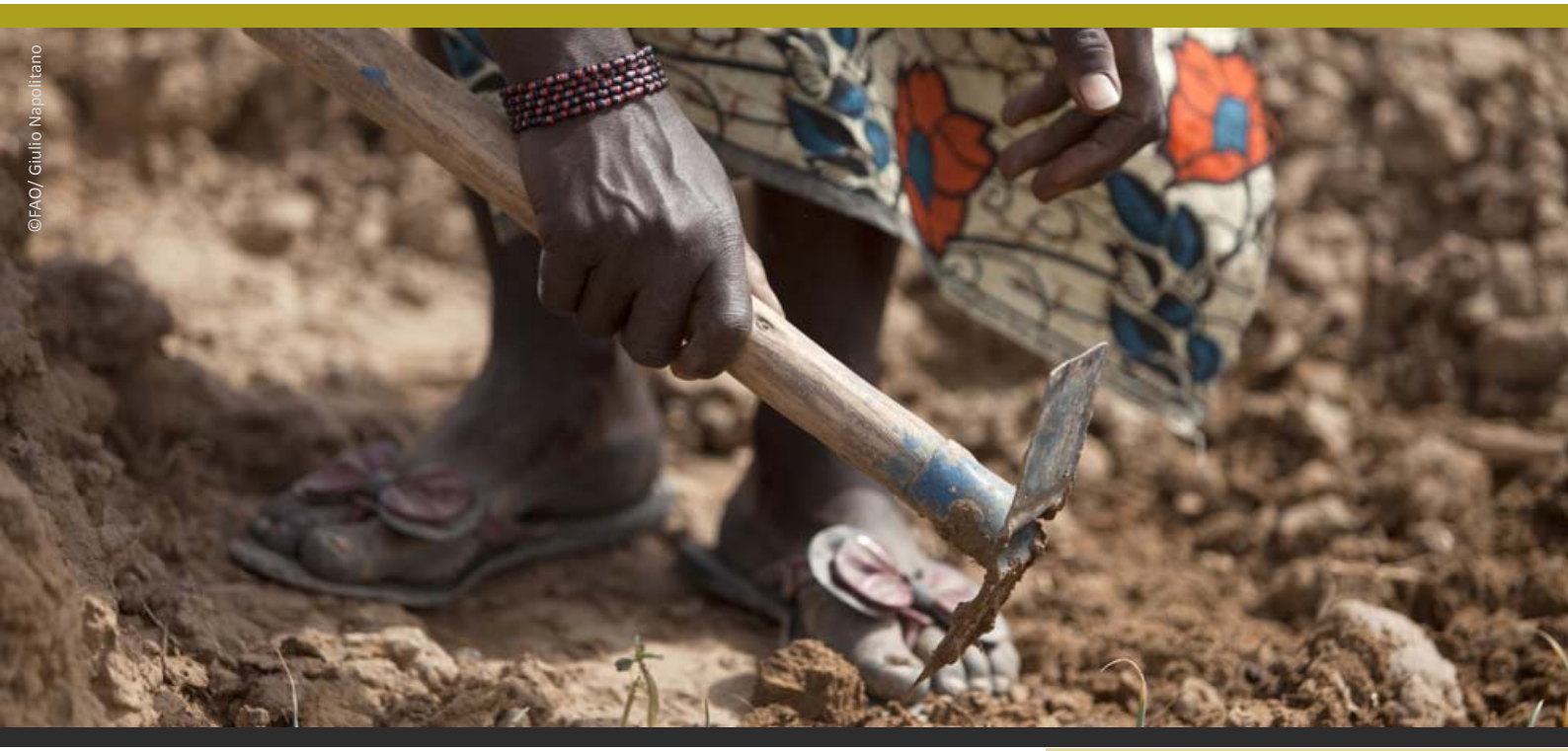
Relationship between climate variability, practices and productivity

- We found that the adoption of both modern inputs and organic fertilizer boosts the value of the harvest per acre. The use of crop residues does not seem to increases the crop value per acre and could even have a negative effect. This result is surprising: given the opportunity costs associated with residue use, we would expect to find a strong farm benefit. One possible explanation is that the use of crop residues for incorporation into soils may reduce the probability of yield losses in the wake of a climate shock (e.g. it reduces yield variance, but does not increase average yield in the short term) but we are unable to estimate this effect with this dataset.
- We found a very strong and consistently negative impact on harvested value of the crop among households reporting that they had experienced a delayed onset of the rainy season.
- Farm plots with a nutrient availability constraint had significantly lower harvest value per acre.
- The presence of a cooperative in the community and proximity to markets were strong positive determinants of the harvested value per acre.
- Crop productivity from plots managed by women tended to be significantly lower than those of their male-managed counterparts. Crop productivity tended also to decrease with the age of the farmer and land size.



Conclusions and recommendations

1. Climate variability and soil quality are key determinants of the practices farmers adopt and the returns they earn. This information could be used to better target interventions.
2. We found very low rates of modern input adoption (inorganic fertilizer and improved seeds) despite high and significant impacts on the harvested value of the crop. This suggests that barriers to the adoption of seeds and inorganic fertilizer are a key issue to address.
3. Crop residue incorporation is the only strategy we found to be positively and significantly correlated with high rainfall and temperature variability, while the use of both organic fertilizer and modern inputs is significantly lower in such regions. Yet we found no positive impact of crop residue incorporation into soils on value of harvested output per acre. The evidence is just one piece of the puzzle, and the finding would have to be confirmed through other types of studies. This also implies that we need to look at potential alternative strategies for risk management in these areas.
4. Soil nutrient availability and land quality are found to be important determinants of practice type and harvested value – yet there is a large and apparently growing problem with land degradation through erosion. Very low adoption of erosion control measures suggests that there are some substantial barriers to adoption and considerable benefits could be reaped by trying to reduce them.
5. We found that cooperatives and extension services are playing an important role in facilitating adoption of practices that are climate smart (e.g. that may give either higher incomes or higher resilience) and that these interventions seem relatively cost-effective.
6. Delayed onset of rains can be expected to increase in frequency and is clearly a major detriment to farm incomes. Measures to help farmers better cope in this circumstance, such as a wider range of varieties that can fit into varying length of growing seasons, weather information services, and soil preparation practices that may be initiated in advance of rains are likely to produce high returns.

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EUROPEAN UNION

ABOUT EPIC

EPIC is a programme of the Food and Agriculture Organization of the United Nations (FAO). It supports countries in their transition to Climate-Smart Agriculture through sound socio-economic research and policy analysis on the interactions between agriculture, climate change and food security.

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