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Correlates of Maize Land and Livelihood Change Among Maize Farming Households in Mexico

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Summary. — We use classification tree analysis to identify the primary predictors of a suite of maize land use and livelihood outcomes for smallholder farmers in three regions of Mexico (Sinaloa, Mexico state, and Chiapas). Our analysis identifies regionally specific correlates with change in maize area, yield, and income, spanning demographic, environmental, and social development factors. Our results indicate that there may be opportunities for surplus production and market participation in some rain fed areas. We confirm the significance of regional and inter-regional heterogeneity in farmers' responses and strategies, underscoring the value of regionally specific policy interventions.
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1. INTRODUCTION

After several decades of neglect and persistent urban bias (Bezemer & Headey, 2008), interest in agriculture as a vehicle for both economic and sustainable development has regained ground in policy circles and academic investigation (IAASTD, 2008; World Bank, 2007). In the wake of significant volatility of global food prices and concerns about future global food security (Godfray *et al.*, 2010) there is renewed debate about the role and potential of smallholder production in the developing world (Chappell & LaValle, 2011; Pingali, 2012). In Latin America, land use and livelihood trends over the last several decades have given rise to the identification of a "new rurality": a context in which ostensibly rural and even marginal spaces are affected by activities that are at once agricultural and urban, local and global (Appendini & Torres-Mazuera, 2008; Kay, 2008). Within the "new rurality" households, rural land use and livelihoods may be divergent: land in agriculture is not necessarily indicative of livelihood identification with agriculture (Eakin & Appendini, 2008; Lerner, Eakin, & Sweeney, 2013); ostensibly rural contexts may be characterized by increasingly urban-oriented lifestyles and consumption patterns (Appendini & Torres-Mazuera, 2008; Barkin, 2006; McNair, 2012).

In Mexico, maize, as the dominant food staple and traditional crop of the smallholder *campesino*, has historically played an important role in rural development and agricultural programing and policy (Appendini, 2001). Nevertheless, national investment in maize production has declined substantially since the 1980s; commercial interests and agribusinesses now play a far more prominent role in driving maize research, production, distribution, and consumption patterns than they did in the past (Appendini, 2014). Some scholars are advocating re-investment in smallholder agriculture (e.g., Donnet, Hellin, & Riis-Jacobsen, 2012; Gravel, 2007), yet the complexity of what constitutes "rural" and "agricultural" activities and interests poses a challenge (Lerner & Eakin, 2011). In face of several decades of trade liberalization as well as domestic policy favoring export commodity production it is not always clear what populations and places currently represent rural interests, and what role maize is playing in rural areas (Appendini & Torres-Mazuera, 2008; Eakin & Appendini, 2008; Saaveda & Rello, 2013).

In this context of changing policy goals, and changing livelihood and land uses in rural areas, simple theoretical models based on spatially aggregated assessments of production or land use trends, or models that assume a relatively homogenous "peasant" farm population, may be inadequate. Mexico's rural households are diverse, and as households organize their livelihoods to accommodate new opportunities, maize farming may play different roles. Indicators of farmers' participation in national commercial maize markets or monetary income derived from maize may not necessarily be indicative of their potential to contribute to the agricultural economy or food system, nor reflective of the importance of maize in households' food security and livelihood strategies.

In this article, we identify the primary household correlates of a suite of maize land use and livelihood outcomes in three regions of Mexico. We use a classification tree method to analyze data from a household survey that we implemented in three maize-producing states in Mexico (Sinaloa, Mexico state, and Chiapas). The classification tree approach allows us to identify the variables within the household survey that best classify households according to the dependent variable, which in our case is farmers' reported changes in maize yield,

area, and income over the decade prior to our survey. The data-driven method allow the characterization of livelihood strategies to emerge from the multivariate space of survey variables with minimal imposition of theoretical priors by the authors. Our results highlight the particular attributes of household structure, production, land use, and or income that are most associated with current maize outcomes in three different geographic regions. Our expectation is that this type of knowledge may both contribute to a new research agenda on the potential of smallholder farming to contribute to food and livelihood security in Mexico, and to a policy agenda that responds to that potential.

2. MEXICAN AGRICULTURAL POLICY AND FARM STRUCTURE

In Mexico, agricultural policy has changed significantly over the last 30 years. In the 1980s, public programs and policy for rural Mexico reflected the bifurcation of rural constituency into two sectors, a bifurcation with roots in 19th century agrarian policy, and reinforced through the agrarian reform movement in the first half of the 20th century. The countryside was divided into larger scale (typically > 20 ha), commercially oriented farmers with private land title ("*pequeña propiedad*") and smaller scale (typically < 10 ha), communally organized farmers with usufruct title to land ("*ejidal*" or "*comunal*" sector, also called the "social sector"). Farmers in the social sector were subject to a suite of public programs in the latter half of the 20th century, including a subsidized credit window via the public bank *Banrural*, crop and credit insurance via *Agrosemex*, and subsidized inputs (namely fertilizer and seeds). Perhaps most important for smallholders was the purchase of maize grain at government-controlled prices via the grain-marketing board CONASUPO. In the late 1980s, CONASUPO was procuring over 7% of the national supply from Mexico state (Appendini, 1988). Almost all of these programs were dismantled during the liberalization reforms in the 1990s; CONASUPO was closed in 1998 (Torres-Mazuera, 2013). [1] In addition, in 1992 an amendment to Article 27 of the Mexican Constitution passed, providing formal title to *ejidal* land (Cornelius & Myhre, 1998). Preceding and accompanying these program changes were the elimination of price guarantees and import tariffs for most crops, with the exception of maize and beans (the maize market was fully liberalized in 2008) (Eakin, 2006).

New supports were developed for agriculture, largely grouped under the umbrella program *ACERCA* (*Apoyos y Servicios a la Comercialización Agropecuario, or* Support and Services for Agriculture and Livestock Commercialization), which now represents approximately 13% of the total federal agriculture budget (see Appendini, 2014). The new policies re-oriented public policy toward those farmers considered to have commercial potential: generally the larger farmers, with land amendable to irrigation and mechanization, and a production capacity that permitted sales to commercial wholesalers (Appendini, 2014; Keleman, 2010). PROCAMPO, the direct per-hectare payment program for all farmers of basic grains (irrespective of scale), was initiated in 1994 and quickly became one of the only remaining accessible sources of agricultural support for maize smallholders.

With the approval of the North American Free Trade Agreement in 1994, smallholder farmers of maize – Mexico's staple crop and principal dietary ingredient – were widely anticipated to succumb to market pressures and to abandon this traditional crop for more high-value alternatives (e.g.,

irrigated vegetables), or to leave farming altogether, leaving the sector to more efficient and productive farmers (Calva Téllez, 1993; Josling, 1992; Tellez, 1994). In addition, a series of severe droughts in the 1990s and concern over declining rainfall associated with climate change have led to assumptions that rainfed farming will be increasingly unviable (Conde *et al.*, 1997; Feng, Krueger, & Oppenheimer, 2010; Monterroso Rivas, Conde Álvarez, Rosales Dorantes, Gómez Díaz, & Gay García, 2010).

Nevertheless, maize farmers have persisted. The most recent national agriculture and livestock census (INEGI, 2007) reports that there are currently 2.8 million maize farmers in Mexico. The total area planted in maize nationally has been remarkably stable since 1980, although an expansion of irrigated maize in the Northwestern states (particularly Sinaloa) indicates a shift in the structure of production (Sweeney, Steigerwald, Davenport, & Eakin, 2013). Perhaps more surprising is the relative constancy of rainfed production in the center and south of Mexico, where smallholder *ejidal* farming has been the norm: while a few states exhibit a decline in maize planted area (see Sweeney *et al.*, 2013), the overall pattern demonstrates a resilience and persistence of maize, despite the policy and trade reforms (Eakin, Bausch, & Sweeney, 2014; Eakin, Perales, Appendini, & Sweeney, 2014). In this context, any national policy based on assumptions that small-scale production is no longer relevant as a contributor to national maize output, or that food security hinges exclusively on the commercial sector may be misguided. There is a need for empirical evidence that demonstrates the heterogeneity of the maize sector, the different pathways of agricultural productivity and rural livelihood that have evolved over the last decades, and thus the potential for diverse policy outcomes and interventions.

3. THE CASE STUDIES

We selected three states for our research, based on their historical prominence in contributing to national maize output for the case of Chiapas and Mexico state (referred to simply as "Mexico" in this article, not to be confused with the country as a whole) and in relation to increased importance in maize supply nationally for the case of Sinaloa. The geographic location of each of the selected case studies (North, Central, South) also allowed us to capture regional differences in economic development and agroclimatic conditions that have always been prominent features of Mexican agrarian history (see, for example, de Janvry, Chiriboga *et al.*, 1995; Sanderson, 1986; Yates, 1981) (Table 1). Chiapas and Mexico (in the south and center of the country respectively) have been among the top five maize-producing states in Mexico for several decades; Sinaloa (located in the north) emerged as the nation's primary maize-producing state in the 1990s. Chiapas and Mexico represent areas of mainly smallholder rainfed production; Sinaloa produces maize largely under irrigation (Table 1).

Mexico state is located on the central highlands (Altiplano) with rainfall concentrated between May and September (ranging between 800 and 1,100 mm/yr). Maize is primarily grown in the valleys between the volcanic ranges, permitting the use of tractors. The farm communities in our case study sample were located at elevations around 2,600–2,800 m.a.s.l. The communities were selected at random (see Section 4) within the Rural Development District of Atlacomulco, which represented nearly a quarter of maize planted area in 2010. Some of the maize area in Atlacomulco (~29% in 2010) receives