

Property rights and water access: Evidence from land titling in rural Peru*

Robyn Meeks[†]

December 2016

Abstract

Insecure land tenure and property rights are an impediment to infrastructure access and services for households in many developing countries. This paper explores whether alleviating this impediment through a land titling program in rural Peru is associated with improvements in household water sources, as well as sanitation and electricity services. The economics literature on the links between property rights and investment decisions has amassed; yet due to the necessity of water for life, the high fixed costs associated with water infrastructure construction, and the positive externalities that can result from water provision, it is not obvious how water services might respond to land tenure improvements. Utilizing the phased-in program timing in a quasi-experimental design, we exploit the differences in implementation timing across space in conjunction with the differences in program impact across households that held property titles prior to the project and those that did not. Results from this modified difference-in-differences

*I am grateful to Erica Field for sharing the PETT survey data and helpful discussions. I also thank Rohini Pande and Bill Clark for their support and guidance. All errors are my own.

[†]School of Natural Resources and the Environment, University of Michigan. Email: meeks@umich.edu.

method indicate that land titling is associated with small in magnitude, but statistically significant increases in water access. Larger gains in sanitation and electricity services are found. We investigate the channels through which this improved access occurs and find evidence of investments in all three services via either government or water utilities. We find evidence of individual household investment only in the case of sanitation. Taken together, these results indicate that land titles are important, but not sufficient to increase access to water and other services.

Property rights and water access: Evidence from land titling in rural Peru

Abstract

Insecure land tenure and property rights are an impediment to infrastructure access and services for households in many developing countries. This paper explores whether alleviating this impediment through a land titling program in rural Peru is associated with improvements in household water sources, as well as sanitation and electricity services. The economics literature on the links between property rights and investment decisions has amassed; yet due to the necessity of water for life, the high fixed costs associated with water infrastructure construction, and the positive externalities that can result from water provision, it is not obvious how water services might respond to land tenure improvements. Utilizing the phased-in program timing in a quasi-experimental design, we exploit the differences in implementation timing across space in conjunction with the differences in program impact across households that held property titles prior to the project and those that did not. Results from this modified difference-in-differences method indicate that land titling is associated with small in magnitude, but statistically significant increases in water access. Larger gains in sanitation and electricity services are found. We investigate the channels through which this improved access occurs and find evidence of investments in all three services via either government or water utilities. We find evidence of individual household investment only in the case of sanitation. Taken together, these results indicate that land titles are important, but not sufficient to increase access to water and other services.

1 Introduction

Residential water access is crucial for development.¹ Yet insufficient access to safe drinking water continues to plague many of the world’s poorest populations, with 748 million people lacking access to safe drinking water and, of those with water access, 1.2 billion being served by contaminated sources (WWAP, 2015). Although the relationship between poverty and water access is well-documented,² less attention is typically paid to the role of land rights in water access. However, as the 2015 United Nations World Water Development Report states, “Access to water is also about access to land.” Indeed, in many lower and middle income countries, populations living in informal settlements and slums or on land without formal property rights are more likely to have inadequate access to safe water than those with property rights (WWAP, 2015).

With an estimated 889 million people living in slums and informal settlements (UN-Habitat, 2010), understanding the relationship between land rights and water access is crucial. The United Nations identified improvements in property rights and land tenure security as a mechanism by which to increase water access. Improvements could happen through several paths. Land tenure could increase households’ power to negotiate improved water provision by the government or utilities or it could increase households’ own investments in water infrastructure (WWAP, 2006).

The role of the state in setting up and protecting property rights is considered to be a precondition for economic growth (Besley, 1995). Property rights and tenure se-

¹See, for example, research documenting various economic, development, and health benefits from improvements in residential water access, including Cutler and Miller (2005), Kremer et al. (2011), Devoto et al. (2014), and Meeks (2015).

²For example, an analysis of household survey data from fifteen developing countries, showed that access to water services is positively and significantly correlated with households income (Komives et al., 2003).

curity improvements can come in various forms, such as land titling programs (Field and Field, 2006), land reform legislation (Besley and Burgess, 2000), and limited and full transfer of property rights (Banerjee et al., 2002). Studies have shown that improved property rights can have numerous economic benefits for households, such as increases in access to credit (Field and Torero, 2004), household investments (Field, 2005; Galiani and Schargrodsky, 2010; Fenske, 2011), agricultural investment (Goldstein and Udry, 2008), access to paid work (Field, 2007), and external finance (Johnson et al., 2002). The question remains: what is the impact of property rights on water access? More broadly, does land tenure security lead to improvements in other services, such as connections to sanitation systems and the electrical grid?³ If land tenure leads to improvements in services, what are the channels through which it occurs: investment by individual households or governments and utilities?

To answer these questions, we study a natural experiment in rural Peru, through which land titles were provided to households previously lacking such land security. Historically, impediments to gaining land tenure included expensive fees, long registration periods, and other bureaucratic hurdles. As a result, only the wealthiest households held title to their land. Starting in 1994, a nationwide titling program provided households in rural Peru with improved property rights, through the Special Rural Cadastre and Land Titling Project (PETT). PETT removed historical impediments to land tenure, making land titles available for the rural population. Due to the administration needs of the project, PETT implementation was phased in over time and, at the time of our survey, had not reached all villages. Utilizing the phased-in program timing in a quasi-experimental design, we exploit the differences in implementation timing across

³Just as water access is key for development, evidence shows that sanitation (Watson, 2006; Spears and Lamba, 2016) and electrification (Dinkelman, 2011; Lipscomb et al, 2013; Rud, 2012; van de Walle et al., 2013) also have substantial impacts on economic development and health.

space in conjunction with the differences in program impact across households that held property titles prior to the project and those that did not.⁴

A simple cross-sectional analysis comparing those households with and without titles could be biased by unobservable factors correlated with both status of households' property rights and water access. To overcome this identification challenge and investigate the relationship between land tenure and water access, we exploit the differences in timing of PETT program implementation across space. Specifically, we use the variation between villages in which PETT was ("program" villages) and was not implemented ("non-program villages") at the time of our survey, in conjunction with the variation between households that had another form of title ("prior title") and those without ("no prior title") titles prior to the PETT project. We refer to this method as a modified difference-in-differences approach. The intuition underlying this identification approach is that households without prior titles would most benefit from the PETT program introduction. In contrast, households with property titles prior to the PETT program should benefit relatively little, if at all, from the project implementation in their region. We provide support for this assumption by comparing household risk of expropriation by title status.

Theories proposed for the mechanisms through which land titles might affect households' investments in agricultural land or housing infrastructure are several fold.⁵ First, land title provision reduces the risk of expropriation and therefore encourages longer-term immobile investments. Second, it increases a household's collateral and therefore their access to credit. Third, it enables the renting and selling of land and thus in-

⁴Important to note, we include region fixed effects to ensure identification occurs off of differences in timing within a region, thereby addressing differential timing of program roll-out to the coast, highlands, and jungle regions.

⁵Besley (1995) discusses these three such theories in great detail.

creases their gains from trade. In contrast, utilities or governments might hesitate to invest due to other legal entitlements that infrastructure may provide, concerns regarding billing logistics in informal settlements, or an infrastructure quality trap caused by a combination of government subsidies for services and low willingness-to-pay in some informal settlements (McRae, 2015). We depict the channels through which land titles might impact water access in Figure 1.

Water is unique in several respects and incentives to invest might differ from those mentioned above. Water is necessary for human life and there are substantial positive externalities from water service provision. Yet, infrastructure construction is associated with high fixed costs. Therefore, it is not obvious *ex ante* whether investments in water infrastructure would occur post land tenure reform similar to other investments. As such, this study contributes to the literature on property rights and investments by testing whether removing barriers to land titles leads to improvements in water sources and other services.

From these analyses, we find that land title provision is associated with significant, albeit small in magnitude, improvements in household water access. We find larger magnitude increases in sanitation and electrical grid connections. Evidence indicates that improvements in all 3 services came at the time of recent public connections in water, sanitation, and electricity, respectively. This indicates that improved services are to some extent related to investments either by the government or utility. We find evidence of program impacts on household investments only in sanitation. Taken together, these results support the hypothesis that land titling alleviated impediments to government and/or utility investments and, at least in the case of sanitation, those investments may be complemented by household investments as well.

The remainder of the paper proceeds as follows: Section 2 provides an overview on the theoretical relationship between property rights and property investments, a background on the general relationship between property rights and water access, and a discussion of the unique characteristics of water that set it apart from typical household investments. Section 3 addresses related legal changes in Peru, including the PETT program and changes related to water provision around this time. Section 4 describes the PETT survey, the main dataset, and some initial tests of differential access to services by household title status. Section 5 describes the marginal effects analysis as well as the main empirical approach, which is the modified difference-in-differences analysis. Section 6 provides results and Section 7 concludes.

2 Property Rights and Investments

2.1 Potential Links and Impediments to Investment

In developing countries, informal settlements (clusters of households without land title) typically face challenges in attaining basic services, including water, sanitation and electricity provision. If the impediments to government, utility, or household investment in water infrastructure are indeed the cause of poor service provision, then programs providing improved property rights and land tenure could lead to an increase in formal water service provision. Such increases in services could impact households through several channels, such as lower volumetric rates charged for services, closer proximity to communal or shared services, and less time spent collecting water or energy sources.

The three main channels through which improved access to infrastructure in informal settlements potentially occurs, includes investments by: (1) the government; (2) util-

ities or private companies; or (3) households, via either individual investments or the collective action of many households. Each of these channels potentially face different impediments to investment that are related to poor tenure security, as described below. Figure 1 illustrates these potential channels.

2.1.1 Impediments to government and/or utility investment

We group together our discussion of utility and government investments because in many developing country settings, the government may maintain control of the utility in one form or another. For example, water or electricity utilities may officially be corporations, but the government retains control as the majority stockholder. Such scenarios make distinguishing between government and utility incentives challenging.

Governments and utilities may lack incentives to invest in infrastructure within informal settlements for several reasons. First, in many countries, local governments are not legally required to provide water services to informal settlements. But beyond that, governments may be concerned that delivering basic services, such as water, sanitation, and electricity, could provide inhabitants with a legal claim to the land on which they reside. These legal barriers can lead to government resistance to such service provision. In addition, individuals without land titles may also lack voting rights, thereby weakening their bargaining power with local politicians. As a result, extending infrastructure to informal areas may be a low priority for politicians.

What then is preventing utilities from expanding? The large fixed costs of water infrastructure make utilities hesitant to expand their services to areas with customers perceived as riskier and less reliable; households in informal settlements. Such households are considered less likely to pay their water bills or more likely to relocate without

notice. Related, the provision of government subsidies for goods such as electricity have been shown to create an "infrastructure quality trap" in which the utilities have little incentive to improve service quality and households have low willingness to pay for services. This can lead to a persistence of low quality services (McRae, 2015).

Utilities must develop methods of coping with non-payment, such as disconnecting non-payers from water supply systems. However, informal settlements bring additional challenges: the party responsible for payment may be unclear when several families or an extended family live in close proximity, a lack of official property boundaries or maps demarcating plots can make laying pipelines difficult, and lack of official address systems or house locations records can make collection difficult.

2.1.2 Impediments to household investment

Poor households often face constraints in connecting to that system. To connect to the water infrastructure typically requires households to make upfront fixed costs. In many developing countries, water utilities may require an initial payment for the tap, a water meter, and the pipeline extension from the main system to the individual household. Households lacking property rights and with weak land tenure might not invest in water infrastructure for two main reasons. Such costs may be difficult to cover for households without access to credit. In addition, a risk of expropriation may also deter households from investing in the fixed cost of infrastructure. Each of these could play a role in improving access to water infrastructure.

Property rights insecurity (and the risk of expropriation) can act as a random tax on a population (Besley, 1995). The presence of strong property rights, and land rights in particular, provide individuals with the incentive to use their land efficiently and to

invest in land improvements (Feder et al., 1988). By decreasing the risk of expropriation, titled households may have a greater willingness to invest in water infrastructure, whether it be through a connection to communal water infrastructure or individual household water storage or rainwater harvesting tanks.

If the individual's land is easier to collateralize, that will cause the bank to charge a lower interest rate and, as a result, individuals will invest more in their land (Besley, 1995). Land titles provide lenders with security to lend to individuals with whom they are less knowledgeable, thereby increasing the circle of people to which they will lend and possibly the number of people to whom they will lend.⁶ Feder formalizes these arguments in his model, by assuming that credit available to a farmer is “positively related to the value of their landholdings (as it would typically be when land is a collateral for loans) and negatively related to their probability of land loss” (Feder et al., 1988). In many developing countries, residents must purchase the tap, meter, and pipes to connect to the municipal water supply systems. Households may find the upfront fixed cost of connecting to be prohibitive. If newly titled households can access credit, they might use it to connect to the water supply system.

Better property rights may be modeled as decreasing the cost of the exchange when land is bought or rented. Trading costs are based on the owner's ability to transfer the property rights; strong property rights translate into lower costs of trade, whereas a lack of property transfer rights is similar to infinite costs of trade. A marginal improvement in the strength of property rights (and the ability to transfer those rights) leads to a decrease in the cost of property transfer, thereby increasing the potential for the land

⁶More recently, several papers have highlighted scenarios in which credit access did not increase with land tenure security. For examples, see Boucher et al. (2005), Markussen (2008), Galiani and Schargrodsky (2010), and Deininger and Goyal (2012).

to be bought or rented (Besley, 19995). Adding a water connection or building water infrastructure at a home would arguably increase the value of the household, thereby increasing the potential gains from trade.

2.2 Unique Aspects of Water Infrastructure

To investigate whether households differ with respect to investments in connections to water services, we compare the dates on which the household received title with the year in which the water supply connection was made. If the connections tend to occur after or around the time that a household received title, then this reinforces the argument that reducing the risk of expropriation will lead a household to increase its investment in the land and household infrastructure.

Existing research has empirically tested the links between property rights and investment in land and housing in numerous contexts, including the Brazilian frontier (Alston et al., 1996), farms in Thailand (Feder et al., 1988), regions in Ghana (Besley, 1995), and urban slums of Peru (Field, 2005; Field and Torero, 2004). The results of the empirical studies in this literature have been mixed.⁷ A few features of water provision and the associated infrastructure differentiate it from these other property improvements previously researched, possibly complicating this relationship.

First, water can be considered to be a pure public good, a private good, or even a common good. In places where water is only available through purchase from profit-seekers, such as water vendors or water companies, then water is a private good and households unable to pay will be excluded from access. When water remains in lakes

⁷Although the articles mentioned here find some effect of improved land tenure on investment in land and/or property, there are also numerous publications presenting evidence of titles having no effect on investments. Field (2005) provides a list of such research.

and rivers for recreational enjoyment and consumption by all who choose, then it is a public good. When access to water is rivalrous but non-excludable, then it is considered to be a common good. The public goods aspect of water clearly distinguishes it from other commodities (Hanemann, 2005).

Second, humans need water to survive. This has led to much debate on whether basic access to water should be considered a fundamental human right, which would require governments or other parties to provide a minimum amount of the resource to people when they are lacking access (Gleick, 2000). This issue ties into disagreements as to how applicable economic concepts are to water. According to the fourth principle of the Dublin Statement, created in 1992 at the United Nations Conference on Environment and Development (UNCED), “Water has an economic value in all its competing uses and should be recognized as an economic good.” However, others in opposition perceive water to be beyond economic analysis, as it is required by all species and is, thus, sacred (Barlow and Clarke, 2002; Shiva, 2002).

When water provision is a service of the municipalities, views of water as a fundamental human right make excluding non-payers from access politically infeasible. Hanemann (2005) notes that the “special significance” of water exists in both developing and developed countries, making it politically challenging for publicly owned water utilities to raise rates even the slightest bit. Certain situations, particularly those in which exclusion is infeasible, can lead to a free-rider problem. Free riding, which occurs when some of the users do not pay although they use the water provision services, tends to cause a commodity to be under-supplied (Hanemann, 2005).

The large fixed costs associated with water supply provision also make it unique from

other commodities. Water is expensive to transport, requiring extensive networks of pipes and other infrastructure to be constructed prior to water provision. In addition, there are economies of scale for water provision. The large fixed costs associated with water infrastructure lend themselves to a natural monopoly and thus a sole water provider for a given location (Galiani, Gertler, and Schargrotsky, 2005). Or, as noted by Hanemann (2005), these aspects of water supply lend themselves to public provision (by a collective or by a monopoly seller) rather than individual, self-provision. Household self-provision, such as is provided through wells, rainwater harvesting, and other small-scale methods, is often prohibited by high costs (Galiani, Gertler, and Schargrotsky, 2005).

Finally, there are positive externalities associated with the provision of safe drinking water and treatment, as it decreases the spread of contagious water-related diseases and the spread of water pollution.⁸ Such positive externalities increase the incentives for municipalities to ensure safe drinking water provision and invest in water infrastructure. For all of these reasons water infrastructure investments might not best be made by individuals, but instead by municipalities or utilities. As a result, we may see no significant household water infrastructure investments associated with property titles.

Other reasons also exist as to why we might not see evidence of individual household investments in water infrastructure following titling. First, people might expect the government or utility to provide such services and that acquiring title makes them more entitled to formal water provision. Thus, titled households might be less willing to invest their own time and resources into infrastructure construction. Second, certain beliefs about water (including water as a human right and religious concepts of water)

⁸Evidence on this is provided in Galiani, Gertler, and Schargrotsky (2005) and Watson (2006).

might make people less willing to pay for water themselves. Finally, water infrastructure takes time to construct and thus the time period for which our data covers might not provide enough time after titling to see investments to occur.

There are reasons to believe that titling might lead to improvements in water access even if households are not investing themselves. The utility may be more willing to serve households that are now perceived as less risky, as they are less likely to abruptly move and are easier to bill with legal titles to their land. It is also possible that the titled households better able to negotiate for coverage by the utility, as they are more likely to cover the utility's marginal cost of serving them.

3 Legal Changes in Peru

3.1 Special Rural Cadastre and Land Titling Project (PETT)

In the second half of the twentieth century, land ownership laws in Peru underwent a series of changes that contributed to the scarcity of property titles in the early 1990s. During the 1960s, a redistribution of land to peasants in the form of agricultural cooperatives occurred. This land, received through the nationwide Agrarian Reform, was prohibited from sale due to legislation changed in the 1970s. This was altered through Legislative Decree 02, which allowed for the dissolution of cooperatives and the division of land amongst cooperative members, however, this typically occurred without the receipt of property titles. In the early 1990s legislation was passed to legalize the sale of land, but property titles were still relatively rare (Torero and Field, 2005).

In 1991, the Peruvian government passed Legislative Decree 25902, which led to the onset of the Special Rural Cadastre and Land Titling Project (PETT). Initially this

project was designed to assist a subset of the country's population;⁹ however, the titling process was extended to include all rural estates in 1996 (Torero and Field, 2005). The goal of PETT was to reduce the cost and duration of registration procedures required to acquire land title and increase the proportion of titled rural estates. For this to occur, PETT focused on surveying rural parcels of land and registering new property titles (Field and Field, 2006).

The project was phased in through the following process. Beginning in 1993, PETT initially focused on the country's coastal region, before extending into the highlands and finally into the jungle in 2000 (Field and Field, 2006). By 2000, 1.9 million parcels of rural land had been surveyed and 900,000 new property titles had been registered (Torero and Field, 2005). Since receipt of land title prior to PETT required time-consuming and costly registration, holding title prior to PETT is highly endogenous to other household characteristics that also might determine access to water sources. The aim of PETT was to increase property titles for all rural estates, therefore we have no reason to believe that acquisition of title via PETT is endogenous to specific household characteristics correlated with water access. However, the timing of PETT's introduction at a village-level might be endogenous. The concerns posed by this source of endogeneity are discussed in greater detail below.

3.2 Water Infrastructure in Peru

Over the past few decades, Peruvian water legislation underwent numerous alterations and attempted changes, including a transfer of water administration and distribution to user groups in the 1980s. Between 1991 and 1996, several attempts at privatizing water

⁹This includes groups such as the recipients of the Agrarian Reform, owners of uncultivated land, and campesino and native communities.

services were made (Zegarra, 2004); however, numerous groups mobilized in opposition to privatization (Isarra and Donner, 2004) and ultimately these privatization attempts were defeated (Zegarra, 2004). As of the end of our study period in 2004, many of the country's water supply systems remained publicly managed.¹⁰ As a result, we need not be concerned of any water policy changes that might simultaneously impact water infrastructure and affect our estimations.

3.3 The Impact of Land Titles on Water and Other Services

In light of both the land titling program and water infrastructure changes in Peru during the study period, our research questions are as follows:

Is land titling via PETT associated with differences in access to water? To answer this question, we investigate a subset of questions including: Is there a difference in overall access to water due to titling differences? Are there changes in the provision of other services, such as sanitation and electricity?

Through which pathways might differences in water access occur? Land titling could lead to greater investment in water infrastructure, by the government, water utilities, or individual households. We look for evidence as to whether infrastructure improvements occurred via individual households or municipality/utility investments.¹¹ We investigate the following questions: Is there a difference as to whether households invest in a water connection? Is there a difference in the amount that households invest in the

¹⁰In 2004, the Inter American Development Bank (IADB) arranged a \$60 million multiyear loan for the Peruvian Government to reform priority regions of the country, primarily via privatization reforms (Isarra and Donner, 2004). This change, however, is outside our study period.

¹¹Changes in certain types of water infrastructure, such as communal outside taps, might signify investments by the municipality and/or utility, whereas other investments, such as indoor taps, would most likely indicate a private household investment.

water infrastructure?¹²

If a utility invested in new water pipelines or wells, one might expect the households' monthly cost of water to decrease. We use responses to the following questions as evidence as to whether utilities and/or municipalities make investments. Is there a difference in whether or not a household makes monthly water payments that is associated with title provision? Is there a difference in how much a household spends in monthly water payments that is associated with title provision?

4 Data and Summary Statistics

4.1 PETT Survey

The data used for this study were collected through the 2004 Land Titling Special Project Survey, a rural household survey implemented throughout Peru in the spring and summer of 2004. The coastal, highlands, and jungle regions are all represented in the survey sample, as the sample was stratified by the three regions (Field and Field, 2006).¹³ At the time of the 2004 survey, PETT had been implemented in all three regions of the country. The survey was developed specifically to be representative of areas in which PETT was implemented and those in which it was not, in order to use the non-program areas as a control group.

¹²Results could indicate greater individual household investments, which would be in line with the theory that titling leads to investments in property. It would not, however, identify whether investment occurred due to reduced risk of expropriation or increased access to credit. Without records of land sales transactions or property value estimates, we cannot test for evidence of the gains-from-trade theory here.

¹³The map from Torero and Field (2005) depicting the locations of the PETT program and survey is included in Appendix Figure 2. The sample is distributed in the following way: sample with the following geographical distribution: 50.62% in Rural Highlands, 33.1% in Rural Jungle, and 16.3% in the Rural Coast.

The survey sample includes 3,204 rural households. Data include household demographics, basic house characteristics, such as type of house and access to electrical, water, and sanitation services, household assets and investments, participation in social programs, family health, household expenses and income, household titles, and estate security. Data on water access and costs in the survey include: (1) the method by which water is supplied to the home; (2) the cost of a household's monthly payment for water consumption, for the particular month; and (3) whether or not the household purchased a connection to the rural water supply system, the cost of such a connection, and whether the purchase occurred before or after the PETT titles was acquired.

4.2 Summary Statistics

Summary statistics are calculated for all households in the sample and are shown in Table 1.¹⁴ The average household size is 4.6 people with approximately one member of the household working. Households are highly literate, with eighty-seven percent of household heads able to read and write. The household heads, approximately ten percent of which are female, are on average fifty-two years old and have just under 6 years of education. Approximately one-third of households report that they are saving money. There is substantial heterogeneity in access to basic services: fifty-two percent of sampled households use electricity for lighting, forty-eight percent have access to tap water (either indoor or outdoor tap) and an even smaller proportion (forty percent) have access to sanitation.

According to the survey data, approximately twenty percent of households in the sample have a PETT title, whereas thirty-four percent of households in the sample have some

¹⁴These are not baseline summary statistics in a traditional sense, in that they are not calculated using data prior to the PETT program onset.

sort of title other than the PETT title. In total, nearly half of the surveyed population has some form of title to their land.

4.3 Explanatory Variables by Tenure Status

Table 2 Panel A shows means of explanatory variables by title status, as well as the differences between PETT-titled households and those with either no title or those with other property titles. Households with titles prior to PETT program implementation ought to differ substantially from those without, as the previous process to obtain title was costly, difficult, and time consuming. PETT, however, was designed to make land titles available to all rural households and, therefore differences between PETT titled households and households with no title (no PETT or other title) are unclear ex ante.

With respect to many characteristics, these groups look very similar, including household size, literacy level of the household head, household propensity to save, and the monthly amount received from social programs. We do, however, see some important statistically significant differences, such as in household land area, the number of workers per household, the household head gender,¹⁵ and the household head's monthly income.

Household ownership is very similar for PETT versus non-PETT titled households, in that between 63 and 66 percent of these households reporting owning their homes. In contrast, only 21 percent of untitled households report owning their home. To better understand this relationship between land title and home ownership, we compare responses to questions regarding risk of expropriation in Panel B.

¹⁵A growing body of literature indicates the importance of gender interacting with property rights. For examples, see Allendorf (2007), Wiig (2013), Ali, Deininger and Goldstein (2014), and Menon et al., (2014). For this reason, we will control for female headed households in all regressions.

In response to both questions regarding the perceived risk of expropriation by either the government or by another person, those households with non-PETT titles are the most certain (94 and 96 percent), then the PETT-titled households (85 and 88 percent), and then followed by those with no titles (74 and 77 percent). That the other titled households report more certainty than the PETT titled households suggests that perhaps the sense of security provided by land title grows with time. In addition, that they already felt so secure in their right to their house underscores the point that households with other titles had no incentive to seek a PETT title. These results help us understand the incentives to participate in the PETT titling program and provides support for our difference-in-differences empirical design that we will later introduce.

In response to the question as to how certain they are that their house will be inherited by their children, PETT titled households report the greatest certainty (97 percent) followed by the other titled households (88 percent) and the untitled households (76 percent). Additionally (results not shown), of households with some property title, either PETT or other, fifty-eight percent believe that having the title has increased the security level of their house and seventy-four percent of respondents believe that the title increases the probability of protection in the court system.

Interestingly, tenure security is not perceived to impact neighborhood safety; only six percent of respondents believe that acquiring title has reduced the level of robberies (results not shown). Most of these households also do not believe that acquiring title has increased their access to public services or police protection. Of households with property titles, one in five believe that acquiring title increased the taxes that they pay.

In summary, on all three of these types of measures of home security (home ownership, risk or expropriation of house, and certainty of house inheritance), the untitled households look significantly worse than titled households (PETT titles or other titles). Together, these differences with respect to the risk of expropriation and inheritance suggest that land title plays an important role in the security one feels regarding their home. These differences by title status could occur with any of the theoretical channels (reduced risk of expropriation, increased collateral and access to credit, and increased gains from trade) proposed in the economics literature.

4.4 Water Sources, Sanitation and Electricity Services by Tenure Status

Given the differences in home ownership and security shown in the previous table, we look to see if and how water is supplied to households and access to other public services differ by land tenure. Using the responses to the survey question regarding the household's water source, we create binary indicators for different levels of water access. First, we create binary variables for each of the main types of water sources: (1) indoor tap; (2) outdoor tap; (3) sink, (4) well; (5) river; (6) vendor; (7) other. In addition, we created a combined indicator variable to indicate access to an "improved source" as defined by the development community's standard for water projects. According the 2006 Human Development Report, "improved" access is defined based on three dimensions: water quality, proximity, and quantity.¹⁶ The definition of "improved" includes in-house connections, shared standpipes, pumps, and protected springs and wells; water provided by vendors, tanker trucks, streams, or unprotected wells and spring is not.

¹⁶The threshold for acceptable water source proximity is less than one kilometer and that for acceptable quantity is at least 20 liters per day.

Table 3 Panel A shows basic indicators of water supply. We can see that untitled households are significantly less likely to have water supplied by a tap outside the house, and an improved water source more broadly, than the PETT titled households. These untitled households are also more than twice as likely to use river water (19 percent for untitled households versus 8 percent for the PETT program households) as the households main water supply. Overall this indicates a pattern of untitled household having worse sources of their water supplies than titled households. These results suggest that there is a relationship between land titles and access to water sources, thus motivating this research as to whether acquiring land title leads to improved household water access.

Panel B of Table 4 shows differences in access to several key services that are considered essential for basic living standards, by the households' title status (PETT title, other title, and no title). Beyond improved water sources for household supplies, we also look for differences as to whether the household reports a public sanitation connection or septic system, as well as whether the household reports using electricity as its primary lighting source. Interestingly, untitled households have lower access to each of these services. As Panel B shows, untitled households are not just less likely to have access to improved water sources (77 percent in comparison to the 88 percent of PETT titled households), but they are also significantly less likely to have access to toilet/sanitation (36 percent compared to 40 percent) and to electricity (46 percent compared to 58 percent). In contrast, the PETT and the other titled households look quite similar both in terms of access to improved water sources and electricity. However, the other titled households are significantly more likely have access to a toilet or sanitation than the households titled via the PETT program (47 percent versus 40 percent).

For ease of understanding in the tables that follow, we will not show the dis-aggregated improved water sources. Instead we will show results on the aggregate group of improved water sources and the individual unimproved water sources (tanker truck/water vendor and the river water), as well as sanitation and electricity services.

5 Empirical Analysis: Land Titles and Services

Conditional on prior title status, the PETT program provides quasi-exogenous variation in the probability of land title acquisition, given that it targeted all rural landholders, regardless of wealth, education, and other such household characteristics.

5.1 Marginal Effects

We investigate the marginal effect of receiving land titles via the PETT program. These results, shown in Table 4, are consistent with the patterns seen in Table 3. Both PETT and other titled households are between 7 to 8 percentage points more likely to have an improved water source and between 8 and 10 percentage points more likely to have electricity. However, like the results in Table 3, only the other titled households see this significant jump in access to sanitation (and increase of 12 percentage points in comparison to a mean of 36 percent amongst the untitled households).

These marginal effects results are suggestive of an important relationship between land titles and access to basic services; however, they are not causal. Indeed, there might be that important variables are omitted from these marginal effects, introducing bias to these calculations. For example, results in Table 2 show that PETT titled households are more likely to have household heads that are older and female than other titled and untitled households. We might be concerned that some of the crucial differences be-

tween the PETT titled households and the untitled households are not being captured by the regression controls. To address these concerns, we next implement our modified difference-in-differences approach.

Comparing access to water sources across titled and non-titled households suffers from an endogeneity problem: the households invested the time and resources to get a title are likely different from those that do not and in ways that are related to the demand for improved water access.¹⁷

5.2 Modified Difference-in-differences

To determine if there is an effect of the PETT titling program on improved water access, we use a modified difference-in-differences (DD) approach. This modified DD, utilizes the phased-in program timing across space in conjunction with differences in program impact across household property title status prior to program arrival in a given location. Comparing differential impacts across regions in which a policy is implemented with regions in which it is not yet is akin to the methods used in Morduch (1998) and Field (2005).¹⁸ We exploit the differences in the variation between villages that the PETT program had reached (“program villages”) and those it had not yet reached (“non-program villages”) at the time of survey implementation, in addition to the variation between the households that had no titles prior to PETT (“no prior title”) and those that did (“prior title”).¹⁹ As the project was implemented earlier within the

¹⁷For example, titled households might be wealthier or better at navigating bureaucracy, and thus better at contacting the municipality to obtain access to improved water.

¹⁸Morduch (1998) assesses the impact of micro-credit provided by the Grameen Bank. To investigate the effect of land titles on investment in urban slums in Peru, Field (2005) used a similar modified DD approach in which a control group comprised of future program beneficiaries residing in neighborhoods not yet reached by the program.

¹⁹We assume that households with “other title” already had that in possession prior to the PETT program arrival. Given that the PETT program lowered the cost of titling, households should not have the incentive to seek other titles once they have opportunity for a PETT title.

coastal region than the other two regions, some program impacts may differ based on location. To control for this, we include regions fixed effects.

To measure the impacts of the PETT titling program on water access using this modified difference-in-differences approach, we follow estimate the following equation:

$$q_{iv} = \tau Program_v * NoPrior_{iv} + \beta Program_v + \delta NoPrior_{iv} + \alpha X_{iv} + \gamma_r + \epsilon_{iv} \quad (1)$$

where q_{iv} is the water source of household i in village v , $Program$ is an indicator equal to 1 if the PETT program had reached village v at the time of the survey, $NoPrior_{iv}$ is an indicator of whether household i in village v had title prior to the onset of the PETT program, X_{iv} is a vector of household-level control variables, and γ_r are region fixed effects. The coefficient on our interaction term $Program * NoPrior_{iv}$ is our estimated treatment effect.

A standard difference-in-differences approach would require that the trends in water access amongst “program” households are parallel to the trends in water access amongst the “non-program” group prior over time. Our modified difference-in-differences method requires a slightly altered parallel trends assumption: the households titled prior to PETT and those not titled prior to PETT need not be the same; they just must not systematically differ across early and late program villages. With only cross-sectional data, we are unable to test the parallel trends assumption using pre-intervention periods. If the relationship between the titling program and water access is confounded by wealth variables, the difference-in-differences estimate would be biased.²⁰

²⁰For example, if richer villages, which would be more likely to have better water access regardless of titles, were more likely to be program villages, then the difference-in-differences estimate would likely overstate the impact of the titling program on water access and the bias would be positive. Conversely, if poorer villages, which would be likely to have worse access to water services, were more likely to be

The modified DD is our preferred method of identifying the impacts of the PETT titling program; however, those estimates may still be potentially biased.

5.3 Difference-in-differences with Propensity Score Matching

Propensity score matching methods have been used in several studies investigating the impact of water access on child health (Jalan and Ravallion, 2003; Galdo and Briceno, 2005), an area of research in which randomizing access to treatment is often difficult due to cost constraints, political feasibility, and implementation issues. Similarly, randomizing implementation of the PETT program would have been politically infeasible. Here, the propensity score is the probability of being assigned to the PETT program, conditional on a vector of observed variables. The benefits of using propensity score matching is that modifying for the propensity score balances the distribution of the observed covariates between the treatment and control groups, based on their predicted probability of participation, and removes bias due to the unobserved covariates (Rosenbaum and Rubin, 1983).

We follow Khandhker et al (2010) and use propensity score matching in conjunction with difference-in-differences to get a secondary estimate of the PETT program’s impacts on water access. To do so, we estimate the propensity score, which is the probability of participating in the PETT program, based on the selected covariates. The distributions of propensity scores for PETT and non-PETT program households are almost entirely overlapping, as shown in Appendix Figure 1. We can drop the observations that are outside of the area of common support in these distributions and run the same modified DD as previously, but only with the remaining sample. Intended to serve as

program villages, then the difference-in-differences estimate would be downward biased and would be likely to understate the effect of the program.

an additional check on the results from the preferred method described in the section above, we are assured that the results using this method remain quantitatively and qualitatively unchanged. For this reason, we do not include separate results tables for the DD with propensity score matching.

6 Results and Analysis

6.1 Land Titling and Differences in Services

Table 5 displays the results from our difference-in-differences regressions estimating the impact of the PETT program on access to water and other services. As with the marginal effects, the modified difference-in-differences results indicate that significant increases in the use of improved water sources and a decreases in river water use as household sources come with the PETT program. These estimates are close in magnitude, albeit somewhat smaller, than the estimates from the marginal effects calculations.

Although there are significant improvements in access to particular types of water sources, the improvements measured by the modified difference-in-differences method are small. It possible, however, that estimates of the relationship between PETT land titles and water access are small due to the amount of time between the PETT project implementation and the survey, which is relatively short in comparison to the time it takes to plan and construct water infrastructure. Therefore, the magnitude of this relationship could potentially be larger after more time has passed after the titling program.

Improved access to water sources was a designated outcome measures to meet goal seven of the Millennium Development Goals (MDGs). Land tenure insecurity has been perceived as a constraint to household access to improved water sources. We find land

titling is associated with overall improvements in access to water that the MDGs seek, suggesting that land titling could provide a possible route towards improving water access.

Likewise, we see improvements in the sanitation and electricity services, as well. The modified difference-in-differences approach estimates the PETT titling program's impacts on use of electricity as the households' main lighting source to be very similar to the marginal effects shown in Table 4. The difference-in-differences results for household sanitation connection and septic systems, however, are substantially greater than the previously estimated marginal effects. The modified difference-in-differences estimate indicates that the PETT titling program resulted in a 15 percentage point increase in these types of sanitation. Given only 36 percent of untitled households have these sanitation connections (as shown in Table 4 means of the omitted group), the 15 percentage point increase is not only statistically significant but also practically and technologically meaningful.

Overall, these results indicate that the PETT titling program led to a significant increase in all three of the public services investigated: household water sources, sanitation and septic connections, and use of electricity for lighting. Water, the service that initially compelled us to undertake this study, saw the smallest increase from the program; however, this is likely tied to the relatively high rates of improved water access even amongst the untitled households (77 percent). Given the increase in all three services, we next seek to understand the channels through which these improvements occurred.

6.2 Channels: Titles, Infrastructure Connections, and Investments

We have shown evidence that the PETT program leads to improvements in certain services, which begs the question as to how these improvements occur: via utility or household investment. To better understand this, we employ our modified DD method to assess the impact of the PETT program on either utility investments or household investments in public services. Table 6 shows the results of this analysis, with the interaction of program and no prior title again being our measure of program impact.

First, we consider evidence of either utility investment in infrastructure. Column 1 shows the impact of the program on household connections to the public water network (Panel A), public sanitation network (Panel B), and the electrical grid (Panel C). These outcomes are binary outcomes equal to one if the household realized a [water, sanitation, electrical] connection within the five years prior to the survey. We consider these variables to be proxies for utility investment. We find significant impacts on access to public water and sanitation networks, as well as the electrical grid.

We seek evidence of either improved credit access or decreased risk of expropriation by investigating whether title acquisition impacts the method of payment used (such as, formal or informal credit or own household finances) for investments in water infrastructure. To test for any differences in access to credit, we look to survey responses regarding financing for household connections to the public water supply. Respondents may reply to any of six types of financing: (1) banking credit, (2) another type of formal credit, (3) informal credit, (4) loan from family or friend, (5) own resources, (6) in exchange for a debt or service.

We do test for impacts of PETT title on whether a household uses their own finances to pay for connections to public water supply systems. If we were to see a positive change in the use of own resources for water infrastructure improvements associated with PETT titles, this would provide evidence in support for the risk of expropriation hypothesis. It would signify that households indeed had the ability to make the investments in water infrastructure but do not do so until they have greater property security, as provided by the PETT title.

Next, we look for evidence of household investments as well, including the amount the household invested in such a connection (Column 2), if the household used its own financial resources for such a connection (Column 3), or if the household used either formal or informal credit for such a connection (Column 4). For both the public water network (Panel A) and the electrical grid (Panel C), we see no evidence of significant household investments in these connections. In contrast, we see some indication that households invest more in public sanitation connections (positive, but not significant in Column 2 of Panel B) and that households are more likely to have used their own financial resources to make this investment (Column 3 of Panel B). This means that the households are not using credit to make sanitation connections, but are using their own out-of-pocket funds.

Although we have evidence that water access is improving and that it is occurring as a result of government or utility investment, such improvements may translate into a slightly greater proportion of households having to pay for their water and a larger payment per month. The most likely explanation for this result is that whatever the prior and current water sources, they probably both incur a fee and the newer one is

just slightly more expensive. This is the likely result if people are transferring away from rivers, from which people tend to collect water for free, as one of their primary water sources to a more formal water source, for which they have to pay for their water. If this is the case, then it would be quite plausible that we would see an increase in the proportion of households making monthly water payments associated with PETT titles. We test whether the PETT program impacts monthly payment amounts for services and find no evidence of any differences (results not shown).

6.3 Robustness Checks

6.3.1 Timing of service improvements relative to PETT program implementation

To investigate whether households differ with respect to investments in connections to water services, we compare the dates on which the household received title with the year in which the water supply connection was made. If the connections tend to occur after or around the time that a household received title, then this reinforces the argument that reducing the risk of expropriation will lead a household to increase its investment in the land and household infrastructure. Indeed, our assessment of dates shows that of all the households reporting the year in which their households received water access, only 3 of them had dates that were prior to PETT. This gives us confidence that our interpretation of the results is accurate.

6.3.2 Households' reports on services still required

Finally, we check whether respondents views on the remaining necessary community services are in line with the finding above. The PETT survey asked respondent to report which services their community needed to get in the future. We employ our

DD again here, with results displayed in Table 7. We find the program had no impact on respondents perceived need for: police stations, clean parks, clean public areas, or public phones. The only significant impact we find is on the perceived need for public water, sanitation, and electricity networks, with program households significantly less likely to report a need for these services (Column 5). We interpret this to be because the program households connected to the public services with the onset of the program, they do not perceive an additional need for those services to be extended in the future. The magnitude of this result shrinks when we control for the individual households connections to these services (Column 6), but the intuition remains. We find these results particularly convincing support given that, as described in Section 4.3, tenure security was not perceived to impact neighborhood safety and most households did not believe that acquiring title had increased their access to police protection.

7 Conclusions

We found that the PETT titling program led to significant increases in household access to certain services. Specifically, program households are more likely to be supplied by an improved water source, have a public sanitation connection or septic system, and use electricity as its primary lighting source. In our effort to understand through which mechanisms these improvements in services occur, we seek evidence of either utility investments or household investments. There is strong evidence of utility investments in all three services: water and sanitation networks and the electrical grid. However, there is only evidence of household investments in the case of connections to the sanitation networks. Notably, sanitation is the service in which we see the largest increase in connections, potentially highlighting the potential of utility and household investments to complement one another.

The relationship found here between land title and water access could also be due to a shift in the households' attitudes towards access to services, particularly water. Newly titled households might expect public investment in water infrastructure and formal water service provision now that they have proper legal title to their land. This relates to our discussions as to how investments in water infrastructure differ from other results that find an effect of land titles on individual household investments in land and housing. Conversely, the positive relationship between PETT land titles and water access is consistent with the hypothesis that newly-titled populations gain increased negotiating powers, particularly with respect to demands for water services.

Together these results indicate that land titling programs, such as PETT, can alleviate constraints to utility and/or government investments in public services. It appears as though these investments are an important channel through which land titles increase access to public services; however, household investments may also be needed to make substantial increases in access to some services.

References

- [1] Alchian, A. and H. Demsetz. 1973. "The Property Right Paradigm." *The Journal of Economic History*, 33(1).
- [2] Ali, D., K. Deininger, and M. Goldstein. 2014. "Environmental and Gender Impacts of Land Tenure Regularization in Africa: Pilot Evidence from Rwanda." *Journal of Development Economics*, 110(2014): 262-275.
- [3] Allendorf, K.. 2007. "Do Women's Land Rights Promote Empowerment and Child Health in Nepal." *World Development*, 35(11).

- [4] Alston, L., G.D. Libecap, and R. Schneider. 1996. "The Determinants and Impact of Property Rights: Land Titles on the Brazilian Frontier." *Journal of Law, Economics, and Organization*, 12(1).
- [5] Barlow, M. and T. Clarke. 2002. Blue Gold: The fight to stop corporate theft of the world's water. The New Press.
- [6] Banerjee, A., P. Gertler and M. Ghatak. 2002. "Empowerment and Efficiency: Tenancy Reform in West Bengal," *Journal of Political Economy*, 110(2), 239-280.
- [7] Besley, T. 1995. "Property Rights and Investment Incentives: Theory and Evidence from Ghana." *Journal of Political Economy*, 103(5).
- [8] Besley, T. & R. Burgess. 2000. "Land Reform, Poverty Reduction, And Growth: Evidence From India," *Quarterly Journal of Economics*, 115(2), 389-430.
- [9] Field, A.J. and E. Field. 2006. "Globalization, Crop Choice and Property Rights in Rural Peru." WIDER Research Paper No. 2007/72.
- [10] Besley, T., J. Leight, R. Pande, and V. Rao. 2016. "Long-run Impacts of Land Regulation: Evidence from Tenancy Reform in India," *Journal of Development Economics*, 118(2016), 72-87.
- [11] Boucher, S., B. Barham, and M. Carter. 2005. "The Impact of "Market-Friendly Reforms on Credit and Land Markets in Hondouras and Nicaragua," *World Development*, 33(1), 107-128.
- [12] Cutler, D.M. and G. Miller, 2005. "The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States." *Demography* 42(1):1-22.
- [13] Deininger, K. and A. Goyal. 2012. "Going Digital: Credit Effects of Land Registry computerization in India," *Journal of Development Economics*, 99(2012), 236-243.

- [14] Demsetz, H. 1967. "Toward a Theory of Property Rights." *American Economic Review*, 57(2).
- [15] Dinkelman, T. 2011. "The Effects of Rural Electrification on Employment: New Evidence from South Africa." *American Economic Review*, 101(7), 3078-3108.
- [16] Do, Q.T. and L. Iyer. 2008. "Land Titling and Rural Transition in Vietnam," *Economic Development and Cultural Change*, 56(3), 531-579.
- [17] Feder, G., T. Onchan, Y. Chalamwong and C. Hongladaron. 1988. Policies and Farm Productivity in Thailand. Baltimore, M.D.: Johns Hopkins University Press.
- [18] Fenske, J. 2011. "Land Tenure and Investment Incentives: Evidence from West Africa." *Journal of Development Economics*, 95(2011), 137-156.
- [19] Field, E. 2003. "Fertility Responses to Land Titling: The Roles of Ownership Security and the Distribution of Household Assets." Working Paper.
- [20] Field, E. 2005. "Property Rights and Investment in Urban Slums." *Journal of the European Economic Association Papers and Proceedings*, April-May 2005, 3(2-3).
- [21] Field, E. 2007. "Entitled to Work: Urban Property Rights and Labor Supply in Peru." *Quarterly Journal of Economics*, 122(4).
- [22] Field, E. and M. Torero. 2004. "Do Property Titles Increase Credit Access Among the Urban Poor? Evidence from a Nationwide Titling Program." Working paper.
- [23] Galdo, V. and B. Briceno. 2005. "Evaluating the Impact on Child Mortality of a Water Supply and Sewerage Expansion in Quito: Is Water Enough?" IADB Office of Evaluation and Oversight Working Paper.

- [24] Galiani, S., P. Gertler, and E. Schargrodsky. 2005. "Water for Life: The Impact of Privatization of Water Services on Child Mortality," *Journal of Political Economy* 113(1): 83-119.
- [25] Galiani, S. and E. Schargrodsky. 2010. "Property Rights for the Poor: Effects of Land Titling," *Journal of Public Economics* 94(2010): 700-729.
- [26] Gleick, P.H. 2000. The Human Right to Water. The World Water 2000-2001: The Biennial Report on Freshwater Resources. Washington, D.C.: Island Press.
- [27] Goldstein, M. and C. Udry. 2008. "The Profits of Power: Land Rights and Agricultural Investment in Ghana." *Journal of Political Economy*, 116(6).
- [28] Hanemann, W.M. 2005. "The economic conception of water." In Water Crisis: Myth or Reality. Editors Peter P. Rogers & M. Ramón Llamas. A.A. Balkema Publishers, The Netherlands. Pgs 61 - 91.
- [29] Isarra, L. and L. Donner. 2004. "The Fight for Public Water in Peru." *Social Policy*. Winter 2004.
- [30] Johnson, S., J. McMillan, and C. Woodruff. 2002. "Property Rights and Finance." *American Economic Review*, 92(5): 13-35.
- [31] Khandker, S., G. Koolwal, and H. Samad. 2010. Handbook on Impact Evaluation: Quantitative Methods and Practices. Washington, D.C.: World Bank.
- [32] Kremer, M., J. Leino, E. Miguel, and A.P. Zwane. 2011. "Spring Cleaning: Rural Water Impacts, Valuation, and Property Rights Institutions." *Quarterly Journal of Economics*, 126(1), 145-205.

- [33] Lipscomb, M., A.M. Mobarak, and T. Barham. 2013. "Development Effects of Electrification: Evidence from the Topographic Placement of Hydropower Plants in Brazil." *American Economic Journal: Applied Economics*, 5(2), 200-231.
- [34] Meeks, R. 2015. "Water Works: The Economic Impact of Water Infrastructure." *Journal of Human Resources*, forthcoming.
- [35] Menon, N., Y. Rodgers, and H. Nguyen. 2014. "Women's Land Rights and Children's Human Capital in Vietnam." *World Development*, 54: 18-31.
- [36] McRae, S. 2015. "Infrastructure Quality and the Subsidy Trap." *American Economic Review*, 105(1), 35-66.
- [37] Rud, J.P. 2012. "Electricity Provision and Industrial Development: Evidence from India." *Journal of Development Economics*, 97(2), 352-367.
- [38] Shiva, V. 2002. Water wars: privatization, pollution, and profit. Cambridge, MA: South End Press.
- [39] Spears, D. and S. Lamba. 2016. "Effects of Early-Life Exposure to Sanitation on Childhood Cognitive Skills: Evidence from India's Total Sanitation Campaign." *Journal of Human Resources*, 51(2), 298-327.
- [40] Torero, M. and E. Field. 2005. Impact of Land Titles over Rural Households. Working Paper OVE/WP-07/August 1, 2005. Office of Evaluation and Oversight (OVE), Inter-American Development Bank, Washington, D.C.
- [41] UN Millennium Project. 2005. "Health, Dignity, and Development: What Will it Take?" Task Force on Water and Sanitation.

- [42] United Nations World Water Assessment Programme (WWAP). 2006. The United Nations World Water Development Report 2 (WWDR) 2006: *Water: A Shared Responsibility*. Paris/New York, UNESCO/Berghahn Books.
- [43] United Nations World Water Assessment Programme (WWAP). 2015. The United Nations World Water Development Report (WWDR) 2015: *Water for a Sustainable World*. Paris, UNESCO.
- [44] United Nations Development Programme. 2006. “Beyond Scarcity: Power, Poverty, and the Global Water Crisis.” 2006 Human Development Report.
- [45] Van de Walle, D., M. Ravallion, V. Mendiratta, and G. Koolwal. 2013. “Long-term impacts of household electrification in rural India.” World Bank Policy Research Working Paper, 6527.
- [46] Watson, T. 2006. “Public Health Investment and the Infant Mortality Gap: Evidence from Federal Sanitation Interventions on U.S. Indian Reservations.” *Journal of Public Economics*, 90(8).
- [47] Whittington, D., D.T. Lauria, and X Mu. 1991. “A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria.” *World Development*, 19(2/3).
- [48] Wiig, H. 2013. “Joint Titling in Rural Peru: Impact on Women’s Participation in Household Decision-Making.” *World Development*, 52: 104-119.
- [49] Zegarra, E. 2004. “The Market and Water Management Reform in Peru.” CEPAL Review, 83.

Figure 1: Potential Channels of Impact

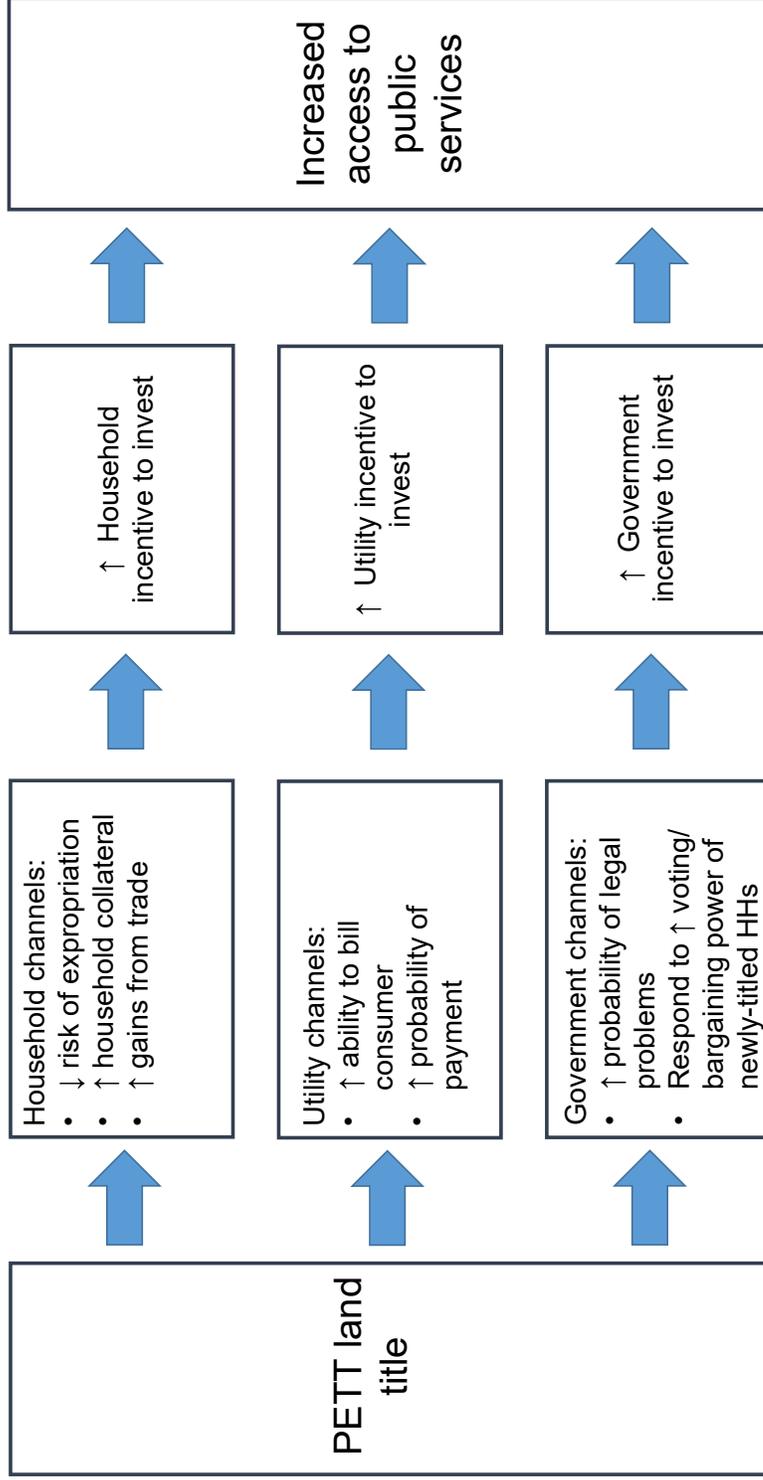


Table 1: Summary Statistics

Household characteristics	Mean for all households	Standard errors
Household members (number of people)	4.56	0.037
Children between age 5-11 years (number)	0.80	0.017
Children between age 12-16 years (number)	0.62	0.015
Household head is female	0.13	0.006
Household head age (years)	51.71	0.269
Household head is literate	0.87	0.006
Household head education (years)	5.59	0.071
Household owns their house	0.45	0.009
Household has tap water, indoor or outdoor	0.48	0.008
Household has toilet access	0.40	0.009
Household uses electricity for lighting	0.52	0.009
Household is saving	0.34	0.008
Monthly amount received from social programs (S./)	568.79	178.02
Household observations	3204	

Notes: Means calculated using data from the 2004 Land Titling Special Project Survey. Monetary values reported in Peruvian Sol (S./). In April 2004, 1 USD = 3.5739 Peruvian Nuevo Sol. Unless otherwise indicated in parentheses, the household characteristics are binary indicators and therefore the means should be understood as the proportion of the sample.

Table 2: Means by Title Status: Explanatory Variables and Perceptions of Expropriation Risk

	PETT title	Other title	No title	t-test of PETT title	
				No title	Other title
<i>Panel A: Household characteristics</i>					
	<i>Household means (by title type)</i>				
Household members (number of people)	4.5	4.5	4.6	0.273	0.718
Children between age 5-11 years (number)	0.6	0.8	0.9	0.000	0.001
Children between age 12-16 years (number)	0.6	0.6	0.6	0.219	0.125
Household head is female	0.2	0.1	0.1	0.003	0.001
Household head age (years)	56.1	52.9	48.9	0.000	0.000
Household head is literate	0.86	0.871	0.876	0.318	0.506
Household head education (years)	5.20	5.63	5.74	0.004	0.035
Household is saving	0.34	0.37	0.32	0.383	0.173
Value of household assets (S./)	6750.1	7230.5	9757.5	0.000	0.892
Monthly amount received from social programs (S./)	618.6	611.0	516.3	0.825	0.989
Household's land size (sq meters)	176465	184717	180436	0.017	0.004
Household owns their house	0.63	0.66	0.21	0.000	0.233
<i>Panel B: Expropriation risk and inheritance questions</i>					
	<i>Percent households replying: "certain" or "very certain" (by title type)</i>				
How certain are you that your house will not be expropriated by the government?	85.04	94.14	73.72	0.000	0.000
How sure are you that your house will not be expropriated by another person?	88.57	96.45	76.89	0.000	0.000
How sure are you that your house will be inherited by your children?	96.59	88.48	76.2	0.000	0.000
Household observations	648	1076	1480		

Notes: Calculations use data from the 2004 Land Titling Special Project Survey. The title categories are the following: "PETT title" are household reporting a title through the PETT program; "Other title" are households reporting having a title, but not via the PETT program; and "No title" are households reporting no title to the property. Unless otherwise indicated in parentheses, the household characteristics are binary indicators and therefore the means should be understood as the proportion of the sample. Monetary values reported in Peruvian Sol (S./). In April 2004, 1 USD = 3.5739 Peruvian Nuevo Sol. P-values are reported as the results of the t-tests.

Table 3: Household Access to Water and Other Services by Household Title Status

	Proportion using water source by:		t-test of PETT title vs:		
	PETT title	Other title	No title	Other title	
<i>Panel A: Basic water indicators</i>					
Tap inside the house	0.440	0.458	0.391	0.033	0.458
Tap outside the house	0.082	0.057	0.041	0.000	0.042
Fountain outside	0.185	0.213	0.161	0.179	0.167
Artisan well / spring	0.176	0.142	0.173	0.869	0.061
River	0.077	0.099	0.192	0.000	0.135
Tanker truck / water vendor	0.006	0.018	0.020	0.021	0.044
Other source	0.032	0.014	0.023	0.207	0.009
<i>Panel B: Summary indicators of</i>					
Improved water source	0.883	0.870	0.766	0.000	0.436
Toilet / sanitation	0.398	0.470	0.357	0.073	0.004
Electricity	0.582	0.574	0.463	0.000	0.762
Household observations	648	1076	1480		

Notes: Calculations use data from the 2004 Land Titling Special Project Survey. Each of the basic water source indicators is a binary indicator created from responses to the question: "How is this household supplied with water?" The "Improved water source" is based on the Human Development Report (2006) definition and = 1 if the household reports using one of the following sources: indoor tap, outdoor tap, fountain or well/spring. "Toilet / sanitation" is an indicator equal to one if the household reports having a public sanitation connection either inside or outside the house or a septic system. "Electricity" is an indicator equal to one if the household reports using electricity as its primary lighting source. The title categories are the following: "PETT title" are households reporting a title through the PETT program; "Other title" are households reporting having a title, but not via the PETT program; and "No title" are households reporting no title to the property. P-values are reported as the results of the t-tests.

Table 4: Marginal Effects: Land Titles and Household Access to Water and Other Services

	Water Source			Sanitation	Electricity
	Tanker truck / vendor (1)	River (2)	Improved source (3)		
PETT title	0.001 (0.003)	-0.078*** (0.012)	0.071*** (0.015)	0.016 (0.025)	0.083*** (0.025)
Other title	0.002 (0.002)	-0.070*** (0.011)	0.079*** (0.013)	0.117*** (0.021)	0.101*** (0.021)
Mean of omitted group	0.020	0.192	0.766	0.357	0.463
Household observations	3182	3182	3182	3182	3182

Notes: The title categories are the following: "PETT title" are households reporting having received a title through the PETT program; "Other title" are households reporting having a title, but not via the PETT program; and "No title" are households reporting no title to the property. Each of the basic water source indicators is a binary indicator created from responses to the question: "How is this household supplied with water?" The "Improved water source" equals one if the household reports using one of the following sources: indoor tap, outdoor tap, fountain or well/spring. "Toilet / sanitation" is an indicator equal to one if the household reports having a public sanitation connection either inside or outside the house or a septic system. "Electricity" is an indicator equal to one if the household reports using electricity as its primary lighting source. All regressions include region fixed effects and controls for household characteristics, including: household head's education, whether household head is female, number of people living in the household, number of workers living in the household, number of children between 5 and 11 years old, whether the family owns a home business, whether the household receives any income from rents. Standard errors are in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Difference-in-differences: Household Access to Water and Other Services

	Water Source			Sanitation	Electrified
	Tanker truck / vendor	River	Improved source		
	(1)	(2)	(3)	(4)	(5)
program *no prior	-0.005 (0.009)	-0.043* (0.024)	0.059** (0.027)	0.151*** (0.0347)	0.0882** (0.0352)
program	0.002 (0.006)	-0.041*** (0.015)	0.022 (0.017)	-0.0320 (0.0242)	0.00458 (0.0244)
no prior title	-0.003 (0.006)	0.071*** (0.016)	-0.076*** (0.018)	-0.104*** (0.0227)	-0.0998*** (0.0222)
Household observations	3,182	3,182	3,182	3,182	3,182

Notes: "Program" households are in areas that the PETT program had reached prior to the survey implementation. "No prior" are those households that did not have an alternative form of title prior to the PETT program arriving. Each of the basic water source indicators is a binary indicator created from responses to the question: "How is this household supplied with water?" The "Improved water source" equals one if the household reports using one of the following sources: indoor tap, outdoor tap, fountain or well/spring. "Toilet / sanitation" is an indicator equal to one if the household reports having a public sanitation connection either inside or outside the house or a septic system. "Electricity" is an indicator equal to one if the household reports using electricity as its primary lighting source. All regressions include region fixed effects and controls for household characteristics, including: household head's education, whether household head is female, number of people living in the household, number of workers living in the household, number of children between 5 and 11 years old, whether the family owns a home business, whether the household receives any income from rents. Standard errors are in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: Difference-in-differences: Titles and Infrastructure Connections and Investments

	Connection to...	Signs of household investments		
		Amount invested in connection (S./)	Used own resources for investment	Used credit for investment
	(1)	(2)	(3)	(4)
<i>Panel A: Public water network</i>				
program*no prior	0.032* (0.019)	6.212 (7.794)	0.019 (0.018)	0.004 (0.004)
program	0.008 (0.013)	-1.843 (7.573)	0.009 (0.013)	-0.001 (0.002)
no prior title	-0.030*** (0.011)	-10.68* (6.331)	-0.031*** (0.010)	-0.001 (0.003)
<i>Panel B: Public sanitation network</i>				
program*no prior	0.151*** (0.035)	5.260 (3.395)	0.024*** (0.009)	0.001 (0.004)
program	-0.032 (0.024)	-3.503 (2.431)	-0.022*** (0.008)	-0.001 (0.003)
no prior title	-0.104*** (0.023)	-5.194** (2.100)	-0.023*** (0.007)	-0.003 (0.003)
<i>Panel C: Electrical grid</i>				
program*no prior	0.088** (0.035)	-5.957 (7.580)	0.019 (0.016)	0.002 (0.005)
program	0.005 (0.024)	3.757 (6.702)	-0.037*** (0.012)	-0.002 (0.003)
no prior title	-0.100*** (0.022)	-5.876* (3.502)	-0.032*** (0.011)	-0.001 (0.003)
Household observations	3,182	3,182	3,182	3,182

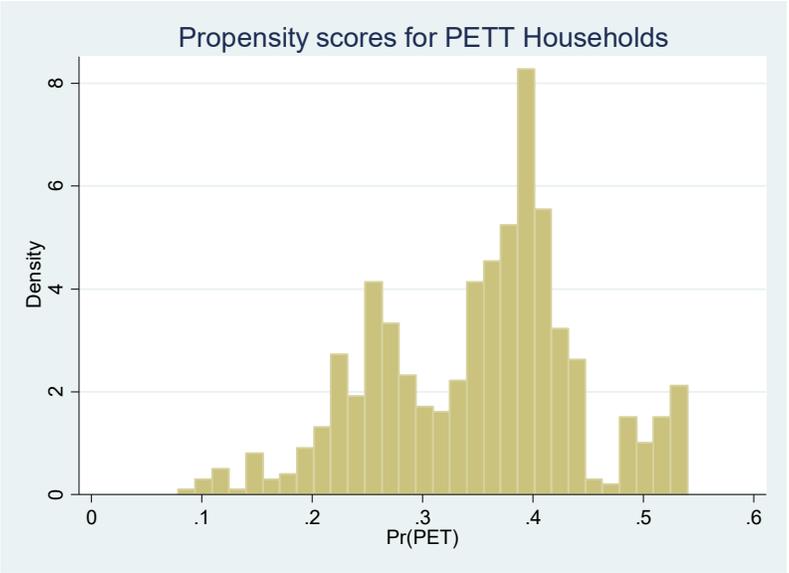
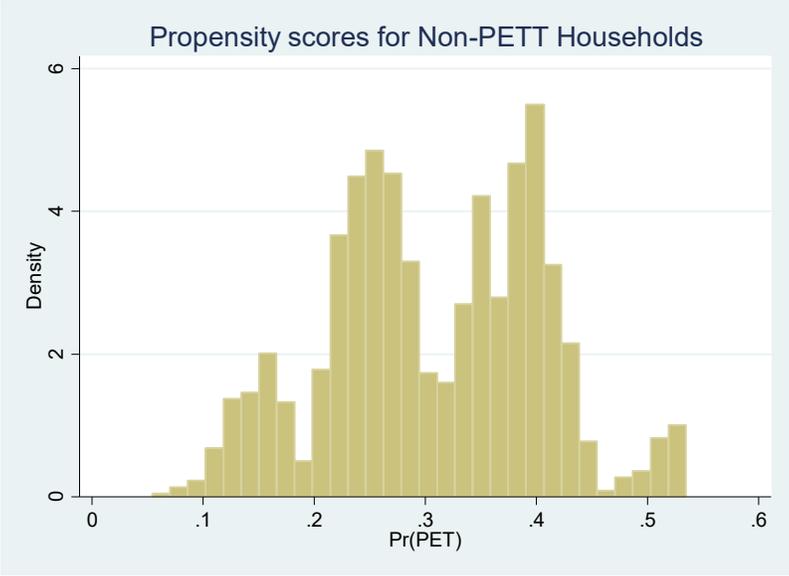
Notes: "Program" households are in areas that the PETT program had reached prior to the survey implementation. "No prior" are those households that did not have an alternative form of title prior to the PETT program arriving. "Connection to..." is a binary indicator equal to one if the household realized a public [water, sanitation, electricity] connection within the five years prior to the survey. "Amount household invested in connection" is the amount the household reported having invested in the [water, sanitation, electricity] connection in Peruvian Sol (S./). "Used household resources for investment" is a binary indicator equal to one if the household paid for the investment with its own resources. "Used credit for investment" is a binary indicator equal to one if the household paid for the investment using some form of formal or informal credit. All regressions include region fixed effects and controls for household characteristics, including: household head's education, whether household head is female, number of people living in the household, number of workers living in the household, number of children between 5 and 11 years old, whether the family owns a home business, whether the household receives any income from rents. In April 2004, 1 USD = 3.5739 S./ Standard errors are in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Difference-in-differences: Titles and Community Services Required

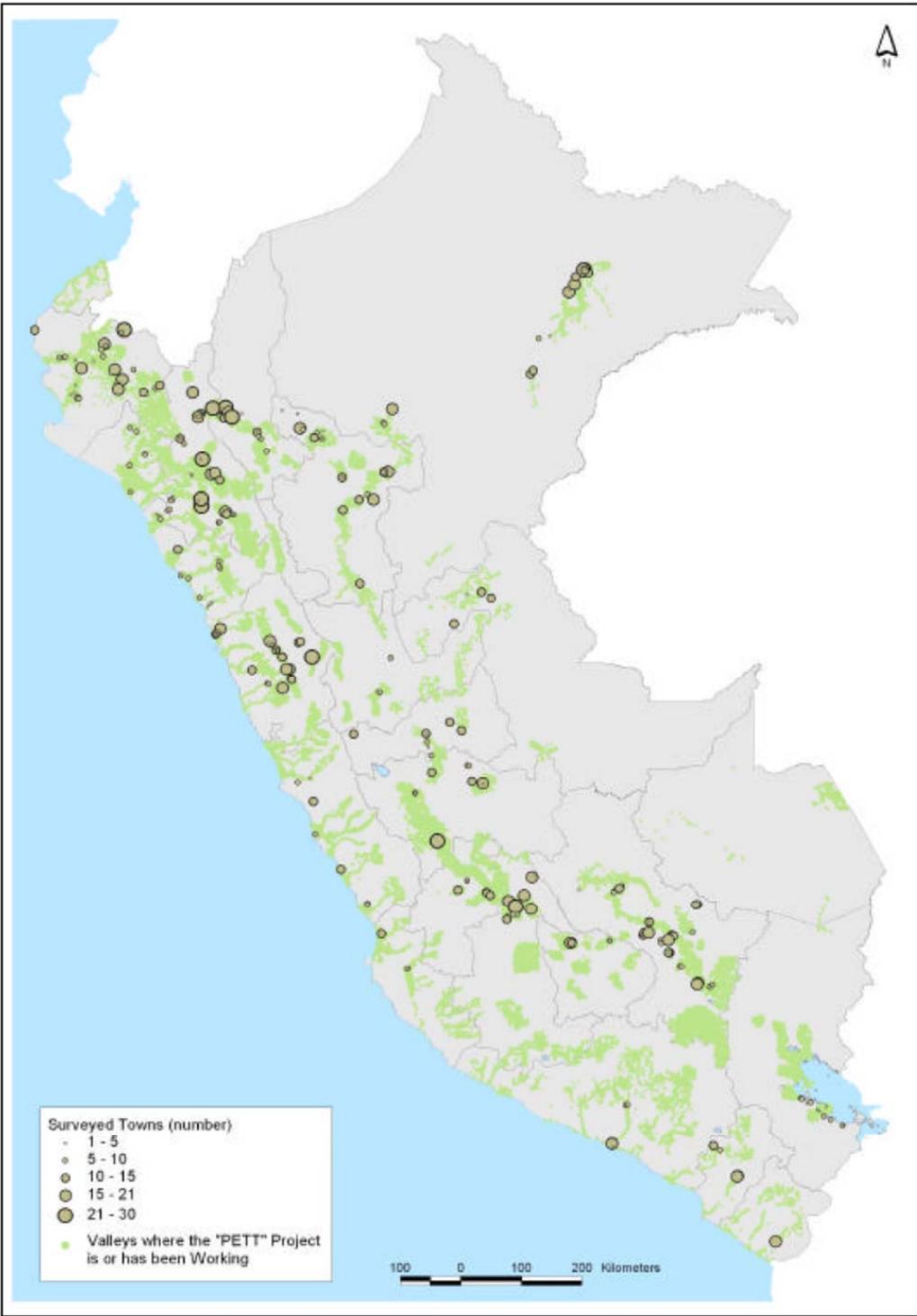
	(1)	(2)	(3)	(4)	(5)	(6)
	Police station	Clean parks	Clean public areas	Public phone	Public networks (water, sanitation, electricity)	Public networks (water, sanitation, electricity)
program*no prior	-0.001 (0.033)	0.009 (0.015)	-0.012 (0.028)	-0.060 (0.038)	-0.110*** (0.034)	-0.067** (0.032)
program	-0.008 (0.023)	-0.014 (0.011)	0.002 (0.020)	0.033 (0.025)	0.007 (0.023)	0.002 (0.021)
no prior title	-0.024 (0.021)	-0.022** (0.010)	0.009 (0.018)	0.050** (0.023)	0.076*** (0.021)	0.039** (0.019)
Control for own water, sanitation, electricity connections	No	No	No	No	No	Yes
Household observations	3,182	3,182	3,182	3,182	3,182	3,182

Notes: "Program" households are in areas that the PETT program had reached prior to the survey implementation. "No prior" are those households that did not have an alternative form of title prior to the PETT program arriving. Outcome variables are binary indicators created in response to the multiple choice survey question asking: What services do you think your community should get in the future? The controls for own water, sanitation, electricity connections are three separate binary indicators that each equal one if the household reports already have such a connection. All regressions include region fixed effects and controls for household characteristics, including: household head's education, whether household head is female, number of people living in the household, number of workers living in the household, number of children between 5 and 11 years old, whether the family owns a home business, whether the household receives any income from rents. Standard errors are in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix Figure 1: Common Support for PETT and Non-PETT Propensity Score Distributions



Appendix Figure 2: Locations of PETT program and survey (Torero and Field, 2005)



Source: Valleys were identified from PETT Project Office sources