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Protecting Rice Land in Vietnam: What's Optimal?

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Abstract

Agricultural land preservation (ALP) is a common policy response to growing food-security concerns driven by urbanisation, population growth and climate change uncertainty. However ALP restricts land use flexibility, hence overprotection might affect economic efficiency and prosperity. Examining rice land policy in Vietnam, this paper aims to determine the optimal level of rice land protection. Using a combination of an optimisation routine, stochastic general equilibrium modelling and microsimulation techniques, applied to Vietnam's social accounting matrix table for 2011 and household survey data for 2010, we find that converting some protected rice land into other crops enhances both economic efficiency and overall equality. While the efficiency gain could amount to nearly 6 billion $US over 20 years at the optimal conversion rate, the impact on overall equality is modest with the poorest quintile worse-off, implying a trade-off between poverty reduction and economic growth. Though our model is calibrated to a specific case, we contend that this approach could be applied in other situations where governments seek for policy parameters.

Keywords: farm land protection, general equilibrium, rice production, inequality, Vietnam

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1. Introduction

Agricultural land preservation (ALP) is applied in many countries in their transition to more modern and industrialised economies. Rapid urbanisation, which is inevitable and often necessary for economic development, generally affects the supply of prime agricultural land (Nelson, 1990; Firman, 2000; Lichtenberg and Ding, 2008; Kong, 2014). In combination with urbanisation, rapid population growth, slow improvements in agricultural productivity and reductions in land suitable for agricultural cultivation due to the effects of climate change, all lead to serious concerns over food security (Godfray et al., 2010; Fazal, 2001). In this context, interventions by governments to preserve agricultural land are often recommended to cope with the decrease in farmland and to guard against uncertainties in the future (Azadi et al., 2011). This recommendation is justified on the grounds of problems that accompany the socio-economic impacts by farmland losses, to rural households in particular, and the presence of multiple land market imperfections that prevent efficient consolidation of farm land in the first place, especially in transitional economies (Nelson, 1990; Deininger et al., 2003).

The existing literature suggests that land policies are both contextual and highly complex (Deininger et al., 2003). High heterogeneity in ALP policy is observed due the differences in the level of development, along with differences in political systems, institutions, history and the extent of agricultural land scarcity in each country (Alterman, 1997; Tan et al., 2009; Bengston et al., 2004; Lichtenberg and Ding, 2008). In spite of this heterogeneity, ALP policies are generally imposed in an arbitrary manner, with basic decrees of how much agricultural land should be protected.

We look at a special case of ALP where land is protected for the production of a particular crop against that of all other agricultural crops. This case is not uncommon in many transition countries where a given crop is of high economic and political significance. Examples are protection of rice land in Southeast and East Asian countries (Markussen et al., 2011; Giesecke et al., 2013; Kurosaki, 2008; Martini and Kimura, 2009; Brandt et al., 2002), or the protection of cotton land in Central Asian countries (Halimova, 2007). While protection measures vary, ranging from restrictions imposed on land use as in Vietnam and Myanmar, to ad-hoc government decisions against production of other products as in Thailand, or heavy subsidies provided to farmers as in Japan, all measures aim to protect land for a particular crop. Unfortunately, the target of how much land is to be protected is not, at least apparently, underpinned by rigorous analyses. Existing literature often focuses, instead, on measuring how much land has been lost (Pandey and Seto, 2015; Gibson et al., 2015), and the impact of land preservation policies (Giesecke et al., 2013; Markussen et al., 2011; Lichtenberg and Ding, 2008; Nielsen, 2003). While there are good reasons to preserve land, it is important to determine the amount of land to be preserved for equality and efficiency reasons; to be determine what is best for land protection. The absence of optimisation exercises on these policies might be explained by the difficulty in quantifying and evaluating alternative land uses, as well as modelling these effects explicitly, let alone putting them in an optimisation framework.

We focus on the case of rice land protection in Vietnam. This case is interesting for a number of reasons. First, rice land played an important role for political survival in Vietnam in the last century (Kerkvliet, 1997), thereby attracting a good deal of attention and cultural concern. Second, rice-related policies have wide-spread impacts on living standards in Vietnam, given that rice remains the main staple food, especially for the poor, and that rice production itself involves about two thirds of rural households (Vu, 2008). Indeed, recent fast economic growth in Vietnam, achieved with impressive poverty reduction and little increase in inequality, has largely been achieved thanks to equal (rice) land redistribution in the early years of the economic reform process, which started in 1986. Third, like many developing countries, Vietnam is currently under enormous pressure to use land more efficiently to enhance economic growth and feed its population, whose diet is shifting towards meat as their income increases (Kompas et al., 2015). Land protection for rice against other crops can result in high inefficiency in the economy, as seen in the import value of animal feed ingredients such as corn and cassava being roughly equal to the export value of rice (DCP, 2013), and large amounts of rice land being left idle due to low incomes from rice production, compared to higher returns and land shortages for other crops (VOV, 2013; Markussen et al., 2011; Tien et al., 2006). A recent government decision to protect 7.0 million hectares of cultivated rice land (equivalent to 3.8 million hectares of rice land) (Resolution 17/2011/QH13), out of the current 7.7 million hectares of cultivated land (General Statistic Office, 2013), raises concerns over the arbitrary nature of this decision and what it is achieving.

To address these concerns, we use a combination of optimization methods, general equilibrium modelling and microsimulation techniques to find out how much rice land should be protected and thus not used for other crops. The application of a general equilibrium (GE) model is relevant in this case since land allocation has a economy-wide impact. However, GE analysis by itself is not enough to answer the question of 'how much conversion' is optimal since GE models can only generate a particular outcome(s) associated with a given policy scenario. Therefore, an overlay of an optimisation routine on top of the GE modelling is needed to find the best policy outcome. The best policy scenario in our case is selected based on changes in efficiency measured by Gross Domestic Product (GDP) and inequality measured by a GINI coefficient, since Vietnam is a market-oriented socialist country where changes in inequality are a fundamental part of the decisions that are made. Finally, we analyse distributional impacts of the best policy scenario using microsimulations of GE model outcomes in terms of effects on prices to households, along with variations in income and consumption, to find out changes in the sum of household consumer and producer surpluses induced by these changes in prices.

Our results are generated using Vietnam's social accounting matrix table for 2011 and household survey data for 2010. We find that conversion of some protected rice land into other annual crops enhances equality, though slightly, and a 19% conversion rate or a release of 1.46 million hectare of protected cultivated rice land to other crops results in the highest efficiency gain in Vietnam's economy. Whilst not pro-poor, at least for the poorest quintile, this policy implies an important trade-off between poverty reduction and economic growth for Vietnam in its course of transforming and modernizing its rural economy to increase rural incomes and enhance economic development.

The method we use and the results we obtain are novel, while providing important insights on rice land protection in Vietnam itself. There are two main differences with the literature in this regard. First, in most studies, the use of partial equilibrium modelling (e.g.,Markussen et al. (2011)), only gives information on the impact of land protection policy on household income and behaviour. Producer effects, especially for cases where households are both consumers and producers, and overall growth effects, are not accounted for. Second, studies which use a CGE framework only, such as the ones by Giesecke et al. (2013); Nielsen (2003), can only give the impact of a particular case of land conversion, and are not able to answer the question of how much land is best protected for rice production.

2. Background

2.1. Agricultural land protection in the world

Agricultural land protection has been implemented in many countries in the world, especially during their periods of transitional economic development and rapid population growth. This implementation is largely driven by concerns over food security and sustainable environmental management due to the pressures of population growth, rapid urbanization and the effects of climate change (Godfray et al., 2010). The fear that rapid population growth might outstrip global food production capacity is an old one; dating back to the third century AD, popularised as Malthusianism doctrine in the late eighteenth century and revived as 'neo-Malthusian' doctrine in the 1950-1970s (Alexandratos and Bruinsma, 2012). This fear basically centres on the population-land equation and highlights the need for increased productivity with constrained farm land and its alternative uses (Bunce, 1998). Furthermore, a shift in diet towards meat, dairy and fish, due to the increasing wealth of the population has added considerable pressure on food supply system (Alexandratos and Bruinsma, 2012), and away from basic cropping. Urbanization has increased these concerns and is closely linked to economic development and the loss of farm land with growing urban populations and industrialisation (Montgomery et al., 2003) . Since urbanization increases the demand for infrastructure, housing and investment, in other words, it generally causes significant agricultural land conversion (Ho and Lin, 2004; Fazal, 2001; Firman, 2000; Nelson, 1992), with the highest quality land near urban areas usually among the first that are lost. Urbanization, of course, has also encouraged searches for rising agricultural productivity on land that remains for agricultural production, growing demands for urban labour, and enhanced transportation networks and connections within and between countries (UN, 2015). Finally, recent evidence clearly suggests that climate has adverse consequences on food production, especially in tropical areas, and that adaptation measures may also greatly affect the food system (IPCC, 2007; Schmidhuber and Tubiello, 2007).

Although there are many good reasons to protect agricultural land at some point in an economy's development process, countries differ in their ALP policies, due to differences in social and economic situations, political systems, as well as the extent of agricultural land scarcity (Alterman, 1997; Bengston et al., 2004; Lichtenberg and Ding, 2008; Tan et al., 2009). In particular, comparing six developed countries, Alterman (1997) suggests that stringent legal controls alone are not enough to protect land, and there is no clear relationship between the degree of success in land preservation and any particular format for land planning. Alterman (1997) also finds that achievements in farmland preservation in the Netherlands and the UK are due in part to their: (i) overt redefinition of farmland preservation as countryside preservation, (ii) wide and resilient public support, (iii) national planning that is driven, shared and applied effectively by local and regional planning authorities; (vi) containment of urban growth by using 'infill policies' and high density housing; and (v) central determinination of the number of size of local governments. Further comparisons of experience in ALP policies between developing and developed countries is made by Tan et al. (2009). Here, it's argued that while the cost of farmland conversion in China is minimized due to substantial central administrative power, the top-down approach results in high illegal conversion rates and less efficient allocation of resources due to the lack of local control, public participation and transparency over information, as compared with the polices implemented in the Netherlands and Germany.

2.2. Rice and rice land protection in the world

Rice has a special position in many Asian countries. Therefore, government interventions and distortions in rice production, marketing and exports are prevalent in this region, making the world rice market and its relative control by a handful of countries in this part of the world more vulnerable to shocks (Timmer, 2010; David and Huang, 1996). In spite of these interventions, there are only two countries, Vietnam and Myanmar, that have strict control over the use of rice land. Here, farmers cannot plant any crop other than rice in rice designated land without having permission from local government. This land policy, coined as 'land designation policy' by Giesecke et al. (2013), partly contributes to low income for rice farmers in Myanmar (Fujita et al., 2009). Since Vietnam is more developed than Myanmar, this policy seems to cause additional problems for Vietnamese farmers. In particular, the apparent difference in rental rates of different types of agricultural land results in high inefficiency due to farmers' inability to choose crops to maximise their profit, thus leaving some rice land idle, with Vietnam's rice sector not responding well to market signals (VOV, 2013; Markussen et al., 2011; Tien et al., 2006).

The desire to protect rice land also exists in other Asian countries but the measures applied and the extent of success differ. Japan is highly successful in maintaining rice land by providing heavy subsidies to farmers. These subsidies, however, result in the lack of competitiveness of the rice sector in Japan and high fiscal burden (Martini and Kimura, 2009). Indonesia, on the other hand, has found it difficult to control land conversion due to rapid urbanization and lack of effective counter-measures (Firman, 2000). China is highly successful in agricultural land protection in terms of its quantity but fails in terms of quality. Indeed, the loss of quality arable land, which is largely in coastal regions in China, ones that best suit rice cultivation, is substantial, thus causing concerns over national food security (Mao et al., 2012; Kong, 2014).

2.3. Rice and rice land protection in Vietnam

Rice is a special economic commodity in Vietnam for a three reasons. First, it is the main staple food in the Vietnamese diet, accounting for 60% and 25% of household calorie consumption and food expenditure, respectively (Vu, 2008). It is especially important for the poor since the shares of rice in their calorie intake and food expenditure are about 70% and 40%, respectively (Vu, 2008). Second, rice production involves about 66% of rural and 77% of the poorest quintile households (Ha et al., 2015). Third, rice export revenues contribute about 3% of total GDP (General Statistic Office, 2009), and still remains as one of the more important contributions to Vietnam's foreign reserves, especially when the county shifted from being a net food importer to being the second rice exporter in the world, a few years after it embarked on its agricultural reform policy.

Rice is of particular political importance for any Vietnamese government. It is an integral part of Vietnamese culture and history, often deemed a 'rice civilization' in the past. Rice was used by the current ruling Communist Party to gain broad-based support against the French colonists in a war that led to the independence of Vietnam in 1945. For its role in the culture and history of Vietnam, golden rice paddy panicles are part of Vietnam's national coat of arms. In short, the formulation of appropriate rice-related policies is important not only for economic development, but also to political and social stability in Vietnam due to the economic and political significance of rice.

Unsuccessful experience in collectivised agriculture for more than two decades in the North and six years in the South put Vietnam in an economic crisis. With all means of production under collective use, agricultural output fell sharply due to the lack of incentives for farmers to exert their effort and capture profits (Pingali and Xuan, 1992; Che et al., 2001; Kompas et al., 2012). Part of the reform process and the transition to a market economy was the promulgation of 1988, 1993 and 2003 land laws and their subsequent revisions in 1998 and 2001, and the most recent land law 2013. Although land users are always required to use land as per their 'land use purpose' and the state reserves the right to monitor, change or grant permission to any changes to land use, rice land was not explicitly specified in any land laws until the 2001 revision (Article 1, point #8). Before that, rice land is implicitly lumped together under the agricultural land or annual crop agricultural land designations. Quantitative indicators of rice land protection including the protection of 3.8

million hectare rice land for a output of 41-43 million paddy rice/year, are fully articulated in Decree No. 63/NQ-CP, issued in 2009 with an aim to ensure food security for Vietnam by 2030. Furthermore, Resolution 17/2011/QH13 issued in 2011 specifies that 3.2 out of 3.8 million hectare protected rice land must be land where (at least) two crops of rice are cultivated annually, implying a total of 7 million hectare of cultivated rice land. To facilitate this rice land protection, Decree 35/2015/ND-CP specifies measures to support (or not) rice farmers and procedures for conversion of rice land to other agricultural crops or production activities.

This rice land protection has been largely successful in protecting rice land in Vietnam. Cultivated rice land in Vietnam has remained stable at roughly 7.5 million hectare since 2001 (General Statistic Office, 2013). However, this rice land protection policy, together with various kinds of support and subsidies provided to rice farmers, results in inefficiency. In particular, too much land is used for rice production while domestic demand for rice falls as household living standards have increased, and rice farmers cannot maximise their profit due to the lack of freedom in crop choice. Rice production is also not highly responsive to market signals as a result.

3. Methodology

To answer the question how much rice land should be protected, we use a combination of optimization methods, GE modelling and microsimulation techniques. GE modelling gives us information about changes in GDP as well as information on changes in prices. A rice land protection rate, or equivalently, the conversion rate of rice land into other crop lands (referred as the 'conversion rate' for short) that gives the highest gain in the real GDP over a planning horizon $\boldsymbol{T}$ years, is defined as the optimal one. Changes in prices from the GE model are then simulated on household survey data to calculate changes in GINI for each level of rice land protection and the distribution effects of the optimal policy. Finally, we calculate the rate of land conversion for each of six regions in Vietnam.

Vietnam currently has about 7.7 million hectare of rice cultivated land. At this level, there is inefficiency in land use as evident in rice land being left idle and clear households dissatisfaction in their crop choices due to the restrictions on land use (Markussen et al., 2011). Therefore, there is no need to model the case where more rice land needs to be protected. We vary the conversion rate from 0% to 40% as our estimated minimum requirement for rice land to ensure rice sufficiency in Vietnam by 2050 is 60% of the current rice cultivated land. This estimate is made based on estimates of the current consumption (IRRI, 2016), population in 2050 projected by (FAO, 2016) and rice yield and rice cultivated area of Vietnam in 2012 (General Statistic Office, 2013)[1].

3.1. GE modelling: measuring gross domestic product

Since land conversion might have both economy-wide and dynamic impacts, we choose to use a dynamic open-economy general equilibrium model to evaluate the impact on real GDP. The GE structure consists of 12 sectors, namely: (i) rice production, (ii) non-rice crops production that includes other staple food and vegetables such as maize, potatoes, cassava, beans, cabbage, etc., and annual industrial crops such as tobacco, sugarcane, cotton, (iii) domestic production of all remaining commodities in the economy, (iv) capital, (v) labor, (vi) rice land , (vii) land for non-rice crops, (viii) land for other production activities, (ix) government, (x) household consumer, (xi) investment, and (xii) international trade including exports and imports.

Commodity producers are assumed to be price-takers, operating in competitive markets which prevent the earning of pure profits. With the subscript t for the values at time t, for all possibly time-varying variables, we use q_t^i as a scalar quantity produced for commodity i where $i \in \{rice, non-ricecrops, others\}$ and Q_t^i is 3-dimensional (column) vector of quantities of the three commodities demanded (as intermediate inputs) for producing q_t^i. We denote the set of primary factors, $F_t^i \equiv [K_t^i, N_t^i, L_t^i]'$, where $'$ is the transpose operator, K^i is capital, N_t^i is labor, and L_t^i is a particular type of land used to produce q_t^i. Here, capital

[1]That is, (145.31kg rice/person × 112.783 million people)/0.7 = 23.412 million tons of paddy. The total rice land cultivated area is 23.412 million tons of paddy / 5.6 ton of paddy per cultivated hectare = 4.151 million hectare of cultivated rice land. This minimum requirement for rice land to ensure rice sufficiency in Vietnam is equivalent of 52.5% of the current cultivated rice area of 7.9 million hectare. We rounded the figure to 60% to take into account the impact of climate change on soil suitability and possible natural disasters.

and labor are assumed to be mobile across sectors while land is designated for producing a specific commodity due to legal requirements and soil suitability. We denote M_t^i as a scalar of aggregate imported commodity input. Using a Constant Elasticity of Substitution (CES) technology, the production of q_t^i can be expressed as:

$$\begin{aligned} q_i &= f^i(Q_t^i, F_t^i, M_t^i) \\ &= \boldsymbol{A_i}\Big([\boldsymbol{\alpha_i}]'[Q_t^i]^{(\boldsymbol{\sigma_i}-1)/\boldsymbol{\sigma_i}} + [\boldsymbol{\beta_i}]'[F_t^i]^{(\boldsymbol{\sigma_i}-1)/\boldsymbol{\sigma_i}} + [\boldsymbol{\gamma_i}]'[M_t^i]^{(\boldsymbol{\sigma_i}-1)/\boldsymbol{\sigma_i}}\Big)^{\boldsymbol{\sigma_i}/(\boldsymbol{\sigma_i}-1)} \end{aligned} \tag{1}$$

where $\boldsymbol{\alpha_i}$, $\boldsymbol{\beta_i}$, $\boldsymbol{\gamma_i}$ (we use bold letters for parameters and normal letters for variables) are the (relevant-sized vector of the) coefficients for the inputs, $\boldsymbol{A^i}$ measures total factor productivity (TFP) which, without the loss of generality, can be always be normalized such that $\sum \boldsymbol{\alpha_i} + \sum \boldsymbol{\beta_i} + \boldsymbol{\gamma_i} = 1$ and $\boldsymbol{\sigma_i}$ is the CES coefficient for industry i. The CES functional form here implies that inputs demanded can be substituted for one another depending on their prices and the elasticities of substitution between them.

Accordingly, the conditional input demand for intermediate commodities and primary factors of industry i is derived by minimising the level of inputs required to produce q_t^i, depending on the prices of those intermediate commodities, primary factors and q_t^i itself such as:

$$\begin{aligned} [Q_t^i, F_t^i, M_t^i] = argmin\{[w_t^Q]'Q_t^i + [w_t^{F^i}]'F_t^i + w_t^M M_t^i]\} \\ \text{subject to } f^i(Q_t^i, F_t^i, M_t^i) = q_t^i \end{aligned} \tag{2}$$

where $w_t^Q \equiv [w_t^{Rice}, w_t^{NonRice}, w_t^{Others}]'$, $w_t^{F^i} \equiv [w_t^K, w_t^N, w_t^{L^i}]'$ and w_t^M represent the prices of the commodities, the factors of production and the imported good.

Household demand follows from maximizing utility given a budget constraint. Since there is a substantial difference in the price elasticity and its substitutability between rice and non-rice crops, versus other and imported commodities, we use a double-layered CES utility function to model household demand. The household demands for the three domestic

$Q_t^H \equiv [H_t^{Rice}, H_t^{NonRice}, H_t^{Others}]'$ and one imported good M_t^H are defined as follows:

$$\begin{aligned}
&[Q_t^H, M_t^H] = argmax\Big(\boldsymbol{\alpha_H} v_1^{(\boldsymbol{\sigma^H}-1)/\boldsymbol{\sigma^H}} + (1-\boldsymbol{\alpha_H}) v_2^{(\boldsymbol{\sigma^H}-1)/\boldsymbol{\sigma^H}}\Big)^{\boldsymbol{\sigma^H}/(\boldsymbol{\sigma^H}-1)} \\
&\text{subject to} \quad [w_t^Q]' Q_t^H + w_t^M M_t^H \leq y_t^H (1 - \boldsymbol{s^{g_G}} - \boldsymbol{s^{h_S}}) \\
&\text{with } v_1 = (H_t^{Rice} - \boldsymbol{\bar{H}_t^{Rice}})^{\boldsymbol{\beta_h}} (H_t^{NonRice} - \boldsymbol{\bar{H}_t^{NonRice}})^{1-\boldsymbol{\beta_h}} \\
&\text{and } v_2 = (H_t^{Other} - \boldsymbol{\bar{H}_t^{Other}})^{\boldsymbol{\gamma_h}} (M_t^H - \boldsymbol{\bar{M}_t^H})^{1-\boldsymbol{\gamma_h}}
\end{aligned} \tag{3}$$

where v_1 is a composite necessity good with Stone-Geary utility from rice and non-rice with respective shares $(\boldsymbol{\beta^H}, 1-\boldsymbol{\beta^H})$ reflecting the assumption that households always consume a basic time-varying subsistence bundle $(\boldsymbol{\bar{H}_t^{Rice}}, \boldsymbol{\bar{H}_t^{NonRice}})$ regardless of their budget and the prices of the bundle, following Dixon and Rimmer (2005); v_2 is a composite non-necessity good functional formed by 'other' and imported commodities with the respective shares $(\boldsymbol{\gamma^H}, 1-\boldsymbol{\gamma^H})$ and the time-varying subsistence bundle $(\boldsymbol{\bar{H}_t^{Others}}, \boldsymbol{\bar{M}_t^H})$; $\boldsymbol{\sigma^H}$ is a CES coefficient measuring the substitutability between the necessity and non-necessity composites goods; y_t^H is household disposable income while $\boldsymbol{s^{h_G}}$ and $\boldsymbol{s^{h_S}}$ are respective shares of income that households spend on government services and savings.

Household disposable income y_t^H comes from transfers from government and returns to factors net of taxes:

$$y_t^H = \boldsymbol{s^{G_h}} y_t^G + \sum (w_t^{F^i} \odot F_t^i)'(\mathbf{1} - \boldsymbol{T^{F^i}}) \tag{4}$$

where y_t^G is government income while $\boldsymbol{s^{G_h}}$ is the ratio of government income being transferred to households; $\mathbf{1}$ is a vector of ones, $\boldsymbol{T^{F^i}}$ is a vector of factor income taxes; $\odot$ denotes component-wise multiplication and $\sum$ denotes the sum operator over all vector elements

The other component of the economy's income is the government income y_t^G. It comes from three sources including household spending on government services, sales tax, and factor income tax. Thus, denoting the 3-dimensional vector of outputs $q_t \equiv [q_t^{Rice}, q_t^{NonRice}, q_t^{Others}]'$, y_t^G can be expressed as:

$$y_t^G = s^{h_G} y_t^H + (w_t^Q \odot q_t)' \boldsymbol{T^q} + \sum (w_t^{F^i} \odot F_t^i)' \boldsymbol{T^{F^i}} \tag{5}$$

where $\boldsymbol{T^q} \equiv [\boldsymbol{T^{qRice}}, \boldsymbol{T^{qNonRice}}, \boldsymbol{T^{qOthers}}]'$ is a vector of sales tax rates in the three production sectors.

Thus, the total income in the economy (nominal GDP), Y_t, is the sum of government and household incomes net the transfers between them, that is $Y_t = (w_t^Q \odot q_t)'\boldsymbol{T^q} + \sum(w_t^{F^i} \odot F_t^i)$. This level of income determines total investment demand which is assumed to be proportional to national income with $\boldsymbol{s^I}$ being the economy investment proportion. It is worth noting that investment demands only the commodity 'others' for capital formulation, hence the first two elements of the 3-dimensional vector Q_t^I that captures investment demands are zero. In other words, investment demands can be expressed as:

$$Q_t^I = [0, 0, \boldsymbol{s^I} Y_t]'/w_t^Q \tag{6}$$

where / is the element-wise division operator.

In the light of government income y_t^G, government saving or yearly budget balance, b_t^G, is specified as:

$$b_t^G = y_t^G(1 - \boldsymbol{s^{G_h}}) - [w_t^Q]'Q_t^G - w_t^M M_t^G \tag{7}$$

where Q_t^G and M_t^G are government demands for commodities produced domestically and imported, respectively. It is also worth noting that similar to industry, government does not consume 'rice' and 'non-rice crops'.

Export demand, on the other hand, is modeled as a function with constant elasticity with respect to the relative price of the domestic goods in terms of imported goods:

$$Q_t^{ex} = \boldsymbol{E} \odot \left(\frac{w_t^Q}{w_t^M}\right)^{\boldsymbol{\varepsilon^Q}} \tag{8}$$

where Q_t^{ex} and $\boldsymbol{\varepsilon^Q}$ are 3×1 vectors of export quantities demanded for and elasticity coefficients with respect to the price of three commodities in the economy, respectively, while $\boldsymbol{E}$ is a 3×1 vector of price shift non-negative parameters. For the export demand schedule to be downward slopping, the elasticity coefficients must be negative in the model.

Next we specify equations which reflect market equilibrium:

$$Q_t^{Rice} + Q_t^{NonRice} + Q_t^{Others} + Q_t^H + Q_t^G + Q_t^I + Q_t^{ex} = q_t \tag{9}$$

$$\sum_{i\in\{\text{rice, non-rice crops, others}\}} K_t^i = \quad K_t \tag{10}$$

$$\sum_{i\in\{\text{rice, non-rice crops, others}\}} N_t^i = \quad N_t \tag{11}$$

$$L_t^i = \quad L_0^i \quad | \quad i \in \{\text{rice, non-rice crops, others}\} \tag{12}$$

$$[Q_t^i; F_t^i; M_t^i]'[w_t^Q; w_t^{F^i}; w_t^M] + \boldsymbol{T^{q_i}} w_t^i q_t^i = w_t^i q_t^i \;\; | \;\; i \in \{\text{rice, non-rice crops, others}\} \tag{13}$$

$$y_t^H = (\boldsymbol{s^{h_G}} + \boldsymbol{s^{h_I}}) y_t^H + [Q_t^H; M_t^H]'[w_t^Q; w_t^M] \tag{14}$$

$$\boldsymbol{s^{h_I}} y_t^H + b_t^G - [Q_t^I]' w_t^Q = [Q_t^{ex}]' w_t^Q - w_t^M \odot \left(\sum M_t^I + M_t^h + M_t^G \right) \tag{15}$$

where equation (9) ensures that total supply is equal to total demand in the economy; equations (10-11) imply the total capital and labor demanded in the three sectors be equal to the total capital and labor supplies under the full employment assumption, while equation (12) implies that the demand for each type of land is equal to the amount of land designated to each individual sector; zero profit condition in all industries is imposed in equation (13) ; equation (14) requires household income being equal its expenditure including saving with $\boldsymbol{s^{h_I}}$ being the share of household disposal income used for saving; and equation (15) reflects an macroeconomic identity, i.e., the gap between savings from both government and household and investment is equal to the net export. The dynamics of total capital stock (K_t) in equation (11) and labor force (N_t) in equation (12) as well as the changes in subsistence consumption are specified as follows:

$$N_{t+1} = (1 + \boldsymbol{g}) N_t \qquad \text{where} \quad t = 0, 1, \ldots, \boldsymbol{T} - 1 \tag{16}$$

$$K_{t+1} = K_t + \boldsymbol{\theta} I_t - \boldsymbol{\delta} K_t \qquad \text{where} \quad t = 0, 1, \ldots, \boldsymbol{T} - 1 \tag{17}$$

$$\bar{\boldsymbol{H}}_{\boldsymbol{t+1}}^{\boldsymbol{i}} = (1 + g) \bar{\boldsymbol{H}}_{\boldsymbol{t}}^{\boldsymbol{i}} \qquad \text{where} \quad i \in \{\text{rice, non-rice crops, others}\} \tag{18}$$

where $\boldsymbol{g}$ is annual working labour growth rate, $\boldsymbol{\theta}$ is the transformation rate of investment into new capital and $\boldsymbol{\delta}$ is the depreciation rate of existing capital.

The policy scenario designed in our paper is a conversion of rice land into other annual crops. This is one-off change which remains fixed throughout the planning horizon, that is:

$$\begin{aligned} L_0^{Rice} &= \quad L^{Rice}(1-r) \\ L_0^{NonRice} &= L^{NonRice} + L^{Rice}r \end{aligned} \tag{19}$$

where the conversion ratio r is determined at the beginning of the time horizon $\boldsymbol{T}$, and $\boldsymbol{L^{Rice}}$ and $\boldsymbol{L^{NonRice}}$ are the status-quo size of protected rice land and land devoted to non-rice crops.

Given model specification, the real GDP at time t associated with conversion rate r can be measured as:

$$GDP_t(r) = [Q_t^H + Q_t^G + Q_t^I + Q_t^{ex}]' w_0^Q - \sum M_t^I w_0^M \tag{20}$$

We need to find how much rice land should be released for other possible annual crops. The optimal policy is the one that maximises the total change in real gross domestic product (GDP) with some rice land converted into other annual crops as per equation (19), compared to the *status quo* when no rice land is released or used to cultivate other annual crops throughout the planning time horizon. We formalise this optimisation problem using the following equation:

$$\max_{r \in [0,1]} \sum_{t=1}^{T} \left\{ \left(\frac{1}{1+\rho} \right)^{t-1} \Big[\mathrm{GDP}_t(r) - \mathrm{GDP}_t(0) \Big] \right\} \tag{21}$$

where ρ is the discount rate, $GDP_t(r)$ are real GDP at year t associated with conversion, while $GDP_t(0)$ is the corresponding GDP at year t but without any land rice converted into other annual crops.

3.2. GE modelling: calibration

Our model is dense in terms of parameters that need to be calibrated. While many of the bold-letter parameters can be calibrated under the assumption that the SAM, presented in Table 1, represents an equilibrium in 2011, a number of them must be specified. In the case of Vietnam, information on parameter values are rough and scant. Thus, we must specify a baseline set of values taken or adapted from various sources that are, to the best of our knowledge, the most relevant for the model, as reported in Table 2 together their sources. To account for the uncertainty in the parameters, we examine how the optimal conversion rate responds to each of these parameters. This is done using sensitivity analysis where we repeatedly solve for the optimal rate while varying each of the parameters in a range that we believe is sufficient to allow for uncertainty (if any). The ranges for the sensitivity analysis are also reported in Table 2.

It is notable that the transformation rate of investment into new capital for Vietnam ($\boldsymbol{\theta}$) in equation (17) is the most difficult among the parameters to set. We could not find any available information that could help calibrate or specify a sensible value for this parameter, except to say its range is between 0 and 1, by definition. To overcome this ambiguity, we first pick a number, arbitrarily, and solve for the growth of real GDP which is augmented only by the accumulation of capital stock and labor force growth, not by the rice land conversion or other policies. We adjust this guess and repeat the process until the resource-augmented GDP growth rate in 2011 is 5.4%, roughly equal to the actual figure. This is similar to 'shooting' or a 'parameter tuning' technique and requires the general equilibrium model be solved many times, especially in the sensitivity analysis where parameters, including the resource-augmented GDP growth rate, are varied. However, we believe that is the currently the best approach to calibrate the parameter in this context.

3.3. Measurement of changes in inequality

Changes in land allocation for different production activities also lead to changes in prices. These price changes, in their turn, result in changes in consumer and producer surplus which alter inequality in Vietnam. To measure this change in inequality, we use the Gini coefficient following Sen (1973):

$$\text{Gini} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|y_i - y_j|}{2n^2\mu}$$

where y is the sum of household consumer and producer surpluses per capita; n is the number of households in the household survey, and μ is the sample average of y.

3.4. Measurement of household welfare and distributional impacts

We use a method based on Deaton (1989) to measure the change in household welfare. This change is a combination of consumer and producer surpluses since a household (especially in rice production) can be a consumer, or a producer, or both. For a household, the change in consumer surplus (ΔCS) associated with the change in the consumer price of a good is approximated as:

$$\Delta CS \cong -q_1^d(p_2^d - p_1^d) = -q_1^d(\Delta p^d) \tag{22}$$

where q_1^d is the quantity demanded before the price change, p_1^d and p_2^d are the consumer prices before and after the change, and Δp^d refers to the change in the consumer price. Here we use only the first order approximation which does not take into account a consumer's response because changes in prices, which are most pronounced in *rice* and *non-rice* commodities, are typically very small.[2] Likewise, the change in producer surplus (ΔPS) associated with the change in the producer price of a good is:

$$\Delta CS \cong -q_1^s(p_2^s - p_1^s) = -q_1^s(\Delta p^s) \tag{23}$$

[2]Estimates for demand elasticities of *rice* and *non-rice crop* in Vietnam are -0.41 and -0.98, respectively (Nguyen et al., 2009); supply elasticities of *rice* and *non-rice crops* are 0.057 and 0.019, respectively (Khiem and Pingali, 1995)

We define the sum of ΔCS and ΔPS to give a measure of net benefit (NB):

$$NB = \sum_{i=1}^{N} (\Delta PS_i + \Delta CS_i) \tag{24}$$

where N is the number of goods a household consumes and/or produces.

To analyse the distribution impacts of land conversion while taking into account the relative wealth of each household, we focus on the ratio of household net benefit to its expenditure, or:

$$NBR = \sum_{i=1}^{N} \frac{(\Delta PS_i + \Delta CS_i)}{Y} \tag{25}$$

where Y is total household expenditure before the price change, and NBR is the net benefit ratio.

4. Data and Results

4.1. Data

We use data from Vietnam's General Statistics Office (GSO) to compile a SAM as presented in Table 1 for our GE modelling. To measure changes in inequality, household welfare and distributional impacts, we use Vietnam's household living standard survey (VHLSS) for 2010. This survey is nationally representative and has 9,399 households with both income and expenditure modules and 29,023 households with an income module only.

4.2. Efficiency-driven optimal rice land conversion

Gains in GDP over 20 years for conversion rates from 0% to 40% are presented in Figure 1. The gain is maximised at the conversion rate of 19%. That means a conversion of approximately 1.4 million hectare of cultivated rice land into land for non-rice crops yields the highest efficiency gain for the economy. Put differently, only 81% of the 7.7 million hectare of the current cultivated rice land or 6.2 million hectare cultivated rice land should be protected. The total gain over 20 years is around 5.5 billion USD (in 2011 values), or 370 million USD per year on average.

The dynamic impacts of the conversion policy on macroeconomic indicators are summarized in Figure 2. The real GDP gain in each year ranges from 200 to 410 million as plotted in Figure 2a. The key drivers of this gain are the improvement in land productivity and the upswing in investment caused by the conversion, ranging from 0.16 to 0.31% a year (Figure 2b). Though the land conversion occurs only once at the beginning, it has a dynamic impact over the entire time horizon. The reallocation of land to a sector where it becomes more productive initializes a GDP increase, provokes an increase in investment and accelerates capital accumulation which contributes to GDP in subsequent years. The overall higher efficiency of land use is also a main driver for the improvement in the consumer welfare ranging from 25 to 80 million USD a year (Figure 2c). The last three panels (2d-2f) show that the impact on fiscal balance, the trade balance and inflation is insignificant. The CPI remains stable with the increase in rice price following the contraction of the rice production sector, and partly compensated for by the decrease in the price of non-rice crops with more land devoted to this use and higher output produced. The trade balance also remains stable where the reduction in rice exports is offset by the increase in net export of non-rice crops. The fiscal balance (as a percentage of the GDP) is also negligible. To sum up, the benefits from the land conversion policy are GDP, investment and consumer welfare while changes in inflation, trade and the fiscal balance are, more or less, neutral.

We check whether the model results are sensitive to parameter values. This is done by varying each of the parameters from its baseline value in a range that we believe is sufficient to allow for uncertainty or errors. The parameters are classified into two groups, namely those are specific to one of the 12 sectors of the economy and the remaining general parameters. The sensitivity result is summarised in Figure 3 which shows the optimal conversion rate varies only slightly from the baseline 19%. When the CES coefficients of the production functions are varied, the optimal rate of land conversion ranges only from 17%-22%. The level at which domestic prices influence export volume also has an impact on the optimal rate though less significant, in the range from 18% and 21%. Other parameters, including, the substitutability coefficient between 'necessity' and 'non-necessity' consumer goods makes little difference to the result, and the length of the time horizon, the depreciation rate, the resource-augmented GDP growth rate (used to fine-tune the investment-transformation rate), the population growth rate and discount rate, have minor or insignificant impacts on the optimal rate of land conversion.

4.3. Rice land conversion in regions

We calculate the conversion rate for each of the region assuming that the rice land with the lowest productivity will be converted first. Based on the data for land size and productivity of 29,023 rice producers from VHLSS 2010, we calculate the regional distribution of various quantile levels of rice land and use to determine the conversion rate as well cultivation area for each of the six regions of Vietnam. Table 3 shows the regional distribution for rice land conversion with the country-wide conversion rate ranging from 10% to 30%, highlighting the range 17%-22%, the most likely optimal efficiency-driven conversion rates suggested by the sensitivity analysis. Within this range, our results suggest that the conversion areas in the Red River Delta and Mekong River Delta are from 72,00 to 111,080 cultivation hectares (column 3), equivalent to 6.35%-9.71% (column 9), and 351,900-481,130 hectare (column 8) equivalent to 8.58%-11.75% (column 14) respectively. In the remaining four regions with much smaller scale of rice production, the conversion is smaller in size, but higher in terms of percentage, consistent with the fact that the two delta regions are relatively more productive in producing rice than other regions.

4.4. Impacts of rice land conversion on inequality and distribution

Impacts of rice land conversion on inequality are measured by the mean of differences between Gini coefficients in the *status quo* and the scenarios of different conversion rates (equation 22). Changes in Gini coefficients are calculated using changes in prices generated from the GE model and VHLSS data. As can be seen in Figure 1, rice land conversion is associated with a reduction, thought slightly, in inequality over the range of 0%-40% conversion. At the efficiency-driven optimal rate of 19%, the Gini index falls by 0.5%. Beyond this conversion rate, there is a trade-off between the efficiency and equality objectives: the lower GDP gain is, the higher is the inequality-reducing impact. Indeed, the Gini index falls by 2.2% when 40% of rice land is converted while the gain in GDP is less than 1 billion USD over 20 years (in comparison with 5.1 billion USD at the optimal conversion rate).

To examine the distributional impacts of the optimal conversion policy, we simulate changes in prices from the GE model on both household consumption and production. Table 4 presents population structure in terms of household position in rice consumption in relation to its urban-rural and wealth ranking statuses as well as by location. Here, a household is defined as a net seller if its value of rice production is larger than its value of rice consumption. Otherwise, it is a net buyer (i.e. its value of rice production is smaller than its value of rice consumption) or self-sufficient (i.e. its value of rice production is equal to its value of rice consumption). Appropriate survey sample weights are used in our calculation to take into account the VHLSS sampling structure.

It is clear from columns 2-5 that rice production is a rural activity. Furthermore, the richer a household is, the less likely they are involved in rice production. Across regions, households in Central Highlands (CH) and South East (SE) are much more likely to buy rice since the former has soil more suitable for perennial crops such as coffee, cashew nuts, etc., while the later is the largest economic and manufacturing hub in Vietnam. While more than 50% of rice in Vietnam is produced in Mekong River Delta, as much as 70% of households here are net buyers due to large-scale production in this region compared to the rest of Vietnam.

Overall, the optimal rice land conversion policy results in an increase of 3.5-4 USD per person per year in Vietnam, whether in rural or urban areas (column 8). This gain translates into 0.16% and 0.25% net benefit ratios for rural and urban households, respectively. The gain in household net benefits largely come from producer surplus for rural households and consumer surplus for urban households. This result makes sense since rice production is largely done by rural households and rice is much more important in rural households' diet. Moving rice land to other crops increases the price of rice, thereby leading to gains for rice producers and losses for rice consumers.

Among the six regions, the Red River Delta (RRD) and Mekong River Delta (MRD) stand out as key beneficiaries from an optimal rice land conversion policy. Producer surplus plays a dominant role in household net benefits, representing 21$ and 6$ per person per year in MRD and RRD, respectively (column 8). Clearly, CH and Midlands and Northern Mountains (NMM) are the worst off, especially in terms of producer surplus (column 7). The reason is that these two regions have soil largely suitable for *non-rice other crops*. A 19% conversion of rice land into non-rice other crops land implies an increase of about 50% of total cultivated land for non-rice other crops, which results in an increase in supply of these crops. As a result, there is a massive fall in prices of non-rice other crops, causing losses to their producers. On the other hand, rice production in these two regions is largely at very small scale. Therefore, farmers here gain little from rice price increases due to the conversion policy. Finally, these two regions have the highest proportions of poor households, whose diet is dominated by rice. To this end, consumer losses are also highest in these two regions (column 6).

Clearly rice land conversion is not a pro-poor policy. As much as 70% households at the bottom of the wealth distribution experience losses in consumer surplus, indicating rice remains important in the Vietnamese diet. While these losses are offset by producer surpluses for most of the population, they are not for the 30% poorest. Indeed, the poorest quintile also suffer from producer losses possibly due to not having access to fertile land suitable for rice. Likely living in difficult terrains, their main source of income comes from maize, cassava, etc., while rice is dominant in their diet. The reallocation of rice land which results in more expensive rice and cheaper non-rice other crops, harms these those households on both fronts, production and consumption.

From results on both inequality and distribution, one might wonder why inequality reduces while poor households are worse off? The answer is that while the poorest household groups are worse off, this policy increases net benefits for the rest of the population and reduces, though slightly, the gap among households. As a result, inequality measured by the Gini coefficients improves.

5. Concluding Remarks

In many countries, agricultural land conversion is largely driven by market forces and the pressure that stems from population increases and urbanization. However, concerns over food security, especially for primary goods, such as rice, often necessitate a desire for more restrictive land use policy. This is especially the case in transitional economies that have a history and culture surrounding rice production, and where basic food security for a key commodity is a concern. Vietnam is one such case.

Nevertheless, restrictions on conversion of rice land to other uses comes at a cost in terms of surplus production, losses in efficiency and an inability to respond to market signals for the best mix of output and land use. However, these effects must be gauged relative to changes in land conversion rates which cause differential impacts in inequality, since changes in rice prices affect both producers and consumers in rural and urban households differently.

Our results illustrate these effects and tradeoffs for Vietnam nicely. Rice land conversion to other uses does generate efficiency gains, and indeed we are able to calculate the optimal conversion rate in this setting. That said, rice land conversion also differentially impacts the rural poor in the lowest quintile, in particular. The effects in different regions across the country are also markedly different. Finding the right balance and the manner in which the poor might be best compensated from a conversion policy, across the country, out of the underlying efficiency gains that come from converting rice land is a useful topic to further research. What is clear from our work, however, is that there is scope for rice land conversion in Vietnam, while satisfying concerns over food security, and certainly so relative to a policy that simple sets rice land aside in an arbitrary fashion.

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Table 1: Social account matrix for Vietnam in 2011 (10,000 billion VND)

	Rice/ Paddy	Non-rice crops	Other sectors	Capital	Labor	Rice land	Land for non-rice crops	Land for other sectors	H'holds	Gov't	Inv'ment	Export	Total
Rice/Paddy	4.399	0.049	6.354						9.775			6.238	26.814
Non-rice crops	1.168	0.419	4.279						1.593			1.063	8.522
Other sectors	3.750	1.338	283.314						144.188	14.855	55.963	214.969	718.377
Capital	1.112	0.365	101.630										103.106
Labor	8.306	1.768	129.805										139.879
Rice land	5.102	0.000	0.000										5.102
Land for non-rice crops	0.000	3.597	0.000										3.597
Land for other sectors	0.000	0.000	11.191										11.191
Households				77.329	139.879	4.898	3.417	10.418		30.094			266.036
Government	0.322	0.071	36.652	25.776		0.204	0.180	0.773	7.588				71.567
Saving									26.750	24.344		4.869	55.963
Import	2.655	0.916	145.152						76.142	2.274			227.139
Total	26.814	8.522	718.377	103.106	139.879	5.102	3.597	11.191	266.036	71.567	55.963	227.139	

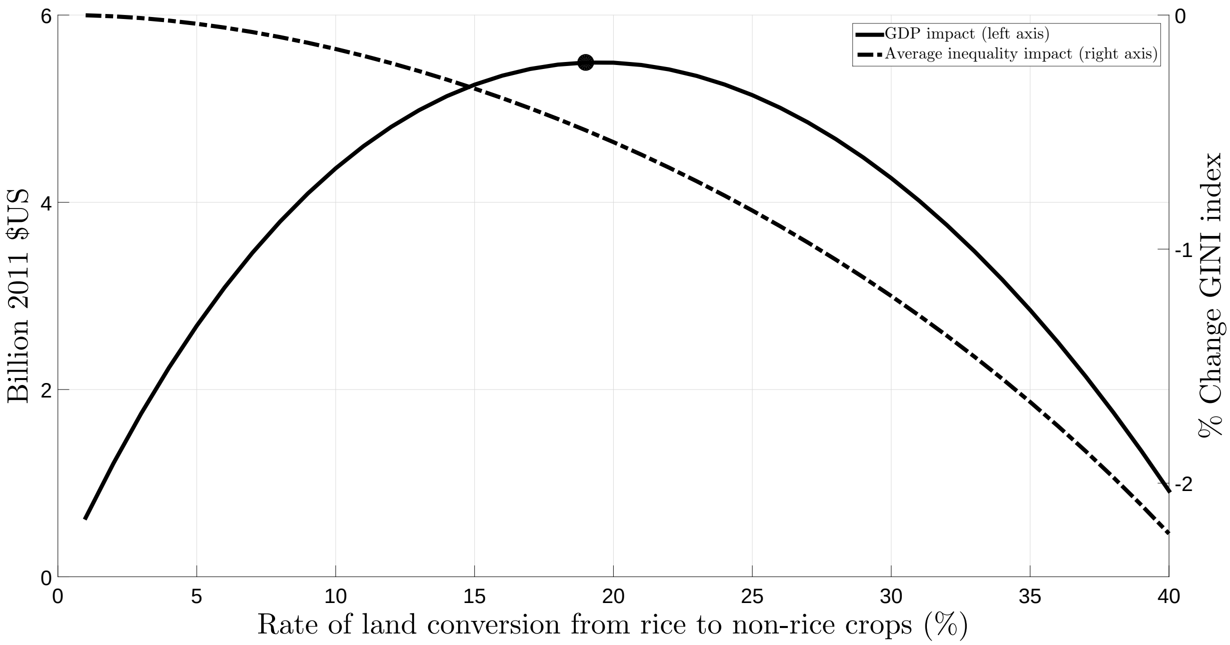
Source: Authors's compilation from data provided by Vietnam's General Statistics Office

Table 2: Modeler-specified parameters

Parameter description	Notation	Baseline value	Sources/ Adapted from	Ranges for sensitivity analysis
CES coefficient for rice production	$\boldsymbol{\sigma^{Rice}}$	0.45	Hoang (2015)	[0.35,0.55]
CES coefficient for non-rice-crop production	$\boldsymbol{\sigma^{Non-Rice}}$	0.45	Hoang (2015)	[0.35,0.55]
CES coefficient for the aggregate sector	$\boldsymbol{\sigma^{Others}}$	1	(Gabriel & Daniel 2014); (Pessoa et al. 2003)	[0.7,1.3]
Price elasticity coefficient of rice export volume	$\boldsymbol{\varepsilon^{Others}}$	-0.75	Chowdhury (2014)	[-0.95,-0.55]
Price elasticity coefficient of the export volume for non-rice crops	$\boldsymbol{\varepsilon^{Non-rice}}$	-0.7	(Dang 2014a)	[-0.9,-0.5]
Price elasticity coefficient of the export volume for the aggregate sector	$\boldsymbol{\varepsilon^{Others}}$	-0.5	(Pham & Nguyen 2013)	[-0.6,-0.4]
CES coefficient of the consumption sector (between necessity and non-necessity goods)	$\boldsymbol{\sigma^{H}}$	0.05	(Hoang & Meyers 2015)	[0.02,0.08]
Length of time horizon (in years)	$\boldsymbol{T}$	20	In consultation with MARD officials	[15,25]
Annual capital depreciation rate	$\boldsymbol{\delta}$	10%	Ministry of Finance of Vietnam[a]	[5%,15%]
Annual labor force growth rate	$\boldsymbol{g}$	1%	GSO[b]	[0.7%,1.3%]
Annual discount rate	$\boldsymbol{\rho}$	3%	Annual report of SBV (2011,2014)	[2%,4%]
Real 2011-12 GDP growth rate generated by capital accumulation and the growth of labor force	$\boldsymbol{g^{resource}}$	5.4%	GSO[d]	[4.4%,6.4%]

[a] Decision 1940-QD-BTC of the Minister of Finance on the depreciation of capital goods.
[b] `https://gso.gov.vn/default.aspx?tabid=387&idmid=3&ItemID=12844`
[c] `https://gso.gov.vn/default.aspx?tabid=621&ItemID=13419`

Figure 1: Impact of rice land conversion on efficiency and inequality



Notes: The gains are converted into USD using the exchange rate of 1USD=20,000VND

Figure 2: Impacts of rice land conversion from a macro perspective

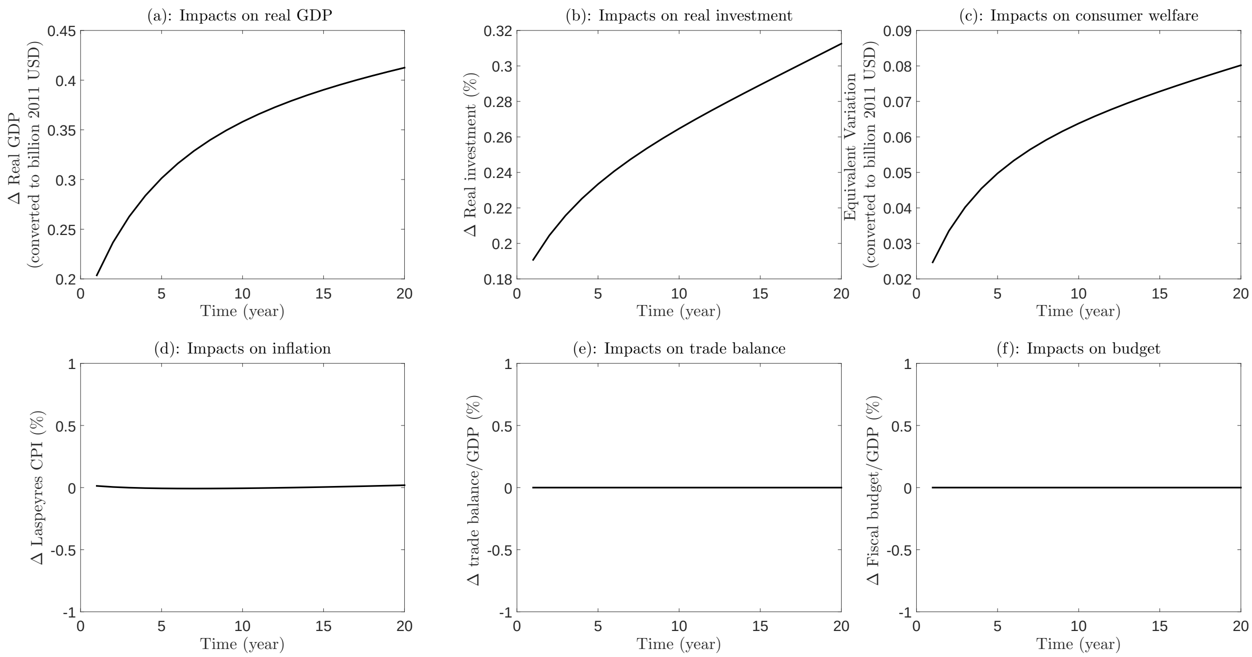


Figure 3: Sensitivity analysis of the optimal conversion rate

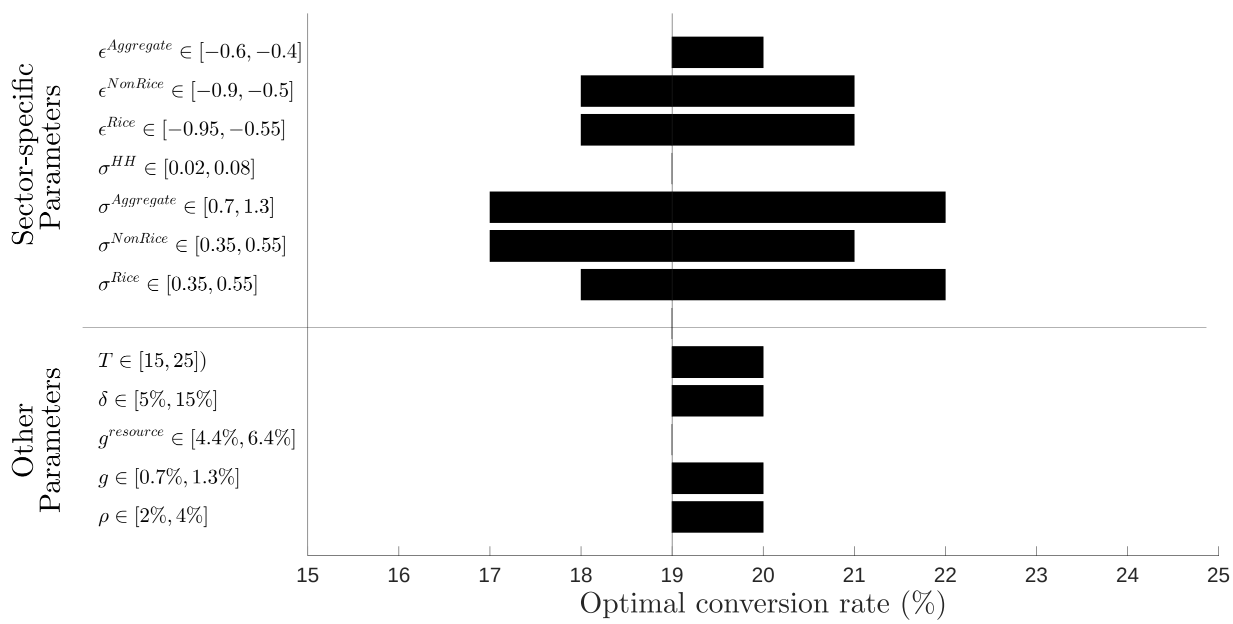


Table 3: Rice land conversion by region

Country wide		Conversion in each region (1000 ha cultivated land)						Percentage of rice land conversion within each region					
%	In 1000 ha cultivated land	RRD	MMNA	NCCR	CHR	SA	MRD	RRD	MMNA	NCCR	CHR	SA	MRD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
10%	765.50	22.84	249.63	169.73	108.41	44.62	170.27	2.00%	37.21%	13.81%	48.35%	15.22%	4.16%
11%	842.05	27.23	269.81	189.05	111.35	50.24	194.38	2.38%	40.22%	15.38%	49.66%	17.14%	4.75%
12%	918.60	30.65	284.85	203.74	118.71	59.87	220.78	2.68%	42.46%	16.58%	52.95%	20.43%	5.39%
13%	995.15	37.10	298.78	223.21	122.59	65.84	247.63	3.24%	44.53%	18.17%	54.68%	22.46%	6.05%
14%	1,071.70	46.42	321.10	242.24	125.79	69.99	266.17	4.06%	47.86%	19.71%	56.11%	23.88%	6.50%
15%	1,148.25	53.84	341.77	261.75	128.44	74.54	287.91	4.70%	50.94%	21.30%	57.29%	25.43%	7.03%
16%	1,224.80	63.97	355.89	277.37	129.28	78.11	320.19	5.59%	53.05%	22.57%	57.66%	26.65%	7.82%
17%	1,301.35	72.70	370.61	290.65	134.30	82.01	351.09	6.35%	55.24%	23.65%	59.90%	27.98%	8.58%
18%	1,377.90	75.08	392.81	323.28	139.33	95.26	352.14	6.56%	58.55%	26.31%	62.15%	32.50%	8.60%
19%	1,454.45	82.33	400.54	330.73	139.97	96.43	404.44	7.19%	59.70%	26.92%	62.43%	32.90%	9.88%
20%	1,531.00	89.78	421.91	350.99	141.66	98.21	428.45	7.84%	62.89%	28.56%	63.18%	33.51%	10.47%
21%	1,607.55	98.92	454.90	361.72	142.28	101.05	448.69	8.64%	67.80%	29.44%	63.46%	34.47%	10.96%
22%	1,684.10	111.08	466.18	378.29	143.58	103.85	481.13	9.71%	69.49%	30.79%	64.04%	35.43%	11.75%
23%	1,760.65	115.66	479.27	390.73	146.30	108.43	520.26	10.11%	71.44%	31.80%	65.26%	36.99%	12.71%
24%	1,837.20	122.75	495.19	407.38	147.25	111.39	553.23	10.73%	73.81%	33.15%	65.68%	38.01%	13.51%
25%	1,913.75	133.17	511.22	420.42	148.61	116.65	583.67	11.64%	76.20%	34.21%	66.29%	39.80%	14.26%
26%	1,990.30	144.98	530.45	431.65	150.67	120.30	612.25	12.67%	79.07%	35.13%	67.20%	41.04%	14.96%
27%	2,066.85	152.79	542.38	450.20	152.82	128.93	639.73	13.35%	80.84%	36.64%	68.16%	43.99%	15.63%
28%	2,143.40	168.14	557.90	460.45	152.94	129.72	674.25	14.69%	83.16%	37.47%	68.21%	44.26%	16.47%
29%	2,219.95	173.53	572.53	492.87	158.65	131.07	691.29	15.16%	85.34%	40.11%	70.76%	44.72%	16.89%
30%	2,296.50	184.79	584.77	500.15	158.64	135.80	732.36	16.15%	87.16%	40.70%	70.76%	46.33%	17.89%

RRD= Red River Delta; MNMA=Midlands and Northern Mountainous Areas; NCCR=Northern and Coastal Central Region; CHR=Central Highland Region; SAR=Southeastern Area Region; MRD= Mekong River Delta.

Table 4: Household net position in rice, consumer and producer surpluses, net benefit per capita (USD) and net benefit ratio (%) under the optimal rice land conversion policy

Categories	% of all hh	% of hh in catergories			Change in Consumer Surplus	Change in Producer Surplus	Change in Net Benefit	Net Benefit Ratio
		Net Seller	Self suf-ficient	Net Buyer				
All	100.0	33.8	0.4	65.8	-0.03	3.81	3.79	0.19
Urban	30.5	8.1	1.0	90.9	2.22	1.29	3.52	0.25
Rural	69.49	45.0	0.2	54.8	-1.01	4.93	3.92	0.16
Red River Delta	24.8	47.0	0.0	53.0	0.12	6.04	6.16	0.94
Midlands and Northern Mountains	12.6	47.5	0.2	52.3	-2.86	-4.01	-6.87	-2.11
Northern and Coastal Central	21.7	40.5	0.0	59.5	-0.64	-0.57	-1.21	-0.50
Central Highlands	5.4	19.5	0.3	80.2	-1.22	-10.0	-11.21	-3.00
South East	16.8	3.9	1.9	94.2	2.43	-2.51	-0.08	-0.13
Mekong River Delta	18.8	30.1	0.3	69.6	0.53	20.82	21.35	2.73
Poorest Decile	8.0	45.8	0.2	54.0	-2.97	-1.91	-4.88	-2.46
2nd Decile	9.2	42.8	0.2	57.0	-2.76	-0.36	-3.12	-0.94
3rd Decile	9.1	48.7	0.1	51.2	-2.28	1.43	-0.85	-0.19
4th Decile	9.7	48.5	0.0	51.5	-1.67	5.37	3.70	0.74
5th Decile	9.8	43.4	0.1	56.5	-1.15	5.03	3.87	0.65
6th Decile	10.0	40.3	0.6	59.1	-0.53	6.02	5.50	0.81
7th Decile	10.7	31.1	0.3	68.6	-0.12	4.89	4.77	0.60
8th Decile	10.8	27.9	0.2	71.9	0.85	8.43	9.29	0.93
9th Decile	11.0	16.1	0.4	83.5	2.22	6.66	8.88	0.69
Richest Decile	11.7	5.3	1.7	93.0	5.79	0.78	6.56	0.28