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Does Land Tenure Security Promote Manure Use by Farm Households in Vietnam?

Trung Thanh Nguyen [1,*], Siegfried Bauer [2] and Ulrike Grote [1]

[1] Institute for Environmental Economics and World Trade, Leibniz University Hannover, Königsworther Platz 1, Hannover 30167, Germany; grote@iuw.uni-hannover.de

[2] Project and Regional Planning, Giessen University, Senckenbergstraße 3, Gießen 35390, Germany; Siegfried.Bauer@agrar.uni-giessen.de

* Correspondence: thanh.nguyen@iuw.uni-hannover.de; Tel.: +49-511-762-4827; Fax: +49-511-762-2667

Academic Editor: Tiziano Gomiero

Received: 6 November 2015; Accepted: 16 February 2016; Published: 18 February 2016

Abstract: Facing widespread poverty and land degradation, Vietnam started a land reform in 1993 as part of its renovation policy package known as "*Doi Moi*". This paper examines the impacts of improved land tenure security, via this land reform, on manure use by farm households. As manure potentially improves soil fertility by adding organic matter and nutrients to the soil surface, it might contribute to improving soil productive capacity and reversing land degradation. Random effect regression models are applied to a panel dataset of 133 farm households in the Northern Uplands of Vietnam collected in 1993, 1998, and 2006. The results confirm that land tenure security has positive effects on manure use, but the levels of influence differ depending on whether the land has been privatized or whether the land title has already been issued. In addition, manure use is also influenced by the number of cattle and pigs, the education level and ethnicity of household heads, farm land size and non-farm income. The findings suggest that speeding up land privatization and titling, encouraging cattle and pig rearing, and improving education would promote manure use in farm production. However, careful interpretation of our research findings is required as land privatization, together with economic growth and population pressure, might lead to overuse of farm inputs.

Keywords: land reform; economic incentive; random effect econometric models

1. Introduction

Land degradation is a threat to food security and sustainability of agricultural production [1–3] and has been given high priority on the international development agenda as it is prevalent in the rural areas of developing countries [4–6]. This threat has generated concerns, since producing sufficient food to feed an increasing population remains one of the biggest global development challenges [7,8]. The world's population is expected to reach 9.6 billion people in 2050 and nearly all of the population growth is forecasted to take place in developing countries [9], where food production would need to almost double to meet the food demand [10]. Additionally, agroecosystems provide not only food, but also various other ecosystem services, such as water provision and sediment prevention [11], which also need to be managed in a sustainable way [12]. Soil erosion losses contribute to the decline of soil productivity [13], deterioration of water quality [14], and intensification of air pollution. When productive land is degraded, the livelihoods of the rural population might be no longer secure, resources become overexploited, social tensions increase, traditional cultural systems collapse, and armed conflicts can break out [15,16]. Thus, conserving and improving soil fertility are becoming increasingly important [17].

In response to these concerns, considerable efforts have been made to promote soil conservation [18,19]. Sustainable land use practices and soil management procedures have been developed that are capable of reducing soil erosion and land degradation, as well as restoring and increasing soil fertility. Examples include reduced tillage, contour farming, grass buffer strips, and increased manure use in agricultural production. However, rates of adoption remain low in developing countries [20]. One of the explanations put forth for low adoption rates is insecure land tenure regimes [21,22]. The relationship between land tenure and economic development has deserved special attention by scholars and policy makers as farmland is the main source of livelihoods for the majority of farmers in developing countries [23,24]. Economic theory has long suggested that increased tenure security, classically defined in terms of private ownership, will lead to increased soil productivity [25,26], and provide an incentive for farmers in developing countries to improve soil fertility [27,28]. An almost universal mechanism of land tenure security is a unified system of land registration and documentation whereby the state provides the landowner with proof that a given well-defined tract of land does indeed belong to the landowner. If the registration system is effective, and if the state can protect the owner from encroachment or false challenges to his or her ownership, such a mechanism does enhance security [29,30]. As soil conservation is considered an investment in land [31,32], farmers in developing countries are more willing to invest in soil conservation if their land tenure is secure so that they can receive the returns of their investment.

Although the basic economic logic between land tenure security and soil-related investments, including soil conservation, is clear [33,34], the available empirical evidence is inconclusive (see a review in Section three), which makes generalization of the research findings difficult. In fact, generalization is only possible if the findings from different site-specific studies are pooled in order to identify common observable patterns [35]. While much of the policy toward land tenure has been theory driven, a more site-specific approach to soil conservation policy is needed to understand the livelihood strategies of local people in developing countries in terms of rationale and constraints [36,37].

Vietnam is one of the countries that have undergone dramatic economic growth over the last several decades. The Gross Domestic Product grew by 7.3% per year during 1995–2005 [38]. The country had a centrally-planned economy in which all land was nationalized in the past. The performance of the economy in general and that of the agricultural sector in particular were very poor at that time. Poverty was widespread, and forest and land resources were seriously degraded [39,40]. Facing these challenges in the late 1980s, Vietnam started its renovation policy package known as "*Doi Moi*" with the primary aim of promoting economic growth. The starting point of this structural adjustment policy was the privatization of the main productive asset, in this case farm land, and then to legalize its free exchange by providing land titles. Other renovations included the elimination of production and consumption subsidies, deregulation of agricultural input–output markets, and liberalization of trade [41]. As a consequence, Vietnam has benefited from rapid economic growth. From a situation of chronic rice shortage in the 1980s, it has transformed itself into one of the largest rice exporters in the world [42].

Although various studies have investigated the impacts of this land reform in Vietnam [33,39,41,43,44], only few of them deal with soil conservation at the household level [45]. This is partly due to the lack of reliable household data. Vietnam can be seen as a prevailing case of anthropogenic land degradation. Though agriculture remains the most important sector of the Vietnamese economy in terms of employment share, agricultural land is, on average, only about 0.11 hectares (ha) per capita. Land degradation is one of the most striking problems for the country. At least 64,000 km^2 of land (19% of the national land area) have experienced persistent declines in biomass productivity over the last 25 years [40]. As agricultural land is scarce, one of the major concerns for the national policy makers is how to use the land in a more sustainable manner, especially in the mountainous regions, where land degradation and soil erosion are serious problems [46]. Our paper thus aims to examine the impacts of improved tenure security via land reform on manure use of farm households in a mountainous area of Vietnam, the Northern Uplands. Manure use adds

organic matter and nutrients such as nitrogen to the soil and thus benefits both crop productivity and soil fertility. We hypothesize that improved land tenure security promotes manure use by farm households in the study area. As the land reform is not yet completed in Vietnam, and land tenure insecurity is still a problem in many regions of developing countries, the study would provide relevant information that might be useful for the formulation of different soil conservation policies and soil management practices. Since land degradation is a complex problem [47,48], and successful soil conservation requires the integration of different methods from different scientific disciplines [3,47], our findings are supposed to contribute, together with the efforts from other disciplines, to the identification of more comprehensible and holistic solutions.

2. Land Tenure in Vietnam before and after the Renovation

2.1. Land Tenure before the Renovation

Vietnam had been invaded several times in the past. The country had been colonized over many years by different Chinese dynasties. This was followed by the French invasion until 1954. Vietnam was then separated into two parts, the North and the South, with two different administrations: a Communist state backed by the former Soviet Union and other socialist countries in the North, and a United States-supported state in the South. The country was reunified in 1975. As land is one of the most important assets for the majority of the Vietnamese, land policy has been the focal concern in every historical period and has been changed continually. This section highlights the land policy before the renovation as a basis for the land reform that is empirically examined in this study.

2.1.1. Land Tenure in the Pre-French Colonial Period

In the pre-French colonial period, the social structure in lowland Vietnam was relatively homogenous, and the systems of land tenure were similar across the lowland regions [49]. The village-level organization was a complex mixture of patriarchy and kinship with Confucian elements dominating the allocation of communal lands [50]. Thus, rather than being strictly feudal, the system of political control in this period was characterized by some signs of "private" ownership and a centralized monarchy [51]. The centralized monarchy, with the King as its symbol, proclaimed itself as the supreme owner of all land. Land could be awarded by the King to his royal officials. The village exerted direct control over the village land. Each village community directly managed and exploited the land within its confines [49]. According to the customary land law at that time, public village land was distributed to households for cultivation based on the number of male household laborers and could be redistributed after a period of three to five years so as to take into account the population change [52]. The overlapping land ownership and the dual management and exploitation of public land within each village created many loopholes to convert public land into private land [50]. The privatization of the public land had made it to be smaller and smaller over the years. At the beginning of the 20th century, the ruling dynasty took back part of the land areas which had been allocated to high officials to return to villages [49,53].

2.1.2. Land Tenure in the French Colonial Period

The French expansion of its colonies into Vietnam from 1859 onwards heralded a shift in the operation and governance of Vietnam, in its institutions and land management in particular [49]. Essentially, colonialism led to the formal institutionalization of capitalism for the first time in Vietnam [50]. This became manifest in the creation of private landlord classes who controlled land and rented it to landless peasants [52]. During this period, generous land grants to French settlers and to Vietnamese bureaucrats resulted in an extremely skewed land distribution and in the creation of a large group of tenant farmers and landless laborers. For the whole country, 52% of the land was owned by only 3% of the indigenous population, and more than 60% of farmers across the country were landless in the 1940s [43,54]. A substantial amount of land fell into the hands of the French.

From 1859 (the beginning of French invasion) to 1912, the French colonial rulers seized 469,724 ha of land [55]. Ten years later, this figure rose to 775,700 ha [54,56]. Thus, by the end of the 1930s, the total amount of land owned by the French was over 1.2 million ha, accounting for one fourth of the total cultivated area in Vietnam at that time [52,54].

2.1.3. Land Tenure in the Separation Period

After the victory over the French in 1954, Vietnam was separated into two parts, the North and the South, and various land reforms were conducted in both parts. In the North, a thorough program of land expropriation and redistribution was carried out between 1953 and 1957. Land was confiscated from the landlords and then transferred to the peasants. By the end of this period, 810,000 ha (37%) of the cultivable land in the North were distributed to 2.1 million households, an average of 0.4 ha per household [51,54]. However, the policy was reversed and land began to be collectivized in the late 1950s [43,54]. The plots of land that peasants had received were soon taken away through the process of collectivization [57,58]. Each member of agricultural cooperatives was assigned a specific number of points for the quantity of work done each day. Payment at the end of the season was based on the number of points accumulated. Since differences in quality of works were costly to monitor and led to conflicts among team members, the point system was quickly degenerated into a fixed point system for the number of hours worked. With the fixed point system, individual members had an incentive to shirk from their assigned responsibilities; hence; productivity declined. Collectivization of agricultural production in the North suffered from the fate of similar systems in other socialist countries [54].

In the South, the distribution of the landholdings at that time was even more skewed compared to that in the North since it was less populated. Land was held by only a small number of landlords and the majority of the population was tenants. By 1955, about 40% of rice land areas in the South were held by some 2500 individuals, or 0.25% of the rural population [54,57]. The government attempted to alter the basic land ownership pattern by limiting the ownership of rice land to a maximum of 100 ha per owner, and requiring that owners who hold more than this sell the excess to the government, which was then redistributed to tenants. As a result, about 1.3 million ha of agricultural land were reallocated to over 1 million farmers, an average of 1.3 ha per farmer by the end of 1974 [43,54,59]. In April 1975, the country was reunified with the victory of the Northern government. The system was then changed towards the collectivization policy as it had existed in the North, even though not completely the same.

A comparison of per capita rice output from 1942 to 1986 reveals the depressed state of rice production in Vietnam. During this 45 year period, per capita rice output had been stagnant at 260–280 kilograms [60]. Agricultural yields were extremely low; for example, rice yield was only 2.8 tons per ha during 1984–1986 [54,60], and even as late as 1985, Vietnam was a net importer of rice, implying an urgent need for the renovation.

2.2. Land Reform in the Renovation Context

In 1981, the Secretariat of the Communist Party of Vietnam promulgated Directive 100, or in short, "Contract 100", aimed at improving agricultural productivity through increased individual incentives. This was done by assigning land use contracts to individual farmers. Farmers were allowed to keep the total surplus they produced over the contracted output that had to be paid to the government, although land and production materials were still controlled by the cooperatives. Land use contracts were signed on an annual basis. The farmers were free to add more inputs and allocate their own time and labor to achieve higher yields. Conceptually, the introduction of the contract system is equivalent to a shift from a fixed wage (of the collective system) to a fixed rent system. This shift led to an annual increase in rice output of 2.8% during 1982–1987 [54]. Directive 100 of the ruling party was formalized with the promulgation of a new land law in 1987 (Land Law 1987). However, land use rights were not transferable and land could not be used as collateral for loans. Agricultural land and production materials remained under control of agricultural cooperatives. In the absence of land titles, farmers continued to feel insecure [43].

In 1988, the Politburo of the Communist Party passed Resolution 10, which recognized the household as an independent economic unit and issued instructions for the allocation of land to households on a more permanent basis. The de-collectivization process was started. This resolution was formalized by a new land law in 1993 (Land Law 1993), which granted additional five rights to the households: rights to transfer, exchange, inherit, rent and mortgage, and allowed the allocation of land to organizations, individuals and households for stable use within the defined time of 20 years for annual crops and 50 years for perennial crops and forestry. The tenure can be renewed on expiry if land users wish to do so and if they have used the land properly in accordance with the regulations. Land use certificates (internationally known as land titles) are provided for privatized land. However, land ceilings that every household can be allocated were introduced for annual crops of two ha in the North and three ha in the South, and ten ha for perennial crop land [61]. Further revisions of Land Law 1993 removed land ceilings and encouraged the establishment of large farms. Recent agricultural land tenure policies and some related economic and environmental issues can be summarized in Figure 1.

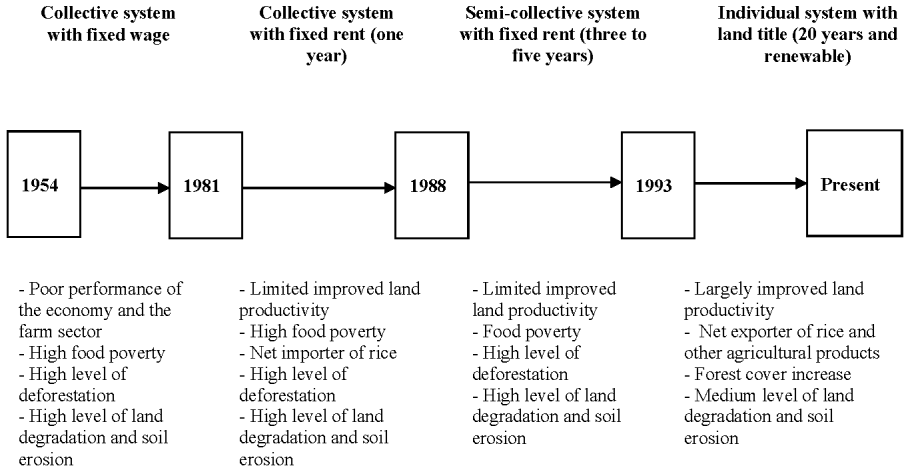

Figure 1. A historical perspective of land tenure policy in Vietnam from 1954.

Similarly to previous land reforms, Land Law 1993 was unevenly implemented throughout the country. A phenomenon likely to slow down the process was the number of disputes that can emerge in villages. The way the allocation was made, the existence of pre-existing property rights, the capacity of local staff of the competent authorities are several determinants that can cause one region to achieve faster registration than another [43,61]. As Land Law 1993 is a cornerstone in liberalizing agricultural production in Vietnam by privatizing land, its impacts on manure use by farm households are thus examined in our study. The essence of Land Law 1993 is the privatization of farm land to individual households, which made agricultural production in Vietnam change fundamentally from a collective to an individual basis.

3. Land Tenure Security and Soil Conservation

3.1. Theoretical Linkage and Empirical Evidence

Property rights underlie the performance and income distribution in all economies [36,62]. By defining the parameters for the use of scarce resources and assigning the associated rewards and costs, the prevailing system of property rights establishes incentives and time horizons for investment, production, and exchange. Since property rights define the behavioral norms for the assignment and use of resources, it is possible to predict how differences in property rights affect economic activities [63]. That linkage is critical for research in economic history to understand variations in growth and welfare across societies and time. Bromley [36] describes property rights as a social relation amongst individuals within a society: if an object is available in insufficient quantity to meet the

objectives of all individuals within a society, then discrimination is necessary to determine the extent to which each individual's objective will be satisfied [64]. As they define the costs and rewards of decision making, property rights establish the parameters under which decisions are made regarding resource use [63].

There are different definitions of land tenure in the literature. For example, it is defined as a system of rights and institutions that govern access to and use of land and other resources [24], or as a bundle of use rights, control rights, and transfer rights [65]. The rights may be enforced by a government whose officials explicitly grant such rights to land users. If so, such rights are *de jure* rights in that they are given lawful recognition. Rights-holders who have *de jure* rights can presume that if their rights were challenged in an administrative or judicial setting, their rights would most likely be sustained. However, in some situations land users cooperate to define and enforce rights among themselves. Such rights are *de facto* as long as they are not recognized by government authorities [62]. Land users who have developed *de facto* rights act as if they have *de jure* rights by enforcing these rights among themselves. In some setting *de facto* rights may eventually be given recognition in courts of law if challenged, but until so recognized they are less secure than *de jure* rights [64,66–68].

Land tenure changes can occur due to either evolutionary changes or institutional reforms (Figure 2). The evolution of individual land rights and a mechanism to enforce such rights in the rural setting is closely related to increases in the population density and to advances in agricultural technology [63]. As land becomes scarce, societies that have practiced shifting cultivation must adopt fertility-restoring technologies to allow for continued use of the land. Since such technologies require investments of both capital and effort, the cultivator must have an investment incentive. For the cultivator, this incentive is given when the right to cultivate continuously and the ability to transfer a given tract of land are secured not only by social customs, but also by an effective state-enforced legal system [29]. Thus, population growth and agricultural progress are typically accompanied by a mechanism to enforce land rights [29,66]. The initial land tenure system can also change with state interventions by conducting land reforms. These two main root causes of land tenure changes are not independent but interlinked, since changes in population, technology, and markets can also be the reason for a state to intervene in its land tenure system [69]. Changes in land tenure systems in turn lead to changes in resource use, productivity, and income. It is also worth putting land tenure changes in the more general context of economic structural change. For example, activation of land markets, either by rentals or by sales, can lead to changes in productivity and the occurrence of land accumulation by some households and the exit of agricultural production by others. Thus, changes in land tenure systems can lead to changes in the economic structure in terms of either income or redistribution of resources, such as land and labor.

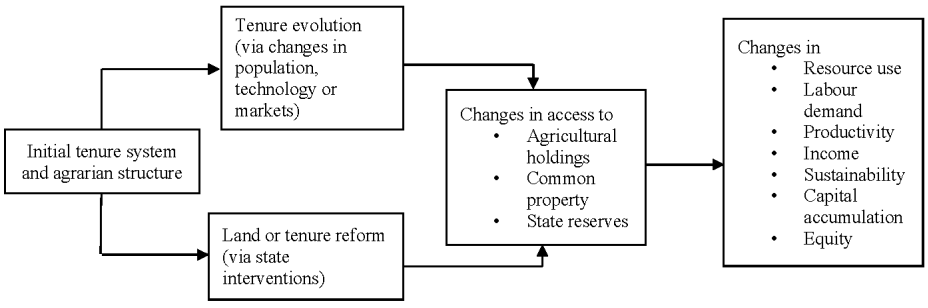

Figure 2. Possible causes and consequences of land tenure changes (Source: modified from Maxwell and Wiebe, 1999 [24] and Nguyen, 2012 [26]).

Although the basic economic logic between land tenure and land use is clear, the empirical evidence is inconclusive. The impacts of increased land tenure security have been investigated for years (see reviews by Robinson *et al.* [70]; Sjaastad *et al.* [71]; Kabubo-Mariara [72], Maxwell and Wiebe [24]), which can be classified into (i) impacts on access to credit, farm investment,

and yield [26,73]; (ii) impacts on land distribution and transfer [33,74]; (iii) impacts on resource conservation [2,15,70,75,76]; and (iv) impacts on food security [23]. However, the major focus has been on investment and productivity [74]. In Honduras, Lopez, [77] concludes that land titles do not affect land productivity. This finding is consistent with Montaner-Larson, [67], who also concludes that giving titles to small coffee farms on state-owned land in Honduras does not affect credit access, technical efficiency, or input use. Feder *et al*. [29] find that tenure security is important for access to formal credit and land investment in Thailand, although such a relationship does not hold in the region with a well-established informal credit market. Carter *et al.* [78] find no significant relationship between land titles and output, income, and profit in Kenya. Besley, [68] finds a positive linkage between tenure security and productivity in Ghana, and argues that tenure security might be endogenous with respect to investments. Hayes *et al.* [79] show that tenure security has a significant positive effect on long-term investment, which has a positive impact on yield in Gambia. Interestingly, as stated by Deininger and Jin (2008), some observers of land reform programs that give land as a grant to beneficiaries suggest that productivity could be lower. The idea is that land reform beneficiaries can include people who are inexperienced with farming, people who are more interested in holding land for speculation than farming, and people who for whatever reason are unlikely to invest in farming [33]. Kabubo-Mariara, [72] finds a positive correlation between land tenure security and land conservation in Kenya. Robinson *et al.* [70] find evidence that land tenure security is associated with less deforestation.

3.2. Empirical Evidence in Vietnam

Applying this theoretical linkage to Vietnam, it is recognized that a sharp increase in population after years of war and the stagnation in cooperative agricultural production forced the government of Vietnam to conduct the land reform. In this regard, the reform was indeed made by the state and driven by social pressure. Therefore, the conceptual framework of the study is developed based on Feder *et al.* [29] and Nguyen *et al.* [39] (Figure 3). The most important features of the land reform in Vietnam are: (i) farmers now have ownership of their land, which is enforced and protected by a legal mechanism; and (ii) land titles are provided for land exchange and used as collateral for credits. It is often theorized that insecure land rights cause market imperfection and increase the risks associated with farming through the threat of dispossession, leading to a lower level of input use and decreased productivity [77,79,80].

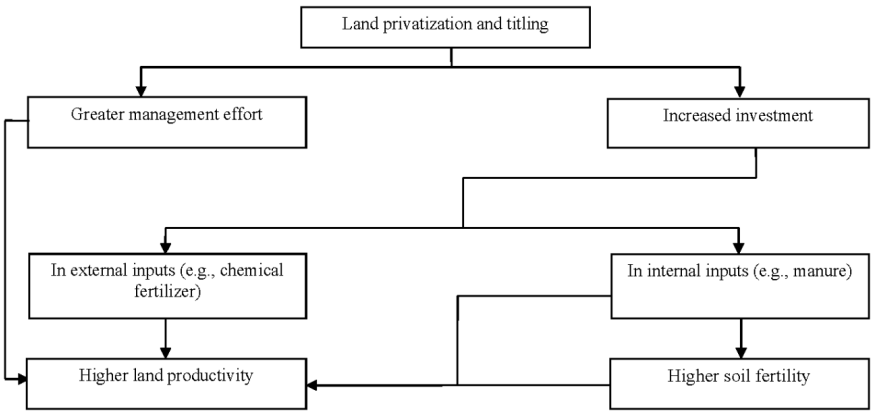

Figure 3. Conceptual framework of the linkages between land reform and investments in farming, soil conservation, and land productivity (Source: modified from Feder *et al.* [29] and Nguyen *et al.* [39]).

In Vietnam, Vo and Pingali [54] examine the impact of the movement from the collective to the contract system introduced for rice production in 1981; they show that collectivization accounts for a total productivity decline of 48%. However, due to the lack of data on input use, they are unable

to separate the impact of decentralization of input supplies and the incentive that farmers had when changing from the collective to the contract system. Regarding the land reform, Do and Iyer [43] find that better land rights lead to a significant increase in area devoted to multi-year crops, in irrigation investment, and in labor devoted to non-farm activities. As the data on land reform for individual households were not available, the authors use the land registration rate of each province as a proxy for land tenure security. The land registration rate, in this case, does not fully reflect the changes in land tenure at the farm level brought by Land Law 1993. Deininger and Jin [33] use the dataset of Do and Iyer [43] to identify factors affecting the development of land markets and to assess the extent to which land transfers enhance productive efficiency. They find that both rental and sales markets have rapidly increased, enhanced by the possession of long-term use rights and off-farm employment. However, they face the same problem of lacking data on land reform at the farm level. Ravallion and van de Walle [41] examine the impacts of land reform on access to credit, on land market operation, and on the level of landlessness. However, similar to the previously mentioned studies, they cannot separate the effects of land privatization and land titling. Nguyen [26] investigates the impacts of land privatization and land titling on chemical fertilizer use and land productivity and find a positive relationship, but these studies do not investigate such impacts on manure use. Saint-Macary *et al.* [45] find that the possession of a formal land title positively influences the adoption of agroforestry practices. Nguyen *et al.* [81] show that land titling motivates farmers to invest more in afforestation in the Northern Uplands of Vietnam.

As described by Do and Iyer [43] and Ravallion and van de Walle [41], the implementation of the land reform is not homogenous in the whole country. This means some regional characteristics might not have been taken into account in the previous studies. In addition, Saint-Macary *et al.* [45] and Nguyen [26] state that the implementation of land privatization and land titling is very lengthy and costly. In principle, land must be privatized first and then a title is provided. This process implies considerable administrative costs for measuring land, registering and issuing land titles. The lack of qualified personnel is another reason for the slowness of the process, especially in the Northern Uplands. In this regard, the present paper contributes to the current research in the following ways: (i) it is the first effort to examine the impacts of land reform on manure use by farm households; (ii) it is able to separate the effects of land privatization and land titling; and (iii) by focusing on the Northern Uplands, the study takes into account the specific characteristics of land reform in this particular region.

4. Study Design

4.1. Study Area and Data Collection

The area of the Northern Uplands is approximately 102,000 km^2, a little less than one-third of the area of the country. It borders with China to the North, Laos to the West and South, and is bisected diagonally by the Red River. Much of the region consists of hills and mountains with elevations between 500 m and 1000 m above sea level [82]. Within the whole region, the mountains alone comprise 89,000 square kilometers (82% of the area). Its ethnic diversity is represented by 31 of 54 officially recognized ethnic groups [26]. Although Vietnam has become a big rice exporter, the region still faces food insecurity problems [39]. In terms of land use, 47% is classified as "unused land" [11]. This is the source of land that farmers claimed for cultivation [83]. Thus, at the time of the land reform, in addition to the land areas that had been granted by Resolution 10, farmers in the Northern Uplands had also free claimed landholdings. Therefore, there was a need for land legalization. This is the process of legalizing free claimed landholdings as privatized land. Finally, land titles were provided for privatized land. These factors made land reform in the region more complicated in comparison with other regions of the country [61].

In 1992–1993 and 1997–1998, the government of Vietnam conducted two Vietnam Living Standard Surveys (VLSS) [61]. The aim of these surveys was to provide a systematic collection of data reflecting the actual material and living standards from those households which are selected for the survey

sample and to provide necessary information to meet the needs for analysis of socio-economic policies. The selection of the sample followed a method of stratified random sampling (see SPC [84] and GSO [85] for detailed descriptions of these surveys). The household questionnaire consists of about 700 questions on living conditions, which are grouped into 15 sections: Household roster, education, health, employment, migration, housing, fertility, agricultural production, non-farm economic activities, food expenditure and consumption, non-food expenditure, durable goods, other income, savings and credit, and anthropometric measures. The prices of all goods and services are included in the price questionnaire.

As our aim is to examine the changes in manure use by farm households, the panel data of the VLSS of 1993 and 1998 were combined with further data collection in our primary survey in 2006. Five provinces in the Northern Uplands were selected for this primary survey, namely Hoa Binh, Thai Nguyen, Tuyen Quang, Yen Bai, and Son La (see Figure 4). There were 32 farm households in each of these provinces that had been interviewed in the two VLSS. These households were re-interviewed in 2006. The household questionnaire and price questionnaire were shortened to cover only the variables of interest (see the next subsection). With regard to the land reform, based on the yearly records and statistics at local institutions, the information on privatized land share and land title of farm households was collected. All data were then cross-checked for plausibility and consistency, and corrected if needed with the heads of the surveyed households.

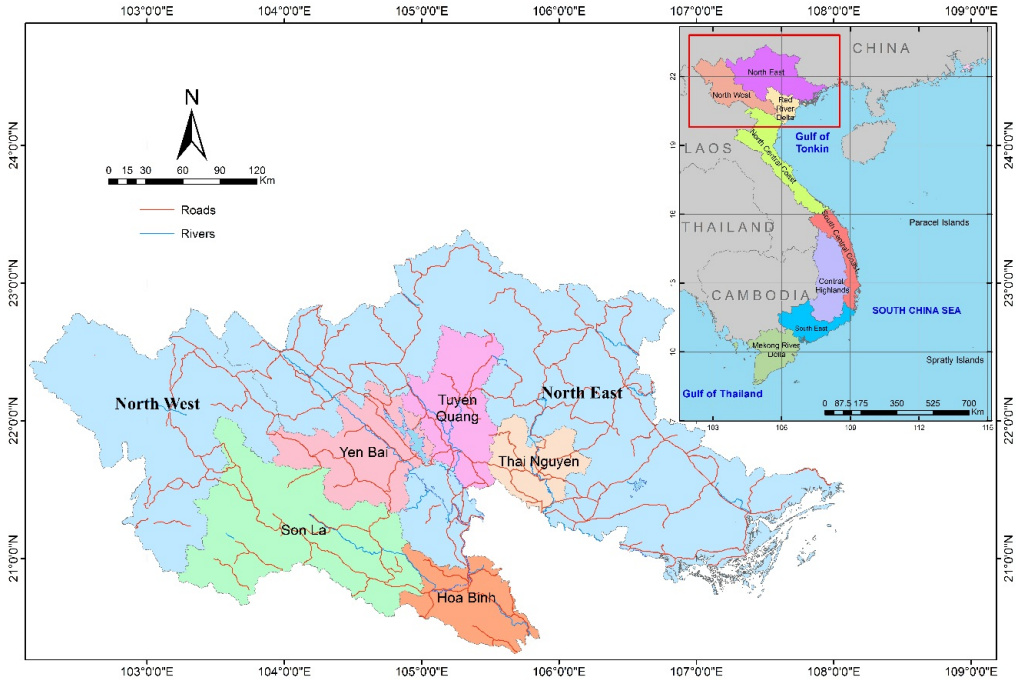

Figure 4. The Northern Uplands and provinces in which the surveys were done.

Although the number of households identified at the beginning of the primary survey was 160 (32 in each province for five provinces), only 133 households were found and agreed to take part in the primary survey. Therefore, a panel dataset for 133 farms in 1993, 1998, and 2006 was established. Panel data provide information on individual behavior, both across time and across individuals, and can enrich empirical analysis in ways that might not be possible with cross-section or time-series data, as panel data provide more information, less collinearity among variables, and more degrees of freedom [86].

4.2. Econometric Specification

In the Northern Uplands, farmers make manure by mixing animal dung with rice straw. It is normally stored in their home gardens until the planting season when it is transported to agricultural

fields. The dependent variable in our econometric model is the quantity of manure use per ha of each household. The independent variables, theoretically, represent household's characteristics, farm endowments, prices of farm inputs and outputs, and land tenure security [64,75]. The relationship can be conceptualized as follows.

$$M_{it} = f\left(H_{it}, L_{it}, I_{it}, O_{it}, S_{it}\right) \quad (1)$$

where M is the quantity of manure use per ha (kg/ha), H is the household's characteristics, L is the land endowment, I is the input price, O is the output price, and S is the land tenure security. The subscripts i and t denote household i in year t.

The household's characteristics include human and financial factors. Human factors are represented by the dependency ratio (dep), which is calculated by dividing the number of dependents (under 16 and over 60 years old) by the number of laborers (from 16 to 60 years old), age (age), education level (educ), ethnicity (ethnic), and gender (gender) of the household head. The financial factors include the value of productive durable assets (hhasset), annual non-farm income (nfin), and a dummy if non-farm income is permanent (nfper). These financial factors represent the financial capability of the households in purchasing farm inputs. Non-farm income is important in crop production. As a result of economic progress in the country, it is expected that the income from non-farm sectors could influence the level of input use. Non-farm activities compete with farming for labor; however, they can increase the purchasing power of the household for other farm inputs such as chemical fertilizers. In this sense, crop production may be more capital and less labor intensive. However, from field observation, we recognize that a household with permanent non-farm income does not invest much in crop production because the household is more food secure and is more interested in investing in other businesses. Some members of the household are permanent workers, teachers, or staff of local institutions. They receive a monthly wage. Thus, a dummy is used to take this into account.

Farm endowments include the farm land area (agland) of the household and the number of cattle and pigs that can provide manure (cattle and pigs are kept in stables). For input prices, as manure is not bought or sold by farmers, we use the prices of chemical fertilizer because this is the input that farmers have to buy and that takes the highest share of farming expenditure (50%, [26]). With respect to the output side, we use the price of rice as a proxy, as rice is the staple food in the region. Since the price data refer to three different years, 1993, 1998, and 2006, the input price index (inpindex) and output price index (outindex) are calculated with 1993 as the base year.

For land tenure security, claimed land must be first legalized by competent authorities as privatized land, and then titled. Thus, a household may cultivate some tracts of land that are not yet legalized. Therefore, two variables, privatized land share (plshare) and land title dummy (title), are used. The privatized land share is the share of privatized agricultural land within the total agricultural land of the farm. The land title dummy indicates if the title of the privatized land is handed over to the farmer. By using these two land reform variables, it is possible to quantify the separate effects of land privatization and land titling. As our data are from three years in five different provinces, two temporal dummies are used for 1998 and 2006, and four spatial dummies are used to take into account the temporal and spatial heterogeneity that are not captured by the above independent variables. All continuous variables are in logarithm (ln) form. Monetary values of non-farm income and household assets are converted to 1994 real values. Therefore, Equation (1) can be further specified as follows.

$$\begin{aligned} \ln\text{manure}_{it} = \alpha \quad & +\beta_1 \ln\text{dep}_{it} + \beta_2 \ln\text{educ}_{it} + \beta_3 \ln\text{age}_{it} + \beta_4 \text{ethnic}_{it} + \beta_5 \text{gender}_{it} \\ & +\beta_6 \ln\text{agland}_{it} + \beta_7 \ln\text{hhasset}_{it} + \beta_8 \ln\text{nfin}_{it} + \beta_9 \text{nfper}_{it} \\ & +\beta_{10} \text{plshare}_{it} + \beta_{11} \text{title}_{it} + \beta_{12} \text{inpindex}_{it} + \beta_{13} \text{outindex}_{it} \\ & +\beta_{14} \text{year}_{1998} + \beta_{15} \text{year}_{2006} + \beta_{16} \text{pro}_2 + \beta_{17} \text{pro}_3 + \beta_{18} \text{pro}_4 \\ & +\beta_{19} \text{pro}_5 + \beta_{20} \ln\text{cattle}_{it} + \propto_{it} \end{aligned} \quad (2)$$

A number of technical challenges in the econometric specification were addressed: (i) the endogeneity of land tenure: the main source of land tenure endogeneity is household's characteristics and land quality. As previously described, the study area is mountainous with poor and rocky soil.

Household's characteristics might thus be a more important source of land tenure endogeneity. At the plot level in Vietnam, Markussen *et al.* [44] conclude that the land title is exogenous. However, it is still plausible that land tenure is endogenous. Therefore, a Hausman specification test [87] was separately performed for the variables plshare and title. The result showed that there are no endogeneity problems; (ii) potential multicollinearity problems between plshare and title and between nfin and nfper. The correlation coefficient between plshare and title was 0.483 and between nfin and nfper was only 0.338, which indicated that there are no multicollinearity problems between these variables; (iii) rich households might have quicker land privatization and titling. This was rejected, as the correlation coefficient between hhasset and plshare was 0.339 and that between hhasset and title was 0.443; (iv) the selection of regression methods for panel data might be an issue. The fixed effect model might be a more appropriate specification than the random effect model for dealing with unobserved time-invariant factors that might be correlated with both land tenure and input demand or productivity. Therefore, a Hausman specification test was conducted and an insignificant *P*-value indicated a similar estimation between the two models; (v) the last challenge was the high number of exogenous variables. The examination of the multicollinearity among these exogenous variables showed that the values of the variance inflation factor of input and output price indices were more than 10. This implies a possible multicollinearity issue for these two variables with other independent variables. Thus, in the empirical analysis, three regression models were examined: (i) full model that includes all these independent variables; (ii) price-excluded model that excludes input and output price indices; and (iii) significant factor model that includes only statistically significant variables and spatial and temporal dummies derived from the full model. It also excludes input and output price indices as in the price-excluded model. The estimated coefficients from these three different models can provide a range of the estimated effects of these factors on the quantity per ha of manure used by farm households.

5. Results and Discussion

5.1. Main Characteristics of Farm Households

The basic characteristics of farm households, as presented in Table 1, show that the household size decreases from 1993 to 2006, but the number of household laborers increases during the same period. There are a number of reasons: (i) the economic growth over years has accelerated the consciousness on reproductive issues and thus reduced the household size; and (ii) some members of the household were still young during the first interview and reached working age in the later interview; and some old members died during the same period. This reduced the dependency ratio. Most household heads are middle-aged. The age has increased from 1993 to 2006. This is because the same households were interviewed. It is noted that in some households, the household head changes over time when one of the sons takes over that role from his father/mother.

Table 1. Main characteristics of farm households.

Characteristic	1993 (1)	1998 (2)	2006 (3)	Test
HH size	5.16 ** 2 *** 3 (1.84)	5.14 ** 1 (1.53)	4.72 *** 1 (1.36)	12.41 *** a
HH labor	2.35 *** 2 *** 3 (0.89)	2.65 *** 1 *** 3 (0.99)	2.92 *** 1 *** 2 (1.05)	28.95 *** b
Dependency ratio	1.31 ** 2 *** 3 (0.80)	1.08 **1 *** 3 (0.65)	0.77 *** 1 *** 2 (0.70)	41.53 *** b
Age (years)	40.7 ** 2 *** 3 (14.27)	43.4 ** 1 *** 3 (13.09)	49.36 *** 1 *** 2 (11.74)	39.47 *** b
Education (years)	5.92 (2.42)	6.12 (2.42)	6.19 (2.37)	0.08 a
Share of male heads (%)	90 (29.81)	89 (30.81)	91 (28.76)	0.17 c

Table 1. *Cont.*

Characteristic	1993 (1)	1998 (2)	2006 (3)	Test
Share of minority heads (%)	70 (46.03)	70 (46.03)	70 (46.03)	0.00 [c]
Asset value (million VND)	2.64 *** [2] *** [3] (0.86)	4.32 *** [1] *** [3] (1.98)	6.72 *** [1] *** [2] (3.28)	180.31 *** [b]
Real non-farm income (million VND)	0.63 *** [2] *** [3] (0.81)	1.64 *** [1] *** [3] (1.53)	2.94 *** [1] *** [2] (3.53)	93.80 *** [b]
Share of HHs with permanent non-farm income (%)	8.27 (27.65)	6.02 * [3] (23.87)	12.78 * [2] (33.52)	3.85 [c]

* Significant at 10%, ** significant at 5%, *** significant at 1%, standard deviations in parentheses, [a] ANOVA test, [b] nonparametric k-sample test (Kruskal-Wallis test), [c] χ^2 test; the superscripts in columns 2, 3, 4 indicate the difference of each respective year to the other years, e.g., the household size in 1993 is significantly different from that in 1998 at 5% significance level according to the ANOVA test; column 5 includes the tests for the difference of all years and shows if at least two years are significantly different from each other.

The education level, in general, is low in the study area. This is because in this remote and mountainous region, low living standards, together with limited access to education, constrain schooling. In general, only primary schools (from class 1 to class 5) are available in villages. The unchanged education level over the years is also due to the fact that all household heads are adults. They have little chance for further education after becoming heads of the households. The change of education level, if it happens, is due to the transfer of the role of the household head from the father/mother to the son, as mentioned above. Regarding gender, most households are male-headed. This is the case in Vietnam in general and in the study area in particular. Traditionally, families are male-headed in Vietnam. Most household heads belong to minority ethnic groups because the study area is the home of different minority ethnic groups. Household non-farm income has increased from 1993 to 1998. This is due to the economic progress that has created wage opportunities for household members. The trend of permanent non-farm income is also similar. The share of the number of households with permanent non-farm income increases from 8% in 1993 to 13% in 2006.

5.2. Farm Land Endowment and Land Reform

The average farm land endowment of a household, as presented in Table 2, shows that the farm land per household decreased from 1993 to 2006; at the same time, the privatized land area increased and the claimed land area decreased. The reduction in farm land per household can be explained by the following: (i) farm land was more abundant in 1993 and was claimed for cultivation; (ii) land privatization was conducted on an egalitarian basis; (iii) land was readjusted among households during the legalization process of claimed land. During this process, part of the claimed land area of large landholders was redistributed to small landholders or newly established households; and (iv) land was divided to heirs.

Table 2. Average farm land endowment of farm households.

Characteristic	1993 (1)	1998 (2)	2006 (3)	Test
Privatized farm land (ha)	0.28 * [2] *** [3] (0.17)	0.34 * [1] *** [3] (0.22)	0.40 *** [1] *** [2] (0.22)	24.190 ***
Claimed farm land (ha)	0.41 *** [2] *** [3] (0.84)	0.29 *** [1] *** [3] (0.61)	0.15 *** [1] *** [2] (0.18)	55.878 ***
Total farm land (ha)	0.69 (0.91)	0.63 (0.71)	0.55 (0.34)	1.939
Farm land per capita (ha)	0.13 (0.12)	0.12 (0.14)	0.12 (0.08)	2.379

* Significant at 10%, ** significant at 5%, *** significant at 1%, standard deviations in parentheses, nonparametric k-sample test (Kruskal-Wallis test); the superscripts in columns 2, 3, 4 indicate the difference of each respective year to the other years, e.g., the household size in 1993 is significantly different from that in 1998 at the 5% significance level according to the Wilcoxon rank sum test; column 5 includes the tests for the difference of all years and shows if at least two years are significantly different from each other.

Table 3 summarizes the progress of land privatization and land titling in the study area. It is noted that farm land had been granted to the households before 1993 in accordance with Resolution 10 (see Section 2). Thus, all sampled households had farm land in 1993. However, none of them had land titles as land titling was only conducted after Land Law 1993. The figures in Table 3 also imply that (i) even with privatized farm land, the land title might not be available due to the time-consuming land titling process. This limits the bundle of land rights to be fully realized; and (ii) in 2006, there is still a portion of farm land that has not been legalized, indicating that the land reform is not yet completed.

Table 3. Progress of land privatization and land titling.

	1993	**1998**	**2006**
Share of HHs with privatized farm land (%)	100 (0.00)	100 (0.00)	100 (0.00)
Share of HHs with title for privatized farm land (%)	0.00 (0.00)	69.92 (46.03)	90.23 (29.81)
Share of privatized land of a HH (%)	51.40 (18.54)	67.19 (23.18)	79.12 (18.50)
Share of titled land of a HH (%)	0.00 (0.00)	57.83 (32.70)	78.64 (20.84)

Standard deviations in parentheses.

5.3. Cattle, Manure Use, Input, and Output Price Indices

The average number of cattle and pigs, manure use, and input and output price indices are presented in Table 4. Cattle and pigs are an indispensable part of the farming systems in the study area [83]. As cattle are expensive, not every household has cattle. Table 4 also shows that the share of households who have cattle and the number of cattle per household is rather low and remains nearly constant over time. This was mainly due to three main constraints farmers faced after renovation: (i) inadequacy of initial investment as purchasing cattle requires a large amount of money; (ii) lack of technical know-how about the treatment of diseases; and (iii) limited grazing area due to the privatization of forest land. In contrast, the number of pigs has increased significantly. Before renovation, pigs had been raised only for home consumption due to limited access to the markets (poor infrastructure and strong control of the government), and low demand due to low income levels. After renovation, the markets for pigs have quickly developed.

Table 4. Livestock and manure use by farm households and price changes.

	1993 (1)	**1998 (2)**	**2006 (3)**	**Test**
Share of HHs having cattle (%)	71.43 (45.35)	66.92 (47.23)	72.93 (44.60)	
No. of cattle per HH	1.74 (2.20)	1.39 (1.57)	1.47 (1.72)	2.069
Share of HHs having pigs (%)	81.20 (39.22)	94.74 (22.41)	88.72 (31.75)	
No. of pigs per HH	1.63 *** 2 *** 3 (1.52)	3.41 *** 1 ** 3 (2.60)	4.62 *** 1 ** 2 (3.98)	77.308 ***
Manure use (ton/ha)	1.31 *** 2 *** 3 (1.79)	3.27 *** 1 *** 3 (2.28)	6.17 *** 1 *** 2 (8.65)	191.685 ***
Input price index	1.00 (0.00)	1.90 (0.28)	2.94 (0.39)	
Output price index	1.00 (0.00)	1.66 (0.12)	2.49 (0.08)	

* Significant at 10%, ** significant at 5%, *** significant at 1%, standard deviations in parentheses, nonparametric k-sample test (Kruskal-Wallis test); the superscripts in columns 2, 3, 4 indicate the difference of each respective year to the other years, e.g., the household size in 1993 is significantly different from that in 1998 at the 5% significance level, according to the Wilcoxon rank sum test; column 5 includes the tests for the difference of all years and shows if at least two years are significantly different from each other.

5.4. Determinants of Manure Use

The results of the full, price-excluded and significant factor models are presented in Table 5. The Wald-chi^2 values show that the presented models are all statistically significant and can be used to explain the variations in manure use by farmers. In all three models, the coefficients of the variables representing land reform, privatized land share, and land title dummy are statistically significant and positive. The results confirm that the land reform has positive effects on the application of manure in crop production by farmers. This finding is consistent with that of Feder *et al.* [29], Hayes *et al.* [79], and Waithaka *et al.* [29]. However, the levels of the influence are different. If privatized land share of a household increases by one percent, the quantity of manure use per ha would increase only slightly; but if a farmer has his or her land title, he or she would use 18% to 22% more manure per ha. Thus, the effect of land title is much higher than that of the privatized land share in the study area. This indicates that having the land title makes farmers more secure than being granted land.

Table 5. Determinants of manure use by farm households.

Random-Effects GLS Dependent Variable: Manure Quantity/ha (ln)	Full Model	Price-Excluded Model	Significant-Factor Model
No. of cattle and pigs (ln)	0.045 *** (0.017)	0.045 *** (0.017)	0.043 *** (0.016)
Dependency ratio (ln)	−0.008 (0.016)	−0.011 (0.016)	
Education (ln)	0.169 *** (0.031)	0.172 *** (0.031)	0.171 *** (0.026)
Age (ln)	−0.079 (0.083)	−0.069 (0.083)	
Ethnicity (Kinh = 1)	0.263 *** (0.052)	0.256 *** (0.052)	0.261 *** (0.050)
Gender (male = 1)	−0.084 (0.076)	−0.099 (0.076)	
Farm land (ln)	−0.855 *** (0.042)	−0.861 *** (0.042)	−0.871 *** (0.041)
Asset value (ln)	−0.001 (0.057)	0.002 (0.057)	
Non-farm income (ln)	−0.042 *** (0.012)	−0.044 *** (0.012)	−0.046 *** (0.011)
Permanent non-farm income (yes = 1)	-0.052 (0.079)	−0.040 (0.078)	
Privatized land share	0.003 ** (0.001)	0.003 ** (0.001)	0.003 *** (0.001)
Land title (yes = 1)	0.200 *** (0.073)	0.168 ** (0.072)	0.174 ** (0.070)
Input price index	0.186 (0.114)		
Output price index	0.536 * (0.286)		
Year 1998 dummy (yes = 1)	0.406 * (0.236)	0.944 *** (0.072)	0.938 *** (0.071)
Year 2006 dummy (yes = 1)	0.336 (0.502)	1.511 *** (0.090)	1.499 *** (0.085)
Province 2 dummy (yes = 1)	−0.090 (0.074)	−0.148 ** (0.070)	−0.159 ** (0.068)
Province 3 dummy (yes = 1)	−0.061 (0.073)	−0.067 (0.073)	−0.073 (0.072)
Province 4 dummy (yes = 1)	0.008 (0.082)	−0.019 (0.080)	−0.021 (0.078)
Province 5 dummy (yes = 1)	−0.058 (0.094)	0.009 (0.083)	0.014 (0.079)
Constant	−1.727 *** (0.464)	−1.054 *** (0.360)	−1.414 *** (0.103)
Wald-chi^2	2267	2238	2246
Prob. > chi^2	0.000	0.000	0.000
R^2 within	0.85	0.85	0.85
R^2 between	0.86	0.86	0.87
R^2 overall	0.86	0.85	0.85

* Significant at 10%, ** significant at 5%, *** significant at 1%; standard errors in parentheses.

In addition, manure use is positively affected by the number of cattle and pigs of farm households. This is logical since households use their own manure. Regarding ethnicity, the dominant ethnic group (the Kinh) applies more manure than the minorities. Manure use has not been the custom of minority ethnic groups in the past even though this has been slowly changing. In the past, ethnic minorities mainly practiced slash and burn agriculture [82]. In general, Kinh farmers apply about 29% more manure per ha than minority ethnic farmers. Education of the household heads contributes positively and significantly to the use of manure. This might be because with a higher education level, farmers better understand the benefits of manure application, including higher outputs and soil conservation. In terms of the gender of the household heads, the evidence shows that there is no statistical difference in manure use between male and female-headed households.

The asset value of the households does not have a statistically significant effect on manure use because farmers do not purchase manure. Non-farm income has a negative and significant effect. This may be due to labor division between livestock rearing and non-farm activities. When household members are busy with non-farm jobs, they have less time for rearing livestock and transporting manure from homesteads to their fields. The evidence also shows that there is no statistically significant linkage between permanent non-farm jobs and manure use. However, agricultural land area has a statistically significant and negative effect. This is understandable since manure comes from home cattle and pigs. Therefore, a small landholding is more manure intensive.

Some spatial and temporal dummies have a significant effect. This indicates that there might be other variables that are omitted from the models. For example, the differences in terms of physical and climatic conditions as well as other socio-economic factors between provinces. This is one of the limitations of our econometric models. In addition, evidence from other countries (see Nguyen *et al.* [88]) shows that land privatization can lead to agricultural intensification, in which the overuse of chemical fertilizers and manure has intensified soil and water pollution. Thus, our results should be interpreted with care. Moreover, the fact that land degradation is still persistent in the study area is an indicator that calls for studies from other disciplines to provide a base of more holistic and comprehensible understanding of the causes of land degradation. For example, studies which measure the organic contents of soils over a long-term period (see Arizpe *et al.* [47]) are needed. The integration of different research methods from all relevant disciplines is increasingly recognized as essentially needed because there is a nexus between land use, water, food, and energy [48,89,90].

6. Conclusions and Policy Implications

Increased land tenure security is theoretically expected to contribute to improved land productivity and soil conservation. However, empirical evidence differs from case to case. This study examines the impact of land privatization and land titling based on a recent land reform in Vietnam. A panel dataset of 133 farm households is used in econometric regression models to determine the factors affecting manure use by farm households in the Northern Uplands. The results of the analysis confirm that increased land tenure security is associated with a higher level of manure use, but land titling has a higher level of impact than land privatization. In addition, manure use by farm households is also significantly affected by the number of cattle and pigs, farm land size, non-farm income, education, and ethnicity of household heads.

These findings lead to a number of policy recommendations. First, the implementation of the land reform should be sped up, as secure land titles are decisive in improving land productivity and soil conservation; second, as the effect of non-farm income is negative, promoting economic growth in non-farm sectors would facilitate economic structural change and allow the establishment of larger farms, which increase the scope for economies of scale; third, developing cattle and pig rearing could also contribute to more manure use in agriculture as its impact is positive; and fourth, enhancing education in the study area is also beneficial to agriculture in particular and to the whole economy in general. This would include the provision of short-term training courses or extension services for ethnic minorities next to schooling to understand the benefits of manure use in farming.

Our research provides useful information from a purely economic point of view. However, this leads to a number of limitations of our research. Firstly, our econometric models are not able to include physical and climatic factors; for example, soil fertility as well as other socio-economic factors such as locally-implemented farm subsidy programs. Secondly, agricultural intensification might lead to negative consequences, such as the overuse of manure, which can pollute soil and water resources. Thirdly, as soil conservation and land degradation are real-life complex issues, a comprehensive understanding of the effects of different bio-physical and socio-economic factors, and of the nexus between land use, water, energy, and food is required. We therefore call for integrated research efforts that combine expertise from different disciplines with different methodological approaches.

Acknowledgments: We acknowledge support by Deutsche Forschungsgemeinschaft and Open Access Publishing Fund of Leibniz Universität Hannover. We thank three anonymous reviewers and the editor for their useful comments.

Author Contributions: Trung Thanh Nguyen wrote the paper, Siegfried Bauer and Ulrike Grote contributed research ideas and read the proofs.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Wauters, E.; Bielders, C.; Poesen, J.; Govers, G.; Mathijs, E. Adoption of soil conservation practices in Belgium: An examination of the theory of planned behaviour in the agri-environmental domain. *Land Use Policy* **2010**, *27*, 86–94. [CrossRef]
2. Lee, L.K. The impact of landownership factors on soil conservation. *Am. J. Agric. Econ.* **1980**, *62*, 1070–1076. [CrossRef]
3. Food and Agriculture Organization of the United Nations (FAO). *Soil Degradation*; FAO: Rome, Italy, 2015. Available online: http://www.fao.org/soils-portal/soil-degradation-restoration/it/ (accessed on 10 October 2015).
4. Kassie, M.; Pender, J.; Yesuf, M.; Kohlin, G.; Bluffstone, R.; Mulugeta, E. Estimating returns to soil conservation adoption in the northern ethiopian highlands. *Agric. Econ.* **2008**, *38*, 213–232. [CrossRef]
5. Bhattacharyya, R.; Ghosh, B.N.; Mishra, P.K.; Mandal, B.; Rao, C.S.; Sarkar, D.; Das, K.; Anil, K.S.; Lalitha, M.; Hati, K.M.; *et al*. Soil degradation in India: Challenges and potential solutions. *Sustainability* **2015**, *7*, 3528–3570. [CrossRef]
6. Food and Agriculture Organization of the United Nations (FAO); Intergovernmental Technical Panel on Soils (ITPS); Status of the World's Soil Resources (SWSR). *Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils*; FAO: Rome, Italy, 2015; Available online: ftp://ext-ftp.fao.org/nr/Data/Upload/SWSR_MATTEO/Main_report/Pdf/web_Soil_Report_Main_001.pdf (accessed on 20 December 2015).
7. Grote, U. Can we improve global food security? A socio-economic and political perspective. *Food Secur.* **2014**, *6*, 187–200. [CrossRef]
8. Alexandratos, N.; Bruinsma, J. *World Agriculture: Towards 2030/2050: The 2012 Revision*; FAO: Rome, Italy, 2012. Available online: http://www.fao.org/docrep/016/ap106e/ap106e.pdf (accessed on 25 January 2016).
9. United Nations (UN). World Population Prospects: The 2012 Revision: Highlights and Advance Tables. 2013. Available online: http://esa.un.org/unpd/wpp/Publications/Files/WPP2012_HIGHLIGHTS.pdf (accessed on 5 November 2015).
10. Food and Agriculture Organization of the United Nations (FAO). The State of Food Insecurity in the World 2012. 2012. Available online: http://www.fao.org/docrep/016/i3027e/i3027e.pdf (accessed on 5 November 2015).
11. Nguyen, T.T.; Pham, V.D.; Tenhunen, J. Linking regional land use and payments for forest hydrological services: A case study of hoa binh reservoir in Vietnam. *Land Use Policy* **2013**, *33*, 130–140. [CrossRef]
12. Nguyen, T.T. Gains and Losses in Ecosystem Services: Trade-off and Efficiency Perspectives. Habilitation Thesis, University of Bayreuth, Bayreuth, Germany, November 2015.
13. Arnhold, S.; Lindner, S.; Lee, B.; Martin, E.; Kettering, J.; Nguyen, T.T.; Koellner, T.; Ok, Y.S.; Huwe, B. Conventional and organic farming: Soil erosion and conservation potential for row crop cultivation. *Geoderma* **2014**, *219–220*, 89–105. [CrossRef]
14. Nguyen, T.T.; Ruidisch, M.; Koellner, T.; Tenhunen, J. Synergies and trade-offs between nitrate leaching and net farm income: The case of nitrogen best management practices in South Korea. *Agric. Ecosyst. Environ.* **2014**, *186*, 160–169. [CrossRef]
15. Le, T.H.S. *Soil Conservation and Sustainable Agriculture: A Case Study of the Coastal Region of Quang Tri Province, Vietnam*; Margraf Publishers: Weikersheim, Germany, 2005.
16. Lambini, C.K.; Nguyen, T.T. A comparative analysis of the effects of institutional property rights on forest livelihoods and forest conditions: Evidence from Ghana and Vietnam. *Forest Policy Econ.* **2014**, *38*, 178–190. [CrossRef]

17. Gomiero, T.; Pettenella, D.; Paoletti, M.G. Is there a need for a more sustainable agriculture? *Crit. Rev. Plant Sci.* **2011**, *30*, 6–23. [CrossRef]
18. Lal, R. Restoring soil quality to mitigate soil degradation. *Sustainability* **2015**, *7*, 5875–5895. [CrossRef]
19. Shively, G. Poverty, consumption risk, and soil conservation. *J. Dev. Econ.* **2001**, *65*, 267–290. [CrossRef]
20. DeLong, C.; Cruse, R.; Wiener, J. The soil degradation paradox: Compromising our resources when we need them the most. *Sustainability* **2015**, *7*, 866–879. [CrossRef]
21. Tang, Q.; He, C.; He, X.; Bao, Y.; Zhong, R.; Wen, A. Farmers' sustainable strategies for soil conservation on sloping arable lands in the upper Yangtze river basin, China. *Sustainability* **2014**, *6*, 4795–4806. [CrossRef]
22. Waithaka, M.M.; Thornton, P.K.; Shepherd, K.D.; Ndiwa, N.N. Factors affecting the use of fertilizers and manure by smallholders: The case of Vihiga, western Kenya. *Nutr. Cycl. Agroecosyst.* **2007**, *78*, 211–224. [CrossRef]
23. Simbizi, M.C.D.; Bennett, R.M.; Zevenbergen, J. Land tenure security: Revisiting and refining the concept for Sub-Saharan Africa's rural poor. *Land Use Policy* **2014**, *36*, 231–238. [CrossRef]
24. Maxell, D.; Wiebe, K. *Land Tenure and Food Security: A Review of Concepts, Evidence, and Methods*; Land Tenure Center Research Paper No. 129; University of Wisconsin-Madison: Madison, WI, USA, 1998.
25. Barrows, R.; Roth, M. Land tenure and investment in African agriculture: Theory and evidence. *J. Modern Afr. Stud.* **1990**, *28*, 265–297. [CrossRef]
26. Nguyen, T.T. Land reform and farm production in the northern uplands of Vietnam. *Asian Econ. J.* **2012**, *26*, 413–421. [CrossRef]
27. Knowler, D.; Bradshaw, B. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy* **2007**, *32*, 25–48. [CrossRef]
28. Mbaga-Semgalawe, Z.; Folmer, H. Household adoption behaviour of improved soil conservation: The case of the North Pare and West Usambara Mountains of Tanzania. *Land Use Policy* **2000**, *17*, 321–336. [CrossRef]
29. Feder, G.; Onchan, T.; Chalamvong, Y.; Hongladarom, C. *Land Policies and Farm Productivity in Thailand*; The Johns Hopkins University Press: Baltimore, MD, USA; London, UK, 1988.
30. Holden, S.T.; Otsuka, K. The roles of land tenure reforms and land markets in the context of population growth and land use intensification in Africa. *Food Policy* **2014**, *48*, 88–97. [CrossRef]
31. Grepperud, G. Soil conservation as an investment in land. *J. Dev. Econ.* **1997**, *54*, 455–467. [CrossRef]
32. Li, G.; Rozelle, S.; Brandt, L. Tenure, land rights, and farmer investment incentives in China. *Agric. Econ.* **1998**, *19*, 63–71. [CrossRef]
33. Deininger, K.; Jin, S. Land sales and rental markets in Transition: Evidence from rural Vietnam. *Oxf. Bull. Econ. Stat.* **2008**, *70*, 67–101. [CrossRef]
34. Michler, J.D.; Shively, G.E. Land tenure, tenure security and farm Efficiency: Panel evidence from the Philippines. *J. Agric. Econ.* **2015**, *66*, 155–169. [CrossRef]
35. Nguyen, T.T.; Do, T.L.; Bühler, D.; Hartje, R.; Grote, U. Rural livelihoods and environmental resource dependence in Cambodia. *Ecol. Econ.* **2015**, *120*, 282–295. [CrossRef]
36. Bromley, D.W. *Making the Commons Work: Theory, Practice, and Policy*; ICS Press: San Francisco, CA, USA, 1992.
37. Scheidel, A.; Giampietro, M.; Ramos-Martin, J. Self-sufficiency or surplus: Conflicting local and national rural development goals in Cambodia. *Land Use Policy* **2013**, *34*, 342–352. [CrossRef]
38. World Bank: Vietnam—Country Brief. Available online: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/VIETNAMEXTN/0,,menuPK:387575~pagePK:141132~piPK:141107~theSitePK:387565,00.html (accessed on 5 November 2015).
39. Nguyen, T.T.; Bauer, S.; Uibrig, H. Land privatization and afforestation incentive of rural farms in the northern uplands of Vietnam. *J. Forest Policy Econ.* **2010**, *12*, 518–526. [CrossRef]
40. Vu, Q.M.; Le, Q.B.; Frossard, E.; Vlek, P.L.G. Socio-economic and biophysical determinants of land degradation in Vietnam: An Integrated causal analysis at the national level. *Land Use Policy* **2014**, *36*, 605–617. [CrossRef]
41. Ravallion, M.; van de Walle, D. *Land Allocation in Vietnam's Agrarian Transition*; Policy Research Working Paper No. 2951; World Bank: Washington, DC, USA, 2003.
42. Orden, D.; Cheng, F.; Nguyen, H.; Grote, U.; Thomas, M.; Mullen, K.; Sun, D. *Agricultural Producer Support Estimates for Developing Countries: Measurement Issues and Evidence from India, Indonesia, China, and Vietnam*; IFPRI Research Report 152; International Food Policy Research Institute: Washington, DC, USA, 2007.

43. Do, Q.T.; Iyer, L. Land titling and rural transition in Vietnam. *Econ. Dev. Cult. Chang.* **2008**, *56*, 531–579. [CrossRef]
44. Markussen, T.; Tarp, F.; van den Broeck, K. The forgotten property rights: Evidence on land use rights in Vietnam. *World Dev.* **2011**, *39*, 839–850. [CrossRef]
45. Saint-Macary, C.; Keil, A.; Zeller, M.; Heidhues, F.; Dung, P.T.M. Land titling policy and soil conservation in the northern uplands of Vietnam. *Land Use Policy* **2010**, *27*, 611–627. [CrossRef]
46. Gomiero, T.; Giampietro, M. Multiple-scale integrated analysis of farming systems: The Thuong lo commune (Vietnamese uplands) case study. *Popul. Environ.* **2001**, *22*, 315–352. [CrossRef]
47. Arizpe, N.; Ramos-Martín, J.; Giampietro, M. An assessment of the metabolic profile implied by agricultural change in two rural communities in the North of Argentina. *Environ. Dev. Sustain.* **2014**, *16*, 903–924. [CrossRef]
48. Flammini, A.; Puri, M.; Pluschke, L.; Dubois, O. *Walking the Nexus Talk: Assessing the Water-Energy-Food Nexus in the Context of the Sustainable Energy for All Initiative*; Environment and Natural Resources Working Paper No. 58; FAO: Rome, Italy, 2014.
49. Adger, W.N. *Evolutionary and Ecological Economics of Land Use and Climate in Vietnam*; CSERGE Working Paper GEC 98-14; Centre for Social and Economic Research on the Global Environment, University of East Anglia: Norwich, UK, 1998.
50. Wiegersma, N. *Vietnam: Peasant Land, Peasant Revolution: Patriarchy and Collectivity in the Rural Economy*; St. Martin's Press: New York, NY, USA, 1988.
51. Nguyen, T.H. *Economic Development of Socialist Vietnam, 1955–1980*; Praeger Special Studies: New York, NY, UAS, 1977.
52. Pham, X.N.; Be, V.D.; Hainsworth, G.B. *Rural Development in Vietnam: The Search for Sustainable Development*; Social Sciences Publishing House: Hanoi, Vietnam, 1999. (In Vietnamese)
53. Phuc, V.H. *Studying the Land System in Vietnam during the First Half of the 19th Century*; Social Sciences Publishing House: Hanoi, Vietnam, 1979. (In Vietnamese)
54. Vo, T.X.; Pingali, P.L. Vietnam: De-collectivization and rice productivity growth. *Econ. Dev. Cult. Chang.* **1992**, *40*, 697–718.
55. Brenier, H. Essai d'atlas statistique de l'Indochine Francaisse. *Bull. l'École Fr. d'Extrême-Orient* **1914**, *14*, 7–8. (in French)
56. Henry, Y. *L'Economie agricole de l'Inochine*; Imprimerie d'Extrême-Orient: Hanoi, Vietnam, 1932. (In French)
57. Gittinger, J.P. Communist land policy in North Vietnam. *Far East. Surv.* **1959**, *28*, 113–126. [CrossRef]
58. Fforde, A. *Coping with the State: Peasant Strategies in North Vietnam*; Discussion Paper No. 155; Birkbeck, University of London: London, UK, 1984.
59. Hendry, J.B. Land tenure in South Vietnam. *Econ. Dev. Cult. Chang.* **1960**, *9*, 27–44. [CrossRef]
60. International Rice Research Institute (IRRI). *World Rice Statistics 1987*; IRRI: Los Banos, Philippines, 1988.
61. Nguyen, T.T. *The Impact of Land Reform on Farm Households in the Northern Uplands of Vietnam*; Margraf Publishers: Weikersheim, Germany, 2008.
62. Schlager, E.; Ostrom, E. Property-rights regimes and natural resources: A conceptual analysis. *Land Econ.* **1992**, *68*, 249–262. [CrossRef]
63. Libecap, G.D. Property rights in economic history: Implication for research. *Explor. Econ. Hist.* **1986**, *23*, 227–252. [CrossRef]
64. Demsetz, H. Towards a theory of property rights. *Am. Econ. Rev.* **1967**, *57*, 347–359.
65. Food and Agriculture Organization of the United Nations (FAO). *Land Tenure Studies 3: Land Tenure and Rural Development*; FAO: Rome, Italy, 2002; Available online: http://www.fao.org/docrep/005/y4307e/y4307e00.htm (accessed on 5 November 2015).
66. Thiesenhusen, W. Review: Land reform lives. *Eur. J. Dev. Res.* **1995**, *7*, 193–209. [CrossRef]
67. Montaner-Larson, J.B. An Economic Analysis of Land Titling in Honduras. Ph.D. Thesis, Worcester College, Oxford, UK, 1995. Available online: http://ora.ox.ac.uk/objects/uuid:be8d5f2d-f676-45f1-8e3f-2b2a7f49b4e0 (accessed on 5 November 2015).
68. Besley, T. Property rights and investment incentives: Theory and evidence from Ghana. *J. Political Econ.* **1995**, *103*, 903–937. [CrossRef]
69. Platteau, J.P. The evolutionary theory of land rights as applied to Sub-Saharan Africa: A critical assessment. *Dev. Chang.* **1996**, *27*, 29–86. [CrossRef]

70. Robinson, B.E.; Holland, M.B.; Naughton-Treves, L. Does secure land tenure save forests? A meta-analysis of the relationship between land tenure and tropical deforestation. *Glob. Environ. Chang.* **2014**, *29*, 281–293. [CrossRef]
71. Sjaastad, E.; Cousins, B. Formalisation of land rights in the South: An overview. *Land Use Policy* **2008**, *26*, 1–9. [CrossRef]
72. Kabubo-Mariara, J. Land conservation and tenure security in Kenya: Boserup's hypothesis's revisited. *Ecol. Econ.* **2007**, *64*, 25–35. [CrossRef]
73. Place, F.; Migot-Adholla, S.E. The economic effects of land registration on smallholder farms in Kenya: Evidence from Nyeri and Kakamega districts. *Land Econ.* **1998**, *74*, 360–373. [CrossRef]
74. Nguyen, T.T. Land reform and farm land rental market operation in the northern uplands of Vietnam. *Econ. Appl. Inform.* **2009**, *1*, 153–160.
75. Duangjai, W.; Schmidt-Vogt, D.; Shrestha, R.P. Farmers' land use decision-making in the context of changing land and conservation policies: A case study of Doi Mae Salong in Chiang Rai Province, Northern Thailand. *Land Use Policy* **2015**, *48*, 179–189. [CrossRef]
76. Marenya, P.; Barrett, C. Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food Policy* **2007**, *32*, 515–536. [CrossRef]
77. Lopez, R. *Land Titles and Farm Productivity in Honduras*; Unpublished Draft; University of Maryland, College Park: College Park, MD, USA, 1995.
78. Carter, M.; Wiebe, K.; Blarel, B. *Tenure Security for Whom? Differential Impacts of Land Policy in Kenya*; Land Tenure Center Research Paper No. 106; University of Wisconsin-Madison: Madison, WI, USA, 1991.
79. Hayes, J.; Roth, M.; Zepeda, L. Tenure security, investment and productivity in Gambian agriculture: A generalized probit analysis. *Am. J. Agric. Econ.* **1997**, *79*, 369–382. [CrossRef]
80. Place, F.; Hazell, P. Productivity effects of indigenous land tenure systems in Sub-Saharan Africa. *Am. J. Agric. Econ.* **1993**, *75*, 10–19. [CrossRef]
81. Nguyen, T.T.; Koellner, T.; Le, Q.B.; Lambini, C.L.; Choi, I.; Shin, H.; Pham, V.D. An economic analysis of reforestation with a native tree species: The case of Vietnamese farmers. *Biodivers. Conserv.* **2014**, *23*, 811–830. [CrossRef]
82. Ayanu, Y.Z.; Nguyen, T.T.; Marohn, C.; Koellner, T. Crop production *versus* surface water regulation services: Assessing trade-offs for land use scenarios in the tat hamlet watershed of vietnam. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag.* **2011**, *7*, 231–244. [CrossRef]
83. Gomiero, T.; Pettenella, D.; Phan, T.G.; Paoletti, M.G. Vietnamese uplands: Environmental and socio-economic perspective of forest land allocation and deforestation process. *Environ. Dev. Sustain.* **2000**, *2*, 119–142. [CrossRef]
84. State Planning Committee (SPC). *Vietnam Living Standards Survey 1992–1993*; SPC: Hanoi, Vietnam, 1994.
85. General Statistics Office (GSO). *Vietnam Living Standards Survey 1997–1998*; GSO: Hanoi, Vietnam, 2000.
86. Baltagi, B.H. *Economic Analysis of Panel Data*, 1st ed.; John Wiley and Sons: New York, NY, USA, 1995.
87. Hausman, J.A. Specification tests in econometrics. *Econometrica* **1978**, *46*, 1251–1271.
88. Thanh Nguyen, T.; Hoang, N.N.; Seo, B. Cost and environmental efficiency of rice farms in South Korea. *Agric. Econ.* **2012**, *43*, 369–378. [CrossRef]
89. Madrid-Lopez, C.; Cadillo-Benalcazar, J.; Diaz-Maurin, F.; Kovacic, Z.; Serrano-Tovar, T.; Gomiero, T.; Giampietro, M.; Aspinall, R.; Ramos-Martin, J.; Bukkens, S.G.F. Punjab state, India. In *Resource Accounting for Sustainability Assessment: The Nexus between Energy, Food, Water and Land Use*; Giampietro, M., Aspinall, R., Ramos-Martin, J., Bukkens, S.G.F., Eds.; Taylor & Francis: Abingdon, UK, 2014; pp. 181–193.
90. Giampietro, M.; Richard, J.; Aspinall, R.; Bukkens, S.G.F.; Benalcazar, J.C.; Diaz-Maurin, F.; Flammini, A.; Gomiero, T.; Kovacic, Z.; Madrid, C.; *et al*. *An Innovative Accounting Framework for the Food-Energy-Water Nexus: Application of the MuSIASEM Approach to Three Case Studies*; Environment and Natural Resources Working Paper No. 56; FAO: Rome, Italy, 2013.