An Exploratory Spatial Analysis of CGE Results: An Application to the US-Ecuador FTA and Ecuador's Agricultural Sector

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Introduction

Computable General Equilibrium (CGE) models have been used to assess many economic policy issues in recent years. Ranging from applications in trade policy studies to environmental strategy topics the strength of CGE modeling lies in its integrated ability to explore policy impacts at different levels. CGE modeling is usually applied to understanding the deep relationship among the multi-sectoral interaction providing detailed information on policy or shock impacts on certain related variables and is capable to deliver detailed information of the different sectors of the economy.

However, it used to be difficult to draw conclusions about the different policy impacts at the regional (sub-national) level because CGE models are not usually disaggregated at this scale. Most of general equilibrium studies and their impacts at the sectoral level are usually presented at the macroeconomic level, focused on changes of a representative household. Some of the models that do bridge the gap between national and regional are for large countries such as the United States or Brazil. For example, the USITC offers a model of the United States at the state level for all 50 states of that country, and De Souza and Horridge (2005) analyze for Brazil the impacts of trade liberalization, using input-output matrices at the regional country level.

However, these country models are data intensive, which for smaller economies like Ecuador, may not be available. Those models also lack a geographic representation of what happens at a spatial level. This is mainly due to the large amount of data needed, or lack of, in such models such as GTAP to make this possible. The macro-micro simulation studies have tried to study more in detail the impacts on the different levels of income to understand how relevant policy shocks affect the social subsystem. However, these also lack the spatial dimension of the analysis.

Spatial geo-referenced consequences of a national wide applied policy are usually of great interest to policy makers, especially when they have to implement national programs based on local patterns. If results at a sub-national level are required, a national CGE model should be complemented with additional information in order to disaggregate outcomes by regions. One common obstacle may be the availability of information at these levels.

At the same time, in agriculture, these macro studies offer results at the sectoral level, but not at a micro level of agriculture (i.e. farm level). Morales et al. (2005) make a spatial localization of farms at the second-level of political division and study how tariff reduction affects them using partial equilibrium analysis. However, this analysis did not offer the differentiated impacts at the regional level within the country.

Disaggregation at the farm level is important, given the fact that the effects of a free trade agreement or technological change are ruled by price transmission at the regional level. Nicita (2005) shows that in Mexico, the impacts of the North American Free Trade Agreement (NAFTA) were higher in the northern states closer to the border with the United States, while these impacts in the southern most states of Mexico were negligible.

This spatial distribution of economic impacts is important, because they determine the implementation of regional compensation policies. Salcedo (2007) mentions that in the compensation program for farmers in Mexico (PROCAMPO), the majority of subsidies were captured by larger farmers, contrary to smaller farmers. Targeted subsidies to farmers is important, given that the impacts of free trade are different to each farmer, given their own characteristic such as market integration, access to technology, credit, etc.

The objectives of this paper are three. First, to map crop distribution at the spatial level by type of producer according to a harmonized product classification. Second, to spatially distribute the economic impacts of generated by a general equilibrium model, taking into account incomplete international price transmission into domestic markets (rural and urban). Third, to identify at the sub-national level a subsidy strategy by producer type and crop.

The ability to incorporate, manage and analyze spatial data, and answer questions based on that, is the distinctive characteristic of the Geographical Information Systems (GIS). Mapping and geographic analysis is not new, but GIS makes it possible to do this type of work more efficiently due to the power and ease of using modern computers. Applications of GIS are becoming an integrated part of many disciplines.

This study merges the results of a computable general equilibrium (CGE) analysis with spatial data at the canton (municipal) third level using a methodology based on micro data. We explore a methodology to integrate the relationship between GIS, which explore the geo-referenced characteristics of the economic system and CGE, which is a used powerful analytical tool, with the aim to join together GIS and economic modeling to develop a better decision support system for policy makers. This tool would enable us to merge the GTAP model and database to data that can be spatially referenced such as household surveys, agricultural census data, weather, transportation and other data. In our specific case, we focus on the Ecuadorian agricultural census data.

This paper is divided in the following sections. First, we review the general equilibrium studies where there is a spatial analysis of results. Second, we review our methodology to spatially distribute the effects of a general equilibrium model on Ecuador's agricultural sector. The third section describes the data and the model used. Fourth, we analyze the results in terms of the spatial distribution of crops in Ecuador, the impacts of a FTA on producers, and the distribution of subsidies by size and type of producers. Finally, we draw some conclusions and future research based on this first exploratory paper.

Economic Models and Spatial Analysis of Model Output

Use of spatial information in economic studies has been mostly focused on environmental models, given the nature of spatial data. Most spatial data is related to weather, land use, slope and elevations, population density, urban-rural interactions, the main reason that spatial data is mostly applied in climate change modeling, land use models, population models, etc. For example, Asadoorian (2005) simulates the geographical distribution of population at a global level until the year 2100. Other models focus on climate change and using satellite imagery data, have also mapped changes on the environment.

The GTAP-AEZ (Lee et al., 2005) is a computable general equilibrium (CGE) model, which contains detailed data on land use based on agro-ecological zones (AEZ), is based in part on the use of satellite data to distribute land use in this global model. Other applications of spatial analysis are on poverty and trade. For example, Habbad and Perobelli (2005) modeled the spatial effects of trade liberalization and their impacts on poverty in Brazil. Schuschny and Gallopin (2004) use information coming from population census and agro-ecological information to map the correlation among poverty and environmental systems in Latin America countries.

However, the majority of these studies are at a global level, without a microeconomic level focus. National or regional policies would benefit by a more narrow approach that takes into account some of the micro level details needed to formulate policies. This is why to use the output of CGE models as a tool to formulate these kind of policies, models that allow a tailored regional approach are needed.

The extension of national CGE models to the regional level is the first step in the design of these more specific policies. The spatial distribution of impacts of CGE models at sub-national level such as in De Souza and Horridge (2005) may be used in this case. Dixon et al. (2004) describe the extension of the USAGE-ITC model, which is a dynamic general equilibrium model of the United States to each of the 50 states in that country. However, these studies are at a macro and sectoral level, where they do not take into account the impacts at the microeconomic level.

To distribute the national level impacts at the regional level we need to take into account several factors. Distributing impacts at the national or sectoral level at the same rate in all regions or all producers ignores regional and farmers differences. We need to take into account regional differences and producer characteristics, such as the level of regional market integration given infrastructure such as roads, if producers sell or not their production to local or regional markets, and how close they are to urban centers, etc.

Kjöllerström (2004) shows that transaction costs in small producers work as a barrier in market integration with export markets. Fixed transactions costs affect the decision making process of farmers to integrate themselves into product and land markets. Therefore, the decision to produce subsistence products in most of the land is a rational decision that results from the high transaction costs that farmers face. High transportation costs are also a significant barrier that may explain the predominance of subsistence products in small farmers.

The structure of market channels also influence how complete price transmission is. Many empirical studies argue that one of the key factors in the asymmetric transmission of agricultural commodity price changes through the marketing system is downstream imperfect competition. Sheldon (2006) shows that incidence of tariff reductions is affected by downstream imperfect competition. McMillan et al. (2002) argue that higher prices gains of cashew nuts in Mozambique due to export tax removal were capture mostly by export traders rather than cashew farmers. The reason was that downstream buyers had monopsony power in the purchase of cashew nuts from farmers.

In terms of regional price transmission, Nicita (2004) finds that in the case of Mexico international prices are transmitted differentially within regions of that country, depending on distance to the border and product. An important element is the "pass-through" of international prices to domestic prices at the border. Nicita mentions that there are two important things: first, that price transmission is not complete and second, that it depends on the type of product. For manufactured products, price transmission from international to domestic prices was 66%, while for agricultural products it was only 25%.

Nicita finds that price transmission decreases as distance to the border increases. Also, urban areas are more sensible to changes in prices at the border than rural areas. Nicita concludes that for rural regions in Mexico, only a small fraction of international prices are felt, especially in the case of agricultural products. One important consequence is that international prices changes due to the Doha Round of trade negotiations would be almost zero in rural areas of Mexico, except for the north, closer to the border to the United States, where farmers obtain small gains.

In another related study, Nicita (2005) explores the impacts of domestic reforms that would allow rural producers to better respond to changes in world markets without incurring in additional costs, such as, increases in productivity or the employment of surplus labor. These changes would allow an increase in rural household welfare in Mexico, except in the south. In the south, there are gains from Doha only when reforms come with an improvement of price transmission, such as better transport and market infrastructure. Démurger et al. (2001) finds that any improvement in the infrastructure to eliminate or reduce geographic barriers is fundamental to increased growth.

In this study, we use the simulation results of a Free Trade Agreement between Ecuador, Colombia, Peru and Ecuador with the United States that estimates the effects on the Ecuadorian economy of such an agreement, as well as the compensation policies for those agricultural sectors negatively affected by the FTA. This program gives income transfers to farmers based on land in production from the last agricultural census. The government estimates to pay farmers $26-100 for every hectare in production, a small number if we compare to payments that US farmers receive. The amount of the subsidy decreases as the size of the production unit increases. We also include the case if Ecuador does not sign the agreement, given that Colombia and Peru have already signed it. This last scenario simulates the case where the Andean Preferences Agreement (ATPDEA) ends after the six month delay that ends in June 2007.

Census, Spatial and Economic Data

Agricultural Census of Ecuador

The Third Agricultural Census data for Ecuador is from the year 1999/2000. This is not a census in the true sense of the word, but a representative sample of 150,000 farms. We present the results at the level of canton (the third geographical political disaggregation level i.e. municipal level), given that meaningful averages can be constructed at that political division level based on the sample design and size of the census. The census includes dozens of variables, with useful information about land size, production, use of inputs (land, machinery, labor, seed, etc), access to credit, markets and technology, among other things.

The agricultural census does not contain information on commodity prices. For this reason, the source of prices is the National Institute of Statistics and Census (INEC in Spanish). This Institute possesses information on 43 agricultural products, 17 permanent crops and 26 non-perennial crops. A list of products and their correspondence to general equilibrium sectors is in Appendix A.

In order to classify producers, we've used the same typology as Morales et al. (2005) (See Appendix B for some insights), which defined three types of Agricultural Production Units (UPA in Spanish): (i) subsistence farming, (ii) traditional enterprises, and (iii) modern enterprises. This classification is based on producer's characteristics, as follows:

(i) Subsistence farmers are those who had the following characteristics: a) They lived in the UPA, b) They did not hire labor, and c) They did not have machinery (tractors).
(ii) Traditional enterprises are defined according to the following attributes: a) They hired labor, b) they had machinery and c) They did not hire specialized technical assistance (agronomists, veterinaries, etc).
(iii) Finally, modern enterprises are those that additionally to those previous characteristics, they a) hired specialized technical assistance (agronomists, veterinaries, etc), b) if it was an individual producer, they had finished basic and medium education and have some degree of higher education, and c) they have access to credit.

The gross value of production (GVP) was built using census data and price surveys from the National Institute of Statistics and Census (INEC) to calculate price indexes. For the main products for each type of UPAs, were selected those that had more than 50% share of total GVP.

GIS – software and data source

Through the use of the Agricultural Census and the GIS geo-referenced process, agricultural sectoral impacts can be disaggregated and registered into individual locations, in our case, the cantons. Details of the conversion process will be discussed in the next sections. The visualization of this disaggregated information by means of GIS techniques enables decision makers to display the results of the policies to be applied and consequently improve the quality their choices. This is especially important in the agro-business sector where the productive units reside along the whole country territory. Visualization helps not only in obtaining a systemic view of a subject matter but also to improve the quality of communication among stakeholders. Also, as we will see, the integration between GIS and CGE analysis is that it is possible to capture additional information which is not included in the macro analysis.

The geographically referenced data (third disaggregating level of political division shapefiles) was provided by the Latin American and Caribbean Demographic Centre (CELADE) at the Economic Commission for Latin America and the Caribbean (ECLAC). In our specific case, we map the agricultural census data from Ecuador into existing polygons that represent each one of the 218 cantons in Ecuador. Geo-referenced data were stored, managed, analyzed, and displayed by means of the ArcView commercial software.

General equilibrium modeling

The framework of analysis of trade liberalization and agricultural subsidies is a computable general equilibrium model, with special features for the analysis of agricultural issues, called GTAP-AGR. The Global Trade Analysis Project (GTAP) model of global trade (Hertel, 1997), is a standard, multi-region, multi-sector model which includes explicitly treatment of international trade and transport margins, global savings and investment, and price and income responsiveness across countries. It assumes perfect competition, constant returns to scale, and an Armington specification for bilateral trade flows that differentiates trade by origin. We use version 6.2 of the GTAP database, which includes Ecuador as a disaggregated region in the database.

However, critiques argue that the standard GTAP model does not capture some of the important characteristics of the agricultural economy. To include these special features there is a modified version of the GTAP model and database called GTAP-AGR (Keeney and Hertel, 2005). The GTAP-AGR model captures certain structural features of world agricultural markets that are not well reflected in the standard GTAP model.

GTAP-AGR provides a more realistic representation of the farm and food system. It explicitly identifies farm households as entities that earn income from both farm and non farm activities, pay taxes, and consume both food and non food products. The model tries to characterize the degree of factor market segmentation between agriculture and other sectors of the economy, as well as to improve the representation of input substitution possibilities in farm production.

We use the simulations' results from Ludena and Wong (2006) (Appendix C) and Durán, Schuschny and de Miguel (2006), where it is assumed that Ecuador, jointly with Colombia and Peru sign simultaneous FTA agreements with the U.S. as a way to become permanent the Andean Trade Preferences known as that ATPDEA (the Andean Trade Preference and Drug Eradication Act), granted by the U.S. Although it is not politically realistic now, this scenario serves our purpose of illustrating the impacts of trade liberalization on Ecuador's agricultural sector. Also, this scenario is aligned with the domestic support policies simulations considered in Ludena and Wong (2006), and can be carried out on this one, too.

As a way to give support to farmers during the 2006 the Ecuadorian government was planning cash compensation payments to farmers based on the amount of land allocated to certain crop's production. The government's plan identifies three specific target's crops: rice, corn and soybeans, which according to government estimations were the agricultural sectors that will be most affected by the FTA with the U.S. The government has developed a subsidy scheme that made distinctions by size of production unit. On this scheme, small farmers with less than 20 hectares received 100% of the land-based payment, farmers with UPAs between 20-50 hectares receive 70% of the subsidy and farmers with more than 50 hectares receive half of the subsidy. For example, in corn, small farmers would receive $110 per hectare, medium size farmers $77 per hectare, and large farmers $55 per hectare. Also, bovine livestock producers would receive cash payments based on UPAs' size. Based on this subsidy scheme and the relevant farmers' characteristics, we plan to identify by geo-referenced mapping, where subsidies are going to be located by type of farmer and crop. See Appendix D for some details about this program and land tenure size characteristics.

Spatial Distribution of Effects on a General Equilibrium Model: An Application to Ecuador's Agricultural Sector

In order to account international prices variations do not affect domestic prices in all geographic areas of a specific country at the same rate, we should set up a model of the local price variation scheme which include as an input the international prices variations' rates. This module should to take advantage of the Ecuadorian's Agricultural Census micro-data information about farmers' characteristics, which allow us to show their degree of market's integration. The variables used to identify the level of integration are: 1) Distance of the agricultural production unit to the closest road, 2) Whether the producer sells their production or not, and 3) For those producer that sell all or part of their production, to whom they sell it (consumers, middle-man, agroindustry or exporters).

This study assumes that these characteristics determine the degree of price transmission, considering that some geographical areas might be more connected to markets and others might be isolated from markets. We expect that for more integrated areas, price transmission should be high and that for less connected areas price transmission should be lower. We base this assumption on Nicita (2005), where he finds that as distance increases from the border, there is less international price transmission. We also assume that the level of market integration is determined by whether the farmer sells or not their production, and if it sells for final consumption or to other destination (exporters, industries or other). Based on these producer characteristics which are available in the agricultural census, we construct a brief model that reflects the level of market integration – and price transmission – to the market.

Using the agricultural census data for Ecuador, Leon and Shady (2003) find that as distance increase to the closest road, the amount of gross value of production decreases. The value of production for farmers on the road is more than two times ($485 vs. $231) the value for those farmers who are for than 5 Km. from the road. This may denote lower production or productivity, or may denote lower prices received by these farmers. Also, if farmers producer for their own consumption, value of production is less than half ($434 vs. $202) compared to those producers that produce to sell.

Escobal (2001) shows the importance of roads on market access for poor farmers in rural Peru. Roads in particular lower transaction costs and substantially improve the incomes of the rural poor in Peru. He shows that transaction costs are appreciably higher for producers who are connected to markets via non-motorized tracks. Some key variables that explain decision to when and where to sell include: a) Distance from market, b) Time to travel to market, c) Stability of relations with trading agents, d) Market research, e) Monitoring of contracts and payments. Finally, he shows that transaction costs are much higher for small-scale farmers than for large-scale ones (67% versus 32% of the sales value).

Vakis et al. (2003) find that as a region becomes more accessible, both buyers and farmers may find it more favorable to buy (sell) at the farm gate as opposed to in local markets. That is, for regions with little accessibility, local markets may be serving as markets of last (or only) resort for farmers who are otherwise constrained to sell at the farm gate because they are inaccessible to local merchants.

Mapping the Impacts of a General Equilibrium Model to Census Data

As we have described in the previous sections, our mapping model of the FTA's impacts along the territory is based in two basic stylized facts. First, we assume that the path through mechanism of a FTA to farmers is ruled by price transmission. Second, the *Jevons's law of one price* does not fit because international prices are differently transmitted within sub-national regions depending on their market accessibility.

In order to transmit changes in prices from our CGE results into our micro-census data, we use a vector of commodity prices and weight it by the composite market integration variable described in the previous section. By doing this, we account for how international prices differ in the domestic market. Using this adjusted price vector we estimate changes in value of production for each crop and each agricultural production unit in the census data. It is important to note that in the census there are UPAs with more than one crop, which may face changes in prices for more than one crop.

We assign agricultural census data on production on certain crops, which are directly mapped to GTAP-AGR agricultural sectors. We distribute the gains and losses according to the importance of a specific crop in the political administrative unit, in the case of Ecuador, cantons. As for the compensation policies, we are able to identify the size of producers, and geographic location of where income transfers would go. The methodology enables to match the economic results data of the GTAP-AGR to the spatial data as follows.

Formally, we define the change in gross production value of the production unit u as:

$$\Delta GPV^u = \sum_{j=1}^{n_u} \Delta GPV_j^u \tag{1}$$

where each term represents the change in production value by product and n_u , the number of them produced by unit u; Each of these variation terms can be represented by changes in prices and quantities:

$$\Delta GPV_j^u = P_{j,t+1}^u \cdot \Delta Q_j^u + Q_{j,t}^u \cdot \Delta P_j^u \tag{2}$$

Given the tariff shock, at the production units' level only the price changes between pre (t) and post ($t+1$) adjustment explains possible variations on GPV because price is the only signal that the production unit receives from local markets. So, assuming the *ceteris paribus* condition their quantities should not be affected by the tariff shock, that is: $\Delta Q_j^u = 0$. In addition, we assume that those units with permanent crops (bananas, coffee, cacao) cannot change their quantities (at least in the short run).

Price variations (ΔP_j^u) can be estimated at the production unit level for each product as the combination of the estimated local product price P_j^c, based on National Institute of Statistics and Census (INEC), and ψ_j the international product price obtained from the CGE simulations, that is to say:

$$\Delta P_j^u = P_j^c \cdot \frac{\Delta \psi_j}{\psi_j} \cdot F_u \tag{3}$$

where $F_u \in [0,1]$ is a sensitivity factor which depends on how the production unit u is susceptible to be affected by the sectoral *ex-post* shock price adjustment $\Delta\psi_j/\psi_j$. It is worth noticing that the factor F_u is being described at the unit level, so we can distinguish how the tariff shock can affect each production unit u and the gross value of their production. This is a key factor which correlates the macro CGE simulations results with the micro level information from the agricultural census.

The value of this sensitivity factor depends on a number of issues and it is structured by a chain of condition-action rules as follows:

(1) If the production unit doesn't sell its production: $F_u = 0$, since the unit is not affected by the change in price concerning the trade policy shock.
(2) If it sells its production, the value of F_u depends on who they sell to their products:

> (2.a) If the unit sells its products to final consumers, we assume that $F_u \in [0, 0.5]$
> (2.b) If the unit sells its products to intermediaries, exporters, and agrifood manufacturers, we assume that the value range of $F_u \in [0.5, 1]$

That is,

$$F_u = \begin{cases} 0, \text{ if } u \text{ doesn't sell its production} \\ g_s(d_u) \in [0, 0.5], \text{ if } u \text{ sells to final consumers} \\ g_s(d_u) \in [0.5, 1], \text{ if } u \text{ sells to exporters, manufacturers, etc.} \end{cases} \quad (4)$$

In both cases we consider a logistic (sigmoid) like curve to model the sensitivity factor as a function of the distance to the closest road that allows farmers marketplace access, such as:

$$g_s(d_u) = a + \frac{b-a}{1 + e^{-\alpha(d_u - \frac{d_{max}}{2})}} \in [a, b] \quad (5)$$

where $F_u \in [a,b]$, d_{max} is the maximum distant value that becomes the sensitivity factor negligible, and α a sensitivity rate that affect the curvature of the function, as it is showed in the example represented in figure 1. For practical purposes the value of α = -3 was chosen in the analysis.

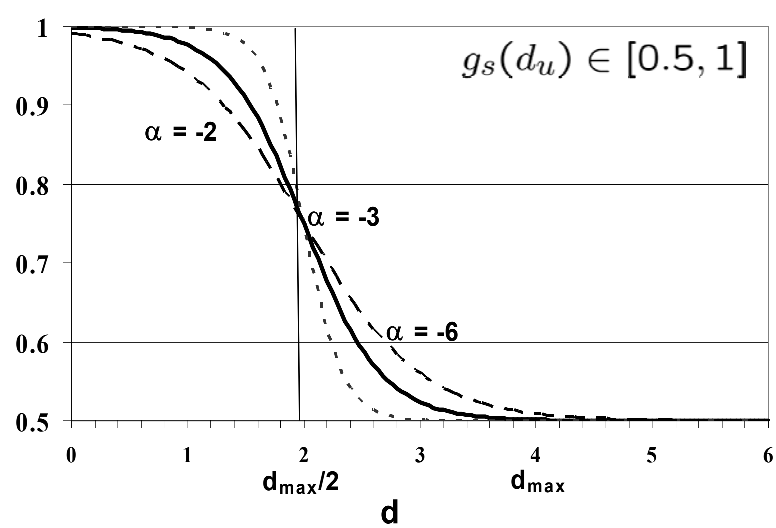


Figure 1. Sensitivity factor behavior as a function of the distance to the closest road.

As distance to road increases, time to place of sale increases, and if the place of sales is the UPA, price transmission decreases. As the degree of market integration increases, denoted by farmers selling their production, the higher the level of price transmission. Thus, the impact of trade liberalization depends on how changes in border prices are translated into changes in the prices actually paid to farmers. Price transmission depends on the competitive structure of the distribution sector, and the extent products are traded. These factors would likely affect the impacts on different types of farmers (subsistence, traditional and modern enterprises), as we will see in our results section.

This methodology to map price changes impacts can be used with both partial equilibrium and CGE models. However, when aggregation of the agricultural sector is needed as a whole, like shows figure 13, it seems to be better to use the CGE models.

Spatial Representation of the Agricultural Sector in Ecuador

This section is divided in three main subsections. First, we show the maps of current production situation in Ecuador based on the Agricultural Census data. This shows the geographic distribution of crops production areas based on geographic and climate suitability of crop production by type of producer. Second, we show the spatial distribution of impacts from the CGE model, where we map the impacts of trade liberalization on the agricultural sector of Ecuador by region and type of producer. Finally, we show the mapping of subsidies by type of producer and product.

Current Situation in Ecuador: Crop Maps

In this section, we discuss some of the results of the geographic distribution of crops and their production zones. Larson and Leon (2006) and The World Bank (2004) in Ecuador's poverty assessment offers a similar mapping of some of the production zones of Ecuador, focusing on rice, potatoes, bananas, coffee, and cocoa. Their discussion is not in depth, mainly due to the nature of their document. In this paper we focus on those crops identified by the government of Ecuador as sensible in a possible FTA with the United States. These crops are rice, corn (both hard and soft) and soybeans (oilseeds) as well as plant based fibers (cotton and abaca).

Before discussing the results from the agricultural census, we first describe the main agro-ecological zones of Ecuador, which are main drivers of the type of crops planted in different areas. This is important, given that these agroecological zones determine which crops are planted in certain regions, and help explain the geographic distribution of crops in the maps.

Ecuador has three main agro-ecological zones: Costa or Occidental region, Sierra or Central Andean, and Oriental region or Amazonia (FAO, 2006). The Costa region is formed by hills and plains suited for tropical agriculture. The highest elevations in this region are 800 meters over sea level, with median temperature of 24 ºC. Rainfall diminishes from north to south, where the climate is more semi-arid. This region includes the provinces of Los Rios, El Oro, Esmeraldas, Guayas and Manabi.

The Sierra region constitutes a mountainous region which is crossed from north to south by the Andes mountain range, at some points 200 Km wide and with elevations of more than 5500 meters over sea level with permanent snow. Rainfall occurs mainly between November and May and the weather is cold and dry. Suitability for agricultural production depends on elevation. At the highest levels (more than 3200 m), the predominant species are tubers and some cereals, with uncertain harvest due to weather conditions. At medium elevations (2200-3200 m), the weather is template and allows the production of cereals, pulses, fruits, vegetables and livestock production. At lower levels (less than 2200 m) there are export crops, cereals, vegetables, pulses and fruits. This region includes part or all of the provinces of Azuay, Bolivar, Cañar, Carchi, Cotopaxi, Chimborazo, Imbabura, Loja, Pichincha and Tungurahua (FAO, 2006).

The Oriental region constitutes almost half of Ecuador and constitutes a large drained plain by rivers that merge later with the Amazon river, with elevations below 600 m. The zones closest to the Andes have medium temperature of 28 ºC. To the east is less humid and rainy, with higher temperatures. Agricultural production systems of slash and burn are prominent, with forestry, extensive livestock production and tropical and subsistence crops as the main agricultural activities. It includes the provinces of Orellana, Morona Santiago, Napo, Pastaza, Sucumbios, and Zamora Chinchipe.

To better illustrate the geographic distribution of ecosystems, Figure 2 shows a map of land use by region. The red and purple areas denote the areas with cropland and managed forest under different management practices. Green denotes the area under tropical forest, which is mainly concentrated in the Oriental region, and north of the coastal region. Large portions of land under pastures are concentrated in the Sierra region, where livestock and dairy production is located. This figure will later help us better understand the geographic location of the crops discussed.

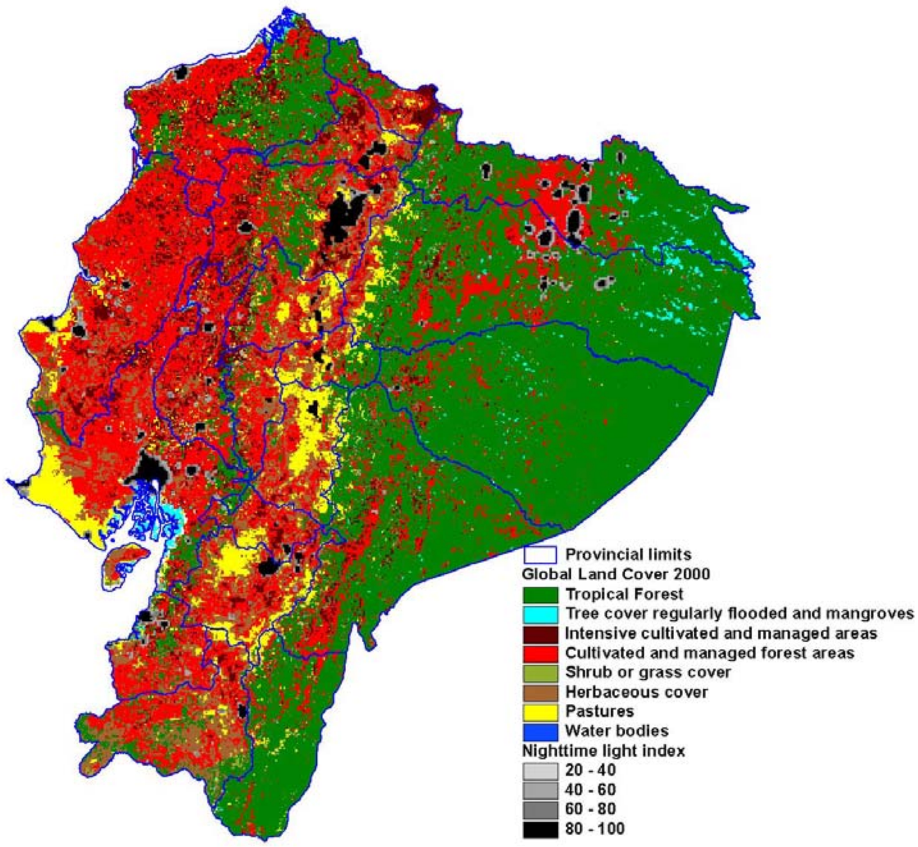


Figure 2. Vegetation Cover and Cropland Areas in Ecuador
Source: Global Land Cover (http://www-gvm.jrc.it/glc2000/defaultGLC2000.htm)

Figures 3 to 12 show the spatial distribution of selected crops in area and number of UPAs. We begin our discussion of the current geographic distribution of crops with rice. Rice production in Ecuador occupies the largest area of production than any other cereal grain crop in Ecuador, and within the Andean community, the country with the largest area of rice under production. In 2005, there were 410 thousand hectares, of whom there were harvested 377 thousand hectares. Total production was 1.5 million tons and total sales were 1.3 million tons (INEC, 2006). Rice production has risen in the last 15 years in Ecuador mainly due to the elimination of price controls and a strong export market due to the Andean free trade area and the sustained production deficit of neighbors Colombia and Peru, the main export markets of Ecuadorian rice.

Almost all area planted (98%) is concentrated near the Guayas river basin, in the provinces of Guayas (56%), Los Rios (37%), and Manabi (5%) (Figure 3). Most of the area and number of UPAs (50-75%) in these provinces are traditional enterprises (Figure 4). The rest is planted in other provinces of the coastal region, and also in the Oriente region, where in this last region, it is mostly a subsistence crop (FAO, 2006). The main production areas in the Guayas river basin are below 10 m over sea level with deep and fertile clay soils, with high and medium level of inputs with intermittent irrigation. These areas can produce up to three harvests per year. Other areas are known as "*pozas* *veraneras*" which are natural depressions that fill with water during the rainy season. According to the Ministry of Agriculture (MAG) of Ecuador (2007b) almost 40,000 Has. are planted under this system in Guayas and Los Rios. Sixty three percent of annual production is harvested between April and June, which corresponds to winter harvest, while the rest of production is harvested between September and December, which corresponds to summer harvest.

For corn production, there are four types of corn registered in the National Census. The first two refer to hard corn, both grain and on the cob (Figures 5 and 6), and the other two refer to soft corn, also as grain and on the cob (Figures 7 and 8). According to MAG (2002), corn production accrued for 4% of agricultural GDP, and the whole value chain (including animal feed and poultry production) 2% of total GDP. As for labor, corn production uses 8% of the economic active population (EAP) in agriculture, and if we include the whole chain it represents 3% of total EAP.

For hard corn (grain and on the cob), both producers and area are mainly concentrated in the Coastal region (76%), mainly in the provinces of Los Rios (31%), Guayas (21%) and Manabi (21%). This region accrues for 88% of all production, with one province, Los Rios, with almost half of all production (48%). This province is followed by Guayas (23%) and Manabi (16%). However, in terms of the number of UPAs, Manabi the largest. Rest of producers and area are in the south of Ecuador, in the province of Loja.

Hard corn (grain) area under production area by 2005 was of 283 thousand hectares, second to the area planted by rice. Of those, there was 263 thousand hectares harvested with a total production of 744 thousand tones of production and 676 thousand tones in sales. Yields have been rising in the last 15 years at an annual rate of 7%, from 1.45 MTn/Ha in 1990 to 2.37 MTn/Ha in 2004.

Corn production is the Coastal region is all year long, with sowing and plating preferably between January and March. Harvest is 5-6 months after planting. In the Sierra region, planting occurs between October and December. In the Oriental region, plating is year round, preferably between October and January. Harvest is bimodal, with the bulk of production between April and July (74%). and the rest between September and December (23%) (MAG, 2007a).

In Manabi, Guayas and Los Rios, the cantons with the highest concentration of UPAs, most of them are traditional enterprises (50-75%). However, in Loja 50-75% of all producers are subsistence farmers. For all other provinces, we find that for those in the Sierra and Oriente region, most are subsistence farmers, while for those in the Coastal region, most of them are traditional enterprises.

Out of the 86294 UPAs, 22610 are in Manabi, 15338 are in Los Rios, 13407 in Guayas and 9645 in Loja. In terms of area of hard corn under production, there are a total of 244 thousand hectares at the national level. Of those, 53011 are in Manabi, 78019 in Los Rios, 51331 Guayas and 18591 in Loja. Manabi has the largest number of producers, but Los Rios has the largest number of area under production. In Manabi, nearly half of the

UPAs are concentrated in four cantons: Portoviejo, Jipijapa, Tosagua and Pajan. As of area, the same cantons, except for Pajan occupy the top three spots. Chone replaces Pajan as the 4th largest cantons in terms of area. In Los Rios, more than 70% of UPAs and area are concentrated in the cantons of Palenque, Ventanas, Mocache and Vinces.

Most of this production according to CORPEI (2007) is used as animal feed (63%), mostly poultry feed. The rest is exported to Colombia (25%) and for human consumption and seed (4%). Due to geographic and climatic differences between production areas in Ecuador and Colombia, Ecuador's harvest production is complementary to that of Colombia, reaching Colombia's market two months earlier than Colombia's harvest (CORPEI, 2007). This is why that the FTA between Colombia and the United States could undermine Ecuador's relative price and geographic advantage in the Colombian market.

Soft corn production and UPAs are mainly in the Sierra region, with the largest concentrations in the provinces of Pichincha, Cotopaxi and Chimborazo (Figure 7). Of those UPAs, the majority (50-75%) are subsistence farmers. This is especially true in the province of Azuay and in some cantons of Chimborazo, where that percentage rises to 75-100%. As for the distribution of area in production (Figure 8), Pichincha (and the Quito's Metropolitan District), Chimborazo, Cotopaxi and Bolivar show the largest areas. Of those, the majority, especially in Central and South Sierra are in the hands of subsistance UPAs. This production structure of soft corn, with the majority of producers both in terms of number of UPAs and area as subsistence farmers would likely affect the type of policies relative to those for hard corn producers.

As for oilseeds (soybeans, sunflower, peanut, raps, and canola), we will focus our discussion on soybeans, which is the main oilseed crop in Ecuador. Both corn and soybean production is inherently linked to feed production, mainly for poultry production. Soybean cake represents 15-20% of feed composition. Soybean yields vary between 1.7-1.9 MTn/Ha, below the world average of 2.2 MTn/Ha. According to MAG (2003), in the early 90's, soybean production represented 2% of agricultural GDP, using 3.7% of the economically active population in agriculture. After those years, there was a decline of soybean production, mainly due to pests (White fly in 1995) and weather events (El Niño and La Niña).

Soybean plating in the Coastal region is mainly between January and February, while in the Oriental region, planting is between January and March, with harvest 90-125 days after. Soybean harvest and production is mainly concentrated (96%) in the months between September and December (MAG, 2007a).

The areas of oilseeds production are mainly in the province of Manabi and in areas between the provinces of Loja and El Oro (Figure 9). Of these UPAs, they are evenly distributed between subsistence farmers and traditional enterprises (Figure 10). The geographic distribution of the area in production is a little different from the distribution of UPAs. Aside from Manabi, EL Oro and Loja, there are production areas at the north of Los Rios province. Traditional enterprises make up the majority of area in the provinces of Manabi, El Oro and Loja. In the province of Los Rios, there is an important share of modern enterprises, sometimes up to 50-75% of area under production.

Plant based fibers is composed by cotton, abaca, paja toquilla, and cabuya. Plant based fibers production is scattered in several provinces of the coastal region, mainly in Manabi, Guayas, Esmeraldas and the coastal area of Pichincha. In terms of the number of UPAs, they are scattered throughout the Coastal region, with no identifiable pattern in the geographic distribution of producers (Figure 11). For example, in Manabi, the north is dominated importance of the type of producer depends

For cotton, which is the main product within this group, production is concentrated in the provinces of Manabi (52%) and Guayas (47%). Plating season is between December and April, with harvesting between May and October. Of the total number of UPAs, 64% are in Guayas and 34% in Manabi. In Manabi, the cantons with the largest production and number of UPAs are Sucre (57% of the province) and Tosagua. In Guayas, Pedro Carbo (51% of the province) and El Triunfo.

In general terms, the crops discussed here, rice, corn, soybeans and cotton are mainly concentrated in the coastal region, expect for soft corn production which is located in the Sierra region. That means that impacts and therefore subsidies, would be focused on producers around the Guayas river basin, where most of hard corn, rice and soybeans production is. As we see in the next section, impacts due to the FTA between Ecuador and the United States follow the geographic distribution of crop location, and are differentiated by type of producer.

Figure 3. Paddy rice: Distribution of the number of UPAs

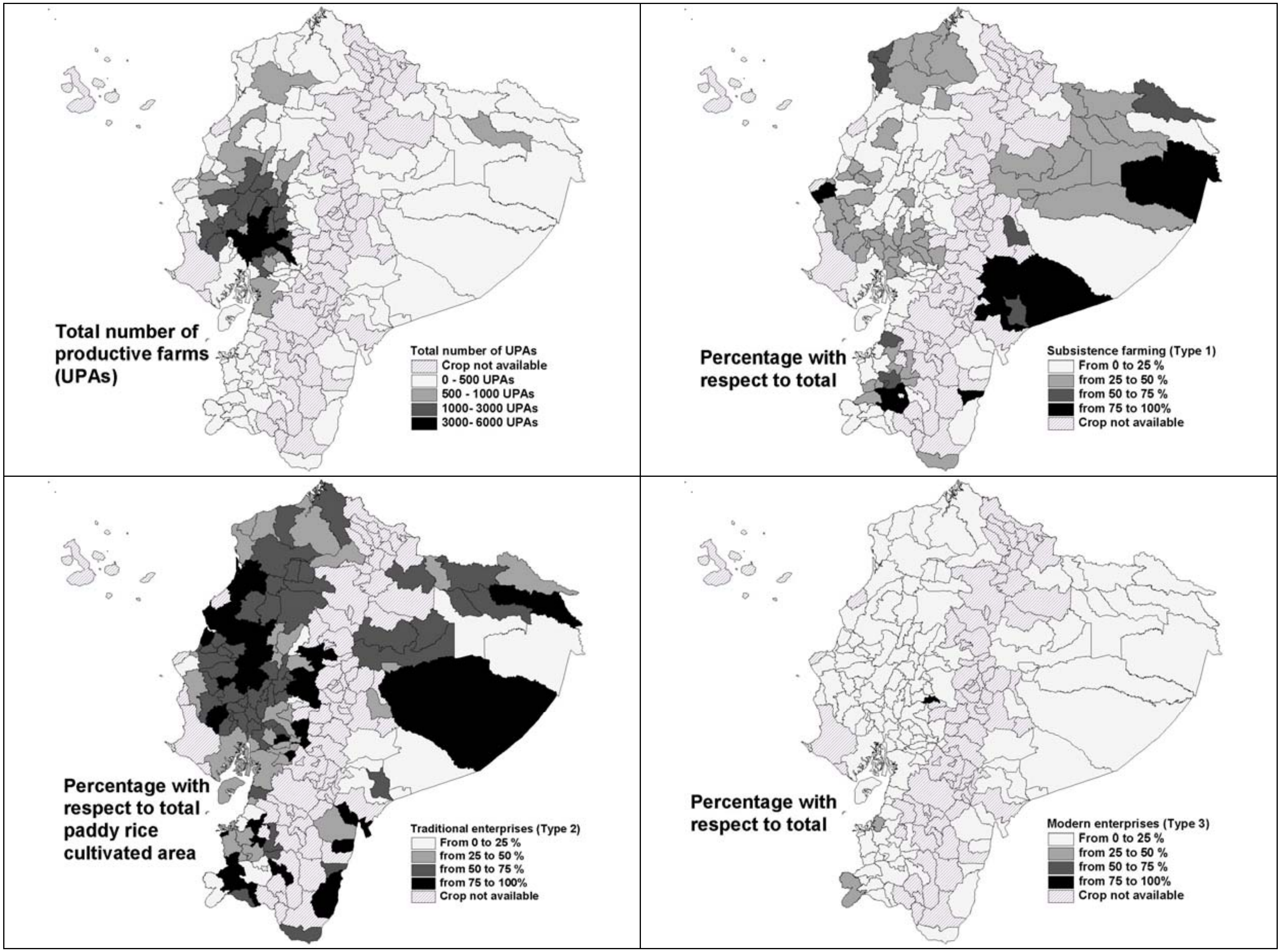


Figure 4. Paddy rice: Distribution of the total cultivated area

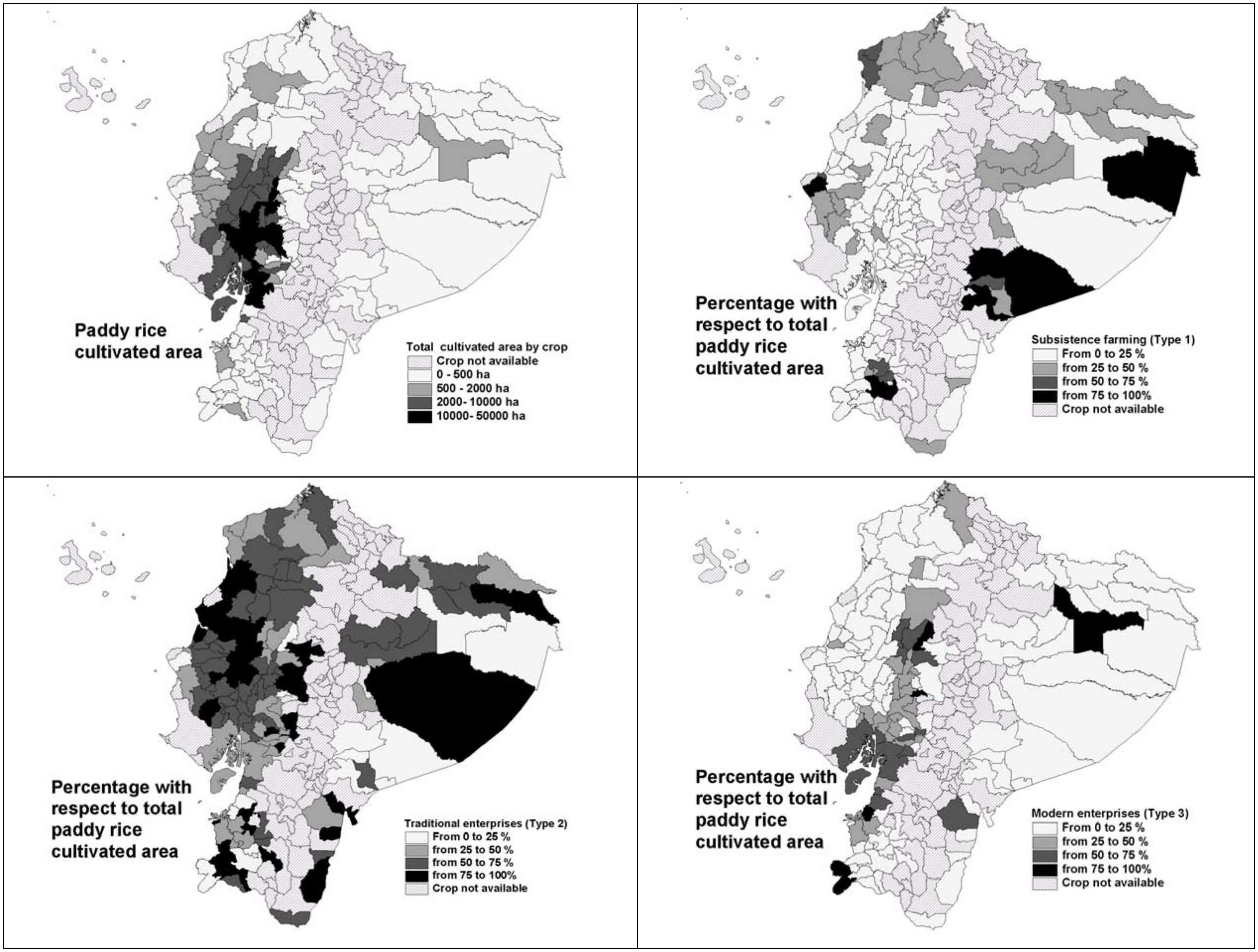


Figure 5. Corn (hard): Distribution of the number of UPAs

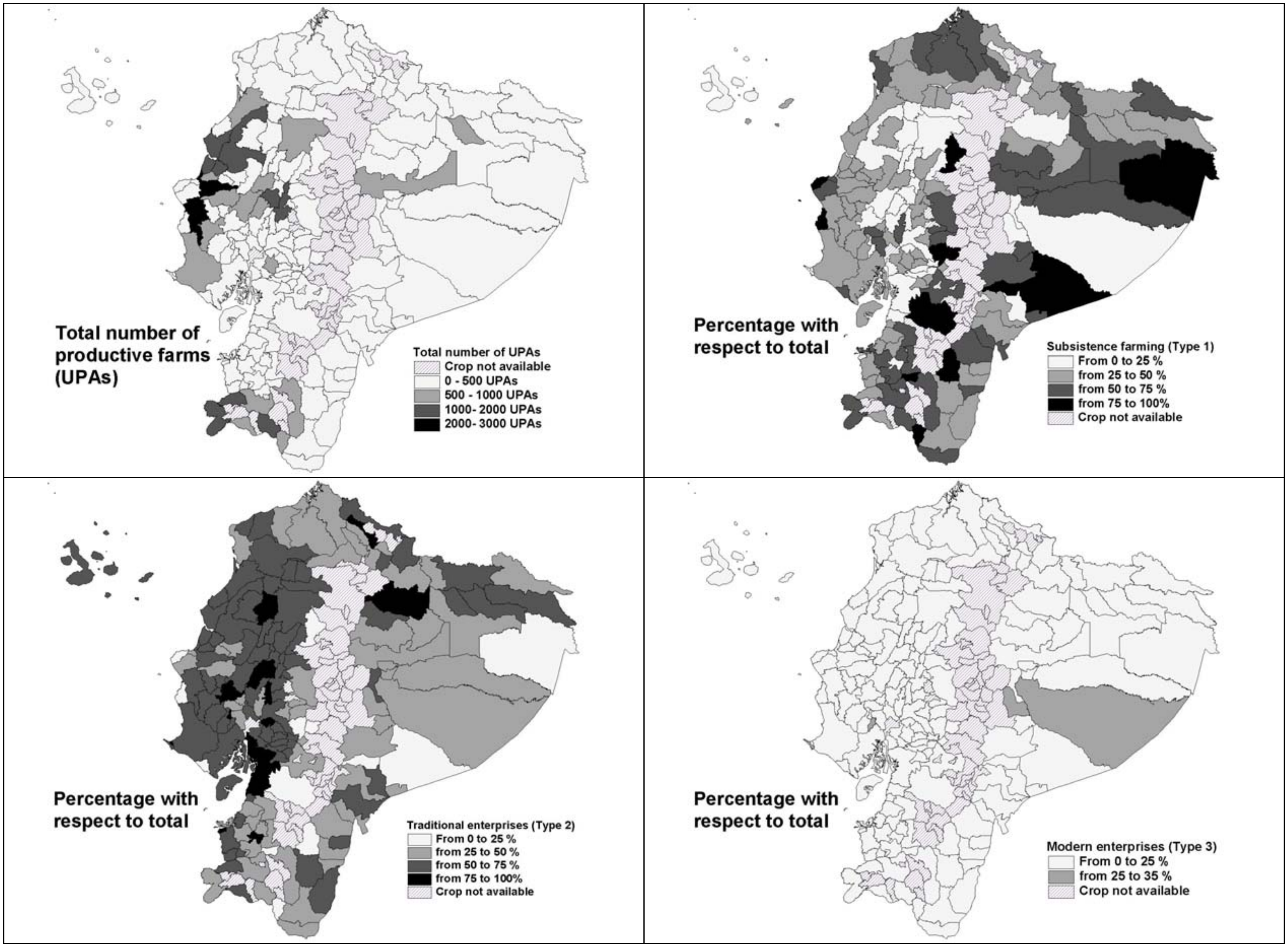


Figure 6. Corn (hard): Distribution of the total cultivated area

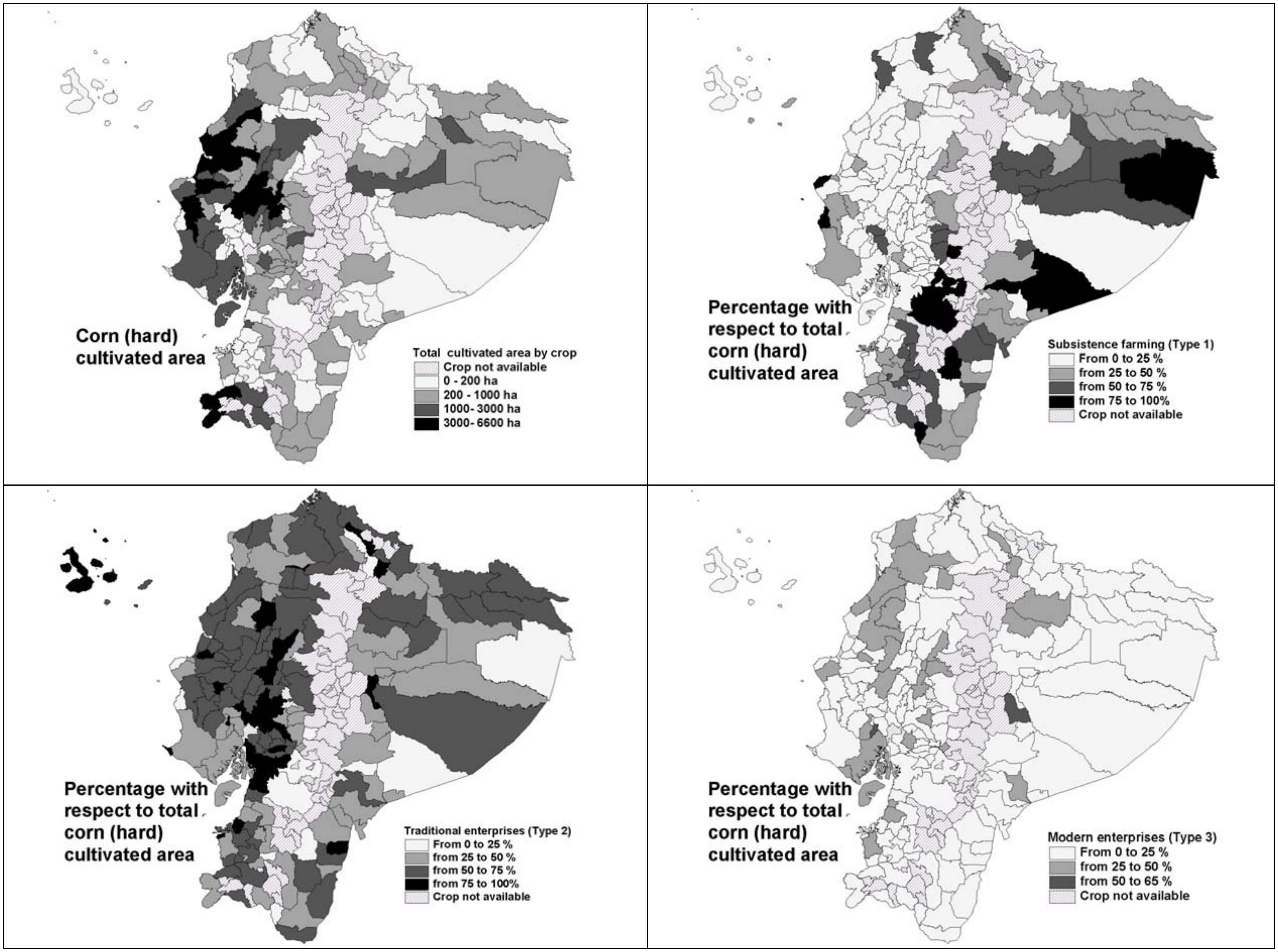


Figure 7. Corn (soft): Distribution of the number of UPAs

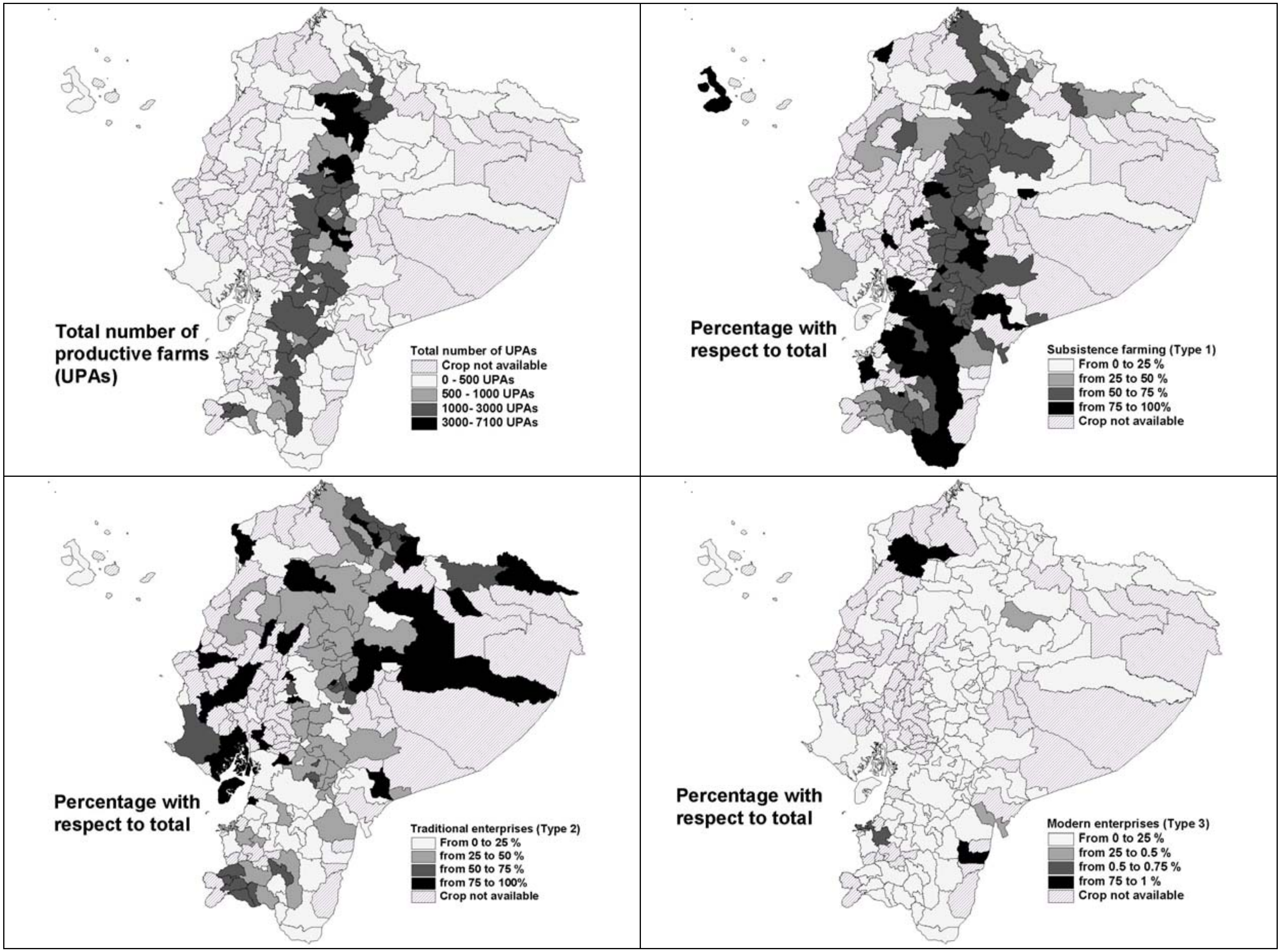


Figure 8. Corn (soft): Distribution of the total cultivated area

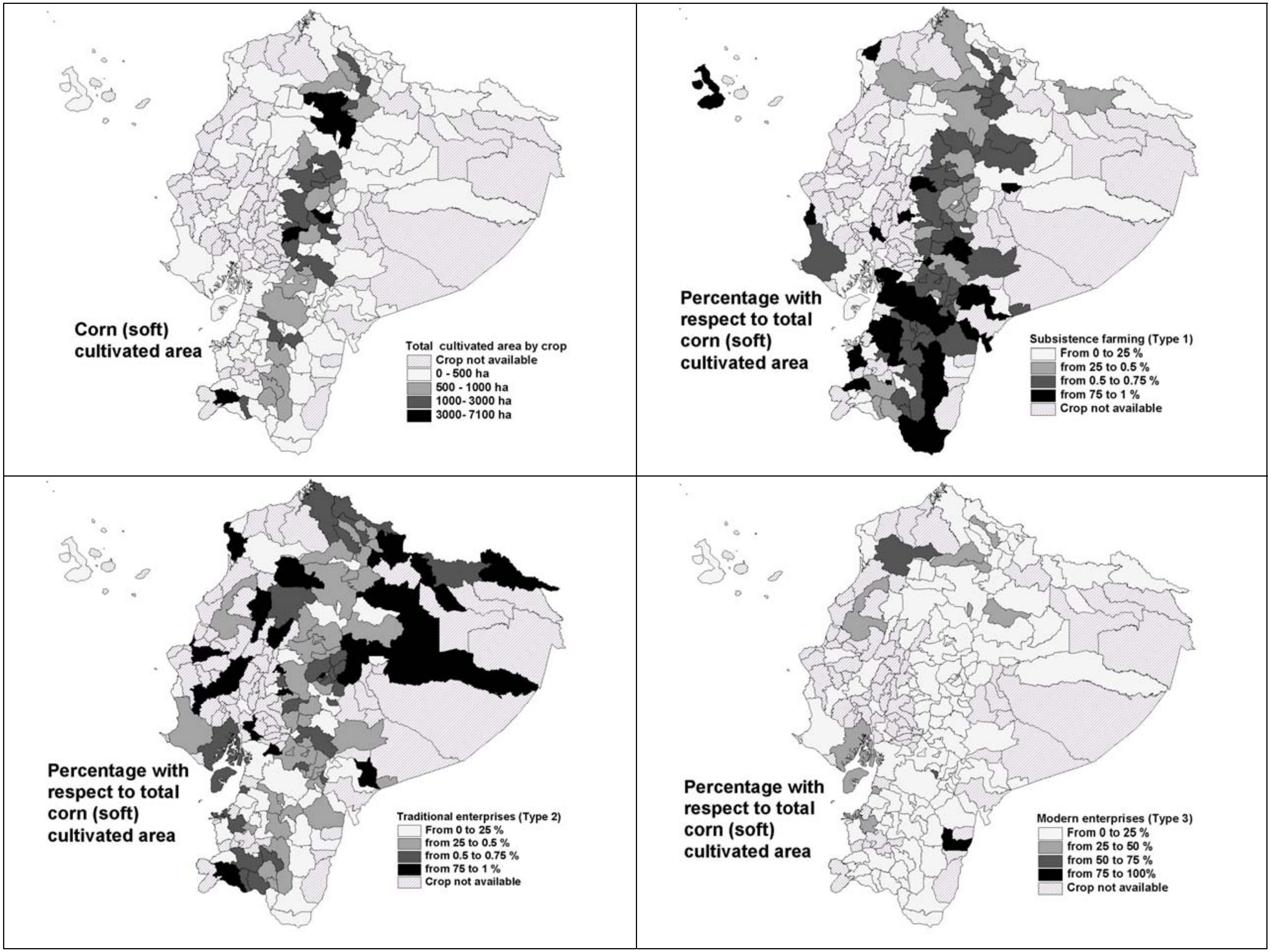


Figure 9. Oil seeds: Distribution of the number of UPAs

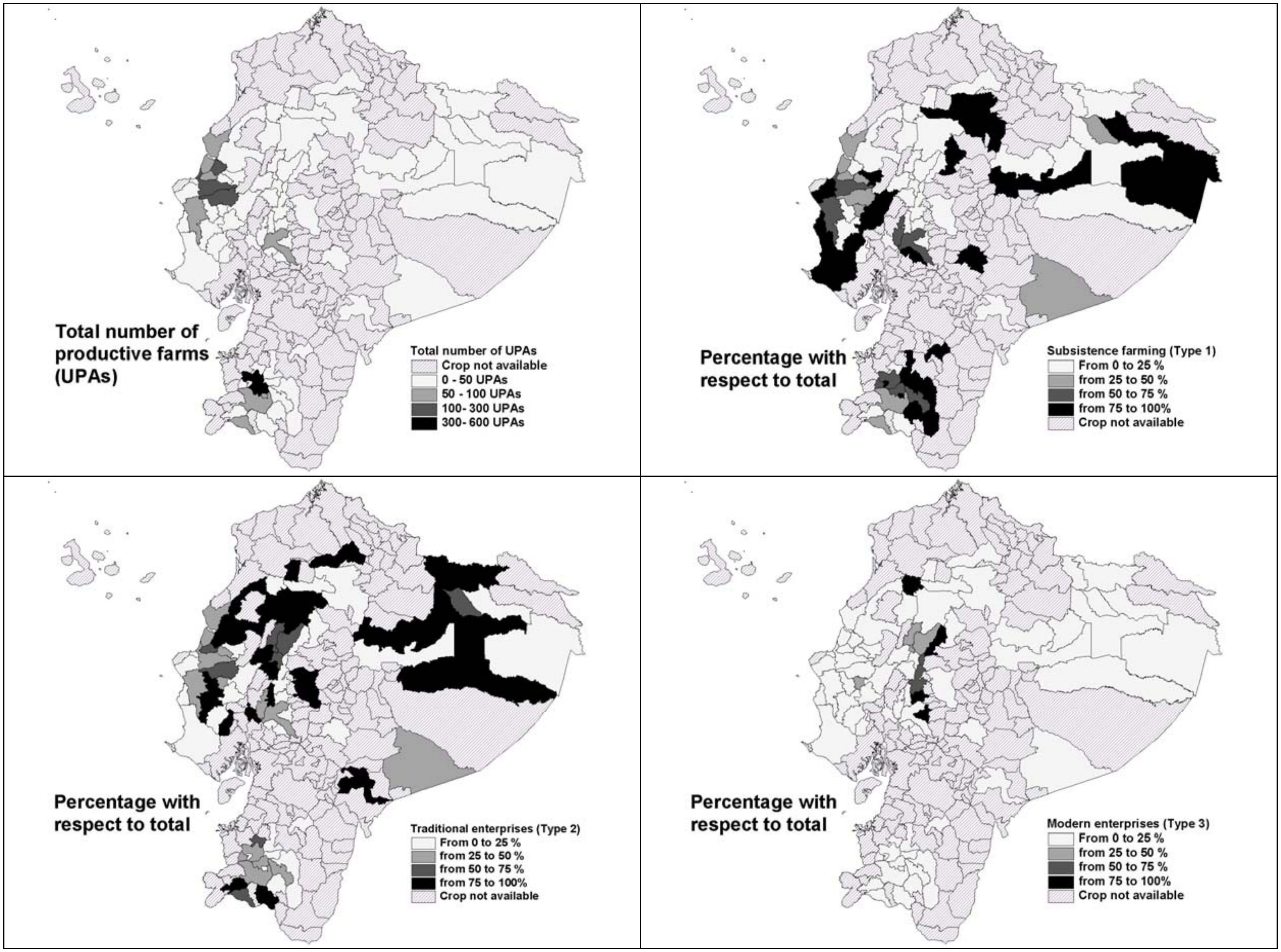


Figure 10. Oil seeds: Distribution of the total cultivated area

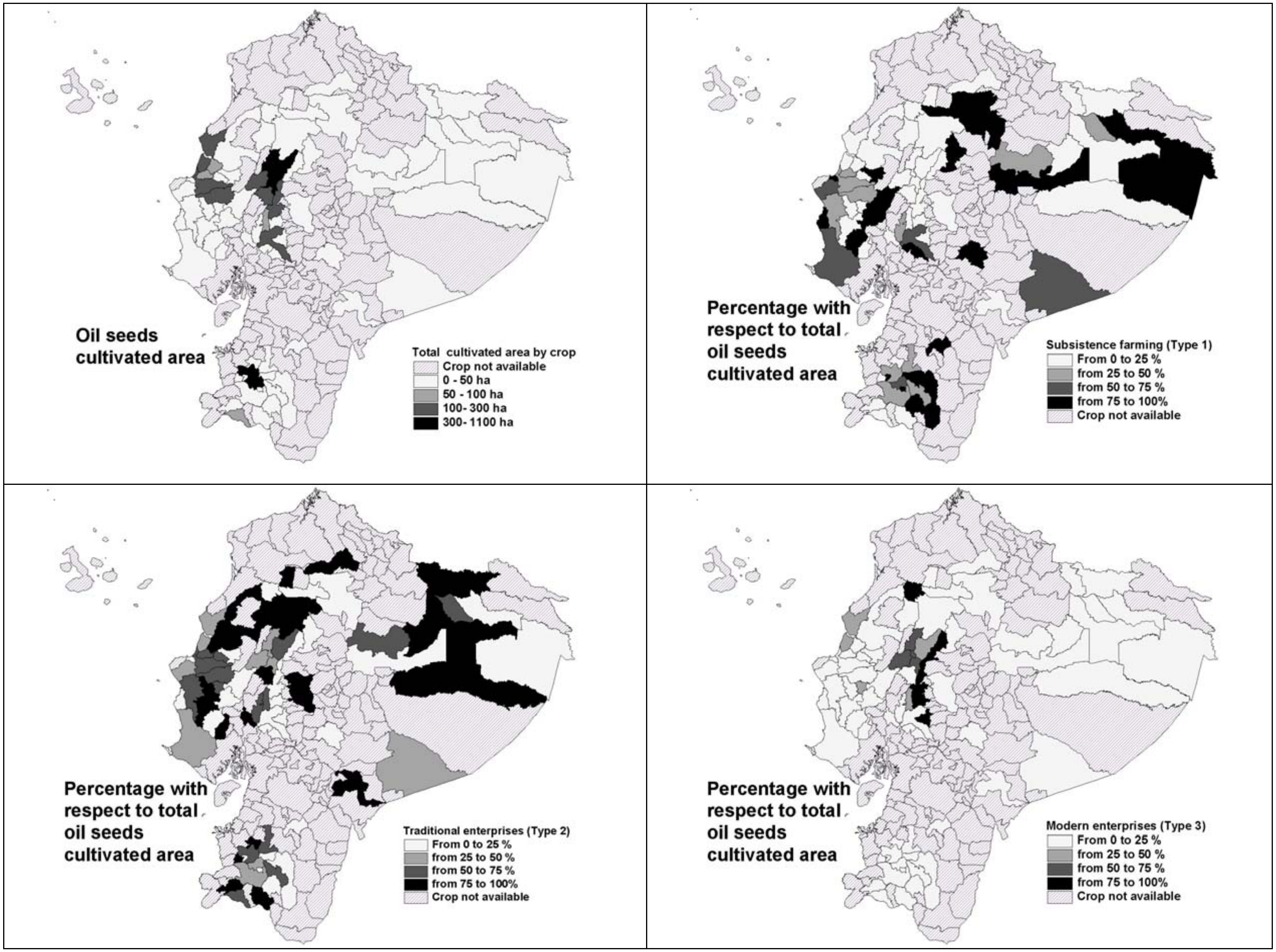


Figure 11. Plant based fibers: Distribution of the number of UPAs

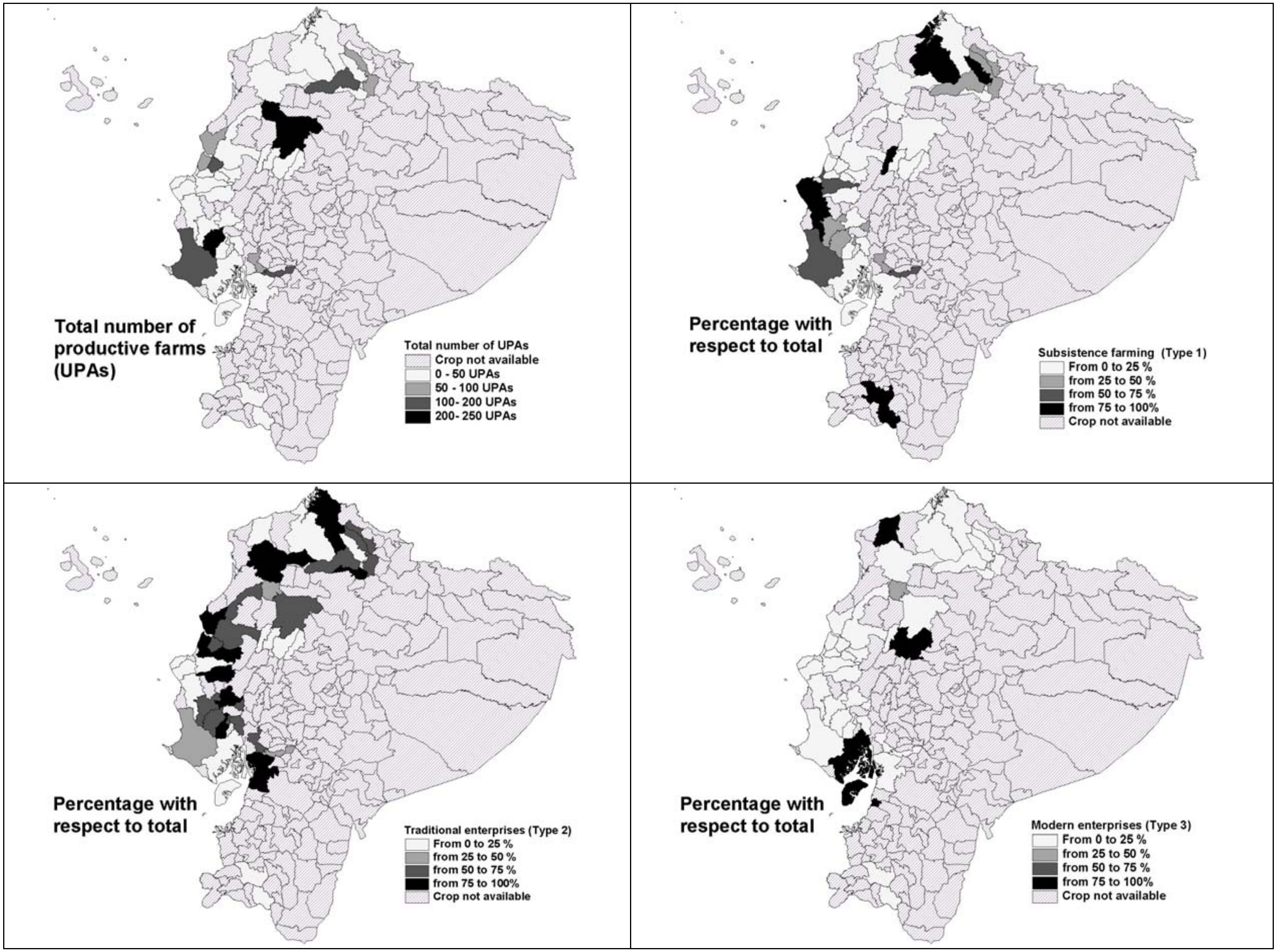
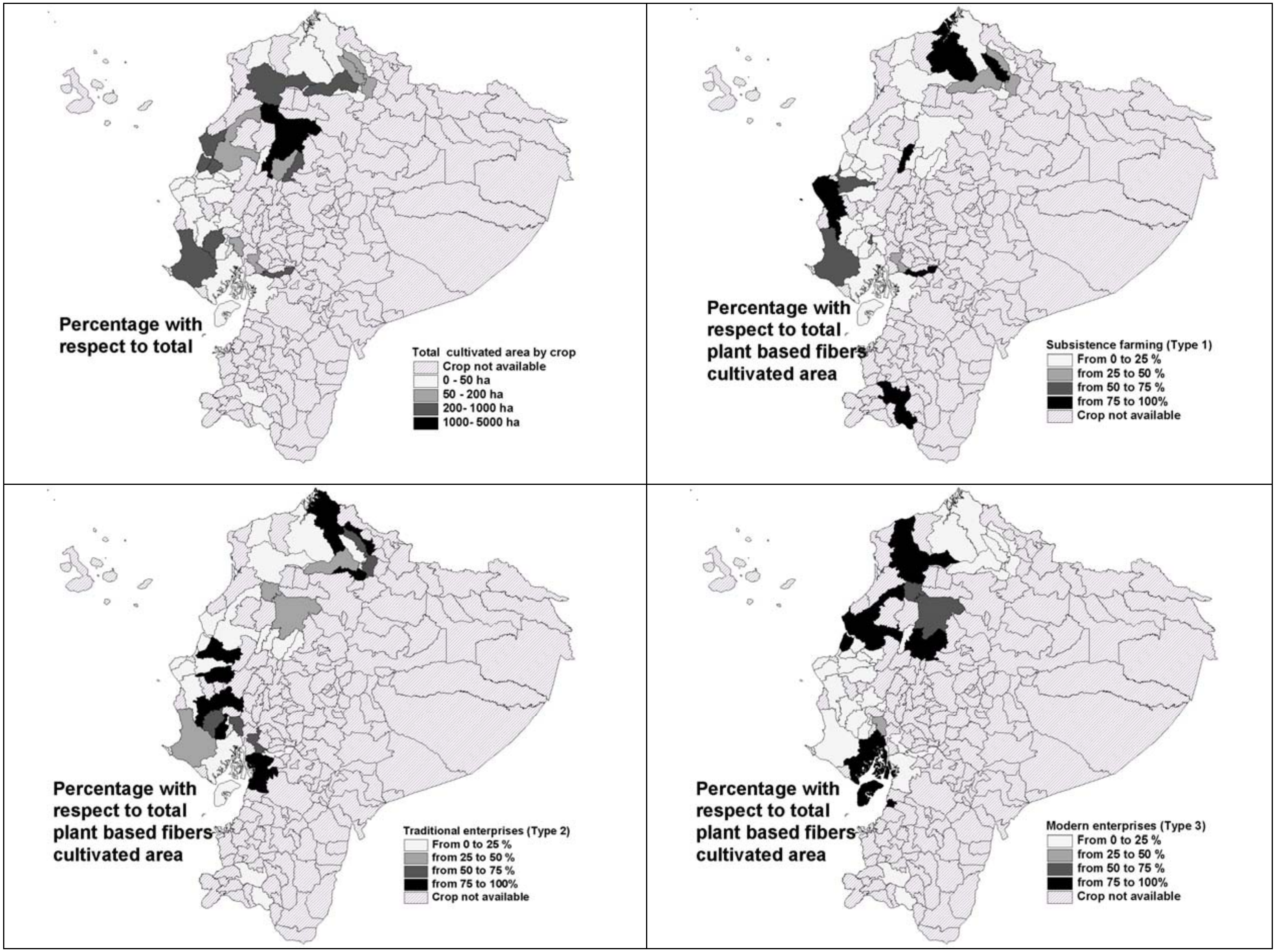


Figure 12. Plant based fibers: Distribution of the total cultivated area



Spatial Distribution of Impacts from an FTA with the U.S. on Ecuador's Agricultural Sector

After discussing the geographic distribution of production zones in Ecuador for some of the most important products in terms of sensitivity to an FTA, we discuss in this section the simulation results of an FTA on farmers of these products. This by no means is a complete picture of the total effects in the value of production, since we do not account for the change in production (quantities) that may happen.

Before discussing the results, we present a map of market access. This map denotes in minutes the distance to the closest local market. The brighter the color, the less time to a market, and the darker the color, the longer the time it takes to reach a market. These distances in minutes take into account access to roads, slope, and other factors. We can notice from this map the Pan-American Highway, which crosses the Sierra region at the middle from north to south. We can also notice the Amazonian highway, which joins the provinces in the Oriental region from north to south, and runs close to the Andes mountain range.

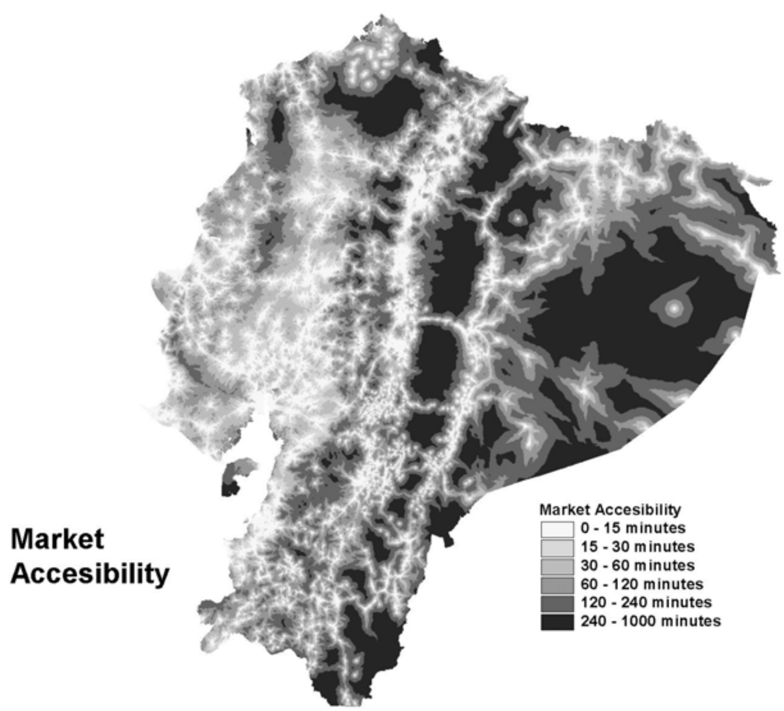


Figure 13. Accessibility to Local markets in Ecuador
Source: CIAT (2004), available from http://www.ecuamapalimentaria.info

Much of the Oriente region has little access, except for that highway and roads that connect the north part of this region where much of the oilfields are located. Much of the coastal region is pretty well connected to markets, except for the north east region, in the province of Esmeraldas. There is also a region that runs from north to south at the east of the Andes mountain range, between the Sierra and Oriental region. These large areas of inaccessibility are protected areas such as national parks or wildlife reverses, which do not have roads that run across them. This map will later help us to better understand some of the results of impacts, which are determined by farmers' market accessibility.

Figures 13 to 18 show the spatial representation of results from the general equilibrium model. All figures show loses in gross value of production (GVP), mainly because the change in the vector of prices used for these graphs was negative. As discussed in the methodology, we applied the changes in prices, assuming that in the short run, there would not be any change in quantities as a response on trade liberalization. The results shown in these figures would change if we assume a long term scenario with changes in prices and quantities.

The highest losses in absolute terms are concentrated in the coastal region, in the provinces of Los Rios and Guayas (Figure 13). This reflects the agricultural nature of the Guayas river basin, and the high concentration of production of sensible products (rice, hard corn, soybeans) in those provinces. The cantons more affected are: Babahoyo, El Guabo, Naranjal, Valencia, Ventanas, Machala, Baba, La Troncal, Puebloviejo, Pasaje y Buena Fe.

The most interesting result is that of those mostly affected in those areas and cantons, the majority of producers are modern enterprises. This reflects the nature of the production systems in those areas, and the market linkage that these modern enterprises have relative to subsistence farmers and traditional enterprises. Given that modern enterprises are linked more to exports markets (especially rice producers), any shock in international prices will be transmitted almost entirely to these producers. That is not the case for subsistence farmers, that although may have access to roads, selling to intermediaries reduces the price transmission shocks from international markets.

Traditional enterprises make up most of those affected in the provinces of Manabi, Esmeraldas, Loja, central Sierra provinces and the northern provinces of the Oriente region. Subsistence farmers make up most of those losing in the southern Sierra (especially Azuay) and in the Oriente region.

As we look the change in GVP by crop, we observe that or rice, loses are mainly concentrated in Los Rios and Guayas (Figure 14). The cantons more affected are Babahoyo, Daule, Sanborondon, Santa Lucia, Urbina Jado, Yaguachi and Naranjal. Most of the producers in those cantons with high losses are mainly modern enterprises and traditional enterprises, which as discussed before, are more connected with the rice export market. These results reflect the concern of the Ecuadorian government that losing the exports markets of Colombia and Peru to imports from the United States. The most affected producers may well be those modern enterprises.

For hard corn (Figure 15), in those areas with the highest losses (Los Rios, Manabi and Guayas), most of the affected are traditional enterprises, and in some cantons, modern enterprises. For soft corn (Figure 16), highest losses in absolute terms are concentrated in

Pichincha, Azuay, Loja and some cantons of the central Sierra. Subsistence farmers make up 75-100% of those losing in Azuay, and 50-75% of those in some cantons of Loja and the central Sierra. Loosing producers by type are evenly distributed in those cantons in the province of Pichincha.

For oilseeds (Figure 17), highest losses are concentrated in a few cantons in the provinces of Los Rios, which is the main production area of soybean production. The cantons more affected are: Babahoyo, Valencia, Montalvo, Ventanas, Quevedo y Buena Fe. Same as in rice, the majority of producers affected are traditional and modern enterprises, which reflects the production structure of oilseeds in Ecuador. It is worth noticing that cantons in the province of Los Rios disproportionally loose to those in Manabi, the other main producer province. This may prove the usefulness of the methodology developed for this paper, which identifies loosing farmers by their market integration.

As for plant based fibers (Figure 18), losses are mainly concentrated in the northern area of the coastal region, between the provinces of Esmeraldas and Pichincha. Most loosing producers are mainly modern enterprises, and with a smaller share of traditional enterprises.

We can conclude that for most crops, some of the most affected producers are those classified as modern enterprises. This has important implications for policy makers, since in most cases, policies and subsidies are focused on those smaller producers that cannot stand for themselves. Modern enterprises may be able to better change and adapt to the new situations produced by an FTA, which may not be true for subsistence farmers. However, and as shown in our results, the focus of policies may as well be modern enterprises. We discuss this policy on subsidies to compensate the negative effects of the FTA in more detail the next section.

Figure 13. Total distribution of GPV loses

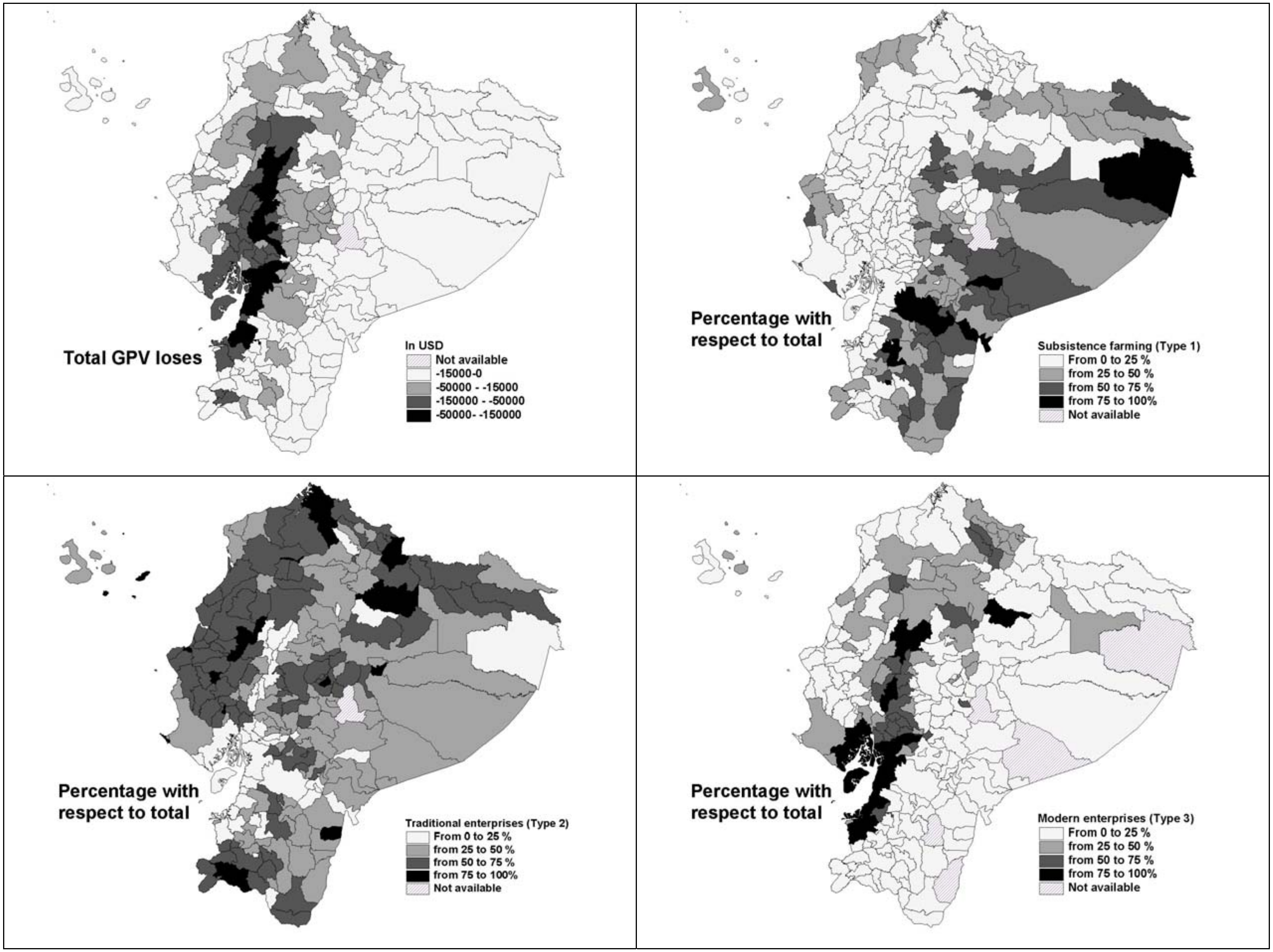


Figure 14. Paddy rice: Distribution of GPV loses

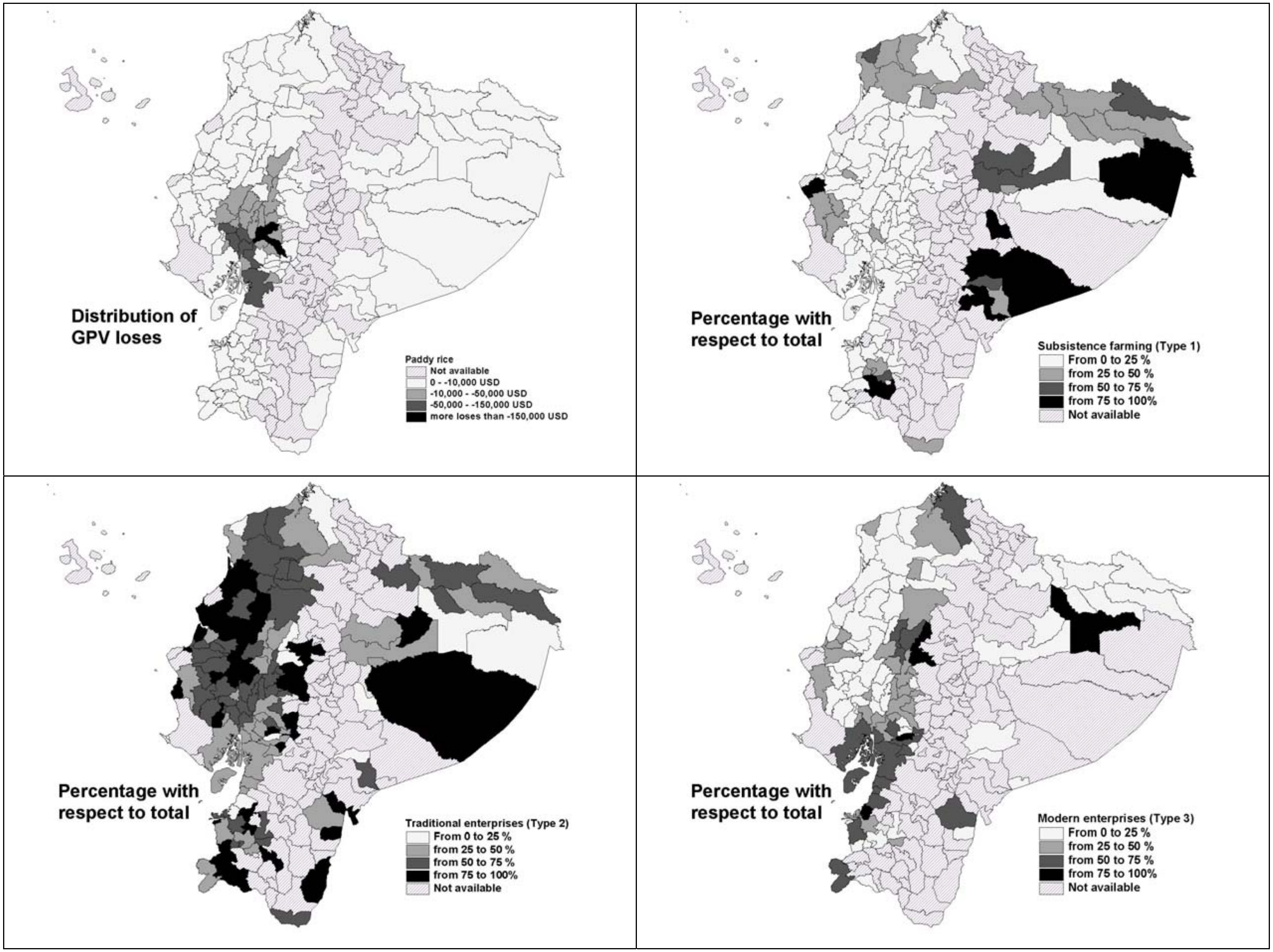


Figure 15. Corn (hard): Distribution of GPV loses

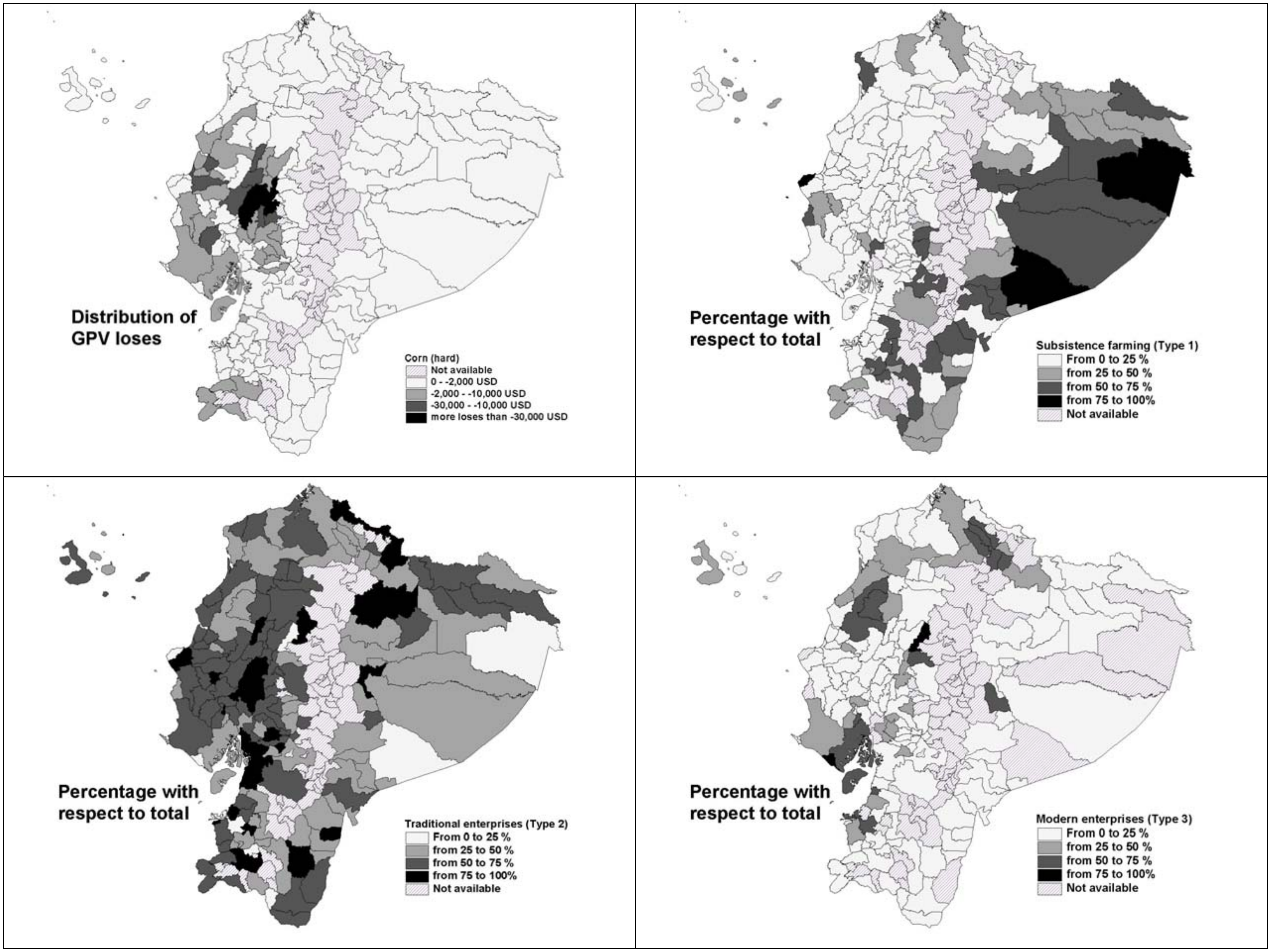


Figure 16. Corn (soft): Distribution of GPV loses

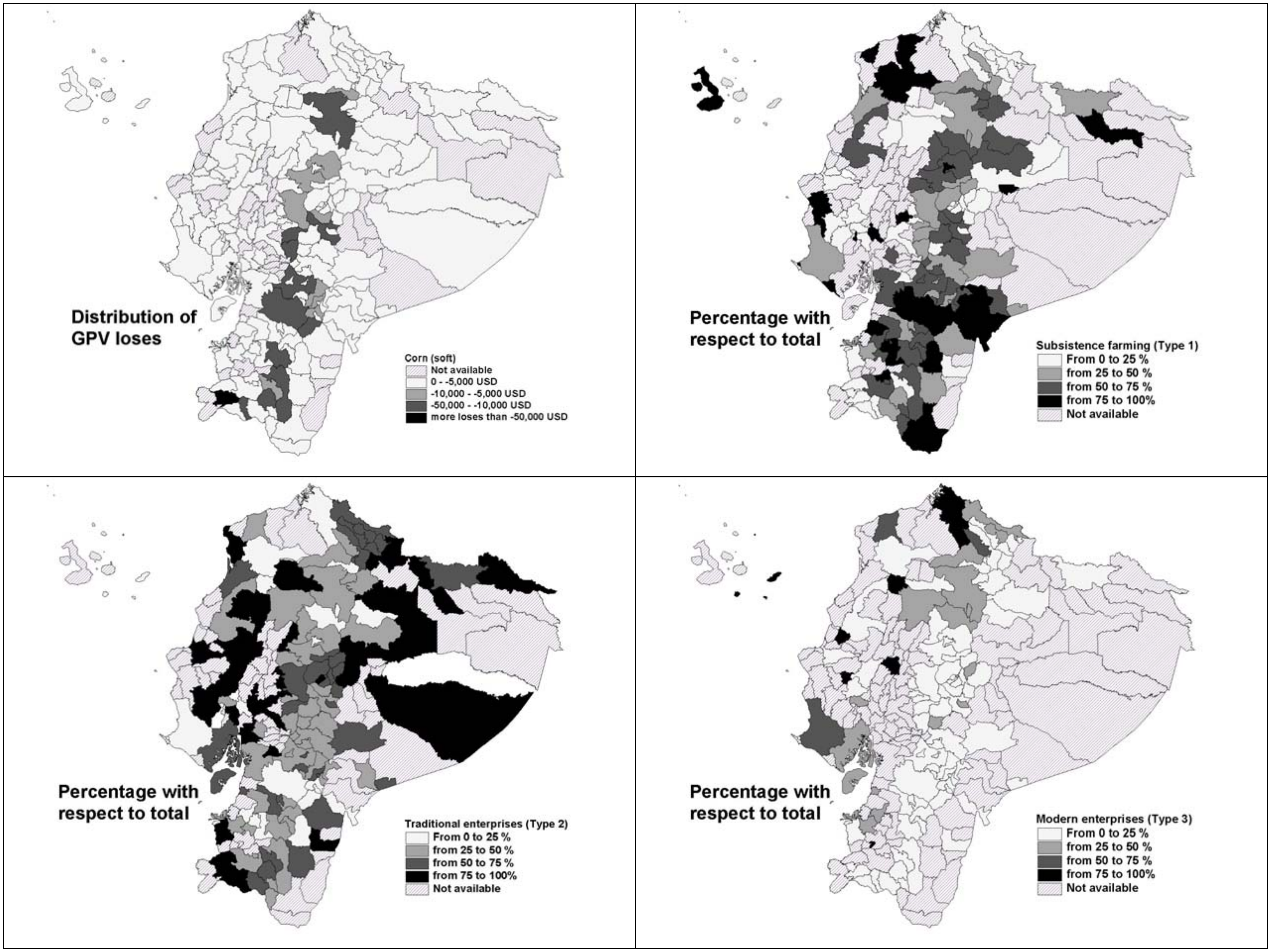


Figure 17. Oil seeds: Distribution of GPV loses

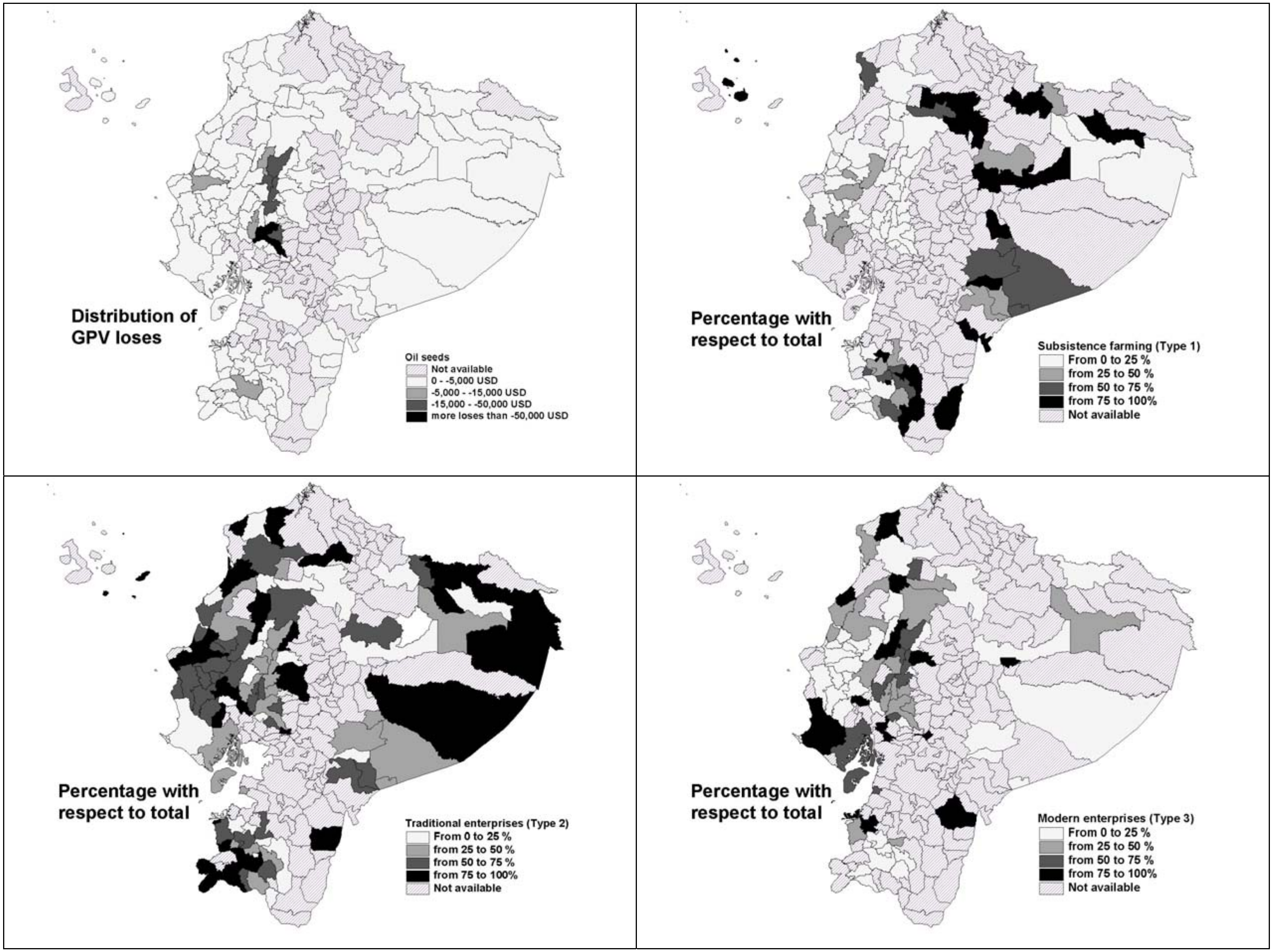
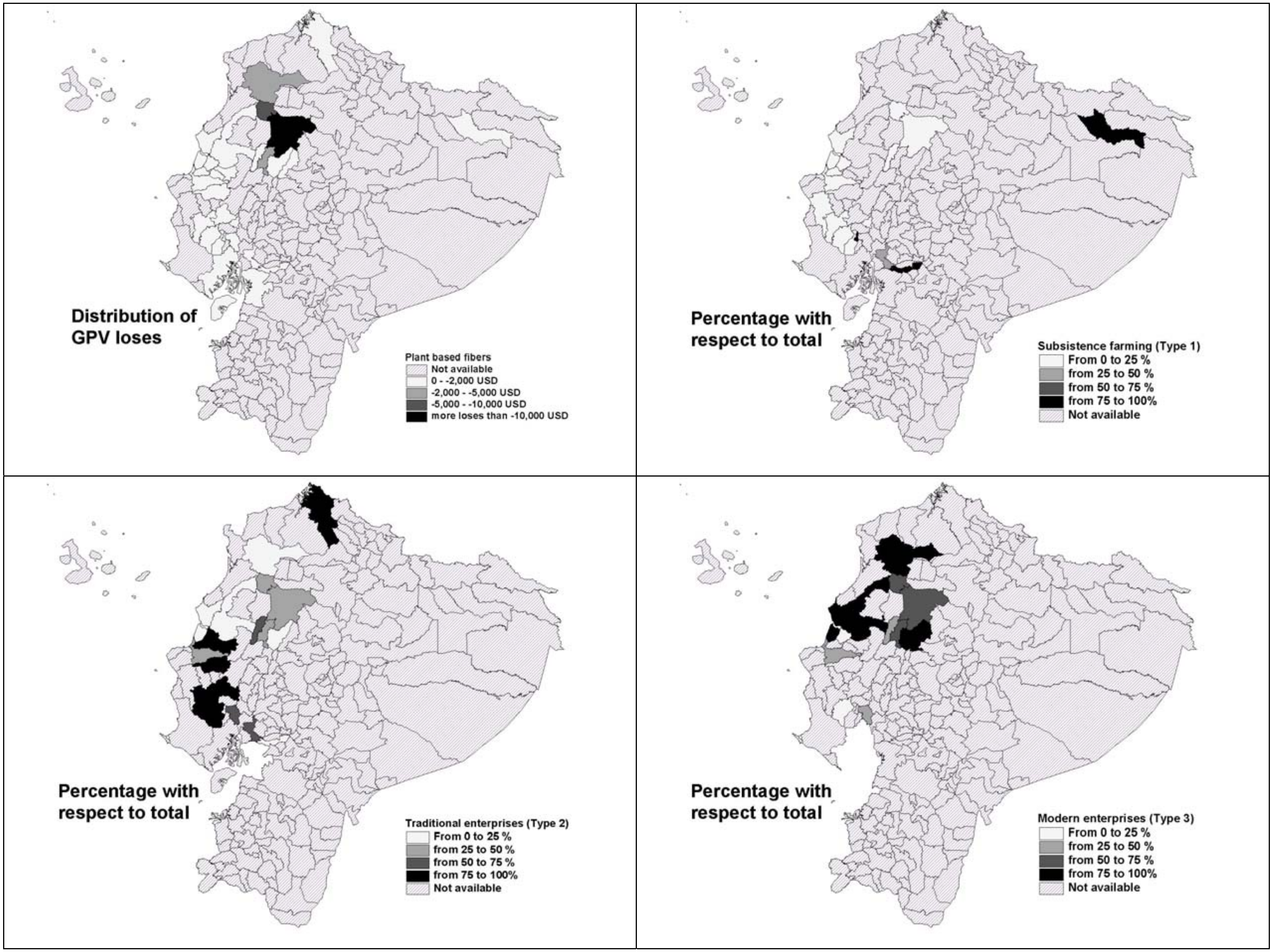


Figure 18. Plant based fibers: Distribution of GPV loses



Spatial Distribution of Subsidies for Agriculture

Given the spatial distribution of impacts in Ecuador, we assume in this case that subsidies to compensate the negative impacts of a FTA between the United States and Ecuador will follow the same spatial distribution. That is, subsidies will be mostly focused in the Guayas river basin, where most producers of cereals and oilseeds are. Rice, hard corn and soybeans production areas and producers are concentrated in Guayas, Los Rios and Manabi. Soft corn producers are mainly concentrated in the Sierra region, especially in the central and south areas.

If the government does not make any distinction between subsistence farmers and traditional and modern enterprises, subsidies will simply follow the distribution of the impacts as shown in the previous section. However, this outcome may change if the government makes distinction between type of producers, focusing in subsistence and traditional enterprises. In this case we assume that modern enterprises have more capability of adapting to changes due to the FTA.

Conclusions

In this study we have shown the results of an applied general equilibrium model through the spatial lens. To do this we have developed a methodology that enables us to merge the CGE results with microeconomic information. We have applied this methodology to the effects of an FTA between Ecuador and the United States on Ecuador's agriculture. We show that most producers and area of the crops that are the focus of Ecuador's subsidies (rice, corn and soybeans) are mainly in the provinces of Guayas, Los Rios and Manabi, around the basin of the Guayas river.

These results would enable policy makers to focus their policies in a geographic or territorial way. Use of this tool with other geographically referenced data (such as income or weather data) would be of great use for policies ranging from poverty reduction to environmental mitigation of global warming. For that reason, future developments of this tool plans to combine other geographically referenced data, such as household surveys with socio-economic information that would enable policy makers to better target specific policies to where they are most needed.

Future Research

We recommend several areas of future research that may improve what we have done in this first exploratory paper. In terms of our methodology, the way the impact distribution is changed should be based more on empirical and econometric work. Market integration and spatial price transmission tests should be a first step in that direction. We find it imperative to estimate a set of parameters where to base the logistic function. Also, we need to be able to distinguish between the different channels of commercialization, and determine whether there are sensible differences between the type of market channel and prices.

We need to improve price information and regional price distribution. Currently, this information is incomplete since we do not have price information for all cantons and for all products. We also need to asses changes in production quantities, and the UPA level. As explained in our methodology, we assume that impacts are short term, and therefore, farmers are not able to change production quantities. This has important implications in our results, since the vector of price changes is negative for all sectors. Thus, all changes in the gross value of production are negative. These results might change if we take into account changes in quantities, where for some sectors, are positive, thus giving a positive expansion component in the value of production.

As for the scope of this paper in terms of Ecuador's agriculture, another area of analysis that has not been addressed is the livestock sector. That sector has also been identified by the government of Ecuador as a sector that would be covered by a subsidy program and that may loose with an FTA. A revised version of this paper should try to include this sector.

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Appendix Table A1. Commodity Aggregation and correspondence of Ecuador's Agricultural Sectors to GTAP Sectors

No.	GTAP Sector	Description	Ecuador Sectors Analyzed
1	pdr	Paddy Rice	Paddy rice
2	wht	Wheat	Wheat
3	gro	Cereal Grains Nec. (corn, rye)	Corn – hard Corn – soft Other cereals
4	v_f	Vegetables, fruits and nuts (bananas)	Fruits Vegetables
5	osd	Oil Seeds (soybeans)	Oil seeds
6	c_b	Sugar Cane	Sugar crops
7	pfb	Plant-based fibers (cotton)	Plant based fibers
8	ocr	Crops nec. (coffee, cacao, roses)	Roses Coffee Cacao Other crops
9	ctl	Bovine Cattle, sheeps, goats horses	
10	oap	Animal Products Nec (Pigs, poultry)	
11	rmk	Raw Milk	
12	wol	Wool, silk-worm cocoons	
13	for	Forestry	
14	fsh	Fishing (Shrimp, Tuna)	
15	Oil and Mining	Oil and Mining	
16	cmt	Bovine meat products	
17	omt	Meat products nec (pork, poultry meat)	
18	vol	Vegetable oils and fats	
19	mil	Dairy products (milk, cheese, etc.)	
20	pcr	Processed rice	
21	sgr	Sugar	
22	ofd	Food Products Nec	
23	b_t	Beverages and tobacco products	
24	Manufacturing	Manufacturing	
25	Services	Services	

Appendix Table A2. Transitional Crops and Mapping to GTAP Sectors

Crop (in Spanish)	GTAP Sector	Code	Crop (in Spanish)	GTAP Sector	Code
Acelga	Fruits & Vegetables	v_f	Linaza	Oil seeds	osd
Ají Serrano	Fruits & Vegetables	v_f	Lufa	Fruits & Vegetables	v_f
Ajo	Fruits & Vegetables	v_f	Maíz duro choclo	Other Cereals	gro
Ajonjolí	Fruits & Vegetables	v_f	Maíz duro seco	Other Cereals	gro
Alcachofa	Fruits & Vegetables	v_f	Maíz suave choclo	Other Cereals	gro
Algodón	Plant based fibers	pbf	Maíz suave seco	Other Cereals	gro
Anís	Other crops	otr	Maní	Oil seeds	osd
Apio	Fruits & Vegetables	v_f	Marigold	Fruits & Vegetables	v_f
Arroz	Paddy rice	pdr	Malanga	Fruits & Vegetables	v_f
Arveja seca	Fruits & Vegetables	v_f	Melloco	Fruits & Vegetables	v_f
Arveja tierna	Fruits & Vegetables	v_f	Melón	Fruits & Vegetables	v_f
Avena	Other Cereals	gro	Nabo	Fruits & Vegetables	v_f
Badea	Fruits & Vegetables	v_f	Oca	Fruits & Vegetables	v_f
Berenjena	Fruits & Vegetables	v_f	Papa	Fruits & Vegetables	v_f
Brócoli	Fruits & Vegetables	v_f	Papa china	Fruits & Vegetables	v_f
Brumancia	Fruits & Vegetables	v_f	Papa nabo	Fruits & Vegetables	v_f
Camote	Fruits & Vegetables	v_f	Pepinillo	Fruits & Vegetables	v_f
Cebada	Other Cereals	gro	Perejil	Fruits & Vegetables	v_f
Cebolla blanca	Fruits & Vegetables	v_f	Pimiento	Fruits & Vegetables	v_f
Cebolla colorada	Fruits & Vegetables	v_f	Quínua	Other Cereals	gro
Cebolla perla	Fruits & Vegetables	v_f	Rabano	Fruits & Vegetables	v_f
Centeno	Other Cereals	gro	Remolacha	Fruits & Vegetables	v_f
Chocho	Fruits & Vegetables	v_f	Romanescu	Fruits & Vegetables	v_f
Cilantro	Fruits & Vegetables	v_f	Sandía	Fruits & Vegetables	v_f
Col	Fruits & Vegetables	v_f	Sorgo	Other Cereals	gro
Coliflor	Fruits & Vegetables	v_f	Soya	Oil seeds	osd
Col de bruselas	Fruits & Vegetables	v_f	Suquini	Fruits & Vegetables	v_f
Espinaca	Fruits & Vegetables	v_f	Tabaco	Other crops	otr
Fréjol seco	Fruits & Vegetables	v_f	Tomate riñón	Fruits & Vegetables	v_f
Fréjol tierno	Fruits & Vegetables	v_f	Trigo	Wheat	wht
Garbanzo	Fruits & Vegetables	v_f	Vainita	Fruits & Vegetables	v_f
Girasol	Oil seeds	osd	Yuca	Fruits & Vegetables	v_f
Haba seca	Fruits & Vegetables	v_f	Zambo	Fruits & Vegetables	v_f
Haba tierna	Fruits & Vegetables	v_f	Zanahoria amarilla	Fruits & Vegetables	v_f
Higuerilla	Oil seeds	osd	Zanahoria blanca	Fruits & Vegetables	v_f
Hongos	Fruits & Vegetables	v_f	Zapallo	Fruits & Vegetables	v_f
Jengibre	Other crops	otr	Mashua	Fruits & Vegetables	v_f
Lechuga	Fruits & Vegetables	v_f	Huerto Hortícola	Fruits & Vegetables	v_f
Lenteja	Fruits & Vegetables	v_f	Planta Medicinal Trans.	Other crops	Otr

Appendix Table A3. Permanent Crops and Mapping to GTAP Sectors

Crop (in Spanish)	GTAP Sector	Code	Crop (in Spanish)	GTAP Sector	Code
Achiote	Other crops	otr	Manzana	Fruits & Vegetables	v_f
Ají	Fruits & Vegetables	v_f	Maracuyá	Fruits & Vegetables	v_f
Abacá	Plant based fibers	pbf	Marañon	Fruits & Vegetables	v_f
Aguacate	Fruits & Vegetables	v_f	Membrillo	Fruits & Vegetables	v_f
Alcaparra	Fruits & Vegetables	v_f	Mora	Fruits & Vegetables	v_f
Arazá	Fruits & Vegetables	v_f	Naranja	Fruits & Vegetables	v_f
Babaco	Fruits & Vegetables	v_f	Naranjilla	Fruits & Vegetables	v_f
Banano	Fruits & Vegetables	v_f	Níspero	Fruits & Vegetables	v_f
Cabuya	Plant based fibers	pbf	Paja toquilla	Plant based fibers	pbf
Cacao	Other crops	otr	Palma africana	Oil seeds	osd
Café	Other crops	otr	Palmito	Fruits & Vegetables	v_f
Caña de azúcar	Sugar crops	sgr	Papaya	Fruits & Vegetables	v_f
Caña guadua	Other crops	otr	Pepino	Fruits & Vegetables	v_f
Capulí	Fruits & Vegetables	v_f	Pera	Fruits & Vegetables	v_f
Cardamomo	Fruits & Vegetables	v_f	Pimienta dulce	Other crops	otr
Caucho	Forestry	for	Pimienta negra	Other crops	otr
Ceibo	Forestry	for	Piña	Fruits & Vegetables	v_f
Cereza	Fruits & Vegetables	v_f	Pitahaya	Fruits & Vegetables	v_f
Chirimoya	Fruits & Vegetables	v_f	Plátano	Fruits & Vegetables	v_f
Ciruelo	Fruits & Vegetables	v_f	Kiwi	Fruits & Vegetables	v_f
Ciruela costeña	Fruits & Vegetables	v_f	Sábila	Fruits & Vegetables	v_f
Claudia	Fruits & Vegetables	v_f	Tamarindo	Fruits & Vegetables	v_f
Cocotero	Fruits & Vegetables	v_f	Taxo	Fruits & Vegetables	v_f
Durazno	Fruits & Vegetables	v_f	Té	Other crops	otr
Espárrago	Fruits & Vegetables	v_f	Tomate de árbol	Fruits & Vegetables	v_f
Frutilla o fresas	Fruits & Vegetables	v_f	Toronja	Fruits & Vegetables	v_f
Granadilla	Fruits & Vegetables	v_f	Tuna	Fruits & Vegetables	v_f
Guaba	Fruits & Vegetables	v_f	Uva	Fruits & Vegetables	v_f
Guanabana	Fruits & Vegetables	v_f	Uvilla	Fruits & Vegetables	v_f
Guanto	Fruits & Vegetables	v_f	Zapote	Fruits & Vegetables	v_f
Guayaba	Fruits & Vegetables	v_f	Orito	Fruits & Vegetables	v_f
Higo	Fruits & Vegetables	v_f	Chonta	Fruits & Vegetables	v_f
Lima	Fruits & Vegetables	v_f	Tagua	Other crops	otr
Limón	Fruits & Vegetables	v_f	Caimito	Fruits & Vegetables	v_f
Macadamia	Fruits & Vegetables	v_f	Uva de monte	Fruits & Vegetables	v_f
Mamey	Fruits & Vegetables	v_f	Borojó	Fruits & Vegetables	v_f
Mandarina	Fruits & Vegetables	v_f	Huerto frutal	Fruits & Vegetables	v_f
Mango	Fruits & Vegetables	v_f	Planta Medicinal perm.	Other crops	otr

Appendix Table B1. Number and share of Producers by type in each Region

Region	Subsistence	Traditional Enterprises	Modern Enterprises	Total
Costa	79,558 36.2	122,424 55.7	17,827 8.1	219,809 100
Sierra	339,203 59.8	210,754 37.1	17,665 3.1	567,621 100
Oriente	24,503 48.7	24,279 48.2	1,569 3.1	50,351 100
Galapagos	153 25.3	370 61.3	81 13.4	604 100
Others	997 22.2	2,885 64.2	614 13.7	4,496 100
Total	444,414 52.7	360,712 42.8	37,755 4.5	842,882 100

Source: Morales et al. (2005)

Appendix Table B2. Average Value of Production by Type of Producer in each Region

Region	Subsistence	Traditional Enterprises	Modern Enterprises	Average	Total
Costa	779	5,218.7	61,577.2	22,525	67,574.9
Sierra	269.2	1,481.8	32,865.4	11,538.8	34,616.4
Oriente	1162	899	2,025.8	1,362	4086
Galápagos & Others	844.6	998.9	474.5	772.7	2318
Total*	1,048.2	6,700.5	94,442.6		
Promedio*	524.1	3,350.25	47,221.3		

Source: Morales et al. (2005)
(*) Excludes Oriente and Galapagos & Others

Appendix Table B3. Average Size of UPA by type of farmer and Region (hectares)

Region	Subsistence	Traditional Enterprises	Modern Enterprises
Costa	8.7	23.5	116.9
Sierra	4.5	11.4	64.7
Oriente	41.5	51.9	200.8
Total	7.5	18.7	93.8

Source: Morales et al. (2005)

Appendix Table B4. Crop Share of total Gross value of Production by type of producer

Sierra

Subsistence		Traditional Enterprises		Modern Enterprises	
Dry soft corn	32.6	Potatoes	22.6	Bananas	35.9
Soft corn	2.6	Sugar cane for sugar	21.6	Sugar cane for sugar	17.7
Dry hard corn	3.1	Dry soft corn	12	Oil Palm	17.1
Potatoes	18.4			Potatoes	13.1
Sub-total	56.7	Sub-total	56.2	Sub-total	82.9
Others	43.3	Otros	43.8	Others	17.1
Total	100	Total	100	Total	100

Costa

Subsistence		Traditional Enterprises		Modern Enterprises	
Rice	54.1	Rice	36.7	Bananas	71.3
Cacao	13.6	Bananas	22.6	Sugar cane for sugar	8.5
Dry hard corn	12.1	Dry hard corn	12.7	Rice	7.5
		Cacao	7.6	Oil Palm	7.3
Sub-total	79.8	Sub-total	79.6	Sub-total	94.6
Others	20.2	Others	20.4	Others	5.4
Total	100	Total	100	Total	100

Source: Morales et al. (2005)

Appendix Table B5. Main products by type of producer and number of UPAs

Subsistence		Traditional Enterprises		Modern Enterprises	
Fruits & Vegetables	378,916	Fruits & Vegetables	257,504	Fruits & Vegetables	31,548
Other Cereals	293,543	Other Cereals	173,048	Other Cereals	11,338
Other crops	79,877	Other crops	108,634	Other crops	8,293
Paddy Rice	23,725	Paddy Rice	50,269	Paddy Rice	5,229
Sugar Crops	23,236	Sugar Crops	15,458	Oil Seeds	1,692
Wheat	19,938	Wheat	9,946	Sugar Crops	1,404
		Oil Seeds	6,824		
Vegetables	303,506	Vegetables	156,241	Fruits	21,947
Corn hard	202,726	Corn hard	126,318	Vegetables	9,601
Other crops	79,877	Other crops	108,634	Other crops	8,293
Fruits	75,410	Fruits	101,263	Corn Hard	8,055
Other Grains	45,683	Paddy Rice	50,269	Paddy Rice	5,229
Corn soft	45,134	Corn soft	23,900	Corn soft	2,220
Sugar crops	23,236	Other Grains	22,830	Oil seeds	1,692
Paddy Rice	23,725	Sugar crops	15,458	Sugar crops	1,404
Wheat	19,938	Wheat	9,946	Other Grains	1,063
		Oil seeds	6,824		

Source: Morales et al. (2005)

Appendix Table C. FTA Impacts on Ecuador Sectors (% change)

Sector	Production	Price	Consumption	Value Added	Imports	Exports	Welfare (millions US $)	Real Farm Income
Paddy rice	-0.3	-0.8	-0.6	-0.3	-0.6	-31.7	-31.7	-0.3
Wheat	-0.5	-3.5	1.3	-0.5	1.3	33.0	33.0	-0.6
Cereal grains	-1.3	-1.0	7.1	-1.3	7.1	-16.7	-16.7	-1.7
Vegetables, fruits and nuts (bananas)	0.8	-0.6	2.1	0.8	2.1	1.3	1.3	1.2
Oil Seeds (soybeans)	-3.8	-1.2	2.9	-3.8	2.9	-11.1	-11.1	-5.2
Sugar Cane	-0.6	-0.8	-2.0	-0.6	-2.0	3.5	3.5	-0.8
Plant-based fibers (cotton)	-1.6	-1.0	4.6	-1.6	4.6	3.2	3.2	-2.1
Crops nec. (coffee, cocoa, roses)	0.8	-0.5	0.4	0.8	0.4	1.6	1.6	1.2
Bovine Cattle, sheep, goat, horses	-0.7	-0.9	-1.6	-0.7	-1.6	-0.4	-0.4	-0.9
Animal Products Nec (Pigs/poultry)	-1.8	-1.1	-0.2	-1.8	-0.2	-1.1	-1.1	-2.4
Raw milk	-0.5	-0.9	-3.8	-0.5	-3.8	5.7	5.7	-0.7
Wool, silk-worm cocoons	-1.5	-1.1	-2.2	-1.5	-2.2	4.0	4.0	-2.0
Forestry	-1.3	-1.3	6.4	-1.3	6.4	4.5	4.5	–
Fish (Shrimp, Tuna)	0.3	-0.3	0.9	0.3	0.9	0.2	0.2	–
Oil and Mining	0.3	-0.3	5.3	0.3	5.3	2.1	2.1	–
Bovine meat products	-0.5	-0.9	23.8	-0.5	23.8	5.4	5.4	–
Meat products nec (pork & poultry)	-2.0	-1.0	36.4	-2.0	36.4	-20.3	-20.3	–
Vegetable oils and fats	-0.8	-1.1	4.5	-0.8	4.5	-2.0	-2.0	–
Dairy products (milk, cheese, etc.)	-0.5	-0.9	8.3	-0.5	8.3	4.5	4.5	–
Processed rice	0.0	-1.3	-2.2	0.0	-2.2	-3.4	-3.4	–
Sugar	-1.2	-0.9	1.5	-1.2	1.5	-10.1	-10.1	–
Food Products Nec	1.1	-1.0	3.6	1.1	3.6	1.8	1.8	–
Beverages and tobacco products	-0.3	-1.0	0.0	-0.3	0.0	1.1	1.1	–
Manufacturing	-2.1	-1.0	2.6	-2.1	2.6	1.0	1.0	–
Real Farm Income in Agriculture								0.36
On farm income								0.40
Off farm income								-0.51

Source: Ludena and Wong (2006)

Appendix Table D1. Government Transfers by size of APU for Crops and Livestock

Commodity	APUs < 20 Ha.	APUs 20-50 Ha.	APUs > 50 Ha.	Total Transfers
		($/Ha.)		($US Millions)
Corn	110	77	55	24
Soybean	53	37	26	2
Rice	162	113	81	44
Livestock (by size of APU)		Percent of Transfers		
Small (1-10 Ha.)		68		17
Medium (10-50 Ha.)		23		6
Large (> 50 Ha.)		9		2
Total		100		25

Source: Ministry of Agriculture.

Appendix Table D2. Land tenure for Selected Crops in Ecuador (2000)

Crop		Less than 10 Ha (Share, %)	10-50 Ha (Share, %)	More than 50 Ha (Share, %)	Total
Rice	APUs	49,595 (65)	21,164 (28)	5,054 (7)	75,814
	Hectares	113,868 (33)	120,094 (35)	109,974 (32)	343,936
Corn	APUs	42,313 (52)	29,587 (36)	10,044 (12)	81,943
	Hectares	64,777 (27)	111,426 (46)	63,998 (27)	240,201
Soybeans	APUs	2,496 (59)	1,296 (31)	433 (10)	4,226
	Hectares	7,724 (14)	16,749 (31)	29,877 (55)	54,350

Source: 2000 Agricultural Census