REFEREED ARTICLE

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# Analysing the Links Between Index-Based Crop Insurance Adoption and Agricultural Investments in Burundi

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**ABSTRACT**

This paper analyses the links between index-based crop insurance (IBI) adoption and agricultural investments based on a cross-sectional sample of 40 crop insurance adopters and 40 non-adopters from two communes located in Gitega province in Burundi. Analysed agricultural investments variables included use of fertilizers, applying crop diversification, and use of land and crop management practices in the most recent year and in the year before IBI implementation started. The results from multivariate analysis indicate that adopters use 36% more chemical fertilizers and invest 18% more in chemical fertilizers than non-adopters ($p \leqslant 0.01$). Adopters apply more land management practices also, in which they invest 15% more than non-adopters ($p \leqslant 0.01$). Furthermore, adopters change crop management practices over time by 38% and their knowledge in crop management practices increased by 23% ($p \leqslant 0.01$). Differences between adopters and non-adopters are however not statistically significant for crop diversification strategies and for the use of organic fertilizers. Hence, in order to be more effective and beneficial to farmers, other actions are also needed to encourage farmers to invest in their farm. Particularly promising in Burundi in this respect is to empower and train farmers by means of the Integrated Farm Planning approach, as well as to enhance farm inputs availability and to promote smart agri-entrepreneurial programs. In order to enhance agricultural development, the Burundi government should have a more prominent role in fostering farmers' agricultural investments and in supporting IBI adoption.

**KEYWORDS:** Index-based crop insurance; adoption; agricultural development; smallholder farming; Burundi

## 1. Introduction

Weather-related shocks are a major threat to the livelihoods of vulnerable farmers in low-income, arid and semi-arid regions of the world (Jensen, Mude, & Barrett, 2018). In response, crop insurance products have been piloted in, for example, Sub-Saharan Africa (SSA) to protect low income farmers against climate related risks (Churchill, 2008, Ntukamazina *et al.*, 2017). However, implementing traditional indemnity-based crop insurance schemes in a viable way with substantial outreach is hampered by information asymmetry (causing moral hazard problems and adverse selection) as well as associated transaction costs to address those problems. Agricultural index-based crop insurances (IBIs) tackle this moral hazard and adverse selection, given that they are based on a verifiable and independent measurement of a variable that impacts crop development (Sinha & Tripathi, 2016). Hence, the advantage of an IBI is that farmers are paid-out based on indices rather than appraised losses. IBIs are therefore considered as a potential solution to the long-standing problem of low rates of crop insurance adoption, especially in risk-prone regions of SSA (Carter *et al.*, 2015).

Nevertheless, the main challenge of the IBI lies in the method of compensation in the event of a climatic shock. This arises partly from the spatial discrepancy between the measured risks at a specific meteorological station and the occurrence of weather shocks at the location of the insured farm. For instance, it may rain more than the trigger level for drought insurance at the meteorological station but not at the insured location, with the result that a farmer is not compensated for incurred losses due to drought. In this case, no payments are done (or payments are lower), even though the farmer has paid the insurance premium (Carter *et al.*, 2014). More spatial targeted IBIs can be designed by using satellite-based information (to limit spatial basis risk), but some elements of basis risks still remains. The basic risk is the

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difference between actual loss and the pay-out on an insurance contract (Fisher *et al*., 2019).

Most farmers appear to be reluctant to opt for an IBI with inherent basic risks (Smith & Goodwin, 2006). Yet the growth of IBIs, primarily weather-index insurances but also area-yield index crop insurances, has been remarkable in the developing world over the past decade (Bobojonov, *et al.,* 2013, Sinha & Tripathi, 2016). An IBI is regarded as a major innovation that could revolutionize access to formal insurance for millions of farmers and related individuals in the near future (Carter *et al.*, 2014). However, ambiguous evidence feed the debate on IBIs and to what extent they represent an opportunity for development, especially in a dynamic and changing environment (Sabatini, 2017).

An insurance program enables farmers to take more risk, which they would not have taken in the absence of it (Aditya, Khan, & Kishore, 2019), leading farmers to invest more in viable activities and use more inputs (He, *et al.* 2016). Increased investments have been found in several empirical IBI studies. For example, Karlan *et al.* (2014) investigated the impact of an IBI on income enhancing agricultural investments in a randomized control trial in Ghana and found a strong response. Also in a field study in Kenya IBI uptake contributed to investments in chemical fertilizers and adoption of improved seeds, as well as to higher yields (Sibiko & Qaim, 2017). Studies in the Philippines (He *et al*., 2016) and in the USA (Chang &Mishra, 2012; Claassen *et al.*, 2017) also revealed a positive effect of IBI adoption on the use of chemical fertilizers. In a review study comprising several field studies in developing countries it was shown that farmers with an IBI increased agricultural investments (Carter *et al.* (2014).

However, there are also studies that find no effect or even the opposite. Babcock and Hennessy (1996) found that farmers in Iowa (USA) with a yield and revenue insurance are likely to use less chemical fertilizers. Similar effects were found in Kansas (USA) where farmers with an index-based insurance used fewer inputs such as chemical fertilizer (Smith & Goodwin, 1996) and improved seeds (Sibiko & Qaim, 2017). Furthermore, also in the USA, Quiggin *et al.* (1993) in a study on a multi-peril crop insurance found an insignificant effect of the insurance on the use of chemical fertilizers.

Although there are many studies that analyse the effect of crop insurances on fertilizer use, there are only few that focus on their effects on the use of land or crop management practices. Prokopy *et al.* (2019) studied adoption of agricultural conservation practices in the USA and found that a crop insurance is sometimes correlated with conservation practice adoption. However, findings from Beckie *et al.* (2019) revealed that the short-term nature of a crop insurance, being an annual expense, does not directly incentivize (more long-term) best management practices.

In summary, how insurance adoption affects input use and land management on the farm is still under debate. This paper aims to fill this gap by analysing the links between IBI adoption and agricultural investments in rural Burundi.

## 2 Methodology

### Context

This study was performed in two communes of Gitega province, namely Bukirasazi and Makebuko, located in the central part of Burundi. Annual and perennial crops are cultivated during the three main agricultural seasons: in the two rainy seasons A (from September to January) and B (from February up to May) and the dry Season C from June up to September (when crops are cultivated only in the marshlands).

Participatory meetings were organized with farmers to discuss the design of the insurance to be implemented. Farmers preferred the weather-based crop insurance rather than a conventional insurance (i.e., indemnity-based multi-peril crop insurance) since implementation was expected to be easier, cheaper and eliminated moral hazard problems. Moreover, a mutual approach was followed in which farmers are the insured and insurers at the same time. The mutual IBI is implemented and coordinated by a Micro-insurance and Finance Cooperative (MAFICO), which is an independent micro-insurance that promotes an agricultural insurance, a health insurance, and micro saving and credit schemes. It is owned and managed by farmers, who are also represented in the executive board (Ndagijimana *et al*., 2017).

The IBI was launched in season B 2017 in the aforementioned two communes. Farmers were targeted on the basis of specific criteria such as belonging to a village saving and loan association (VSLA) with a high adoption level of land management practices, and a subscription to the health insurance scheme. As a result, only VSLAs with at least 60% of the members having implemented land management practices were allowed to participate in the insurance program. Although the VSLAS' main objective is to promote savings and service loans to their members, it also constituted to save 30% of the contributions for an agricultural insurance (premium payment). Next to these savings for premium payments, VSLA members were trained on how to increase farm productivity through the implementation of the so-called Integrated Farm Planning (PIP) approach, which was introduced in the study area by the project ''Fanning the Spark'' in 2013. The approach implies that families make a visionary integrated farm plan (the PIP) which is developed and drawn on a map, and which aims at transforming small-scal subsistence farm households into more productive and sustainable farms, based on sound natural resource management (Kessler *et al*., 2016). The PIP approach works to some extent like a theory of change (Taplin *et al.*, 2013), since it defines long-term goals and then maps actions to achieve the planned changes. The PIP approach focuses on the household and the farm as a 'farming system', where integration of practices and a diversity of crops and activities are crucial to make the household more resilient.

### Agricultural investments analysed in this study

The term ''investment'' in this study includes both monetary and non-monetary expenditures. Thus, farm investment is the monetary value spent by the farmer to obtain certain farm inputs and the cost of implementing the farm practices based on the time used to do so. Four types of investments are considered for this study, namely investments in fertilizers, crop diversification, land management and crop management:

- Fertilizer investments comprise organic and chemical fertilizers. Organic fertilizers are either manure from own livestock or purchased. In the study area, most farmers possess big and/or small livestock which provides manure. Chemical fertilizers are purchased mainly from the communal or provincial extension services (as part of a subsidized public policy).

- Crop diversification investments comprise nine annual crops: beans, cassava, maize, potatoes, peanuts, peas, rice, soybean and sweet potatoes. These are the main staple crops in the study area, but also at national level, and are seasonally grown (mainly in season A and season B). Furthermore, eight vegetable crops were considered: amaranth, cabbage, carrots, marrow, onion, pepper, spinach, and tomato. Most of these crops are grown around the homestead in a vegetable garden, as well as in marshlands during season C (dry period). Finally, eight perennials were considered: avocado, banana, coffee, citrus/lemon, Japanese plum, mango, maracuja, pineapple. Most of these crops are cash crops and commercialized on the local market.
- Land management investments considered eight land management practices: agroforestry, basic compost pits (traditional, unroofed), improved compost pits (well-designed and roofed), mulching, ploughing along the contour line, trenches on the contour lines (with or without vegetation on the bunds), and vegetative borders (hedges).
- Crop management investments covered eight crop management practices: kitchen gardens, continuous ridges, planting in triangle form, adequate crop spacing, crop rotations, mixed cropping, row cropping, and relay intercropping.

## Sampling and data collection

The sample comprised 40 farmers who started with the IBI in 2017 and 40 farmers who were not involved. Farmers in both groups were randomly selected from VLSAs in the same areas to minimize the heterogeneity of agro-ecological characteristics which could influence farmers' decisions on the four types of agricultural investments as above mentioned. Furthermore, some control variables were taken into account (i.e. gender, age and education of the respondent, and whether or not the respondent runs his/her farm with the PIP approach). Quantitative information was collected through a household survey with a structured questionnaire, which was administered by trained enumerators in May 2019. The farm-level household survey was complemented with focus group discussions (FGD) to interpret and strengthen individual information provided by farmers. In total, four focus group discussions were organized, with in each commune, one FGD for the IBI adopter group and one for the non-adopter group.

## Description of variables and empirical analysis framework

By means of a cross-sectional survey with recall estimates, we were able to consider two time periods, i.e. the time before the IBI implementation ($T_0$=2016) based on recall estimates of the farmer and more recent estimates three years after IBI implementation ($T_1$=2019). First a simple Difference-in-Difference (DD) test was used to analyse differences between the adopters and non-adopters. The DD model which estimates the average IBI effect was estimated for each agricultural investment under analysis by the following formula based on Shahidur *et al.* (2010):

$$DD = E(Y_1^T - Y_0^T | T_1 = 1) - E(Y_1^C - Y_0^C | T_1 = 0) \quad (1)$$

$Y_t^T$ and $Y_t^C$ are respectively adopters and non-adopters in time $T_1$ (=1) denoting the presence of the insurance program, and with $T_1$ (=0) the time before the IBI started. The superscripts $^T$ and $^C$ represent beneficiary group (treatment) and non-beneficiary group (control).

The univariate regression equation is as follows:

$$Y_j = \beta_0 + \beta_1 insurance_j + E_j \quad (2)$$

$Y_i$ is the dependent variable representing changes in the amount or costs of one of the agricultural investment (i.e fertilizers, crop diversification, land and crop management practices) used by farmer j between 2019 and 2016 and $E_j$ is the error term. Insurance is a dummy variable indicating whether insurance was adopted or not.

Subsequently, by means of multivariate analysis control variables were taken into account in addition to insurance, The equation based on He (2016) becomes as follows:

$$Y_j = \beta_0 + \beta_1 insurance_j + \beta_j X_j + E_j \quad (3)$$

Xj is a vector including farmers' and farm management characteristics (control variables) that can potentially affect input use.

- Gender of the respondent (1= Male, 2= female)
- Age of respondent (number of years)
- Education of respondent 0=illiterate, 1=attended primary school, 2=attended secondary school, 4= attended university)
- PIP approach (1= farmer runs his/her farm with PIP approach, 0 otherwise).

We assume that IBI adoption has a positive effect on agricultural investments above mentioned. The four agricultural investments under analysis were assessed as follow:

- Changes in fertilizer used in this study cover both chemical and organic (either 'purchased' or 'own production') and were rated by farmers with a three point Likert scale (1=used less, 2= no change, 3= used more). The expenditures associated to purchasing fertilizers were derived from the market prices (normally fixed by the government through government's fertilizer subsidy program) and the amount purchased (kg). The amount of fertilizer used in this study refers to seasons A and B in 2019 to minimize errors from farmers who might not remember how many kg was purchased a long time ago.
- Changes in crop diversification investments were obtained by asking farmers for each crop if it was grown in 2016 and 2019, and if they had invested in new seeds/plants. The outcome could therefore be either a score of -1 if the crop was grown at $T_0$ and no longer at $T_1$; a score of 0 if no change happened between $T_1$ and $T_0$; or a score of 1 if the crop was grown at $T_1$ whereas it was not at $T_0$. Then, mean scores were calculated based on these three outcomes

[-1, 0, 1] concerning the changes over the study period ($T_0$ and $T_1$).

- Land management investments were analysed by evaluating (i) changes in different measures before ($T_0$) and after ($T_1$) the start of the IBI, and (ii) the costs associated to land management implementation. These costs were derived either by multiplying the cost of a daily manpower and the total number of days spent to implement the practice or multiplying the size of the implemented practices by the cost per unit. For the same reasons as with fertilizers, the cost of the land management implementation refers to the year 2019.
- Crop management investments were analyzed by (i) the change in use of a given practice between $T_0$ and $T_1$, as well as (ii) the change in knowledge of practices since the start of the IBI (1 = no change, 2 = some increase in knowledge level, 3 = substantial increase in knowledge level).

## 3. Results

### Fertilizer investments

Total fertilizer use changed over time ($p \leqslant 0.05$) between non-adopters and adopters as estimated in the univariate DD analysis. Approximately 26.1% of the adopters used more fertilizers compared to 17.8% of the non-adopters between $T_0$ and $T_1$, while 18.1% of the adopters used less fertilizer compared to 34.1% of the non-adopters (Table 1).

Concerning organic fertilizers, the non-adopters did not significantly differ from the adopters, mainly because farmers in the study area predominantly used organic fertilizer produced by owned livestock rather than purchasing it. For chemical fertilizers the results from Table 2 indicates that the adopters were significantly different ($p \leqslant 0.01$) from the non-adopters: BIF 56,370 (US$ 30.84)[1] versus BIF 37,755 (US$ 20.65), i.e. a difference of BIF 18,615 (US$ 10.19).

### Crop diversification investments

By comparing adopters and non-adopters at $T_0$ (Table 3), 67.2% of adopters cultivated all nine annual crops versus 57.2% of the non-adopters. By using the difference-in-difference test for analysing the degree of crop diversification in disaggregated form (annual crops, perennial crops, and vegetable crops) during the two periods ($T_1$ and $T_0$), the results of the "mean investment scores" indicate that adopters replaced some annual (DD=-0.05) and perennial crops (DD=-0.05) by vegetable crops (DD=0.01). However, changes over time between adopters and non-adopters showed no statistically significant differences (not only at disaggregated form but also as a whole).

### Land management investments

Over time, significant differences were found between the adopters and non-adopters in overall land management practices ($p \leqslant 0.01$) meaning that adopters were 8% more likely to apply land management practices than the non-adopters. Of the individual practices the use of vegetation borders and ploughing along counter lines were the most significant ones ($p \leqslant 0.01$) (Table 4).

However, the results show also that the number of non-adopters applying basic compost pits and contour line without vegetation decreased at $T_1$ compared to $T_0$ (the mean investment scores are negatives). This suggests that these two 'basic' practices have been replaced by the more 'modern' ones i.e. basic compost pits were replaced by improved compost pits and contour lines were planted with vegetation.

The cost associated to the implementation of these land management practices was also found statistically significant between both groups ($p \leqslant 0.01$). Adopters invest more in land management (BIF 14,728; US$ 8.05) than non-adopters (BIF 7,434; US$ 4.06), hence a difference of BIF 6,843 (US$ 3.99). These results show that, in general, the implementation of land management practices in the study area requires little investments. This is linked to the average size of the farm (cultivated area) which is small in Burundi (74.3 acres per household) and in the study area (73.5 acres per household) (ISTEEBU, 2015).

### Crop management investments

The overall analysis of crop management investments reveals that adopters have doubled ($p < 0.01$) these practices over time (42.6% in $T_0$ versus 84.5% in $T_1$), while investments were less profound for non-adopters (Table 5). Findings from the DD test indicate that adopters are 38% more likely to invest in all crop management practices together ($p \leqslant 0.01$). Specifically, adopters are significantly different from non-adopters in the use of crop spacing ($p \leqslant 0.01$), crop rotation ($p \leqslant 0.05$), mixed intercropping ($p \leqslant 0.05$), continuous ridges ($p \leqslant 0.01$), use of triangle ($p \leqslant 0.10$), and row intercropping ($p \leqslant 0.05$).

Crop management knowledge has significantly improved for all practices for the adopters (positive mean knowledge score) based on the results from Table 6. On average, 55% of the adopters recorded substantial changes in knowledge compared to only 6.5% of the non-adopters ($p \leqslant 0.01$). Furthermore, only 27% of adopters stated to have the same knowledge level, while 81% of non-adopters remained on the same level as in 2016.

### Links between index-based insurance on agricultural investments

Multivariate linear regression models were used to determine the link between the IBI adoption and considered agricultural investment variables. Tests revealed a good fit of the models as indicated by for example Chi-square coefficient and $R^2_{adj}$ (Table 7). IBI adoption was found to have a positive and significant effect on the fertilizer investments (in amount as well as the cost of fertilizers), on land management (in change of practices as well as the cost associated to the implementation of these practices), and on crop management (in change of practices and knowledge). The findings indicated that adopters used more chemical fertilizers with 36%-point ($p \leqslant 0.01$) and invest 18% more than non-adopters ($p \leqslant 0.01$). In addition, adopters were found to be more likely to change land management practices (12% higher, $p \leqslant 0.01$) and increased their investments by 15% (i.e. BIF 15 for BIF 100 invested) for the implementation of land management practices ($p \leqslant 0.01$). Adopters were more likely to change crop management practices (38% higher, $p \leqslant 0.01$) and their knowledge in crop management practices can be expected to increase by 23% ($p \leqslant 0.01$).

[1] At the time of writing BIF (Mid-June, 2019): 1 US$ was approximatively equivalent to BIF 1827.929.

**Table 1:** Differences in the fertilizers use between adopters and non-adopters in 2019 ($T_1$) compared to 2016 ($T_0$)

| Category of respondent | Changes Fertilizers ($T_1$-$T_0$) | Frequency (%) | Mean score | Std. Dev. | DD |
|---|---|---|---|---|---|
| Adopters | | | 1.70** | 0.88 | 0.01** |
| | Used less | 18.1 | | | |
| | No changes | 58.8 | | | |
| | Used more | 26.1 | | | |
| Non-adopters | | | 1.69** | 0.75 | |
| | Used less | 34.1 | | | |
| | No changes | 48.1 | | | |
| | Used more | 17.8 | | | |

Test $T_1$-$T_0$, DD: *$p \leqslant 0.05$, **$p \leqslant 0.01$. N=80 (adopters=40, non-adopters=40)

**Table 2:** Differences in fertilizer investments between adopters and non-adopters in 2019

| Fertilizers | Category of respondent | Mean | Std. Dev. | DD |
|---|---|---|---|---|
| Organic fertilizer: quantity purchased (in kg) | Adopters | 2.50 | 27.38 | 0.83 |
| | Non-adopters | 1.67 | 18.25 | |
| Organic fertilizer: quantity own production (in kg) | Adopters | 1,099 | 1,594 | 392.74 |
| | Non-adopters | 706.26 | 1,342 | |
| Organic fertilizer: cost (in BIF) | Adopters | 100 | 1,095 | 33.33 |
| | Non-adopters | 66.67 | 730.29 | |
| Chemical fertilizer: quantity used (in kg) | Adopters | 49.36 | 52.07 | 19.71** |
| | Non-adopters | 29.65 | 39.88 | |
| Chemical fertilizer: costs (in BIF) | Adopters | 56,370 | 55,231 | 18.62** |
| | Non-adopters | 37,755 | 50,210 | |

DD: **$p \leqslant 0.01$. N=80 (adopters=40, non-adopters=40)

**Table 3:** Differences in crop diversification between adopters and non-adopters in year 2019 ($T_1$) and 2016 ($T_0$)

| | | Frequency (%) | | | | |
|---|---|---|---|---|---|---|
| Type of crops | Category of respondent | $T_0$ | $T_1$ | Mean investment score | Std. Dev. | DD |
| Annual crops | Adopters | 67.2 | 63.1 | -0.04 | 0.09 | -0.05 |
| | Non-adopters | 57.2 | 58 | 0.01 | 0.33 | |
| Perennial crops | Adopters | 37.8 | 35.9 | -0.02 | 0.25 | -0.05 |
| | Non-adopters | 26.3 | 26.6 | 0.03 | 0.27 | |
| Vegetable crops | Adopters | 30.6 | 33.4 | 0.03 | 0.01 | 0.01 |
| | Non-adopters | 20.9 | 22.5 | 0.02 | 0.12 | |
| All types of crops | Adopters | 45.2 | 44.1 | -0.01 | 0.18 | -0.02 |
| | Non-adopters | 34.8 | 35.7 | 0.01 | 0.12 | |

N=80 (adopters=40, non-adopters=40)

Furthermore, male-headed households invested 16% and 5% less in fertilizers and in land management respectively ($p \leqslant 0.05$) than female-headed households. Since Burundian men are not as much involved in field activities as women, they are less receptive to problems related to agriculture and therefore invest less in agriculture. Moreover, highly educated respondents applied more crop diversification ($p \leqslant 0.05$) than lower educated respondents. Finally, farmers who run their farm with a PIP approach were more likely to increase the amount of fertilizers ($p \leqslant 0.05$), with the amount of fertilizers used being 22% higher for farmers running their farm with a PIP approach as compared to others who don't have a PIP.

## 4. Discussion

This study explored the links between IBI adoption and agricultural investments in Burundi by comparing adopters and non-adopters. It was hypothesized that adopters invest more than the non-adopters in fertilizers, crop diversification, land and crop management practices.

The findings indicated that IBI adopters invest much more in chemical fertilizers. However, The IBI adoption did not show any significant difference between adopters and non-adopters in terms of investment in organic fertilizers. This is due to the fact that farmers in the study area predominantly used organic fertilizer produced by owned livestock rather than purchasing it. Other constraint is hampering farmers to invest in organic fertilizers, such as its limited local availability as reported during the FGD meetings.

The effect of IBI adoption on crop diversification is not conclusive to prove that adopters diversify crops (particularly annual and perennial crops) more than non-adopters. Farmers in the FGD meetings (adopters and non-adopters) stated that the reason why they diversify vegetable crops more than annual and perennial crops is due to the fact that vegetable crops mature quickly (from one up to two months) and require less space. In addition, vegetables are more lucrative than annual crops because customers are available all year round regardless of the growing season. Furthermore, some awareness-raising campaigns on the promotion of vegetable crops

**Table 4:** Differences in land management investments between adopters and non-adopters in year 2019 ($T_1$) and 2016 ($T_0$)

| Land management practices | Category of respondent | Frequency (%) $T_0$ | Frequency (%) $T_1$ | Mean investment score | Std. Dev. | DD |
|---|---|---|---|---|---|---|
| Agroforestry | Adopters | 51.7 | 87.9 | 0.36* | 0.48 | 0.16* |
| | Non-adopters | 51.9 | 72.2 | 0.20* | 0.49 | |
| Basic compost pit | Adopters | 79.3 | 84.5 | 0.05 | 0.46 | 0.07 |
| | Non-adopters | 67.9 | 66 | -0.02 | 0.29 | |
| Improved compost pit | Adopters | 40.4 | 78.9 | 0.38* | 0.4 | 0.18* |
| | Non-adopters | 28.8 | 46.3 | 0.20* | 0.49 | |
| Contour lines only | Adopters | 34.5 | 38.2 | 0.04 | 0.47 | 0.09 |
| | Non-adopters | 27.1 | 22 | -0.05 | 0.39 | |
| Contour lines + vegetation | Adopters | 60.7 | 94.6 | 0.34 | 0.51 | 0.05 |
| | Non-adopters | 17.9 | 56.1 | 0.39 | 0.49 | |
| Mulching | Adopters | 26.3 | 48.3 | 0.21 | 0.41 | 0.11 |
| | Non-adopters | 16.9 | 27.1 | 0.10 | 0.3 | |
| Ploughing along contour line | Adopters | 50 | 90 | 0.40** | 0.50 | 0.34** |
| | Non-adopters | 0 | 6.3 | 0.06** | 0.25 | |
| Vegetation borders | Adopters | 29.6 | 44.4 | 0.15** | 0.35 | 0.15** |
| | Non-adopters | 20 | 20 | 0.00** | 0.00 | |
| All land management practices | Adopters | 50.7 | 68.1 | 0.17** | 0.43 | 0.08** |
| | Non-adopters | 34.9 | 44.2 | 0.09** | 0.37 | |
| Cost of land management practices ($T_1$) (BIF) | Adopters | | | 14,278** | 43,800 | 6,844** |
| | Non-adopters | | | 7,434** | 30,248 | |

Test $T_1$-$T_0$ and DD: *$p \leqslant 0.05$, **$p \leqslant 0.01$. N=80 (adopters=40, non-adopters=40)

**Table 5:** Differences in crop management investments between adopters and non-adopters in year 2019 ($T_1$) and 2016 ($T_0$)

| Crop management practices | Category of respondent | Frequency (%) $T_0$ | Frequency (%) $T_1$ | Mean investment score | Std. Dev. | DD |
|---|---|---|---|---|---|---|
| Crop spacing well-used | Adopters | 50 | 94.7 | 0.45** | 0.50 | 0.39** |
| | Non-adopters | 21.9 | 28.1 | 0.06** | 0.25 | |
| Crop rotations well-planned | Adopters | 52.5 | 90 | 0.38* | 0.49 | 0.25* |
| | Non-adopters | 29 | 41.9 | 0.13* | 0.34 | |
| Mixed intercropping well-planned | Adopters | 31.4 | 54.3 | 0.23* | 0.43 | 0.18* |
| | Non-adopters | 14.6 | 19.5 | 0.05* | 0.22 | |
| Use of kitchen garden | Adopters | 89.7 | 94.9 | 0.05 | 0.22 | -0.01 |
| | Non-adopters | 13.9 | 19.4 | 0.06 | 0.23 | |
| Use of continuous ridges | Adopters | 41.5 | 82.9 | 0.41* | 0.5 | 0.35** |
| | Non-adopters | 24.2 | 30.3 | 0.06* | 0.24 | |
| Use of triangle | Adopters | 50 | 82.5 | 0.33* | 0.47 | 0.18* |
| | Non-adopters | 6.1 | 21.2 | 0.15* | 0.46 | |
| Row intercropping well-planned | Adopters | 33.3 | 42.4 | 0.09* | 0.29 | 0.09* |
| | Non-adopters | 4.5 | 4.5 | 0.00* | 0.00 | |
| Relay intercropping well-planned | Adopters | 27.3 | 33.3 | 0.06 | 0.24 | 0.06 |
| | Non-adopters | 2.3 | 2.3 | 0.00 | 0.00 | |
| All crop management practices | Adopters | 42.6 | 84.5 | 0.42** | 0.49 | 0.38** |
| | Non-adopters | 12.7 | 17.2 | 0.04** | 0.23 | |

Test $T_1$-$T_0$ and DD: *$p \leqslant 0.05$, **$p \leqslant 0.01$. N=80 (adopters=40, non-adopters=40)

were organized for farmers who participated in training courses as part of the PIP approach. The reason that annual crops are less diversified, according to farmers in the FGDs, is that in each cropping season particular annual crops are grown, and variation is therefore more difficult. Overall, the link between the IBI adoption and crop diversification was not clearly proven with these results, and hence, crop diversification is influenced by other factors among others farmer's motivation or preferences, seed availability and agro-ecological conditions. These results are partly consistent to the results from Carter *et al.* (2015) who stated that there are a number of agro-ecological and economic environments in which an index insurance is unlikely to have an impact on the adoption of agricultural technologies, either because risk is intrinsically low or high.

The results also revealed that the adopters invest much more in land management practices than non-adopters. Furthermore, the number of farmers using the basic compost pits and contour lines without vegetation by non-adopters has dropped over the study period and these were replaced by improved compost pits and

 

**Table 6:** Differences in crop management knowledge between adopters and non-adopters in year 2019 ($T_1$) and 2016 ($T_0$)

| Changes in knowledge of crop management | Category of respondent | $T_1$-$T_0$ | Frequency (%) | Mean knowledge score | DD |
|---|---|---|---|---|---|
| | Adopters | | | 2.28** | 0.23** |
| | | No changes | 27.4 | | |
| | | Some changes | 17.6 | | |
| | | Big changes | 55.0 | | |
| | Non-adopters | | | 2.05** | |
| | | No changes | 81.5 | | |
| | | Some changes | 12.1 | | |
| | | Big changes | 6.5 | | |

Test $T_1$-$T_0$, DD: $p \leqslant 0.01$, N=80 (adopters=40, non-adopters=40)

contour lines with vegetation respectively. This transition from the more basic to the more modern land management practices observed for both adopters and non-adopters can be explained by the fact that improved land management practices were already promoted by the PIP approach before the start of the IBI implementation. This means that a considerable part of the farmers considered in this study (both adopters and non-adopters of the IBI) were already trained in the PIP approach and with the knowledge how to implement good agricultural practices, as well as improve existing ones. The PIP approach is strongly based on farmer-to-farmer learning, and during participatory discussions non-adopters stated that they have strengthened some farming practices due to the good examples demonstrated by adopters within the implementation of land management practices. This ''spill-over effect'', which refers to a process in which people adopt a new product or practice when they come in contact with others who have adopted it (Young-Peyton, 2009; Rogers, 2003), is enforced and accelerated by the IBI implementation and adoption, as IBI adopters even faster recognize the benefits of better land management in terms of yield increase. During the FGD meetings with insured farmers, participants declared that the IBI has increased their commitment in land management because yield losses are lower for those who protected their lands than for those who didn't. Farmers refer to the excessive rainfall in Gitega in the first insured year, where - though all were paid-out the same amount (for the same event) - farmers confirmed that they noticed a net income difference between farmers who had protected their land by contour-lines (trenches) and others who did not. The first received pay-outs and were also able to harvest some of the crop, the latter received only pay-outs.

It was also found from this study that adopters changed crop management practices over time and their knowledge increased more than non-adopters. Farmers in FGD meetings reported that they have acquired some knowledge in land and crop management during the PIP approach introduction, but with the mutual crop insurance approach, their knowledge has improved even more because every time the insured farmers came together, they exchanged experiences and strengthened their knowledge. Farmers from group discussions said that learning through farmer groups (group learnings) allowed learners to better understand the practices as well as the best way to implement them. Furthermore, group learnings stimulated the use of improved farming techniques particularly land management as well as crop management. Group learning sometimes takes more time before getting tangible results for diffusion and adoption of practices. Young-Peyton (2009) said that people adopt once they see enough empirical evidence to convince them that the innovation is worth adopting, where the evidence is generated by the outcomes among prior adopters. In the community, IBI adopters are considered champions since they started and keep running an innovative program that didn't exist before and are convinced and self-confident to continue with it. In the FGD meetings they expressed that they want to demonstrate the difference with the rest of the community in terms of land and crop management. They argued that with these considerations, they want that their farms become like the farmer field schools where other community members will come to learn.

Looking at all investments made by farmers, according to the results from this study there is evidence of a causality effect between IBI adoption and agricultural investments, with adopters investing more in agricultural practices than the non-adopters. However, reverse causality could also be the case, i.e. that farmers who already invest in different farming practices are more willing to adopt the IBI. This can however not be verified with the results from this study. The fact that the early adopters were chosen on the basis of precise and specific criteria (i.e. selective method) could lead to an interpretation bias on reverse causality between the two variables i.e. agricultural investments and IBI adoption. Given the current setting it was not feasible to conduct a randomised control trial to estimate the impact more robustly.

## 5. Conclusion

Using cross-sectionally data from a household survey, this study analysed the links between index-based insurance (IBI) and agricultural investments in Burundi. By analysing the findings, three main lessons were learnt.

Firstly, IBI adoption increases investments in chemical fertilizers, as well as in land and crop management practices. Therefore, if well organized, the IBI could be a good tool to stimulate agricultural investments as it helps farmers to mitigate the adverse effects of weather risks.

Secondly, during the IBI implementation, the IBI non-adopters also invested substantially in farming practices, which is the result of the PIP approach being there before and the spill-over effect which is a result of the peer learning method that has enabled farmers to improve these farming practices. The PIP approach builds the foundation for sustainable change, with farmers becoming

**Table 7:** Results of multiple regressions analysis between adopters and non-adopters in year 2019 ($T_1$) and 2016 ($T_0$)

| | Chemical fertilizer | | Crop diversification | Land management | | Crop management | |
|---|---|---|---|---|---|---|---|
| | Quantity (%) | Cost (%) | Change in use $T_1$-$T_0$ (%) | Change in use $T_1$-$T_0$(%) | Cost (%) | Change in use $T_1$-$T_0$(%) | Change in Knowledge (%) |
| Constant | 1.02 | 1.11 | -5.35 | -4.50 | 2.35 | 0.01 | 1.25 |
| Insurance adoption | 0.36** (0.02) | 0.18** (0.140) | 0.02 (0.01) | 0.12** (0.04) | 0.15** (0.04) | 0.38** (0.04) | 0.23**(0.56) |
| Gender of the respondent | -0.08 (0.28) | -0.16* (8009) | -0.02 (0.01) | -0.02 (0.38) | -0.05* (0.03) | -0.04 (0.03) | -0.03(0.06) |
| Age of the respondent | 0.05 (9.01) | -0.10 (0.24) | -0.01 0.01 | -0.04 (0.01) | -0.04 (0.01) | 0.32 (0.02) | 0.27(0.08) |
| Education level of the respondent | -0.01 (0.80) | 0.10 (0.35) | 0.05* (0.01) | 0.09 (0.03) | -0.003 (0.01) | -0.06 (0.02) | 0.13(0.05) |
| Having a working PIP | 0.22* (0.63) | 0.13 (0.22) | -0.05 (0.01) | 0.06 (0.02) | 0.01 (0.02) | -0.032 (0.05) | 0.86**(0.06) |
| $R^2_{adj}$ | 0.719 | 0.72 | 0.01 | 0.09 | 0.02 | 0.6 | 0.39 |
| Prob > $Chi^2$ | 0.00 | 0.00 | 0.18 | 0.01 | 0.00 | 0.03 | 0.00 |
| Log likelihood | -101.84 | 51.16 | 0.15 | 40.30. | 57.41 | 12.10 | 69.02 |
| Wald chi2 (8) | 15.77 | 4.72 | 1.50 | 2.99 | 5.04 | 8.86 | 9.84 |

*$p \leq 0.05$, **$p \leq 0.01$. N=80 (adopters=40, non-adopters=40). *The first row of each variable is made up of coefficients and the second row with numbers in brackets represents the standard errors*

curious and willing to learn from others, because they are more aware and want to improve their investments. Once well organized and all having implemented a PIP, the peer learning method would be a key factor in the diffusion of innovation in the community; this should be promoted, because teachers and learners are familiar with each other and the knowledge transmission becomes easier and more cost-effective.

Thirdly, although IBI is a tool with a high potential to stimulate agricultural investments, the adoption of IBI has not had significant effects on certain farming practices such as crop diversification and the use of organic fertilizers. These practices require either more substantial investments (for crop diversification) or the limited local availability (as is the case of organic fertilizers). Therefore, the IBI has its limitations and does not necessarily result in an overall improvement and progress towards more sustainable agriculture. Hence, next to an IBI, additional activities are needed to further and more quickly transform Burundian agricultural towards sustainability.

In that respect, in this paper we have seen that scaling-up the PIP approach is a promising option, as it enhances farm inputs availability and encourages farmers to invest more in land and crop management, including crop diversification. This requires action from the Burundi government and other partners involved in land and crop management, and supporting IBI adoption by farmers can play an important role in agricultural development.

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