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# Rwanda's Commercialization of Smallholder Agriculture: Implications for Rural Food Production and Household Food Choices

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**Abstract:** Rwanda has experienced exceptional economic growth since 2000 despite more than 60% of the predominately-agrarian population living on less than \$1.25 a day. Approximately 76% of the country's working population are engaged in agricultural production, which makes up about one-third of the national economy. Agriculture is also an important source of foreign exchange, making up about 63% of the value of Rwanda's exports. An important component of household diets – food produced on subsistence agriculture parcels averaging 0.6 ha – faces the challenge by government and private sector development to replace subsistence farming with a value-creating market-oriented food sector. A complex set of relationships across public incentives and programs encourages participation in markets. Designed to promote wealth, the Crop Intensification Program (CIP) has increased access to land, inputs, extension services, markets, supply chains, etc. Wealth and access to land are the dominant predictors of the ability to participate in markets and the extent of participation. For example, smallholders producing a diversity of crops are more likely to sell in markets. Within the confluence of competing policy objectives and market forces, further research is necessary to understand the household-level tradeoffs of both producers and consumers along the food value chain.

## 1 Introduction

Agricultural trade is an important component of Rwanda's economy. Hence, changing its agrifood market structure is an extremely consequential experiment for Rwanda. However, Rwanda's government seeks to transform the agricultural sector from subsistence farming to a sustainable, value-creating, market-oriented food sector with expansive contributions to national output and household food security (MINAGRI 2019). This paper considers the policies targeting this transformation to address land reform; infrastructure; and input, output, and export markets, as well as the impact of these policies on smallholder farmers' market participation.

Subsistence farming, the predominant source of livelihood for approximately 76% of Rwanda's population (NISR 2020), is a limiting factor in reaching the government's desired agricultural transformation. There are several reasons for the large percentage and number of subsistence farmers, including limited land/small plots, limited use of modern inputs, and reliance on rain-fed production (MINAGRI 2019). The dependence on rain-fed production limits production in terms of crop variety and yield during the two main growing seasons: September to January and February to June. Human capital resources are also a constraint, as a large number of farmers lack education for key agricultural skills (26% have no formal education; those with formal education include 66% at the primary education level, 6.6% at the secondary education level, and 1.4% at the tertiary education level). In addition, Barrett (2008) argues that market rigidities, in the form of private and public financial barriers, further hampers commercialization by excluding access to globally integrated markets.

There is tension between the macro-level objective of transforming the agriculture sector to a market-oriented production system and the household-level need to improve dietary quality and employment (NISR 2020). The

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National Agriculture Policy (NAP) provides guidelines to ensure that Rwanda's strategy to transform the agriculture sector (MINAGRI 2017) fits into a broader call to implement a Green Revolution in Sub-Saharan Africa (SSA). Research shows that subsistence smallholder farmers can profit through commercial activities, but welfare gains are not universal, and successful integration into commercial commodity markets depends on many factors (Fan et al. 2013). While shifting subsistence production to market-based production improves household incomes, studies also show that advancing market participation can have a negative effect on large sections of rural populations that are slow to adapt (Ansoms 2008; Ansoms and McKay 2010). In particular, tension exists between land consolidation to increase production and productivity, and household-level land use for risk management (Del Prete et al. 2019; Ntihinyurwa et al. 2019). An alternative policy approach is to help smallholders use a portion of their land to participate in cash-crop operations, which has had notable success in the Rwanda coffee subsector in raising incomes and reducing poverty, but with less impact on diet and nutritional outcomes (Moss et al. 2016, 2017, 2020; Weatherspoon et al. 2019). Similarly, Bolarinwa, Oehmke, and Moss (forthcoming) found that reducing market transaction costs, among other factors, increases the likelihood of smallholder commercialization.

Despite high expectations, market liberalization – characterized by shifts from subsistence to commercial agricultural activities – has been less effective than anticipated in generating market growth (Zagha and Nankani 2005). Policies that are effective at promoting market participation focus on making markets more accessible to smallholders (Bernard, Taffesse, and Gabre-Madhin 2008; Barrett et al. 2012). However, the presence of localized and macro-level market imperfections limit smallholders' realized gains to commercialization (Bernard, Taffesse, and Gabre-Madhin 2008). The objective of realizing efficiency gains through trade is the cornerstone of such policy objectives. Unfortunately, the same factors that contribute to the high prevalence of subsistence farming keep smallholder farmers from realizing the efficiency gains to generate the surpluses needed to participate in markets. When households generate surpluses (of labor, capital, or goods), they have the opportunity to reinvest in their household or operations. Surpluses also promote risk-taking over subsistence production where surplus output and capacity act as a buffer against supply and income shocks.

This leads to a fundamental development question: Is Rwanda development policy best served by emphasizing land consolidation and monocropping, or smallholder

diversification into cash crops with policy enabling smallholder access to markets and cash-crop value chains? As an initial step we evaluate three questions: Does commercialization policy transform smallholder farmers' market participation? What factors influence smallholders' market participation? Does land and agricultural policy improve smallholder farmers' welfare?

## 2 Background

Subsistence agriculture, an important source of economic maintenance for many Rwanda households, has welfare-enhancing attributes (Azariadis and Stachurski 2005). For instance, it increases land-tenure security for vulnerable groups and reduces food insecurity for many small-scale farmers (Cioffo, Ansoms, and Murison 2016). Some researchers note that subsistence agriculture reduces intensive exploitation of soils, promotes climate-change resiliency, and avoids capital investment in mechanized agricultural equipment that often results in obsolescence in practice (Kostov and Lingard 2004; Magnan 2014). However, subsistence agriculture can have a lock-in effect on poverty due to low productivity and lack of surplus resources for self-investment (Azariadis and Stachurski 2005). That is, the relatively low productivity and market engagement of subsistence agriculture producers assure that surplus resources cannot increase in the form of savings experienced by market participants. Surpluses are required to afford self-investment. At the individual level, self-investment includes education and productivity-enhancing tools that afford future surpluses. At the family level, surpluses contribute to wealth accumulation, providing resources for accumulating land and capital and investing in children's education. At the community level, surpluses are required to drive positive public revenues for investment in infrastructure, enforce property rights, and maintain market access. However, the extent to which financial gains impact food security is not always clear or evident should be an important consideration in targeting nutritionally compromised communities.

Economies, especially within a regional context, can be constrained by limited market participation. For agrarian communities, the lack of smallholder participation in markets and the efficiencies that would be gained through the development of a functioning exchange economy has region-wide implications on the functioning of local economies. Under widespread subsistence farming, communities lose the welfare gains of comparative advantage and the dynamic effects of fixed investment in those activities that will lead to minimum efficient scales of operations

(Romer 1993, 1994). Underdeveloped regions often lack public and private infrastructures that promote efficiency in trade. Without these infrastructures, transaction costs are high, discouraging participation and reducing regional competitiveness in national and global markets (North 1989). For such economies, an equilibrium state called a poverty trap (Azariadis and Stachurski 2005) assures low economic growth and the continuing incidence of food insecurity. Recognizing the efficiency gains of market-based systems over autarky allows policies that remove the barriers to participation in competitive markets.

A growing field of research in international development looks at community and individual decisions to participate in markets over subsistence agriculture. Recognizing that exchange generally leads to welfare gains for individuals and society, much of this literature focuses on factors that contribute to participation in markets (Barrett 2008). In poverty traps, low-productivity subsistence farming entraps households to low-income, low-social mobility status by constraining resources for promoting self-investment to escape poverty and food insecurity. That is, low productivity mandates long work hours to meet minimum needs for subsistence. Workers become entrapped in low-skilled work with no time resources to invest in human development. Similarly, fields are planted with low-nutritional value but reliable field crops, rather than planted to income-generating commodities. Common subsistence crops, including some grains and most starchy staples, are generally calorie-dense and low in nutritional value compared to market crops, further compromising food choices and adequacy. Household resource constraints make taking on riskier endeavors with higher potential returns impractical as no buffer exists in the event of failure.

Rwanda policy makers sought to transform the agricultural landscape by promoting modern commercial agriculture over subsistence agriculture. Policies by the Ministry for Finance and Economic Planning (MINECOFIN) proffered land reforms, agricultural resources, modern agricultural practices, and value chain supports to elevate the incomes of Rwanda smallholder farmers from poverty trap-inducing subsistence farming to mono-cropping practices and trade (MINAGRI 2017). The land reforms facilitated the realization of land as a means to finance and secure investment in new agricultural processes, and for the widespread commercialization of agricultural production.

Several policies and reforms were introduced, including the National Agriculture Policy (NAP) in 2004 that encompassed four phases of the Strategic Plan for Agriculture Transformation (2005–2024) of the National Agricultural Export Board (NAEB 2018). Each phase built on prior strategy successes, starting with those for reducing

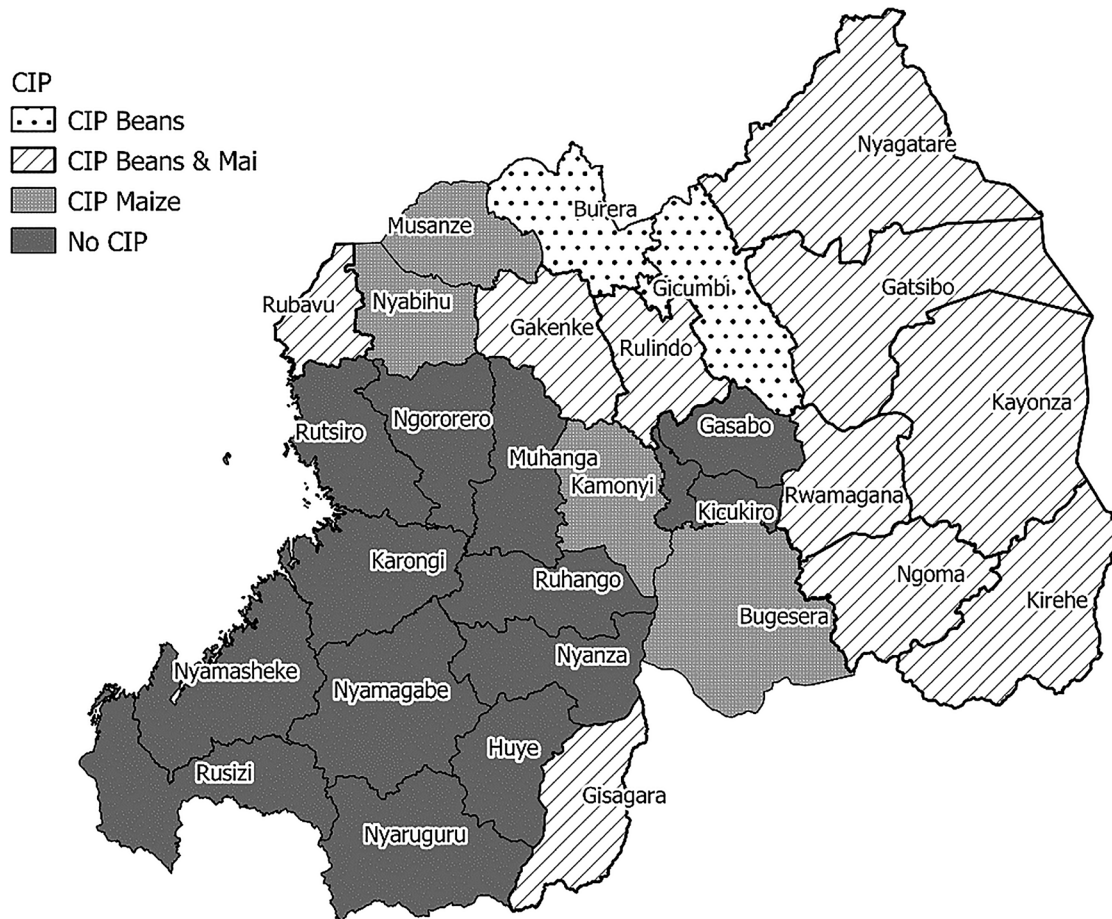
rural poverty through productivity improvements and commodity diversity, followed by strategic initiatives to promote smallholder market participation. These were accomplished by modernizing smallholder practices and providing improved agricultural inputs and extension services to optimize commercial applications (MINAGRI 2019). These poverty-reducing strategies made possible more ambitious strategies to reduce malnutrition and improve food security for all Rwandans through diffused economic growth (MINAGRI 2019). The fourth phase further integrates agricultural reforms within the Comprehensive Africa Agriculture Development Program (CAADP) (MINAGRI 2018; World Bank 2018).

Collectively, these land reforms coalesced in the Crop Intensification Program (CIP); a crop production subsidy program (Nilsson 2019) that makes available modern inputs, education, market support, and agrifood value chain development to promote economic growth and encourage participation in agrifood markets. Efficient use of improved and subsidized inputs, such as seeds, chemical fertilizers, and pest management is key to the success of these programs. Many village-level Rwanda communities benefit from a peer-monitoring system called “umudugudu” that ensures norms for all aspects of the community. This peer approach is unique and assists with compliance with policies and program rules.

In response to increasing land fragmentation, Rwanda instituted a policy that requires land consolidation for participation in the Crop Intensification Program (CIP), which is a crop production subsidy program (Nilsson 2019). The CIP provides advanced agricultural inputs to promote farm profitability while limiting the crops that can be grown based on national priorities (Kathiresan 2012). This program expands the number of acres cultivated with priority crops, improves crop yields and promotes food security. By consolidating their land parcels and participating in the CIP, farmers can cultivate and specialize in select crops for market while retaining ownership of the land (MINAGRI 2019).

Figure 1 shows designated CIP regions for two major crops: beans and maize. As shown in the map, there is a significant level of overlap in both major commodity CIP programs. Regional designations of CIP priority crops largely depend on the suitability of the region to the commodity. Thus, since maize production is most amenable in the eastern provinces of Rwanda, the districts that have set maize as a priority crop mostly exist in the eastern side of Rwanda.

The Rwanda Vision 2020 Umurenge Program (VUP) is a local development program put in place in response to the realization that while current policies were effective at



**Figure 1:** CIP targeted districts: Beans and maize.  
Source: QGIS (2020) and authors' calculations.

reducing poverty in Rwanda, the rate of improvement was hardly keeping pace with population growth (Gahamanyi and Kettlewell 2015). This 'graduation program' (Devereux 2017) targeted rural area growth through two objectives: to provide social assistance to the neediest and to promote self-reliance of households in extreme poverty. This program has three dominant channels of support: direct support or cash transfers to households, promotion of financial services, and federal investment in local public works (Muberanyana 2013).

Price supports largely have a negative impact on smallholder farmers, as most are net buyers of the grain commodities they produce, rather than net suppliers. That is, they buy more than they sell, and higher prices leave them worse off (Weber et al. 1988). Relatively small groups of growers are net sellers of staple crops (Barrett 2008). If demand is inelastic, as it is with food, benefits of efficiency gains accrue to consumers in the form of lower prices, and the net benefit of the efficiency gain to growers may be negative (Barrett 2008; Oehmke and Crawford 2002).

However, keep in mind that staple crops are quite different from high-value specialty crops.

### 3 Data

We use the Rwanda 2015 Comprehensive Food Security and Vulnerability Analysis (Hjelm 2016) data in our survey of rural smallholder households in Rwanda. This survey of household units is a collaborative initiative of the Rwandan National Institute of Statistics (NISR), the Ministry of Agriculture and Animal Resources (MINAGRI) and the World Food Program (WFP). Geocoding of households performed at the village level was based on village centroids, and population density at the village level was assigned via a raster file of population density at the village centroid.

One question was used to determine if the household had farming operations and the analysis is limited to those with farm activities. Those with farm production were also asked how much was marketed as share of production.



Figure 2 shows the geographic dispersion of surveys used in this analysis against the backdrop of the self-reported shares of crop output sold. Categories are associated with greater average participation in agricultural crop markets. As evident in Figure 2, survey responses are well dispersed throughout the country. Each dot represents at least one completed survey and may represent multiple completed surveys in the same proximity. The extent of participating in agricultural crop markets appears equitably distributed across districts with both low and high participation (exceptions of higher rates of participation occur along Rwanda's eastern border with Tanzania and the southern border with Burundi). Respondents in the western districts appear less inclined to sell crop output in markets, while those in the northern districts of Rubavu, Nyabihu, and Musanze were more apt to sell crops in markets.

The dataset is limited to production of the following seven common commodity crops: beans, maize, sweet potato, cassava, white potato, sorghum, and banana (for cooking and wine). Other untracked potential crops include rice, vegetables (including peppers), herbs, and fruit. While this analysis is not inclusive of all crop commodity activities, we postulate that these limitations do not hinder the interpretation of the outcomes.

Table 1 shows the number of surveys collected, and the actual number used in this analysis by district. The survey sampling totaled 7500 (250 surveys from each of the 30 Rwanda districts). Not all surveys entailed households growing crops for own-use or for market. Hence, the actual sample used in the analysis is 5170 (those surveyed but not growing crops are excluded in the study). The non-grower exclusion impacts regions differently (e.g., 25 of the 250 surveys from Kicukiro and 225 of the 250 surveys of Burera entailed household-produced crops).

The model variables are reported in two groups (Table 2). The first column of Table 2 shows the summary statistics of the first hurdle variables, which explain households' willingness to sell in markets. The dependent variable is a binomial variable taking the value of one if the household indicated selling food crops they produced (livestock is excluded as a dependent variable in the survey). Accordingly, about 60% of the responses indicated that households with many crops and larger acreage are more likely to participate. The share of household income from agricultural production should be positively associated with participation, as income from agriculture has an almost tautologically positive relation with selling in markets. Similarly, financial assistance and loans should

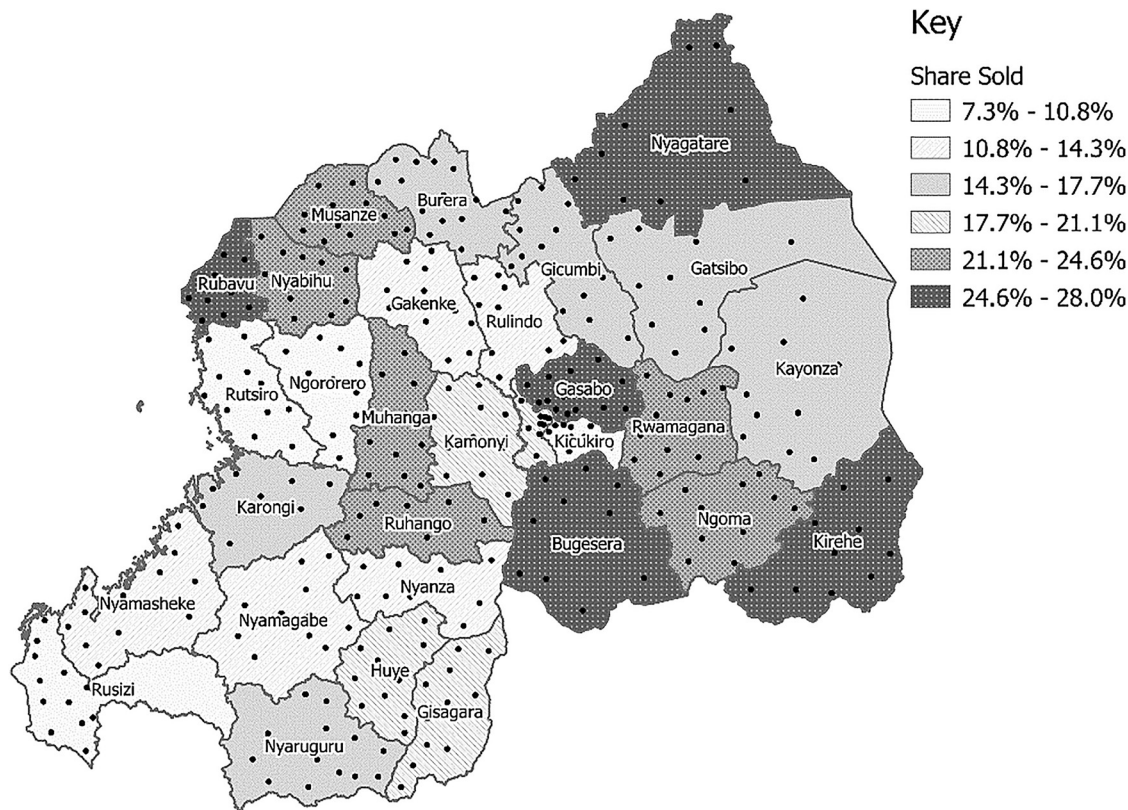


Figure 2: Share of rural household production sold by district. Source: QGIS (2020) and authors' calculations.

**Table 1:** Number of surveys collected, and the actual number used in this analysis by district.

District	Overall sample		Analysis sample	
	Frequency	Share of land consolidation	Frequency	Share of land consolidation
Bugesera	250	0.240	135	0.237
Burera	250	0.760	225	0.782
Gakenke	250	0.920	184	0.913
Gasabo	250	0.200	60	0.583
Gatsibo	250	0.600	207	0.652
Gicumbi	250	0.800	209	0.837
Gisagara	250	0.960	222	0.955
Huye	250	0.440	139	0.525
Kamonyi	250	0.680	161	0.739
Karongi	250	0.840	200	0.875
Kayonza	250	0.240	197	0.234
Kicukiro	250	0.000	25	0.000
Kirehe	250	0.400	190	0.411
Muhanga	250	0.440	180	0.539
Musanze	250	0.800	152	0.829
Ngoma	250	0.680	185	0.714
Ngororero	250	0.800	195	0.810
Nyabihu	250	0.800	205	0.839
Nyagatare	250	0.560	189	0.566
Nyamagabe	250	0.600	183	0.634
Nyamasheke	250	0.720	200	0.715
Nyanza	250	0.640	195	0.667
Nyarugenge	250	0.000	52	0.000
Nyaruguru	250	0.600	219	0.584
Rubavu	250	0.840	149	0.919
Ruhango	250	0.640	191	0.639
Rulindo	250	0.600	204	0.623
Rusizi	250	0.833	162	0.901
Rutsiro	250	0.880	187	0.914
Rwamagana	250	0.720	168	0.786

Source: Rwanda 2015 Comprehensive Food Security and Vulnerability Analysis.

be positively associated with participation, as they facilitate agricultural marketing. Indicators of food stress may have a negative association with participation, as self-preservation may favor subsistence uses of crop output, but there is no reason this will hold universally. In addition, we postulate that certain commodities are more amenable to markets. Therefore, indicator variables of commodities grown are included. Finally, because Goma and Kigali are dominant market centers, we include distance from these centers as factors to participation. As indicated in Figure 2, districts exhibit variation in participation in crop markets. Hence, district fixed effects are included but not shown in Table 1.

The second column of Table 2 shows the summary statistics of the second hurdle model, indicating the amount sold in markets when participating in markets. The

dependent variable is the self-reported share of total crop production sold in market and only includes households that indicated selling to market (past the first hurdle). Accordingly, the simple average suggests that of those that sold produce to market, the average share of crop production sold was 30.5%. We postulate that distance to market will affect the extent of participation. As seen in the first hurdle, food stress should be negatively associated with participation extent, while financial assistance and loans should be associated with increased levels of participation. Finally, direct measures of wealth (Wealth Ind.) and indirect measures of wealth (Monthly expenditures per person) should be positively associated with level of market participation. Because expenditures and income, along with other independent variables in the models, should be related, we assessed multicollinearity threats in the model by Pearson correlation analysis. There were no correlations within either of the hurdles exceeding 0.60, so we deemed no significant threat of multicollinearity exists within each of the two models.

## 4 Methods

Because households choose whether to participate in markets and, if so, to what extent they participate, a double-hurdle model is appropriate. Double-hurdle models are especially useful where a large share of observations is censored. This model has had considerable success in agricultural applications and agricultural marketing studies (Barrett 2008; Tufa, Bekele, and Zemedu 2014; Woldeyohanes, Heckeley, and Surry 2017). In our sample, some 60% of the observations used in the modeling indicated having agricultural sales. Of those indicating having sales from own crops, the average and median shares of crop output sold were 30.4 and 26.7%, respectively.

In our double-hurdle model, the first hurdle is the decision of whether or not to participate in the market and the second hurdle is the level of participation. Following Engel and Moffatt (2012), the double-hurdle model posits two equations as a combined probit-tobit estimator:

$$d_i^* = z_i' \alpha + \epsilon_{1,i} \quad y_i^* = x_i' \beta + \epsilon_{2,i} \quad (1)$$

In Equation (1),  $d_i^*$  is a latent variable with observed binary outcomes of choosing to participate in markets ( $d_i = 1$ ) or not. That is,

$$d_i = \begin{cases} 1 & \text{if } d_i^* > 0 \\ 0 & \text{if } d_i^* \leq 0 \end{cases} \quad (2)$$

**Table 2:** Descriptive statistics for the first and second hurdle variables.

First Hurdle Variable	Mean	Std. dev.	Second hurdle variable	Mean	Std. dev.
Dep (selling crops to market)	0.600	0.490	Dep (% of own crop production sold)	30.488	19.241
Number of crops reported by HH	2.886	0.915	Market distance is less than 60 min	0.279	0.448
Farmland owned (ha)	3.133	1.459	Market distance is 60–120 min	0.349	0.477
Farmland rented (ha)	0.308	0.462	Market distance is more than 120 min	0.315	0.465
Number of crops*farmland	9.489	5.896	Received loan (last 12 months)	0.243	0.429
Ag share of HH income	68.860	28.284	Financial assistance (last 12 months)	0.096	0.295
Land consolidation	0.690	0.462	Any food access issues	0.437	0.496
Received loan (last 12 months)	0.209	0.406	Monthly expenditures per person	12446.9	30846.9
Any food assistance (last 12 months)	0.066	0.337	Number in household	4.994	2.112
Financial assistance (last 12 months)	0.102	0.303	Improved water	0.791	0.406
Agricultural assistance (last 12 months)	0.035	0.184	Land consolidation	0.691	0.462
Any food access issues	0.514	0.500	CIP beans district	0.476	0.499
Household own livestock	0.640	0.480	CIP maize district	0.526	0.499
Household growing beans	0.878	0.327	CIP beans and maize district	0.396	0.489
Household growing maize	0.470	0.499	CIP beans district and CIP village	0.341	0.474
Household growing cassava	0.292	0.455	CIP maize district and CIP village	0.367	0.482
Household growing white potato	0.185	0.389	Log (population density)	5.880	0.640
Household growing sorghum	0.150	0.357	Log (distance to port of entry)	3.476	0.544
Head of household (HH) can read	0.635	0.482	VUP (schemes applied in the village)	0.665	0.472
HH category: Low-income agriculturalists	0.376	0.484	Wealth Ind. (poor)	0.207	0.405
HH category: Agro-pastoralists	0.159	0.366	Wealth Ind. (medium)	0.245	0.430
HH category: Agricultural daily labor	0.113	0.317	Wealth Ind. (wealthy)	0.222	0.415
Number in HH	4.971	2.097	Wealth Ind. (wealthiest)	0.109	0.312
VUP (schemes applied in the village)	0.684	0.465			
Log (population density)	5.912	0.626			
Log (distance to port of entry)	3.470	0.547			
Wealth Ind. (poor)	0.220	0.414			
Wealth Ind. (medium)	0.227	0.419			
Wealth Ind. (wealthy)	0.196	0.397			
Wealth Ind. (wealthiest)	0.089	0.284			

Source: Authors' calculation using the Rwanda 2015 Comprehensive Food Security and Vulnerability Analysis.

Probit estimation is appropriate for  $d_i^*$ , and results in an inverse Mills ratio that is used to correct for data truncation in the second equation (Engel and Moffatt 2014; Heckman 1977). The observed level of participation ( $y_i$ ) is measured as

$$y_i = \begin{cases} y_i^* & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \quad (3)$$

That is,  $y_i$  is a truncated variable and hence, tobit estimation is appropriate. The vectors of model independent variables  $z_i'$  and  $x_i'$  are factors perceived to impact one's decision to participate in markets differently than the extent of one's participation should one choose to participate in markets, respectively. Factors that contribute to the decision to participate may also contribute to the level of market participation, such that the same variables may appear in both  $z_i'$  and  $x_i'$ . As we posit that different factors influence one's willingness to participate in markets than influence one's allocation to market activities, the set of

independent variables differ between  $z_i'$  and  $x_i'$ . The  $Z$  matrix denotes those factors that impact one's willingness to sell crop output in markets, while the  $X$  matrix denotes those factors that influence how much to sell, as described in the data section. Correspondingly, the alpha ( $\alpha$ ) coefficients measure the "willingness to sell" responses while the beta ( $\beta$ ) measures responses on how much production is allocated to markets.

Allowing for error correlation across equations, the log-likelihood function for the double-hurdle model is (Aristei, Perali, and Pieroni 2008)

$$\begin{aligned} \text{Log}(L) = & \sum_0 \ln [1 - \Phi(z_i' \alpha, x_i' \beta, \rho)] \\ & + \sum_+ \ln \left\{ \Phi \left[ \frac{z_i' \alpha + \frac{\rho}{\sigma} (y_i - x_i' \beta)}{\sqrt{1 - \rho^2}} \right] \right. \\ & \left. \times \frac{1}{\sigma} \phi \left[ \frac{(y_i - x_i' \beta)}{\sigma} \right] \right\} \quad (4) \end{aligned}$$

The first hurdle, modeled by probit on  $z_i'\alpha$ , is our participation model, indicating whether the household participates in the market. The second hurdle is modeled as a tobit on  $x_i'\beta$  and is the degree of market participation with the dependent variable taking values from zero to one, indicating the proportion of crop production sold in markets.

## 5 Results

Table 3 shows the two-step, double-hurdle model estimates. Stage 1 provides first-hurdle estimates of determinants of smallholder household entry into the market, excluding district fixed effects. Stage 2 provides second-hurdle estimates of the level of market participation.

The factors associated with scale of farm operations are tracked, as they relate to willingness to sell in crop markets. Farms producing a diversity of crops are more likely to sell in markets, as those producing for subsistence are more likely to focus on one or two plant crops. This finding is consistent with previous studies that show certain commodities and having a diversity of commodities grown are associated with market participation (Weatherspoon et al. 2017). More directly related to operations scale is the number of hectares owned. According to the estimates, more farmland, in itself, is not a good predictor of market participation, but the combination of having both more farmland and diverse crop operations increases the likelihood of market participation. Households that rent farmland often do so to participate in markets. That is, renting land is strongly associated with participation in markets and may represent reinvesting surpluses into the operations. Finally, having livestock is associated with larger farms, and those with livestock exhibit higher rates of market participation.<sup>1</sup>

We anticipated that geographic access to markets would be an important factor in market participation. While not shown in the estimates, we found no relationship with regard to spatial distance to the major markets of Goma and Kigali. Through regional fixed effects (not shown in Table 3), we found that westerly farms are more likely to sell in crop markets than easterly farms (the reason for this spatial disparity is unclear, as urban centers are largely uniformly distributed across Rwanda and at the major border entry points). In fact, we use population

density as a proxy for urbanization, conjecturing that those in higher density locations have greater access to markets (although less agricultural activities could offset this). Rwanda is investing heavily in transportation infrastructure to connect major cities via paved roads (David 2014). Although over-road transportation remains out of reach for many Rwandans, transportation is not a major constraint to commercial shipping of agricultural products (Aoun, Matsuda, and Sekiyama 2015). Because we did find significant association between participating in markets and distance to major ports of entry, there is evidence that transportation costs influence participation in markets.

Household factors, such as occupation of head of household and household income status, are also associated with willingness to sell in markets. It is interesting to note that agricultural labor practices (agro-pastoralists and agricultural daily laborers) do not necessarily correlate with market participation. There is greater market participation for households with multiple economic activities than for low-economic households. Similarly, those who indicated earnings (ag share of HH income) from agricultural production are more likely to be associated with selling crops. The coefficient estimates in Stage 1 of the model imply that the presence of household surpluses is a vital predictor of participating in markets. That is, escaping subsistence production and the poverty trap requires surplus income and human capital for reinvestment.

Other factors may be relevant to one's willingness to sell in markets. The educational attainment of the head of household (HH), as measured by ability to read and write, is not a predictive factor. It should be noted that receiving assistance, especially with food and agricultural assistance, was associated with lower rates of market participation. We interpret this as indicating that disadvantaged households use crop production to augment household nutrition needs. That is, they specialize in subsistence production. However, financial influxes such as receiving a loan are positively associated with participation, although the coefficient on financial assistance is positive, it is not significant.

The Stage 2 model assesses the extent of market participation of those who selected to participate in markets, measured as the share of aggregate crop production sold at market. Similar to the Stage 1 results, distance to markets does not appear to be a significant factor in the extent of participation. In the Stage 1 results, population density was negatively but insignificantly associated with selling through markets, but in the Stage 2 estimate, the inverse association with share of production sold is significant. Similarly, the Stage 1 finding that distance from border ports significantly decreases participation shows no

<sup>1</sup> While households with livestock are more apt to sell in markets, livestock's role as a source of wealth versus a marketable commodity is not addressed here.



**Table 3:** Two-step, double-hurdle model estimates.

log likelihood = -16013.149 chi square overall = 847.17971 P overall = 0.000					
Stage 1: Hurdle*	coef	Se	z	P	
Number of crops reported by HH	0.5292	0.0789	6.710	0.000	***
Farmland owned (ha)	-0.0431	0.0647	-0.665	0.506	
Rent Farmland	0.1747	0.0640	2.731	0.006	***
Inter: No. of crops & farmland	0.0636	0.0232	2.739	0.006	***
Ag share of HH income	0.0101	0.0013	8.041	0.000	***
Land consolidation (CIP)	0.1697	0.0681	2.491	0.013	**
Received loan (last 12 months)	0.0883	0.0785	1.124	0.261	
Any food assistance (last 12 months)	-0.2616	0.0739	-3.541	0.000	***
Financial assistance (last 12 months)	0.0510	0.1012	0.504	0.614	
Agricultural assistance (last 12 months)	-0.1049	0.1508	-0.695	0.487	
Any food access issues	-0.1167	0.0658	-1.773	0.076	*
Household own livestock	0.1980	0.0603	3.284	0.001	***
Household growing beans	-0.9927	0.1064	-9.332	0.000	***
Household growing maize	-0.2239	0.0689	-3.252	0.001	***
Household growing cassava	-0.3881	0.0796	-4.873	0.000	***
Household growing white potato	-0.0746	0.0895	-0.833	0.405	
Household growing sorghum	0.5695	0.1417	4.018	0.000	***
Head of household (HH) can read & write	-0.0418	0.0607	-0.689	0.491	
HH category: Low-income agriculturalist	-0.3220	0.0760	-4.237	0.000	***
HH category: Agro-pastoralist	0.1853	0.1067	1.737	0.082	*
HH category: Agricultural daily laborer	-0.1898	0.1002	-1.894	0.058	*
Number in household	-0.0273	0.0152	-1.791	0.073	*
VUP (schemes applied in the village)	-0.0858	0.0629	-1.364	0.172	
Log of population density	-0.0886	0.0758	-1.168	0.243	
Log of distance to nearest border port	-0.1412	0.0717	-1.969	0.049	**
Wealth Ind. (poor)	0.0134	0.0871	0.153	0.878	
Wealth Ind. (medium)	0.0917	0.0908	1.009	0.313	
Wealth Ind. (wealthy)	-0.0274	0.0995	-0.275	0.783	
Wealth Ind. (wealthiest)	0.0863	0.1345	0.642	0.521	
Intercept	0.4452	0.4664	0.955	0.340	
Stage 2: Participation					
Market_distance is less than 60 min	0.1350	1.9794	0.068	0.946	
Market_distance is 60–120 min	0.7975	1.9722	0.404	0.686	
Market_distance is more than 120 min	0.5976	2.0081	0.298	0.766	
Received loan (last 12 months)	3.0394	1.0807	2.813	0.005	***
Financial assistance (last 12 months)	-2.8013	1.5726	-1.781	0.075	*
Any food access issues	-4.2611	0.9618	-4.430	0.000	***
Monthly expenditures per person	0.0001	0.0000	4.094	0.000	***
Number in household	-0.8144	0.2248	-3.623	0.000	***
Improved water	-1.4778	1.10049	-1.343	0.179	
Land consolidation (CIP)	-4.1586	1.4154	-2.938	0.003	***
CIP beans district	-0.7924	2.5057	-0.316	0.752	
CIP maize district	6.5023	2.2055	2.948	0.003	***
CIP beans and maize district	-7.9947	2.2721	-3.519	0.000	***
Inter: CIP beans district and CIP village	0.7918	2.4127	0.328	0.743	
Inter: CIP maize district and CIP village	6.1752	2.4335	2.538	0.011	**
Log of population density	-1.9028	0.8581	-2.217	0.027	**
Log of distance to nearest border port	-0.2664	0.9286	-0.287	0.774	
Wealth Ind. (poor)	0.4077	1.4534	0.281	0.779	
Wealth Ind. (medium)	3.4626	1.4137	2.449	0.014	**
Wealth Ind. (wealthy)	5.7819	1.4825	3.900	0.000	***

**Table 3:** (continued)

Wealth Ind. (wealthiest)	11.0096	1.8805	5.855	0.000	***
Intercept	39.5371	7.2890	5.424	0.000	***
Sigma: Intercept	22.4200	0.4007	55.952	0.000	***

\*Stage 1 estimates include regional fixed effects (not shown). Source: Authors' calculation using the Rwanda 2015 Comprehensive Food Security and Vulnerability Analysis.

relationship with the amount sold of those who do participate. That is, distance to entry port cities tends to generate a lockout effect but has no influence on the amount sold of those who do participate. In addition, while households closer to urban centers or those in higher population density locations, should likely benefit financially from improved water access, we found that access had no bearing on the volume of sales reported.

Other factors support the notion that surplus resources are important components of the extent to which households participate in markets. Factors associated with wealth and resources appear to be positively associated with how extensively one participates in markets. Household expenditures per person—a measure of spending capacity—is positively associated with sales volumes, while the number of persons in the household—a draw against earnings—is negatively associated with selling volume.

Of the policy variables, land consolidation (CIP at the village level) has a positive and significant association with the choice to sell crops in markets (first stage), while the presence of a VUP scheme shows a negative, although insignificant, relationship. Counterintuitively, those who participate in land consolidation and sell crops in the market tend to sell less than those who do not participate in land consolidation (second stage). However, because participation in the CIP requires crop production on land-consolidated fields, the CIP maize district sells more crops than the other districts. That is, for those selling crops in markets, land consolidation is associated with a smaller share of crops sold in markets, with farmers in CIP maize districts having a larger share of crops sold in markets than those not participating in land consolidation (chi-squared (1) joint test of significance = 22.3 with  $(Pr > ch2) = 0.000$ ). While policy favors maize production in CIP maize districts, the actual crops grown for market may not be maize and those growing maize were less likely to sell in markets (first stage). What these results do show is a complex set of relationships across public incentives and programs to encourage participation in markets, and actual participation in markets. Although we initially included the VUP scheme at the village level in the second stage regression as well as the first stage, we found no association with being

in a VUP scheme and the extent of crops sold for those selling in markets. That is, one may be in a CIP targeted district without any direct benefits from the CIP program. In addition, farms in CIP targeted districts may benefit from neighborhood (or spillover) effects. Those living in CIP targeted areas may have greater access to knowledge, inputs, markets, and resources designed to benefit CIP communities even without direct participation. For that reason, we included two sets of CIP variables. First, we designate households as CIP depending on whether they live in a village with land consolidation. Second, we include an indicator variable for CIP targeted districts for beans and maize. We find that being in a CIP village is associated with lower shares of crops sold on the market. CIP maize district farmers tend to sell more shares than CIP beans district farmers. Adding interactive terms to assess whether being in a CIP-targeted district and CIP village changes the shares of production sold, we find an overall positive effect, although it is statistically significant only for maize-targeted districts.

## 6 Conclusion

To help transform the prevalent subsistence farms into a market-oriented commercial agricultural system, Rwanda has enacted several policies and programs with an overall strategy to increase smallholder farmers' productivity, income, and welfare while simultaneously increasing regional and global trade. The expansive policies include land tenure, land access, inputs, extension services, markets, supply chain, etc. We have analyzed the effect of the policies related to land consolidation and access to input subsidies. The focus is on the CIP because we found no association for the VUP scheme. The role of CIP in smallholder market participation is complex and varies across crops and location, with 60% of the sample selling their own produce on the market and, market participants selling 30.5% of their crop production.

The findings show that access to wealth is a dominant predictor of both the ability to participate in markets and the extent to which one participates. Those participating in

the CIP experience income growth on average. However, due to the nature of the cross-sectional dataset, causal association cannot be inferred. Access to land, owned or rented, is an indicator that smallholders participate in market, with smallholders producing a diversity of crops more likely to sell in markets. This is consistent with the smallholder livelihood approach of diversifying a small portion of land into cash crops. Other findings show that financially destitute households receiving social safety net benefits are less likely to participate in markets and are more apt to practice subsistence farming. This is the case where the types of crops grown are not sufficiently diverse to provide adequate dietary quality and are likely affected by seasonality, thus not addressing the serious problem of food insecurity that is an important consideration in these vulnerable target groups (Barrett 2008; Bolarinwa, Oehmke and Moss forthcoming).

Given the expected importance of CIP policy in the country's economic growth, particularly at the micro-level, the impact of the land consolidation (CIP) policy on smallholder farmers' welfare has become a topic of discussion and research. The literature shows that the CIP policy has been effective in transforming the production of CIP crops in Rwanda (Nilsson 2019), but the impact of this transformation on smallholder farm households is less clear. Those who participate in land consolidation and sell crops in the market tend to sell less than those who do not participate in land consolidation, except in the CIP maize districts. There remain concerns about smallholder farm household participation in the market due to this policy, as well as their crop yield and household diet quality (Weatherspoon et al. 2017). Our results show a complex set of relationships across public incentives and programs to encourage participation in markets, and growers' actual participation in markets.

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