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Environmental and Gender Impacts of Land Tenure Regularization in Africa

Pilot Evidence from Rwanda

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Abstract

Although recent developments greatly increased interest in African land tenure, few models to address these issues at the required scale have been identified or evaluated. Rwanda's nation-wide land tenure regularization programme is of great interest. A discontinuity design with spatial fixed effects that is used to evaluate the pilot for this programme points to three main effects; namely, (i) improved land access for legally married women and better recordation of inheritance rights; (ii) significant and large investment impacts that are particularly pronounced for women; and (iii) a reduction in land market activity rather than distress sales. Implications for programme design and policy are discussed.

Keywords: gender, agricultural investment, land administration, Rwanda
JEL classification: J16, O13, Q12, Q15

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Tables and figures appear at the end of the paper.

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1 Introduction

While Africa has been historically rather land abundant, three factors have recently focused attention on land rights and the way in which land is managed. First, a combination of population growth, soil degradation, urban expansion, exacerbated more recently with a ‘rush’ for land to benefit from rising global demand for agricultural commodities and environmental services, increased pressures on land. Second, even lands currently cultivated are characterized by an enormous productivity gap; recent studies show that no African country except South Africa achieves even 25 per cent of the potential (Deininger et al. 2011b). The investments needed to bridge this gap are unlikely to be forthcoming without secure rights. Third, structural transformation from an agrarian to a manufacturing- and service-based economy will require shifts of population and associated transfers of land to other producers. Given their potential to contribute to all of these objectives, land registration programmes should be high up on the policy agenda. Yet, limited success and sustainability of many past programmes, together with a lack of mechanisms to document impact over time, led many observers to believe that such interventions will have limited benefits or be too complex and risky to undertake.

As the most densely populated country in Africa, Rwanda illustrates the relevance of the above issues. Recognizing the urgency of solving them, the government has taken far-reaching measures to overcome a history of often land-related conflict and tribal division, end gender discrimination in land access, and provide a framework to make optimum use of available land resources so as to contribute to social and economic development. In this context, the country has launched a programme of land tenure regularization (LTR) which, after extensive piloting, is now being implemented nationwide. This programme constitutes probably the most thoroughly designed and quantitatively ambitious programme of its nature in Africa. An evaluation of the extent to which it lives up to its objective of securing rights and improving opportunities and livelihoods for all Rwandans can thus provide broader lessons.

We aim to provide such an evaluation by assessing the impact of the (rural) pilots that preceded the programme’s national roll-out. Outcome variables considered are the incidence of land-related investment, female land ownership and inheritance, and the frequency of land transactions. We find that, in the short time since its implementation, the intervention has led to a doubling of the change in investment in soil conservation, with an even larger increase for females. Formalization of women’s land rights helped to expand their land access and tenure security while clarification of intended inheritance increased clarity. The programme is thus likely to allow the country to realize sizeable economic and gender benefits. As the programme did not lead to any increase in land market activity, it is unlikely to have contributed to distress sales or increased landlessness.

The programme’s positive impacts can be enhanced—and potential negative ones avoided—if areas where policy is unclear, ambiguous, or at variance with practice on the ground, are addressed and performance in high risk areas is carefully and continuously monitored. Based on our results these include (i) land rights by women who are not legally married; (ii) fee structures that rural residents cannot afford and subdivision restrictions that the majority of land holders will not be able to comply with; and (iii) systems to reduce the transaction cost of registering subsequent transactions so

as to ensure sustainability. All of these areas are being discussed by the government in the context of programme implementation and an ongoing review of the land law. Beyond Rwanda, our evidence suggests that well-designed land regularization can yield large benefits even in the short term but that realization of these will require a conducive policy context, careful design based on local conditions, and continued monitoring during implementation.

The paper is organized as follows. Section two places the topic in context and identifies areas that warrant greater empirical attention by reviewing lessons from the literature on land titling in Africa. Section three describes the challenges confronted by Rwanda, the institutional changes made in response to these, and relevant characteristics of the LTR programme. Econometric approach and sampling strategy are described in section four, followed by a discussion of key results with respect to investment, women's land rights, inheritance, and land market participation in section five. We conclude with a number of policy implications in section six.

2 Background and context

While issues of land tenure formalization in Africa have long been the subject of debate, increased land scarcity and recent growth in demand for land reinforce the importance of securing rights to allow land-related investment that would close the productivity gap while at the same time ensuring that increased land values benefit local land users rather than raising the specter of dispossession. A review of the pros and cons of land titling interventions as evidenced by the conceptual and empirical literature sets out the challenges which any programme of LTR will have to confront.

2.1 The debate on land tenure formalization in Africa

Given the economic and social importance of land, the desirability, nature, and impact of interventions to increase security of land tenure in Africa have long been intensely debated. Three arguments have traditionally been advanced to caution that such measures may not be needed or may have unintended negative consequences that could outweigh whatever positive impacts they may bring.

First, land tenure systems evolve dynamically over time and many studies have documented that, as payoffs from investment increase, institutional innovations to increase tenure security emerge endogenously (Brasselle et al. 2002; Bruce and Migot-Adholla 1994; Otsuka 2001; Platteau 1994). Titling of land in pursuit of credit benefits (de Soto 2000) has in many cases created unsustainable institutions but failed to deliver the expected benefits. Especially in the absence of a clear and enabling legal framework, it thus failed to bring about the transformations needed to make investment profitable.

Second, land tenure systems are complex and top-down campaigns that lack awareness of existing arrangements or are not accompanied by campaigns to create public awareness have often triggered short-lived waves of speculative land acquisition that benefited the powerful and well-connected. Holders of secondary land rights such as women and migrants often lost out as some of the positive aspects of traditional

systems, e.g., their flexibility and accessibility, were reduced without bringing commensurate benefits and possibly exacerbating pre-existing conflicts (Baland and Francois 2005; Firmin-Sellers and Sellers 1999; Sjaastad and Bromley 1997).

Finally, even where tenure formalization was desirable in principle, the cost of conventional approaches, US\$20 to US\$60 per parcel for first time adjudication alone in what were considered successful projects (Burns 2007) and much larger than this in Africa (Jacoby and Minten 2007; Larbi 2011), could undermine outreach and sustainability of the most desirable programmes (Bruce and Knox 2009). Taken together, these factors led to land titling being portrayed as paradigmatic example of a naïve top-down approach that produced white elephants on a large scale by prescribing 'solutions' based on abstract reasoning rather than recognition of ground realities and locally grown solutions (Bromley 2009; Easterly 2008).

A number of recent developments have led to a reassessment. First, while adaptations such as 'informal formalization' and land sales had long been observed as levels of land scarcity increased (Chimhowu and Woodhouse 2006), legal innovations providing a basis for more flexible recognition of a continuum of rights have now been widely adopted throughout Africa (Alden-Wily 2003) and received backing at the highest political level (African Union 2009). This creates a range of legal options to recognize and gradually strengthen rights as social and economic realities evolve. Second, recent escalation of demand highlights that traditional systems are not without shortcomings, in particular (i) weak protection of community lands against abuse, e.g., by chiefs who perceive themselves as landlords rather than custodians of a vital community asset (Berry 2009); (ii) adoption of rules that explicitly disadvantage migrants and non-nationals even if they have long-established use rights (Colin and Ayouz 2006; Fenske 2010); and (iii) discrimination against women who generally have great difficulty holding on to land in the case of divorce or death of their husband (Deininger and Castagnini 2006). Third, low-cost and participatory mechanisms for land adjudication have been shown to be viable (Deininger et al. 2008) and to lead to equitable outcomes that allow clear productivity gains over time (Deininger et al. 2011a). This has not only brought land back to the policy agenda (Place 2009) but also creates a need for empirical evidence to help base decisions in this area on evidence regarding what works and what does not in a specific situation rather than broad generalizations and preconceived notions.

2.2 Conceptual framework

Establishment and maintenance of a property rights system is a public good that affects economic outcomes through two main channels (Besley and Ghatak 2010). The first is the reduction of expropriation risk that will reduce the need to spend private resources on protecting property and increase investment incentives. The second is the facilitation of market transactions that allow efficiency-enhancing transfers of land to more productive users and its use as collateral in financial markets

If property rights are insecure or boundaries ill-defined and land values are high or increasing, a process of adjudication and first-time registration to document existing rights that enjoys legal recognition and is backed up by local consent and enforcement can reduce expropriation risk and spur land-related investment. The magnitude and distribution of the associated benefits will depend on the reduction in enforcement effort

afforded by formal recognition, the increment in security provided by an intervention (which may be affected by the legitimacy and legality of existing arrangements and the existing level of disputes) and the availability of investment opportunities. Benefits are expected to be larger if the arrangements adopted enjoy wide legitimacy, if the increase in tenure security is large, if high levels of resources had earlier been expended in efforts to secure rights or conflict over these, if formalization involves recognition of rights by groups (e.g., women or migrants) that had previously been excluded, and if the scope for improving land use, through either land-related investment or transfers, is high.

While unlocking investment is contingent ‘only’ on removal of impediments to tenure security, realizing gains from transferring land to more productive uses or users, often beyond a given community, requires that, in addition to clearly defined property rights, reliable information on such rights is broadly available at low cost. To allow this, public registries normally make complete, current, and authoritative information on property rights assignment available to interested users. If imperfections in markets for credit and insurance are not too severe and non-agricultural opportunities are available, this can facilitate transfers to bring land to its most productive use and spur development of a financial system.

The conceptual basis for credit-effects of land titling is that immobility and indestructibility make land ideal collateral but that it is very costly for banks to determine whether plots offered as collateral can be accepted.¹ A reliable and comprehensive central registry dramatically reduces the cost of such enquiry, making it possible to exchange land in impersonal markets and use it to secure loans. If lack of reliable information on land ownership precludes access to credit for large segments of land owners but land rights are well defined, reductions in the associated transaction cost, e.g., through computerization, can have a major impact on expanding credit access (Deininger and Goyal 2010).

2.3 Empirical evidence

The link between tenure security and land-related investment is well established in the literature (Deininger and Feder 2009). In Africa, following a seminal study in Ghana (Besley 1995), weak rights, often held by disadvantaged groups such as women or outsiders, can undermine investment and reduce productivity (Deininger and Jin 2006; Fenske 2011; Goldstein and Udry 2008). Beyond Africa, positive impacts of tenure security on investment in rural areas have been documented in China (Jacoby et al. 2002), Thailand (Feder et al. 1988), Latin America (Bandiera 2007), and Eastern Europe (Rozelle and Swinnen 2004). What is at stake in the empirical debate is not whether improvements in tenure security increase land-related investment but whether (i) land registration programmes help to increase rather than reduce tenure security; (ii) they do without negative distributional effects such as ‘land grabbing’ or distress sales; and (iii) benefits significantly exceed the cost to ensure interventions are cost-effective.

¹ In general, this would require physical inspection and inquiry with neighbours to ensure that there are no other ownership claims and some form of a registry to ensure that the land has not already been pledged as a security for other transactions.

While few studies explicitly explore the cost-effectiveness of relevant interventions, the literature suggests positive impacts in many cases. Receipt of titles allowed former squatters, especially women, to join formal labour markets instead of staying at home to guard their land, thereby increasing their income and reducing child labour (Field 2007). In Vietnam, awarding certificates prompted higher investment in perennials and prompted households, especially the poor, to spend more time in non-agricultural activities (Do and Iyer 2008). In Ethiopia land certification helped to empower women and led to increased productivity as well as land market transactions (Deininger et al. 2011a). Titles that include women in Argentina are also credited with having helped to reduce fertility and increase investment in children's human capital (Galiani and Schargrodsky 2004) although impacts arise through investment in physical and human capital rather than through improved credit access (Galiani and Schargrodsky 2010).

Compared to the overwhelming empirical support for investment-impacts, evidence of credit-impacts from land titling, although not entirely missing (Feder et al. 1988), is surprisingly limited. They may accrue only to wealthy producers (Carter and Olinto 2003) and often expectations for property rights reform to improve credit access failed to materialize (Field and Torero 2006). One reason is that better access to information on land ownership will affect credit supply only if other impediments are absent, i.e., if agents have been credit constrained before and are endowed with sufficient levels of illiquid wealth that can be foreclosed upon at reasonable cost (Besley and Ghatak 2010). Lack of investment opportunities, risk aversion, and political, social or economic restrictions on land market liquidity that make foreclosure difficult are key reasons identified in the literature. In light of this, our assessment of the impacts of land regularization in Rwanda below will focus on impacts with respect to investment, equity, and land transfers, noting where appropriate the potential impact of obstacles to land market operation.

3 Rwanda's setting

As the most densely populated country in Africa, Rwanda has long faced the challenge of establishing a land system that would provide incentives for investment and rational land use to create economic opportunities while at the same time overcoming gender and ethnic biases in land access. A failure to meet these challenges has been identified as contributing to the 1994 genocide. Since then, enormous effort have been undertaken to clarify land rights and provide the basis for overcoming traditional biases, culminating in the LTR programme that is to be evaluated here.

3.1 The challenges posed by land scarcity and conflict

With some 85 per cent of its population deriving their main income from agriculture and the highest population density of any African country (384 inhabitants per km² in total and 526 per km² for agricultural land), land-related investment and effective land use are key determinants of poverty reduction in Rwanda (Republic of Rwanda 2009). In 2008, the average household had 0.72 ha of land, slightly below the threshold of 0.75 ha that official sources estimate is needed for a family to satisfy nutritional needs with available technology. Land is highly fragmented; the average household owns four parcels, with average parcel size varying between 0.13 ha in the North and 0.37 ha in

the East. Rapid population growth has led farmers to push into marginal lands, clear forests, and cultivate steep hillsides without proper soil and water conservation, creating severe environmental challenges (Republic of Rwanda 2004).

In Rwanda customary land tenure systems had traditionally provided high levels of tenure security. However, outdated processes and misuse, e.g., by state representatives invoking eminent domain even for private benefits, had led to serious deterioration and weakened the system's ability to cope with far-reaching social, economic and political changes. Increased land scarcity and population pressure failed to trigger institutional innovations to encourage greater investment and more intensive land use. Instead competition for land in an environment characterized by slow expansion of non-agricultural income opportunities resulted in illegal land sales, pervasive land disputes, and 'land grabbing' that exacerbated inequality, landlessness, and social tensions. Although they are not the only factors, land-related conflicts have been identified as contributors to the 1994 genocide (André and Platteau 1998) and land policy is widely recognized to have a central role in creating preconditions for sustained growth and conflict prevention in today's Rwanda. To rise to this challenge, the country embarked on an integrated strategy of legal and institutional reform, the pilots evaluated here, and eventually nation-wide implementation of the LTR programme.

3.2 Legal and institutional changes

To provide secure land tenure to all Rwandans in the context of national unity and reconciliation, and with the goal of creating the preconditions for rapid structural transformation, far-reaching legal and institutional changes were embarked upon. Adoption of the 1999 inheritance law, key provisions of which were also incorporated into the 2003 constitution, aimed to eliminate bias against female land ownership. It was followed by the 2004 land policy and its codification in the 2005 organic land law (OLL). Establishment of institutional structures at national and local level then created the preconditions for the pilots the evaluation of which is the topic of this paper and a national programme.

As is common in customary systems, women in Rwanda formerly had land use rights only through their husbands whose lineage controlled the land, implying that their right to own or inherit land was severely compromised. In fact, widows were unable to inherit their deceased husband's property and at most were allowed to use it until male children grew up. Those without children lost even use rights to family land unless they maintained family ties by marrying one of their husband's brothers (Republic of Rwanda 2004). The 1999 inheritance law changed this by advancing in three areas. First, daughters and sons are granted equal rights to inherit their parents' property. Second, subject to the provisions of the family law (which under the most common conjugal property regime mandates equal shares), property rights by women under a legally registered marriage are protected.² Third, spousal consent is required for transaction (e.g., sale, mortgage or exchange) of matrimonial property by any of the marriage partners. Nevertheless, the law does not protect property rights by women who live in marriages that are unregistered or arrangements, including consensual unions,

² Rwanda's constitution gives legal recognition to registered monogamous marriage between a man and a woman. Any other arrangements such as consensual union, customary or religious marriages are not recognized by law and hence do not get any legal protection and property rights.

customary or religious marriages, and polygamous unions, that are not formally recognized.³

After animated debate, the 2004 land policy put forward general principles for efficient and sustainable use of scarce land resources and called for a legal and institutional framework to achieve these. The 2005 OLL provides the legal basis for the necessary arrangements. One of its key provisions is to establish a single statutory system of land tenure in order to end the dualism created by parallel existence of customary and formal tenure systems. Ownership of land is vested with the state; landholders are provided long-term, usufruct rights (up to 99 years, depending on land use) that can be sold, passed on to heirs, mortgaged, leased, or otherwise transferred. At the same time, and in line with the land policy, further subdivision of agricultural parcels of land less than or equal to one ha is prohibited and any subdivision of parcels between 1 and 5 ha requires approval by a competent authority. The law also lays the basis for land expropriation (with appropriate compensation) in the public interest.

To translate the unification of land tenure systems into reality, the OLL recognizes land acquired through customary law but makes first-time land registration and recording of any follow up transfers compulsory. At national and district levels, land commissions were formed to oversee OLL implementation.⁴ The National Land Center (NLC),⁵ which includes the registrar's office, was established as the technical agency in charge of all activities related to land administration, land use planning and management, and OLL implementation more generally. At district, town, and municipality level, District Land Bureaux (DLBs) are made responsible for land administration and use planning, complemented by land committees at sector and cell levels to serve as focal points for land registration and land use planning and thus facilitate a decentralized and participatory implementation process.

3.3 The national LTR programme

To clarify existing land rights on all of the country's estimated 11 million land parcels, the NLC has been tasked with development and implementation of a programme of LTR (Sagashya and English 2010). The goal is to create the precondition for formalization and full legal recognition of rights to these lands, as manifested in the

³ Anecdotal evidence suggests that, especially for the post-genocide generation, the cost of conducting a 'proper' marriage ceremony is often prohibitive, something that can result in delays during which couples live together informally.

⁴ The Republic of Rwanda is composed of five local administrative entities along with that of the central government. Accordingly, the country is divided into four provinces (North, South, East, and West) and the city of Kigali, 30 districts (of which three of them are in the city of Kigali), 416 sectors, 2,146 cells, and 14,876 villages (umudugudu). The roles and responsibilities of each of the entities are clearly specified in the 'Rwanda Strategic Decentralization Framework' (Republic of Rwanda 2007). Provinces are to serve as a liaison 'for coordinating district development planning with the national policies and programmes' and to supervise their implementation at the district level. The districts play a prominent role in the decentralization process as they are responsible for 'local economic development planning and coordinating the delivery of public services'. Sectors assume a coordinating role in the delivery of public services and gather data and information. As the smallest administrative unit, cells prioritize needs and mobilize the community to address them. They are composed of villages that do not have specific administrative functions.

⁵ In 2011, the NLC was integrated into the Rwanda Natural Resource Authority as the Department of Land and Mapping.

award of title certificates to land holders. Given the lack of successful models that could be drawn upon and the heterogeneity of situations across different parts of the country, it was decided to develop and fine tune the methodology through a pilot exercise in four cells, chosen to reflect typical situations encountered throughout the country, before embarking on a national roll-out.

This pilot, which was implemented in 2007/2008, resulted in demarcation and adjudication of 14,908 parcels with a total area of 3,448 hectares, owned by 3,513 households. After declaration of an area as subject to adjudication and conduct of stakeholder sensitization programmes, locally trained para-surveyors conducted land demarcation in the field to identify parcel boundaries in the presence of land owners and all adjoining neighbours, mark them on an aerial photo to create a graphical record and, for undisputed parcels,⁶ issue a claim receipt that is signed by all adjoining neighbours. Information from this receipt, in particular the names of all persons, including women and minors, with a claim or interest on the property, is then transferred to a registry book, digitized, and displayed publicly. If no objections are raised within a period of public display of at least 2 weeks, the information is formally registered, creating the precondition for award of a formal certificate upon payment of a nominal fee.⁷

Figure 1 displays the location of the trial areas on the map, and a brief review of their main characteristics will be of interest (Republic of Rwanda 2008). Nyamugali, located in a densely populated peri-urban area (3,500 inhabitants per km²) in Kigali city, is a largely residential area interspersed with small agricultural plots where a thriving informal land market and high levels of expropriation risk had created demand for legalization of existing land records. Kabushinge cell represents a high population density rural area (768 inhabitants per km²) in the North where high population pressure and land scarcity together with land conflicts arising from high levels of polygamy and post-genocide land allocation to refugees and soldiers created land pressure. Biguhu cell, in a moderately populated Western area (337 persons per km²), represents areas severely affected by the genocide with many female household heads and orphan landholders. Finally, Mwoga cell is in a low population density sector (274 per km²) in the East where extensive land sharing and high concentration of refugees caused widespread fear and tenure insecurity. Completion and careful analysis of operational aspects of the pilot experience allowed NLC to scale up to a nation-wide programme that currently deploys more than 60 field teams who, in the programme's first year, demarcated a total of 4.8 million parcels.

4 Sampling, econometric approach, and data

While the programme presents a number of interesting aspects, a key methodological challenge to overcome for a rigorous socio-economic assessment of the pilots was the lack of a baseline data. To deal with this, we adopted a spatial discontinuity design and administered a short survey to some 3,500 households on both sides of the boundaries

⁶ Parcels, the ownership claims to which are disputed, are recorded in a separate dispute register. Disputed claims can then be pursued separately through either administrative or judicial channels with the possibility of legal NGOs playing an important role in moving the process along.

⁷ The fee of RWF 1,000 (US\$1.84 at the 2008 rate) per parcel or about RWF 4,000 (US\$7.36) per household taking the national average of four parcels per household compares to a cost of approximately US\$9.11 in the pilot—since then reduced to about US\$5—per parcel.

of the four pilot cells. This section describes the sample design and the econometric methodology, relying on the use of spatial fixed effects that is used to interpret the data.

4.1 Sampling strategy

As there was no usable baseline survey to assess the impact of the pilot programme, we rely on cross-sectional data, sampled from both sides of the boundaries of the pilot cells to allow comparison of outcome variables between treated and non-treated households (inside and outside the borders of the pilot cells, respectively) close to the borders of the pilot cells. We thus exploit the discontinuity which administrative boundaries created in the introduction of the pilot programme as an identification strategy. The key assumption is that before the start of the programme, households close to a cell boundary were similar in unobservable and observable factors affecting relevant outcomes.

To obtain household information, we administered a light survey during April-May 2010, about 2.5 years after the start of LTR in the pilot cells. The sample was designed to yield numbers of households in each pilot cell equivalent to their share in the total, with a size of 3,554 households with some 6,330 land parcels, intended to be split equally across pilot and their neighbour cells. To sample inside pilot cells, we used parcel index maps created by the programme. As no such maps were available for the adjacent (control) cells, we used high resolution satellite imagery to identify dwellings that could then serve as a sample frame. Figure 2 illustrates the procedure graphically. To ensure that the share of households in each pilot cell corresponded to the cell's share in the target population, the widths of the bands from which households were selected were adjusted.⁸ Note also that, as we lack enough statistical power to make strong conclusion for the urban sample, i.e., the city of Kigali, the empirical analysis given below is solely based on data from rural areas.

Table 1 shows the distribution of sampled households in the pilot and their adjacent cells. Information was collected both at household and parcel levels. Household level information includes demographics, housing, assets, participation in the credit market, participation in the registration programme and knowledge of the law and the GPS coordinates of the main residential plot. Parcel level questions included land characteristics, investment, inheritance dynamics as well as participation in land sales and rental markets.

4.2 Econometric approach

To examine the effects of LTR, we estimate the following equation:

$$Y_{ph} = \alpha + \beta_1 T_{ph} + \beta_2 X_{ph} + \beta_3 Z_h + \varepsilon_{ph} \quad (1)$$

where Y_{ph} is the outcome of interest for parcel p in household h , T is an indicator for LTR participation, X is a set of parcel characteristics, Z household characteristics, and ε an error term. If land registration were voluntary, we would be concerned about endogeneity of outcomes such as investment and land market activity. However, tenure

⁸ Outer and inner bandwidths were 125 m in Nyamugali, 400 m in Kabushinge, 350 m in Biguhu, and 1250 m in Mwoga.

regularization was compulsory and covered all private land in the cell. In other words, plots were registered up to a cell's administrative boundaries, but not beyond the cell border. The spatial discontinuity generated by this allocation rule thus can be used to allow identification of programme effects by comparing individuals who live within a band on either side of the border following Magruder (2011). This approach extends work comparing enterprises on either side of a state border in the US to look at the effects of minimum wage legislation (Card and Krueger 1994) to explore effects of centralized bargaining agreements on employment using geographic and labour force data. For the approach to be valid, communities on either side of the border have to be identical and cell-level effects that could drive our results need to be absent. To assess the validity of this assumption, we note that key policies with respect to land rights and use are set and enacted by higher levels of government; for example land inheritance policy is determined nationally and soil conservation policies are mostly enacted at the district level. Thus, while the cell administration plays an important role in key aspects of implementing the LTR process such as public sensitization, conflict resolution, display, and registration, all of these are part of the treatment of interest and there are no significant cell level interventions that could drive our results.

We might, however, still be concerned about the possibility of local variations in soil quality, market conditions or other factors that could be driving our results. We follow the literature (Conley and Udry 2010; Goldstein and Udry 2008; Magruder 2011) and use spatial fixed effects to control for local level unobservables. Equation (1) now becomes:

$$\begin{aligned}
Y_{ph} - \frac{1}{N_p} \sum_{q \in N_p} Y_{qh} = & \beta_1 \left(T_{ph} - \frac{1}{N_p} \sum_{q \in N_p} T_{qh} \right) + \beta_2 \left(X_{ph} - \frac{1}{N_p} \sum_{q \in N_p} X_{qh} \right) \\
& + \beta_3 \left(Z_h - \frac{1}{N_p} \sum_{q \in N_p} Z_{qh} \right) + \varepsilon_{ph} - \frac{1}{N_p} \sum_{q \in N_p} \varepsilon_{qh}
\end{aligned} \tag{2}$$

where N_p is both the set of parcels within a critical distance of parcel p and the number of such parcels. In other words, (2) provides a continuous way to compare treatment and control households whereby each household is combined with those in a neighbourhood (some of whom will be literally next door) which are some combination of treatment and control households. As noted above, we interviewed all households in the band close proximity to the cell border (i.e., inside and outside) to make it more likely that households are similar. Indeed, while this approach will give us a local treatment effect only, it is ideally suited for spatial fixed estimations by delivering a high density of treatment and control households in close proximity to one another. As explained above, we do not have geographic data on the location of individual parcels. Instead, we define the critical distance based on a neighbourhood of households. To ensure that we capture all of a household's parcels and in order to ensure that each treatment (control) household's neighbourhood contains at least one control (treatment) household for comparison, we defined this critical distance as 1,000m. Finally, to deal with possible spatial autocorrelations in the error term, we will use the method of Conley (1999) to correct the standard errors.

5 Results

Tables 2 and 3 present summary statistics by treatment status. Table 3 points towards high levels (22 per cent) of female headship, small landholdings (0.93 ha for the average household), and formalized marriages by about three quarters (76.4 per cent) of the sample. It also documents that for most of the time-invariant household characteristics of interest, treatment and control households are not different from one another in any meaningful way. However, for some of the characteristics that might be affected by the programme, such as mode of acquisition of a parcel and length of possession (Table 3), significant differences emerge. Since this is cross-sectional data, it is quite possible that some of these differences may be driven by the programme. For example, the fact that average length of possession is higher in the treatment area than the control is consistent with the result below that land markets are less active in the treatment area.

Table 4 displays the mean values of key outcome variables of interest. Contrary to the earlier tables, there are highly significant differences between programme and control areas that may point towards programme impacts. However, use of spatial fixed estimates (and correction of standard errors for spatial dependence) will be required to draw robust conclusions regarding the programme's impact. As there are indeed a number of cases where differences suggested by descriptive tables lose significance once a proper methodological framework is applied, we discuss these variables in the context of the econometric estimations below.

5.1 Land related investment

A primary reason for the Government of Rwanda to initiate LTR was to increase levels of tenure security. Table 5 reports evidence on programme impacts on subjective expropriation risk using a binary measure and the five-scale grade included in the questionnaire.⁹ While the sign on the treatment coefficient is negative as expected, it is not statistically significant. Possible reasons include the fact that LTR does not change overall policy and that households' knowledge of the policy may be limited, something that could be addressed in a follow-up by asking more specific questions on knowledge of expropriation procedures.

In contrast to the above result, Table 6 documents household behavior that is consistent with a lengthening of time horizons due to LTR-induced increases in tenure security. Consistent with the notion that improved seeds do not yield long-term benefits, the coefficient of this variable in column 1 is positive but not statistically significant. At the same time, column 2 suggests that households affected by LTR are almost 10 percentage points more likely to make or maintain soil conservation investments in structures such as bunds, terraces, and check dams. This is about double the change in investment in the control group, a very large effect. Women seem to benefit more in this respect; estimated effects of LTR on such investment by female-headed households are double that of men with female-headed households exhibiting a roughly 19 percentage point increase in likelihood of measures to construct or maintain soil conservation

⁹ The wording of the question was 'What is the likelihood that you will lose this parcel due to expropriation in the coming 5 years?'. The binary index is set to one for anybody indicating some expropriation risk.

structures. This suggests that low levels of tenure security by females acted as an obstacle to investment by this group and that removing such impediments by increasing women's tenure security and formalizing rights which they may have enjoyed on an informal basis.

5.2 Women's land rights and inheritance

A more direct test of the extent to which Rwanda's policy of actively increasing women's rights to land had the desired impact is to assess the extent to which LTR helped to increase female land ownership. However, a key provision of the legislation is that legally married women are entitled to equal ownership rights over household parcels. 76 per cent of couples in our sample have a marriage certificate, in line with legal provisions requiring registration of marriages at the local commune. Table 7, which presents regressions for an indicator of land ownership and the share of land owned by females, illustrates that LTR has dramatically changed women's rights over land by helping to create documentary evidence of such rights. While the first four columns, based on the full sample, show little change in female land ownership rights, columns 5 and 6, which restrict the sample to cohabitating/married couples, reveal a large programme impact. The first row shows that, for women in this group who are not legally married, LTR results in a small but statistically significant reduction (by 8 percentage points) of the probability of having documented land ownership.¹⁰ However, for women who are part of a union formalized through a marriage certificate, the effect of the programme is overwhelmingly positive—they are 17 percentage points more likely to be regarded as joint land owners after LTR than before. The final column displays results with the share of the land owned by women as the dependent variable which point to a positive but not statistically significant effect, regardless of the presence of a certificate.

As many past land adjudication efforts failed to tackle inheritance issues, it is of interest to explore LTR-induced effects in this regard. Table 8 highlights that, most likely because it requires an explicit record of who will inherit the parcel, the process significantly reduces succession-related uncertainty. We find a 9 percentage point increase in the respondent's response that she/he now knows who will inherit the parcel. Column 2 shows that greater certainty along these lines strongly benefits the respondents' children and that gender bias has virtually been eliminated, at least for couples. In LTR areas, children are 13 points more likely to inherit the land and, as columns 4 and 5 document, girls benefit almost equally. Column 4 suggests that girls in female-headed households are significantly less likely to be designated as an heir compared to their counterparts in male-headed households. This result deserves further research, but it is not inconsistent with data from Mexico which shows that women exhibit strong and persistent preferences for male versus female heirs (Deere and Leon 2003).

¹⁰ While our questionnaire did not elicit information on disputed claims, it would in principle be straightforward to use the dispute register to explore how many of these were able to register disputed claims and how many of these had actually been resolved.

5.3 Land market activity

It is often claimed that, by reducing the transaction costs of transferring land, interventions to improve land tenure may set off a wave of distress sales whereby households who lack access to credit and insurance sell off their land in periods of distress well below its fair market value, thereby entering into a downward spiral of impoverishment. Results from testing this directly with our data as reported in Table 9 allow us to convincingly reject this hypothesis for our sample; instead of an increase, we find a statistically significant reduction in land market activity and the size of land area traded due to LTR.

To interpret this finding, two contextual factors are relevant. First, in early 2008, i.e., during pilot implantation, stamp duty, which is the fee to be paid upon registration of a transfer, was changed from six per cent of the property value to a flat fee of RWF 20,000 which, for smaller plots, could easily exceed 25 per cent of the land value.¹¹ Second, at the time of the survey, a formal system to register land transfer was not yet in place and it was unclear to what extent the prohibition on registering transfers of parcels below the legally prescribed minimum size of 1 ha—which would have affected virtually all the transfers in our sample—would be enforced. Thus one possibility for the reduced level of land market activity is that households refrained from land transfers in an attempt to not jeopardize their newly acquired tenure security, especially if sensitization in the course of programme implementation had increased their awareness of registration fees. Another possibility is that, since this was a pilot that preceded the national roll-out by approximately 2.5 years, the benefits from registration in land markets were still unclear and beneficiaries preferred holding on to their land in expectation of increased land values as others would realize the benefits from having secure land ownership documentation. This is an area that will be more fully explored in upcoming work on the national roll-out of this programme.

6 Conclusion and policy implications

Taken together, our results point towards significant benefits from land tenure regularization in Rwanda. The positive results are even more impressive in light of the fact that the programme analyzed here was a pilot that involved considerable learning and that the period elapsed between its completion—in particular the actual award of titles—and our survey had been quite short. Individuals whose parcels had been registered through LTR, in particular female-headed ones, were much more likely to invest in soil conservation measures on their land. Clarification and documentation of rights reduced uncertainty over who would inherit land, with substantial benefits for female children who might otherwise have been discriminated against. This programme also provided large additional gender benefits. Legally married women were significantly more likely to have their informal ownership rights documented and secured after registration. But women who were not legally married saw diminished property rights, in accordance with the law. And girls residing in female-headed households were less likely to be designated as heirs.

¹¹ At the same time, transfers due to inheritance, which had earlier been exempted, were required to pay the same level of fees. In light of the high levels of land market transactions observed in Rwanda, such a fee structure could quickly result in a reversion to informality.

The nature of the survey instrument and the short time since the pilots preclude a full assessment of the productivity and welfare impacts of increased investment, stronger rights by women, and changes in the functioning of land markets. All of these, as well as the programme's impact on households' vulnerability and ability to deal with risk, its interaction with other interventions (in particular government programmes), and the extent to which modalities of programme implementation affect observed outcomes re left for future research. These limitations notwithstanding, our results suggest that LTR indeed focuses on a key constraint to environmental protection, agricultural development, and female empowerment in Rwanda. They also help to identify risks in the areas of policy, implementation processes, and sustainability which, if not attended to in a proactive manner, might jeopardize or at least attenuate the programme's positive impact or undermine its sustainability. Follow-up research will be of great interest to document how these risks are addressed, explore in greater detail the programme's social, environmental, and productivity dimensions, and help to better appreciate the magnitude of long-term programme benefits and the channels through which they materialize.

Table 1: Distribution of sampled households by programme participation

Province	District	Sector	Pop. density	Number of sampled households	
			Pers./km ²	Treatment	Control (adjacent cells)
West	Karongi	Ruganda	337	125	245
North	Musanze	Rwaza	769	465	694
Kigali City	Gasabo	Gatsata	3591	462	502
East	Kirehe	Mubama	274	404	657
Total number of households				1456	2098

Source: Republic of Rwanda (2008)

Table 2: Parcel level descriptive statistics by treatment status

	Total		Control		Treatment		
	Mean	SD	Mean	SD	Mean	SD	
Parcel size in hectares	0.284	0.735	0.273	0.708	0.300	0.769	
Number of years possessed	17.644	15.461	17.272	15.787	18.146	14.998	***
Parcel was purchased	0.449	0.497	0.463	0.499	0.430	0.495	***
Parcel was inherited	0.360	0.480	0.341	0.474	0.386	0.487	***
Parcel allocated by government	0.171	0.376	0.165	0.372	0.178	0.382	
Acquired through other means	0.020	0.141	0.030	0.171	0.007	0.081	***
Number of parcels	6327		3634		2693		

Source: Own computation from 2010 World Bank Land Tenure Regularization Survey

Note: Significance levels are reported for t-tests of the equality of the means for each of the variables between control and treatment areas (* significant at 10%; ** significant at 5%; *** significant at 1%).

Table 3: Household level descriptive statistics by treatment status

	Total		Control		Treatment		
	Mean	SD	Mean	SD	Mean	SD	
Head's age	45.317	15.392	45.533	15.578	44.980	15.099	
Married couple	0.711	0.454	0.707	0.455	0.717	0.451	
With legal marriage certificate	0.764	0.425	0.752	0.432	0.782	0.414	
Female-headed household	0.224	0.417	0.239	0.426	0.201	0.401	**
Head has at least primary education	0.326	0.469	0.320	0.467	0.335	0.472	
Head reads and writes	0.617	0.486	0.611	0.488	0.628	0.484	
Number of male children age 14 and less	0.900	1.044	0.899	1.045	0.902	1.044	
Number of female children age 14 and less	0.899	1.031	0.909	1.044	0.884	1.011	
Number of adult male age 15 to 60	1.190	0.899	1.189	0.900	1.193	0.898	
Number of adult female age 15 to 60	1.303	0.917	1.280	0.880	1.339	0.971	
Male members age 60 and above	0.116	0.321	0.116	0.320	0.117	0.322	
Female members age 60 and above	0.122	0.330	0.130	0.341	0.108	0.311	
Land holdings in hectares	0.932	1.742	0.909	1.805	0.968	1.639	
Total number of households	2268		1369		886		

Source: Own computation from 2010 World Bank Land Tenure Regularization Survey

Note: Significance levels are reported for t-tests of the equality of the means for each of the variables between control and treatment areas (* significant at 10%; ** significant at 5%; *** significant at 1%).

Table 4: Outcome variables by treatment status

	Total		Control		Treatment		
	Mean	SD	Mean	SD	Mean	SD	
Perceived risk of expropriation (1 if medium and above risk out of a 5 scale measure)	0.846	0.361	0.859	0.348	0.827	0.378	***
Perceived risk of expropriation (5 scale measure: 5=Very high risk, 1=Very low risk)	4.061	1.146	4.090	1.068	4.021	1.248	***
Change in proportion of parcels receiving soil conservation measures between 2007 and 2010							
Construction of new conservation structures	0.066	0.430	0.042	0.424	0.098	0.435	***
Maintenance of existing structures	0.089	0.366	0.073	0.355	0.110	0.378	***
New/maintenance of existing structures	0.140	0.510	0.101	0.499	0.193	0.520	***
Changed seed type from local to improved variety since 2007	0.529	0.499	0.498	0.500	0.571	0.495	***
Change in new/maintenance of buildings	0.034	0.297	0.037	0.315	0.030	0.270	
Female head/spouse jointly or alone owns parcel	0.869	0.338	0.879	0.326	0.855	0.353	***
Share of parcel owned by female (%)	42.486	27.400	42.028	27.120	43.112	27.770	
Know who will inherit the parcel	0.638	0.481	0.596	0.491	0.695	0.461	***
Sons will inherit land	0.741	0.438	0.718	0.450	0.767	0.423	***
Daughters will inherit land	0.690	0.463	0.661	0.474	0.723	0.448	***
Spouse will inherit parcel	0.321	0.467	0.343	0.475	0.291	0.455	***
Children will inherit parcel	0.763	0.425	0.719	0.449	0.821	0.383	***
Change in land market (sales/purchases) participation ^a	0.011	0.498	0.022	0.511	-0.008	0.477	
Change in the size of land traded in hectares ^a	0.005	0.421	0.021	0.380	-0.020	0.477	**
Number of parcels	6327		3634		2693		

Source: Own computation from 2010 World Bank Land Tenure Regularization Survey

Note: Significance levels are reported for t-tests of the equality of the means for each of the variables between control and treatment areas (* significant at 10%; ** significant at 5%; *** significant at 1%).

^aHousehold level outcome variables.

Table 5: Spatial fixed effects estimates of the impact of LTR on perceived risk of expropriation

	Binary measure	Five scale measure
Treatment indicator	-0.047 (0.997)	-0.204 (1.251)
Treatment X female headship	-0.042 (0.512)	-0.106 (0.478)
Number of years possessed	-0.000 (0.411)	-0.001 (0.454)
Parcel was purchased	-0.053* (1.911)	-0.219** (2.333)
Parcel was inherited	-0.073* (1.905)	-0.317** (2.447)
Acquired through other means	-0.004 (0.056)	-0.273 (1.132)
Parcel size in hectares	-0.010 (1.254)	-0.044** (2.128)
Head's age	0.000 (0.295)	0.001 (0.246)
Female-headed household	-0.066 (1.444)	-0.231* (1.653)
Head has at least primary education	0.005 (0.335)	0.051 (0.922)
Number of male children age 14 and less	-0.015* (1.661)	-0.056** (2.108)
Number of female children age 14 and less	-0.019* (1.775)	-0.052 (1.643)
Number of adult male age 15 to 60	0.010 (0.828)	0.001 (0.032)
Number of adult female age 15 to 60	0.019* (1.830)	0.044 (1.383)
Male members age 60 and above	-0.022 (0.434)	-0.075 (0.495)
Female members age 60 and above	-0.074 (1.451)	-0.226 (1.347)
Constant	-0.001 (0.165)	-0.015 (0.497)
Number of observations	5345	5345
R2	0.030	0.032

Source: See text.

Note: The geographical neighbourhood of each household is defined at a distance of 1,000 meters. Absolute value of t-statistics corrected for spatial dependence (1500 meters).* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: Spatial fixed effects estimates of the impact of LTR on rural investment

	Change in improved seed use	Change in soil conservation measures		
		New or maintenance	New construction	Maintenance
Treatment indicator	0.064 (1.008)	0.099** (2.460)	0.075 (1.544)	0.038 (1.271)
Treatment X female headship	0.003 (0.076)	0.094** (2.076)	0.026 (0.713)	0.050 (1.314)
Number of years possessed	0.001 (1.187)	-0.002** (1.988)	-0.000 (0.194)	-0.002*** (2.645)
Parcel was purchased	-0.074** (2.438)	-0.030 (0.901)	-0.018 (0.623)	-0.017 (0.940)
Parcel was inherited	-0.083 (1.373)	-0.065 (1.030)	-0.016 (0.334)	-0.052* (1.705)
Acquired through other means	0.087 (1.226)	-0.209** (2.512)	-0.133 (1.640)	-0.081* (1.732)
Parcel size in hectares	0.032* (1.826)	-0.002 (0.199)	-0.001 (0.088)	-0.004 (0.650)
Head's age	-0.001 (0.927)	-0.001 (0.978)	-0.001 (0.720)	-0.001 (0.762)
Female-headed household	-0.052* (1.668)	-0.044 (1.183)	-0.040 (1.144)	-0.003 (0.094)
Head has at least primary education	0.005 (0.268)	-0.002 (0.118)	0.005 (0.311)	-0.014 (0.805)
Number of male children age 14 and less	0.002 (0.176)	0.019** (2.017)	0.011 (1.160)	0.018** (2.366)
Number of female children age 14 and less	-0.005 (0.430)	-0.003 (0.227)	-0.004 (0.519)	-0.007 (0.829)
Number of adult male age 15 to 60	0.020* (1.936)	0.020* (1.674)	0.009 (0.868)	0.016* (1.802)
Number of adult female age 15 to 60	-0.002 (0.146)	0.004 (0.278)	0.004 (0.335)	0.009 (0.829)
Male members age 60 and above	-0.041 (0.910)	0.001 (0.017)	-0.013 (0.301)	0.009 (0.256)
Female members age 60 and above	0.046 (1.095)	0.070* (1.872)	0.060* (1.832)	0.037 (1.094)
Constant	0.008 (0.619)	0.003 (0.289)	0.003 (0.308)	0.001 (0.174)
Number of observations	6325	6325	6325	6325
R2	0.014	0.020	0.010	0.016

Source: See text.

Note: The geographical neighbourhood of each household is defined at a distance of 1,000 meters. Absolute value of t-statistics corrected for spatial dependence (1500 meters).* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Spatial fixed effects estimates of the impact of LTR on female access to land

	Full sample				Sample of married couples	
	Owns land	Share of land	Owns land	Share of land	Owns land	Share of land
Treatment indicator	-0.030 (-1.644)	2.706 (1.127)	-0.033 (-1.633)	1.476 (0.788)	-0.080** (-2.308)	0.438 (0.263)
Treatment X female headship			0.016 (0.600)	6.309 (1.276)		
Treatment X marriage certificate					0.170*** (3.057)	4.355 (1.269)
Has marriage certificate					0.076*** (2.775)	3.179** (1.974)
Number of years possessed	-0.002** (-2.059)	-0.030 (-0.726)	-0.002** (-2.061)	-0.030 (-0.731)	-0.001* (-1.873)	-0.079** (-2.151)
Parcel was purchased	0.003 (0.227)	-1.724 (-1.535)	0.003 (0.203)	-1.829* (-1.673)	0.012 (0.998)	-1.646 (-1.545)
Parcel was inherited	0.017 (1.063)	-2.170 (-1.333)	0.017 (1.044)	-2.306 (-1.458)	0.019 (1.372)	-2.335 (-1.622)
Acquired through other means	0.013 (0.436)	8.148*** (3.588)	0.013 (0.444)	8.241*** (3.539)	0.044** (2.195)	7.500*** (3.598)
Parcel size in hectares	0.001 (0.097)	-0.085 (-0.162)	0.001 (0.104)	-0.065 (-0.125)	0.005 (0.693)	0.025 (0.086)
Head's age	-0.001 (-1.070)	0.103 (1.430)	-0.001 (-1.056)	0.106 (1.483)	0.002* (1.663)	0.246*** (2.762)
Female-headed household	0.096*** (5.281)	29.886*** (11.119)	0.089*** (4.193)	27.317*** (12.064)		
Head has at least primary education	0.006 (0.388)	-0.035 (-0.035)	0.006 (0.390)	-0.017 (-0.017)	0.009 (0.628)	-0.633 (-0.669)
Number of male children age 14 and less	0.047*** (6.250)	1.293*** (2.930)	0.047*** (6.288)	1.329*** (3.028)	0.010 (1.499)	-0.490 (-1.285)
Number of female children age 14 and less	0.046*** (5.926)	1.137** (2.389)	0.046*** (5.915)	1.187** (2.445)	0.007 (1.060)	-0.742 (-1.566)
Number of adult male age 15 to 60	0.020** (2.112)	-1.294 (-1.500)	0.020** (2.133)	-1.265 (-1.504)	-0.002 (-0.175)	-1.370** (-2.018)
Number of adult female age 15 to 60	0.082*** (7.496)	2.190*** (3.429)	0.082*** (7.511)	2.140*** (3.474)	0.027* (1.884)	0.807 (0.871)
Male members age 60 and above	-0.071** (-1.984)	-11.030*** (-4.068)	-0.072** (-1.973)	-11.152*** (-4.104)	-0.101*** (-2.765)	-9.894*** (-3.193)
Female members age 60 and above	0.317*** (8.623)	16.317*** (8.604)	0.317*** (8.651)	16.593*** (9.002)	0.129*** (2.708)	8.058*** (2.675)
Constant	-0.001 (-0.248)	0.181 (0.392)	-0.001 (-0.245)	0.188 (0.403)	0.023* (1.939)	-3.495*** (-5.960)
Number of observations	6,225	6,219	6,225	6,219	4,609	4,608
R2	0.149	0.348	0.149	0.350	0.120	0.100

Source: See text.

Note: The geographical neighbourhood of each household is defined at a distance of 1,000 meters. Absolute value of t-statistics corrected for spatial dependence (1500 meters). * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8: Spatial fixed effects estimates of the impact of LTR on inheritance dynamics

	Know who will inherit	Children inherit	Son inherits	Daughter inherits
Treatment indicator	0.094** (2.186)	0.133** (2.276)	0.102** (2.552)	0.096** (2.039)
Treatment X female headship	-0.044 (0.741)	-0.046 (0.779)	-0.052 (0.735)	-0.158** (2.326)
Number of years possessed	0.001 (0.745)	0.000 (0.112)	0.001 (0.708)	0.001 (0.396)
Parcel was purchased	-0.008 (0.344)	-0.021 (0.964)	0.043 (1.642)	0.008 (0.361)
Parcel was inherited	0.026 (0.719)	0.004 (0.136)	0.072** (2.247)	0.038 (0.995)
Acquired through other means	-0.051 (0.369)	0.025 (0.276)	0.167* (1.928)	-0.030 (0.254)
Parcel size in hectares	-0.023** (2.375)	-0.012 (1.248)	0.006 (0.567)	0.004 (0.284)
Head's age	0.001 (0.820)	0.003** (2.347)	0.002 (1.285)	0.004** (2.476)
Female-headed household	0.071* (1.789)	0.094*** (3.003)	0.210*** (5.764)	-0.003 (0.062)
Head has at least primary education	0.018 (0.818)	0.024 (1.337)	0.031 (1.297)	-0.001 (0.025)
Number of male children age 14 and less	0.028*** (2.779)	0.053*** (5.292)	0.155*** (11.481)	-0.017 (1.417)
Number of female children age 14 and less	-0.003 (0.303)	0.028*** (3.178)	-0.041*** (3.064)	0.161*** (13.739)
Number of adult male age 15 to 60	0.014 (1.319)	0.029** (2.362)	0.144*** (10.160)	-0.056*** (3.165)
Number of adult female age 15 to 60	0.010 (0.729)	0.014 (1.157)	-0.040** (2.499)	0.137*** (9.142)
Male members age 60 and above	0.068 (1.296)	0.078** (1.992)	0.123*** (3.077)	-0.160** (2.113)
Female members age 60 and above	-0.035 (0.600)	-0.027 (0.481)	0.026 (0.385)	0.091 (1.572)
Constant	-0.002 (0.209)	-0.002 (0.237)	0.228*** (10.160)	0.212*** (11.360)
Number of observations	6325	6325	4053	4053
R2	0.018	0.057	0.345	0.057

Source: See text.

Note: The geographical neighbourhood of each household is defined at a distance of 1,000 meters. Absolute value of t-statistics corrected for spatial dependence (1500 meters). * significant at 10%; ** significant at 5%; *** significant at 1%.

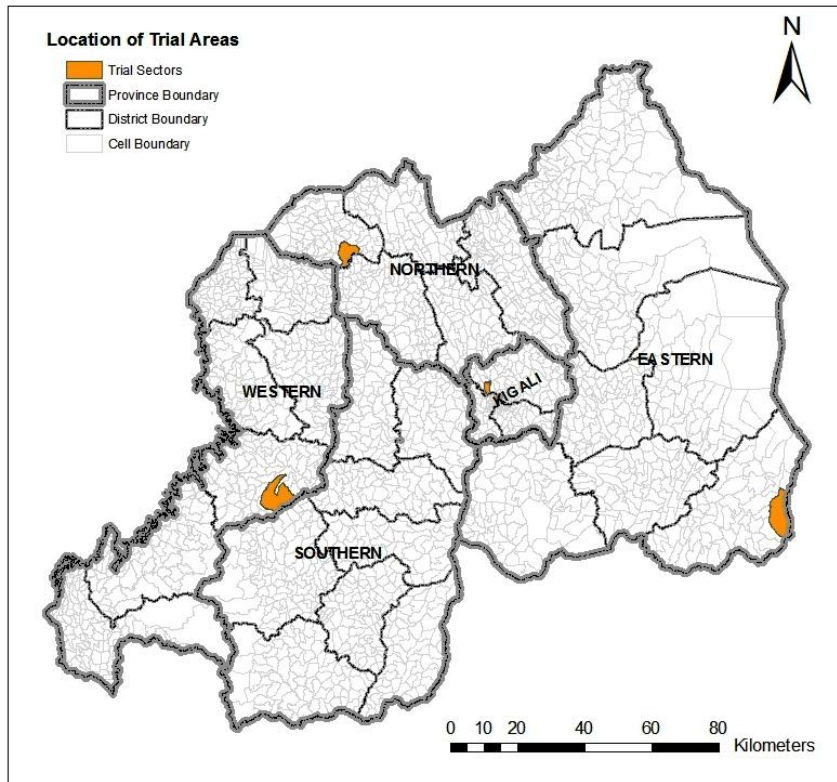
Table 9: Spatial fixed effects estimates of the impact of LTR on land market participation

	Change in participation	Change in traded area
Treatment indicator	-0.048** (1.970)	-0.054*** (2.787)
Treatment X female headship	-0.020 (0.456)	0.044 (1.498)
Head's age	0.001 (1.563)	0.001 (1.111)
Female-headed household	-0.002 (0.044)	-0.003 (0.153)
Head has at least primary education	0.021 (0.963)	-0.002 (0.064)
Number of male children age 14 and less	-0.001 (0.116)	-0.004 (0.633)
Number of female children age 14 and less	0.003 (0.324)	-0.002 (0.286)
Number of adult male age 15 to 60	0.002 (0.187)	0.008 (0.691)
Number of adult female age 15 to 60	-0.015 (1.496)	-0.007 (0.714)
Male members age 60 and above	-0.027 (0.811)	0.003 (0.126)
Female members age 60 and above	-0.009 (0.473)	-0.041 (1.046)
Constant	0.000 (0.001)	0.001 (0.189)
Number of observations	2267	2258
R2	0.003	0.004

Source: See text.

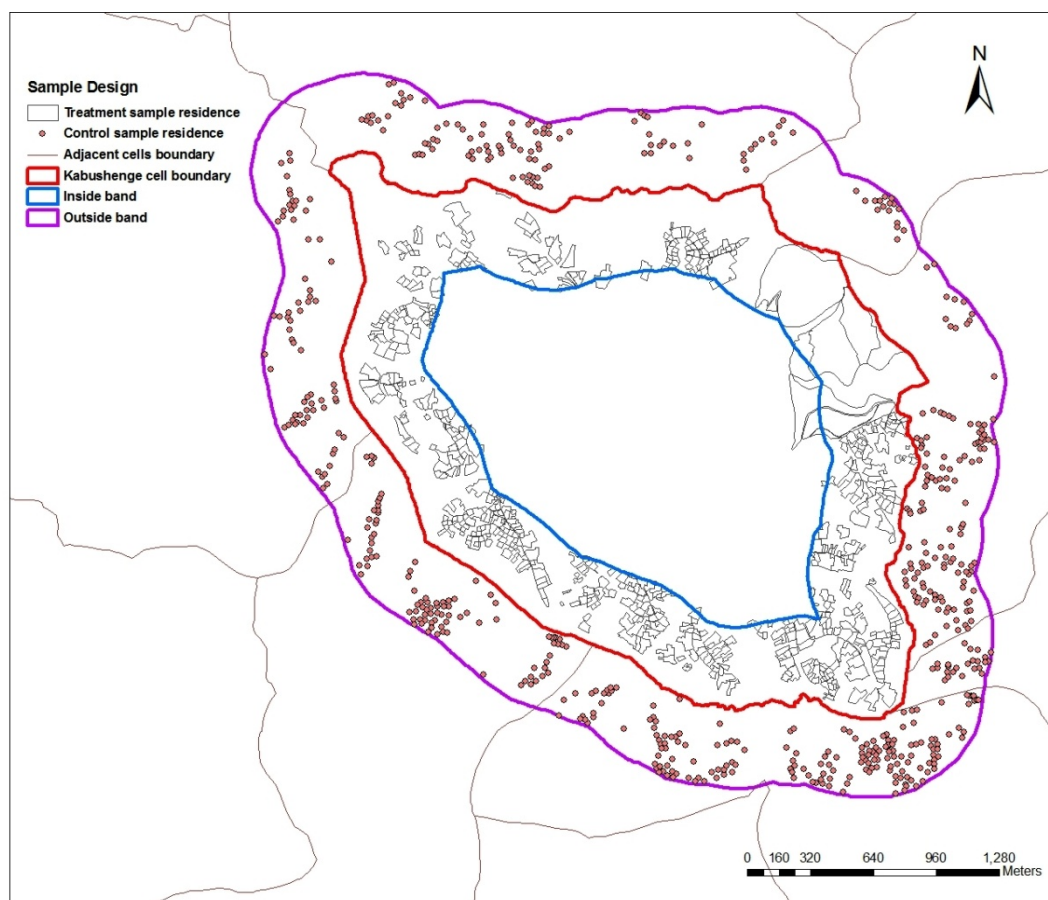
Note: The geographical neighbourhood of each household is defined at a distance of 1,000 meters. Absolute value of t-statistics corrected for spatial dependence (1500 meters). * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 1: Location of trial areas



Source: Authors' illustration.

Figure 2: Example of sample design: Kabushinge cell



Source: Authors' illustration.

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