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Land Policy and Food Prices: Evidence from a Land Consolidation Program in Rwanda

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Abstract: Rwanda's "Crop Intensification Program (CIP)" is primarily a land consolidation program aimed at improving agricultural productivity and food security. The program, which began in 2007, focuses on monocropping and commercialization of six priority crops: maize, wheat, rice, white potato, beans, and cassava. CIP has facilitated easy access to improved seed stocks, fertilizer, extension services, and postharvest handling and storage services. Although studies have documented the impact of CIP on changes in farm yield, incomes, and productivity, less is known about its impact on food prices. In this study, we examine the crop-food price differences in intensive monocropped CIP and non-intensive monocropped CIP zones in Rwanda. Specifically, the study evaluates price variations of beans and maize along with complementary food crops in intensive and non-intensive monocropped zones before and after the introduction of the CIP policy. We find that the CIP policy is not associated with differences in CIP crop prices between the intensive and non-intensive monocropped zones. Over time, prices increased for CIP crops but generally, the crop prices in the two zones were cointegrated. Prices for non-CIP crops in the two different zones did show price differentials prior to the implementation of CIP, with the prices in intensive monocropped zones being greater than in the non-intensive monocropped zones. Moreover, the prices in intensive areas are cointegrated with prices in non-intensive areas for maize and beans and these prices are converging. This indicates that farmers who intensively produced one CIP crop were able to go to the market and purchase other food crops and

that price differences between zones have decreased over time, potentially making the CIP intensive farmers better off.

Keywords: land policy, land consolidation, monocrop farming, food prices

1 Introduction

Development of the agricultural sector is essential to improving rural welfare and increasing national economic growth for many Sub-Saharan African (SSA) countries, where most poor rural households rely on small-scale agriculture for survival. Rwanda is one example, with nearly 83% of the population living in rural areas, and the majority being smallholder farmers cultivating crops on less than one hectare (Nilsson 2018; World Bank 2018). The agricultural sector in Rwanda is dominated by traditional agriculture; improved farm technologies such as the use of improved seeds, fertilizers and pesticides, and irrigation are rarely adopted. As a result of traditional agriculture practices, on-farm productivity levels have been very low countrywide, with the majority of farmers producing only for subsistence living.

In a 2007 effort to increase agricultural productivity and address persistent poverty in the countryside, the Government of Rwanda launched the Crop Intensification Program (CIP) to improve land use with a greater focus on the commercialization of food crops (MINAGRI 2012). Specifically, CIP sought to increase access to productive inputs (improved seeds and fertilizers), water use (improved irrigation), land use intensification, extension services, and postharvest handling and storage services. To achieve its goals, the program incentivized farmers to monocrop fields and to cultivate six particular crops (maize, wheat, rice, white potato, beans, and cassava). These structural changes were expected to increase agricultural production and improve food security of smallholder farmers (Cantore 2011).

As is the case in many SSA countries, the Rwandan agricultural sector is characterized by a high degree of land fragmentation, wherein farmers operate different plots of land that are noncontiguous and separated geographically (Bizimana, Nieuwoudt, and Ferrer 2004). In 2016, the average farm holding was 0.76 hectare per farm household,

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typically divided over four to five plots located in different areas (NISR 2016). High population growth and the nature of policies on land property rights in Rwanda have tended to encourage land fragmentation, which represents a key obstacle to agricultural development because it impedes agricultural mechanization, causes inefficiencies in production, and incurs higher costs to alleviate its effects (Deininger et al. 2017; Wan and Cheng 2001). To counter the deleterious effects of land fragmentation in restructuring land ownership, land use consolidation was introduced in 2008 under CIP, in which farmers located in the same farming areas may cultivate one selected crop while retaining ownership of their original smallholder lands (MINAGRI 2009a; Nilsson 2018).

As a result of the CIP policy, the cultivation of CIP crops increased significantly in terms of land cover, farm yield, and monoculture development. With the introduction of CIP program in Rwanda, the farmers in some districts become actively engaged in producing prioritized crops (we call them intensive zones) while other districts did not produce under CIP program (Non-intensive zones). Over the first three years, the cultivated area under the CIP policy reached 254,000 hectares (Kathiresan 2011; Nilsson 2018), which is about 18% of the total cultivated land. Four years after initiation of the CIP and land use consolidation, the productivity of priority crops had increased considerably: wheat and maize production increased six-fold, cassava and white potato production tripled, and rice and beans production increased by 30% (MINAGRI 2011).

Given the expected importance of CIP policy in the country's economic growth – particularly at the micro level – the impact of CIP policy on the welfare of smallholder farmers has become an important topic of discussion and research. Nilsson (2018) studied the role of land use consolidation in improving crop yields among farm households in Rwanda and found a positive and significant effect of land use consolidation on CIP crop yields, but only for farms larger than one hectare. Magrini et al. (2018) studied the impact of land consolidation on Rwandan household diet and found a positive impact of land consolidation on root and tuber consumption and a negative impact on meat, fish, and fruit consumption.

The literature, however, has primarily focused on the impact of CIP on farm production and consumption, while little is known about the impact CIP has had on farmers from the market perspective. This raises concerns about what, if any, effect the CIP policy had on own and cross food prices in intensive and non-intensive CIP zones. The current study investigates the crop-food price differences in both intensive and non-intensive monocropping zones in Rwanda. Specifically, the study evaluates price

variations of the most commonly produced and consumed food staples – beans and maize – in intensive and non-intensive CIP zones in Rwanda. We hypothesize that the CIP has created complementary crop-food price variations by CIP zones and that farming under the CIP improves household welfare and reduces poverty. The findings of the study contribute to the literature by revealing the role land use consolidation policy plays in addressing food price volatility. We also shed light on the success of land use consolidation in enhancing small-scale farmers' welfare. This paper seeks to inform future policymaking, especially in SSA countries, on ways to manage land resources.

2 Agricultural Transformation in Rwanda and Land Policy

Agriculture transformation in Rwanda began with planning sessions from 1998/99 with the goals of transforming the national economy and reducing poverty to propel Rwanda from a low to medium income country (MINAGRI 2004). The process of elaborating first sector strategy was decided by the Ministry of Finance and Economic planning (MINECOFIN) through its strategic planning and poverty reduction guidelines, which, some years later, resulted into sector and sub-sector strategies and decentralized development plans in the country. In 2004, the Ministry of Agriculture and Animal Resources (MINAGRI) developed a national strategy to promote rapid economic growth through agricultural investments and policy (National Agriculture Policy [NAP]). Other significant agricultural policy and strategic reforms were accomplished through the Strategic Plan for Agriculture Transformation (SPAT), which was implemented in four phases: SPAT I (2005–2008), SPAT II (2009–2012), SPAT III (2013–2017), and SPAT IV (2018–2024). Phase I (2005–2008) focused on poverty reduction by encouraging multi-stakeholders to increase the productivity of agricultural inputs and the diversification of income opportunities. Phase II (2009–2012) focused on transforming agriculture from a subsistence to a commercial sector to raise income and reduce poverty by encouraging crop diversification and production of export crops. The first two phases had similar wimplementation approaches with four programs: (1) intensification and development of sustainable production systems; (2) support to the professionalization of the producers; (3) promotion of commodity chains and agribusiness development; and (4) integrated institutional development (MINAGRI 2009b). Phase III (2013–2017) focused on improving nutrition and food security by including economic development, fertilizer distribution

and markets through policy actions (MINAGRI 2009c; IRDP 2018). Phase IV (2018–2024) broadly focuses on agricultural sector transformation within the Comprehensive Africa Agriculture Development Program (CAADP) framework, that is, increased wealth contribution, economic opportunity and transformation, food security, and increased resilience through supporting smallholder farmers (MINAGRI 2018; World Bank 2018).

To achieve the national targets for secure agricultural land tenure, the government centralized policies and programs (National Land Policy [2004], Organic Land Law [2005], National Land Commission [2006], Office of Registrar of Land Titles [2007], National Land Center [2008], National Land Use Planning [2007], and Land Tenure Regularization [2009]) under the Rwanda Natural Resources Authority (RNRA 2016). Under this new system, acquiring land through heritage or purchase requires formal land titles through a national land registration process (Rurangwa 2004). The land reforms have opened the door for long-term investment and sustainable improvements for all economic sectors in Rwanda, particularly agricultural transformation that takes advantage of land as an economic asset for investment and shifts from subsistence to commercial purposes (Rurangwa 2004). The demarcation of parcels and land titles has been shown to contribute positively to the success of the CIP by increasing agricultural productivity through maximizing the use of the factors of production (IRDP 2018).

The agricultural transformation and land reforms were accompanied by a prioritization of crop intensification and value chain strategies that addressed several limiting factors of production (feeder roads, irrigation, fertilizers, seeds, pesticides, extension services, rural finance, etc.). In this context, the CIP was focused on enhancing monocropping with the hope that it would also have positive externalities for other food value chains (MINAGRI 2009c). The implementation of the CIP to increase food security and self-sufficiency involved different stakeholders, including the government through different ministries, civil society organizations, and private sector donors.

Oversight of land use consolidation belonged to the national, regional, and district level authorities. The evaluation of the performance of these CIP areas was managed at the district level (MINALOC 2010). For example, oversight for specific crops was administered by district authorities according to region (maize in the Northern and Eastern Provinces; wheat in the Southern and Western Provinces; cassava in the Southern Province; rice in the marshlands of the Eastern, Western, and Southern Provinces; white potato in the Northern Province; and beans in the Eastern Province). In addition, farmers received authorization to grow

selected crops in their respective zones in specific locations. The detailed scheme for the consolidated lands included land size, crop type, and farmers' rights. Locally elected farmers at the village (umudugudu) level were given the authority to spearhead all CIP activities (monitoring input use, distributing benefits, and selling outputs), which were then reported to the district level. The consolidated sites were key to the success of the CIP, with households mobilized to increase crop productivity by moving to CIP villages in respective zones under the resettlement program. The advantages of consolidated lands included reduced logistics and transportation costs of inputs and outputs, increased access to input and output markets, access to extension services, and improved access to environmentally friendly management practices (MINAGRI 2011). Specifications for CIP land size (measured in hectares [ha]) per province for beans (Figure 1) and maize (Figure 2) were Matimba (400 ha), Nasho (600 ha), and Humure (200 ha) of the Eastern Province; Kijote (320 ha) of the Northern Province; and Kinazi (200 ha) of the Southern Province of Rwanda (Dusengemungu et al. 2013).

Based on agroecological and selected sites in the zones, selected varieties and improved seeds for maize, beans, cassava, wheat, white potato, and rice were imported (mainly from Kenya and Tanzania) and distributed to farmers. The CIP integrated various market-based and other strategies such as (1) subsidized fertilizers via contracted input suppliers; (2) integrated pest disease management; (3) integrated soil fertility management; and (4) farm mechanization. These strategies increased the efficiency of mineral fertilizers, management of natural and water resources, and the building of soil nutrients. Market-related strategies to improve information and quality included the development of grades and standards, quality certification, and consistent market locations and hours.

Market access was among the most important national, regional, and international strategies for agricultural transformation. Changing the market structure was a key component of the CIP strategy to create a market-driven economy that facilitated market versus subsistence production for smallholder farmers. Vision 2020 and government strategic programs (2010–2017 and 2017–2024) sought to promote market-oriented agribusinesses to commercialize crop and animal value chains (MINECOFIN 2012). The final national agricultural policy addressed the need for agricultural input and output price stabilization as a way of sustaining farm income in the short, medium, and long term. Equilibrium between higher and lower selling prices was to be achieved through enhanced contract farming and the development of suitable legal instruments to stabilize market prices (MINAGRI 2017).

Figure 1: CIP intensive and non-intensive zones of bean production in Rwanda.

3 Methodology and Data

In this study, we use mixed methods and approaches to explain the possible relationship between Rwanda's land use policy, locally known as Crop Intensification Program (CIP), and food crop prices. The study relies on descriptive and comparative analysis. Independent *T*-tests are used to compare the average crop yields and crop prices between different seasons and by different regions (CIP and Non-CIP) over time. Augmented Dickey-Fuller cointegration tests for stationarity were used to analyze the long-term relationship between prices in non-CIP regions and CIP regions. We specify our model as follows:

$$PNI_t = \alpha_t + PI_t + \pi_t \quad (1)$$

where PNI_t is the price in the non-intensive region, PI_t represents the price in the intensive region and π_t is the

error term. We used the time series price data for the main food crops: beans and maize.

The implementation of the CIP policy took place over time, requiring the authors to diligently review public documents and cross reference them with the local household surveys and food market price administrative data collection managers.

Two types of data were used for this study: (1) monthly food market prices from the Rwanda Ministry of Agriculture (MINAGRI) and (2) information from the household living condition surveys. The monthly nominal food market price data are collected regularly by MINAGRI at more than 150 open rural and urban food markets across the country. Data from 2005 to 2015 (prior to and after the land use policy implementation) were used for this study. To account for inflation, we computed real market food crop prices using 2010 as the consumer price index base-year.

Table 1: Food production levels for key crops (maize and beans) in Rwanda.

Distribution of major food crop production using EICV4 (Wave: 2013/14)						
	Observations	Mean	Q25	Median	Q75	Q90
Maize (kg/ household)	7079	126	20	50	120	285
Beans (kg/ household)	10,380	115	30	70	140	250
Distribution of major food crop production using EICV5 (Wave: 2016/17)						
	Observations	Mean	Q25	Median	Q75	Q90
Maize (kg/ household)	6,020	119	20	50	100	250
Beans (kg/ household)	9,924	106	30	60	120	215
Distribution of major food crop production using EICV4 and EICV5						
	Observations	Mean	Q25	Median	Q75	Q90
Maize (kg/ household)	13,099	123	20	50	100	260
Beans (kg/ household)	20,304	111	30	70	130	240

Authors' computation using EICV4 and EICV5 NISR data.

2005/06, a pre-CIP annual maize production per household was higher in non-intensive zones by about 14% on average. After initiation of the CIP, annual maize production in intensive zones grew rapidly; annual maize production per household was higher by 81, 56, and 95% in intensive than in non-intensive zones in 2010/11, 2013/14, and 2016/17, respectively.

Likewise, maize market prices showed a positive change between intensive and non-intensive zones after initiation of the CIP. Pre-CIP, the price of maize averaged about 6% less in non-intensive zones than in intensive zones. After initiation of the CIP, the price of maize in intensive zones dropped in relation to the price in non-intensive zones, albeit slightly; the maize price in intensive zones was lower by 12.7, 7.6, and 12.5% than in non-intensive zones in 2010/11, 2013/14, and 2016/17, respectively.

Table 3 displays bean production and commercialization between intensive and non-intensive zones across four waves: 2005/06, 2010/11, 2013/14, and 2016/17. For all waves, the total household land and cultivated land areas are greater in intensive zones than in non-intensive zones. Further, the results show a steady decline in total household land size and cultivated land areas in the intensive and non-intensive zones across the years.

Table 2: Farmland size, unit values, and farm yield in maize intensive and non-intensive zones.

Wave	Description	Intensive zone	Non-intensive zone
2005/06	Total land owned by farmers (ha)	0.89	0.77
	Cultivated land (ha)	0.85	0.67
	Annual farm household yield (kg)	72	82
	Market price (Rwandan francs/kg)	162	153
2010/11	Total land owned by farmers (ha)	0.65	0.53
	Cultivated land (ha)	0.65	0.52
	Annual farm household yield (kg)	132	73
	Market price (Rwandan francs/kg)	166	187
2013/14	Total land owned by farmers (ha)	0.64	0.52
	Cultivated land (ha)	0.60	0.50
	Annual farm household yield (kg)	161	103
	Market price (Rwandan francs/kg)	185	199
2016/17	Total land owned by farmers (ha)	0.64	0.51
	Cultivated land (ha)	0.62	0.47
	Annual farm household yield (kg)	150	77
	Market price (Rwandan francs/kg)	208	234

In this Table, we describe the land size owned by farm households, average farm yield and average market price values across CIP and Non-CIP zones. The figures were computed by authors based on four waves: EICV 2 (2005/06), EICV 3 (2010/11), EICV 4 (2013/14) and EICV 5 (2016/17). Market prices are the real market values (kg), with 2013/14 used as the base.

With regard to farm household productivity, Table 3 indicates that in all the waves, annual bean yield per household has been greater in intensive zones than in non-intensive zones. For instance, annual bean yield per household averages 37, 59, 46, and 42% higher in intensive zones than in non-intensive zones in 2005/06, 2010/11, 2013/14, and 2016/17, respectively. Conversely, the results of Table 3 indicate a robust positive change in bean yield before and after the introduction of CIP in intensive zones. Compared to the average annual bean yield per household in intensive zones (92 kg before 2005/06), bean yield after 2005/06 has significantly increased in these zones, averaging 76, 54, and 37% in 2010/11, 2013/14, and 2016/17, respectively.

Table 3: Farmland size, unit values, and farm yield in bean intensive and non-intensive zones.

Wave	Description	Intensive zone	Non-intensive zone
2005/06	Total land owned by farmers (ha)	0.86	0.80
	Cultivated land (ha)	0.81	0.71
	Annual farm household yield (kg)	92	67
	Market price (Rwanda francs/kg)	194	189
2010/11	Total land owned by farmers (ha)	0.64	0.55
	Cultivated land (ha)	0.63	0.55
	Annual farm household yield (kg)	162	102
	Market price (Rwanda francs/kg)	291	325
2013/14	Total land owned by farmers (ha)	0.63	0.55
	Cultivated land (ha)	0.58	0.53
	Annual farm household yield (kg)	142	97
	Market price (Rwanda francs/kg)	329	344
2016/17	Total land owned by farmers (ha)	0.54	0.60
	Cultivated land (ha)	0.53	0.56
	Annual farm household yield (kg)	126	89
	Market prices (Rwanda francs/kg)	318	340

Computed by authors based on EICV 2 (2005/06), EICV 3 (2010/11), EICV 4 (2013/14), and EICV 5 (2016/17). Market prices are the real market values (kg) with 2013/14 used as the base.

Similar to Table 2, Table 3 indicates a positive change in bean prices between intensive and non-intensive zones after 2005/06, with the price of beans averaging about 3% less in non-intensive zones than in intensive zones. As with maize, the price of beans in intensive zones dropped in relation to prices in non-intensive zones after 2005/06, with bean prices in intensive zones being lower by 12, 5, and 7% than in non-intensive zones in 2010/11, 2013/14, and 2016/17, respectively.

To investigate farm yield and crop price differences in the two zones, we created a sample of 9,395 and 10,320 smallholder farm households growing both beans and maize in the intensive and non-intensive zones, respectively (Table 4). The sample was restricted to smallholder farmers who grew both maize and beans to ensure that all observations in the two groups had the required information. It is important to note that the common farming system in Rwanda is a mixed cropping system, where farmers integrate their crops on the

same land. Hence, criteria must be established to decide which areas are labeled as CIP and non-CIP. This study uses two criteria: average production and MINAGRI-designated areas. Specifically, we categorized CIP areas as those where the average production per farming season is greater than 100 kg; otherwise, areas are categorized non-CIP. From these criteria, we identified four separate areas in Rwanda: bean intensive (CIP beans), bean non-intensive (non-CIP beans), maize intensive (CIP maize), and maize non-intensive (non-CIP maize).

4 Results

Farm yields and crop price differences provide relevant indicators of production performance among smallholder farmers in intensive monocropped and non-intensive monocropped areas of Rwanda. There is a major difference in bean and maize yields between intensive and non-intensive monocropped areas (Table 4). Smallholder farm households in intensive monocropped areas produce triple the beans and double the maize of those in non-intensive monocropped areas. However, despite this significant difference in bean and maize yields between intensive and non-intensive monocropped areas, the prices of beans and maize in the two areas are similar. This suggests that bean and maize production in intensive monocropped areas has a significant effect on increasing farm household income and improving livelihoods based on increased production only.

Table 4 provides a basic statistical comparison for the control variables for the smallholder farm households between intensive and non-intensive monocropped areas. Smallholder household characteristics include the following: household size, age of household head, gender of household head, education level of household head, household poverty status, non-farm business owned by household head, a dummy defining farm households with a household member receiving a wage/salary, land area (hectares) owned by farm household, number of livestock raised by farm household, access to farm credit, land consolidation practices, land irrigation practices, ownership of land title, and equivalized food consumption of household (Rwandan francs). Smallholder households located in intensive monocropped areas have higher farm income and food consumption levels than smallholder households in non-intensive monocropped areas (Table 4). This finding directly shows the impact the CIP program has had on smallholder households in terms of income and welfare.

Table 4: -Statistics of demographics and farm attributes for bean and maize growers located in intensive and non-intensive monocropped areas in Rwanda.

Variables	Description	Intensive	Non-intensive	Difference
<i>Crop price differences</i>				
Bean prices	Price, Rwandan francs (frws/kg)	354.51	353.07	1.448
Maize prices	Price, Rwandan francs (frws/kg)	216.46	215.62	0.835
<i>Farm yield differences</i>				
Beans	Quantity of beans (kg/hh)	160.03	38.41	121.62
Maize	Quantity of maize (kg/hh)	118.68	58.80	59.88
<i>Farm, demographic, and head of household (HH) differences</i>				
Household size	Number of members in household	4.98	4.21	0.76
HH age	Average age of head of household	47.72	46.22	1.50
HH gender	Gender of HH (1 = male; 0 = female)	0.78	0.69	0.09
HH education	Completed primary school	0.93	0.95	0.02
	Completed secondary school	0.20	0.15	0.05
	Completed college	0.04	0.05	0.01
Poverty status	Household is poor (yes = 1)	0.34	0.44	0.10
Nonfarm work	HH has nonfarm business (yes = 1)	0.26	0.22	0.04
Wage/Salary	HH with wage/salary (yes = 1)	0.32	0.39	0.07
Farm size	Land area owned by HH (ha)	0.73	0.39	0.34
Livestock	Number of livestock in household	0.94	0.41	0.52
Farm credit	HH access to farm credit (yes = 1)	0.17	0.12	0.05
Consolidation	HH land consolidation (yes = 1)	0.35	0.24	0.11
Land title	HH has land title (yes = 1)	0.95	0.91	0.04
Irrigation	HH uses irrigation (yes)	0.01	0.00	0.01
Farm income	Annual household income (frws)	189115	97946	91169
Food cost	Equivalized consumption (frws)	272287	257632	14655
<i>Farm household location</i>				
South	Southern Province (yes = 1)	0.31	0.30	0.01
West	Western Province (yes = 1)	0.22	0.23	-0.01
East	Eastern Province (yes = 1)	0.27	0.26	0.01
North	Northern Province (yes = 1)	0.19	0.20	-0.01
Total sample	Number of households sampled	9,395	10,320	-0.01

Computed by authors using EICV 4 (2013/14) and EICV 5 (2016/17) NISR data.

Table 5: Variations in farm and household characteristics in Rwanda based on EICV4 (2013/14) and EICV 5 (2016/17) data.

Variable	EICV4 (2013/14)			EICV 5 (2016/17)			Total Sample		
	Mean	Variance	SD	Mean	Variance	SD	Mean	Variance	SD
Average HH age	46.4	258.9	16.1	46.9	244.6	15.6	46.7	252.0	15.9
Household size	4.64	4.2	2.1	4.6	4.1	2.02	4.6	4.1	2.0
Total land size (ha)	0.6	1.2	1.1	0.5	3.5	1.9	0.6	2.4	1.5
Cattle/household	0.65	2.1	1.5	0.8	3.6	1.9	0.7	2.7	1.6
Maize prices	194.0	1671.9	40.9	239.5	2729.1	52.2	216.2	2706.6	52.0
Bean prices	337.4	4866.5	69.8	373.0	4592.2	67.8	354.8	5048.5	71.1
Maize (kg)	96.9	14178.7	119.1	90.2	13165.7	114.7	93.8	13721.0	117.1
Beans (kg)	100.7	9590.7	97.9	91.9	7905.1	88.9	96.4	8784.0	93.7
Farm income (frws)	151336.9	2.02330e+10	142242.9	125082.4	1.59402e+10	126254.4	138490.5	1.83039e+10	135292.0
Equivalized food consumption (frws)	249495.7	5.11808e+10	226231.6	278888.1	3.21339e+10	179259.4	264497.4	4.16732e+10	204140.2

Computed by authors using EICV 4 (2013/14) and EICV 5 (2016/17) from NISR data.

Table 5 compares the basic statistics of smallholder farm household characteristics across the two waves of data (EICV4 and EICV5). The results reveal no significant difference in variables such as age of household head, household size, or total land size, across the two waves. Further, the results show an increase of 15.8% in the number of livestock cattle raised by farm households between 2013/14 and 2016/17. During the same period, there was a decrease in maize and bean yields and an increase in maize and bean prices between the two waves. This explains the decrease of 17.3% in farm income between the two waves. Despite the decrease in farm income, household equivalized food consumption (Rwandan francs) increased. One possible reason for this may be the rise in food prices due to the limited food supply that occurred in 2016/17 (NISR 2018).

The CIP policy successfully stimulated an increase in bean and maize production in the monocropped areas of Rwanda. Between 2005 and 2015, bean prices (Figure 3) and maize prices (Figure 4) in non-intensive areas were higher than in intensive areas. Both maize and bean prices were found to be cointegrated with their counterpart prices in the intensive monocropped and non-intensive monocropped areas. This indicates that the land use program increased farm yield and productivity, and created a small price wedge between the two different monocropped areas. However, production of these crops required farmers to sell the produced goods and purchase food from the market.

These results are confirmed with the cointegration test results between maize and bean prices. The cointegration test (R-Square = 0.99) showed that prices in non-intensive and non-CIP regions are cointegrated with prices in

Figure 3: Historical food prices of beans in CIP intensive and non-intensive zones. Computed by authors using data from MINAGRI.

Figure 4: Historical food prices of maize in CIP intensive and non-intensive zones. Computed by authors using data from MINAGRI.

intensive CIP regions, an indication that prices move together regardless whether the policy is implemented in one area and not another.

To determine whether the smallholder farmers are better off due to the market structure change, we need to understand whether the CIP-intensive farmers face higher market prices for other staple Rwandan food items. Figure 5 shows price inflation for other staple foods (bananas, groundnuts, eggplants, and tomatoes). Figure 6 shows the percentage price changes from 2005 to 2015 in the bean and maize CIP and non-CIP zones for other staple foods. The impact of CIP on pricing has normalized over time in the CIP and non-CIP zones.

Figure 5: Historical prices for non-CIP staple crops before and after the introduction of CIP. Computed by authors using data from MINAGRI.

Figure 6: Percentage price changes from 2005 to 2015 for non-prioritized food crops in CIP and non-CIP zones of Rwanda. Computed by authors using data from MINAGRI.

In summary, farmers in intensive zones increased output, received slightly lower prices for CIP-intensive crops, and paid close to the national average for their staple foods. Further research is needed to understand how own and cross prices impact dietary diversity in intensive and non-intensive zones.

5 Conclusion and Future Direction

Monocropping and commercialization of the six priority crops in Rwanda (maize, wheat, rice, white potato, beans, and cassava) have been the focus of national land use consolidation as the primary component of the Crop Intensification Program (CIP). The main target of the CIP is to enhance land use efficiency, agricultural production and productivity, and food security. Studies have found significant effects associated with Rwanda's land use consolidation program. For instance, Nilsson (2018) found a positive and significant relationship between the land use consolidation program and crop yields in Rwanda for larger farms (>1.1 ha) and Del Prete et al. (2019) found a positive impact of land use consolidation on food consumption in Rwanda. Few studies have examined the impact of the program on food prices. We evaluate the land use consolidation program on food market prices in the context of Rwanda's CIP and examine the variations in bean and maize prices along with the prices of complementary staple food crops in intensive and non-intensive monocropped CIP areas in Rwanda before and after the introduction of the CIP. Our findings

indicate that CIP crop (maize and beans) prices are coin-tegrated with non-CIP prices. From the two different farm household surveys, we find that non-CIP crop prices have diverged less between intensive and non-intensive monocropped areas than CIP crop prices, suggesting that the CIP has contributed to land use efficiency through increased farm productivity and food price changes, resulting in positive income effects.

While our findings provide some evidence linking land use policy and market food prices from CIP and non-CIP intensive zones in Rwanda, we can only speculate on whether or not these effects are causal. Nevertheless, our analysis of land use policy and food market prices has revealed crucial evidence on the price gaps between CIP and non-CIP areas for both prioritized (maize and beans) crops and other staple food crops. The priority given to maize and bean production has boosted farm yield of these crops under the CIP, while at the same time causing price spikes in other staple food crops. Our study could not measure potential welfare losses due to crucial price gaps between zones. The fact that some zones specialize in the production of only one crop despite the need for local households to consume a varied balanced diet makes evaluating the causal welfare impact of price gaps between CIP and non-CIP zones an important potential topic for future work.

Based on these findings, Rwanda's policies have targeted transforming a traditional farming system with fragmented plots of land into an integrated commercial agriculture system. Food price inflation, market efficiency, and relative prices appear to be adjusting over time.

Because it is unclear whether the suite of crop intensity-based programs has increased income inequality across the zones, resource allocation inequality needs further study. Smallholder farmers in CIP intensive zones receive government input subsidies, hence distorting input markets and increasing farm income inequality between the two cropping zones.

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