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Agricultural policies and local sustainability: a normative coherence for development analysis of Mexico's pineapple sector

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ABSTRACT

This article examines agriculture and sustainability in Mexico with specific focus on pineapple producing communities. Because this is an internationally healthy market and because Mexico has increased its pineapple production in recent years, it can be considered a representative case in which to study the impact of agricultural policies on local sustainable development. Moreover, during the last four decades, Veracruz has led Mexican states in pineapple production and extension, with three municipalities as the foremost producers, which has consequently, impacted their ecosystems. This article documents land cover, economic, and social transformations in these municipalities. First, it shows how extension of this crop has made pineapple the dominant land cover in the region. Second, the article illustrates how parallel markets exist between export-oriented large producers and smaller ones who sell locally. Third, the article documents the increase in social marginalisation in these communities even though increased pineapple production has generated more overall wealth. These trends are then explained through a normative coherence for development analysis of Mexico's agricultural programmes and their focus on increasing productivity.

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KEYWORDS
Economic viability; land use; Mexico; social well-being; sustainable development

1. Introduction

The expansion of agricultural systems, particularly extensive monocrops and mechanised agriculture for trade, is considered a major environmental challenge and one of the most important drivers of change in ecosystems (Curtis et al. 2018; Geist and Lambin 2002; Gibbs et al. 2010; Leblois, Damette, and Wolfersberger 2017). The increase in the extension of croplands and pastures has had environmental consequences as they exacerbate the consumption of energy, water, and fertilisers (Boillat et al. 2017; Foley et al. 2005) and are catalysed by policies that incentivize large scale production at the expense of sustainable practices (see Morales 2020; Torres-Jiménez et al. 2020), even amidst the global Covid-19 pandemic (see Rodríguez-Wallenius 2021). For this reason, many international organisations such as the Food and Agriculture Organisation (FAO), the European Union (EU), and the Organisation for Economic Cooperation and Development (OECD), have highlighted

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the need for increased coherence between agriculture policies and sustainable development practices. (i.e. Cohen 2019). This article engages with these trends by asking: How coherent are Mexico's agriculture policies with local sustainable development in terms of environmental, economic and social impacts? It focuses on the relationship between national agriculture programmes and local practices in pineapple-producing communities in Veracruz, Mexico. The study includes analysis of land cover, decision-making of local producers based on market incentives, and social well-being.

1.1. Literature review

The literature on agriculture and sustainability has generally focused on the bifurcation of agricultural markets. On one hand, scholars such as Amedzro St-Hilaire (2018) have documented how agribusiness and food production have expanded exponentially in the twenty-first century (up to the Covid-19 pandemic). According to the Food and Agricultural Organisation (FAO), total production of primary crops was 9.4 billion tonnes in 2019 which represents a 53% increase from 2000. (FAO 2021, 15). At the same time, mergers amongst multinational corporations have concentrated the number and power of businesses that control global food systems (Monteiro and Cannon 2012) resulting in the emphasis of monocrops. According to the FAO (2021), half of global primary crop production comprises just four crops: sugar cane, maize, wheat and rice. Humberto González (2012, 1) explains this phenomenon by citing three important trends: (1) the integration of markets on a global scale and increased demand for certain agricultural goods, (2) transnational corporations have adopted models of production, the principal goal of which is to increase productivity and improve competitiveness, and (3) the expansion of markets has led to loss of local cultural capital which eroded sustainable agricultural systems.

In contrast to these trends, a new focus has emerged on local sustainable food systems. This has taken different forms. Some scholars have emphasised the establishment of local circular economies in order to address economic inequalities and food waste (Cembalo et al. 2020). Others have identified sustainable systems through paradigms such as Local Food Systems, Short Food Supply Chains, and Civic Food Networks (Reckinger 2018). Political movements (e.g. the Milan Urban Food Policy Pact) have also promoted more sustainable food trends. Reckinger (2022) identifies the ensemble of these movements as values-based territorial food networks (VTFN).

Mexico can be considered a critical case for the study of agriculture and sustainability as it is characterised by numerous paradoxes which are typical of emerging economies (Koff et al. 2022). The country generates enormous wealth (GDP of US$1.29 trillion) while 42% of the population lives in poverty (World Bank 2020). Agricultural exports are worth US$39.5 billion (Economist 2021) but more than two-thirds of the country's poor live in rural areas. In addition, Mexico is considered one of the twelve megadiverse countries in the world, but it also faces severe challenges regarding management of environmental and social well-being.

The literature on agriculture in Mexico highlights these trends. Numerous studies have shown how free trade agreements and exposure to international markets drive large-scale land use dynamics (Bonilla-Moheno and Aide 2020; Hernández Pérez 2021), environmental pollution (García Salazar and Fuente Carrasco 2021) and abuses of migrant farm workers (López-Gálvez et al. 2018).

This literature also documents various cleavages in the sector. In line with international trends, scholars on Mexico have documented local sustainability initiatives based on food security (Negrete-Yankelevich et al. 2018), environmental conservation (González Merino and Castañeda Zavala 2019) and economic viability for small growers (Tapia Guerrero and Sánchez Juárez 2021), even though these initiatives remain limited in scope. Important differences also exist geographically in the country. Traditionally, large agribusiness has thrived in the northern states where the North American Free Trade Agreement (NAFTA) and now the United States (US)-Mexico-Canada Free Trade Agreement, have promoted globalised exports (Gerber 2020) due to the proximity to the US. While the distinction between North and South is nuanced southern Mexico has traditionally

been characterised by small private landholders (*pequeña propiedad*) and *ejidos* which are communal lands for agriculture established following the Mexican Revolution (see Aguilar-León 2018).

1.2. Agriculture and sustainability in the pineapple sector

Like other crops, the pineapple sector has been characterised by globalisation of supply chains and the rise of agribusiness. Uriza-Ávila et al. (2018) examine the evolution of this sector and Mexico's emerging place in it. The authors document how low labour costs and limited regulation shifted production from Hawaii to Southeast Asia in the 1950s. Latin American countries, namely Costa Rica and Mexico, emerged as major producers in the 1980s for two reasons. First, consumer demand for fresh pineapple combined with the expansion of refrigerated transport and crop innovation led to a replacement of canned products with fresh fruit. Second, the proliferation of free trade agreements, such as the Caribbean Basin Initiative in 1983 and NAFTA in 1992, reduced the cost of export to the United States. NAFTA also permitted US exports of agricultural machinery to Mexico.

This led to many of the negative sustainability impacts described above. Henry and Chato (2019) illustrate how pineapple production in the Philippines has generated wealth for the country but it has not contributed to social mobility amongst producers. Vagneron, Faure, and Loeillet (2009) have shown how high-value export objectives have negatively impacted small producers in various Latin American countries. Finally, Shaver et al. (2015) examine how export-oriented pineapple policies in Costa Rica have contributed to the expansion of monocrops and the loss of natural habitat in that country.

The emergence of Mexico within this context provides interesting lessons because of the importance of innovation in the process. Pineapple (*Ananas comosus*) originates from South America, but it has a long tradition of production in Mexico. According to Uriza-Ávila et al. (2018), some rustic varieties of pineapple were cultivated in Mexican tropical regions before pre-hispanic times. However, it was not until the 1900s that the Cayena commercial variety was introduced to Mexico, originally to Loma Bonita (Oaxaca) and shortly after (1924) to the study region, specifically to Isla. By the 1940s, its cultivation had become widespread, and some processing plants were established in the region. At this point, some of the most important technical practices were adopted, such as double-row planting; increasing planting densities; chemical fertilisation; chemical control of pests, diseases, and weeds; and artificial floral induction, etc., and production took a business approach. From the 1970s, production became mostly absorbed by the national market. At the end of the 1990s, and the beginning of this century, most of the production was commercialised for the national fresh market, while international fresh markets (mostly to the US), occupied only a small proportion. Currently, most of the national production (80–85%), comes from rainfed plots (Uriza-Ávila et al. 2018).

In 2020, pineapple was one of the 30 crops with the highest production value at the national level, and within the top five most important cash crops for the state of Veracruz (SIAP 2020). Torres-Avila et al. (2022) explain how Mexico encouraged scaling up of production of the MD-2 variety which has achieved great economic success but caused negative sustainability consequences. This trend did not emerge in a vacuum. It was promoted by agricultural policies driven by corporatist partnerships including government agencies, growers and interest groups. Torres-Avila et al. (2022) show how production and commercialisation innovation in Mexico's pineapple sector reflects the decisions of stakeholders, such as the Consejo Veracruzano de Productores de Piña A.C (Veracruzano Pineapple Producers Council A.C.) and the Comité Sistema Producto Piña de México (Pineapple Product System Committee of Mexico) in collaboration with government agencies. Because current trends in pineapple production and commercialisation systems seem to reflect policy frameworks promoted by actors in the sector, this article proposes policy coherence for sustainable development as a conceptual approach for analysis of these frameworks.

1.3. Conceptual approach: policy coherence for sustainable development

Policy coherence for sustainable development (PCSD), which is part of SDG 17 on Partnerships for the Goals, promotes "whole of government" approaches aimed at reconciling trade-offs and facilitating synergies between different sustainable development objectives, such as the well-being of rural communities and the sustainable use of resources and the maintenance of ecosystems. On a practical level, PCSD implementation has often been criticised for pursuing institutional reform at the expense of policy effectiveness (see Häbel 2020).

PCSD studies have focused on agriculture and sustainability. Matthews and Giblin (2006) examined the interaction of EU agricultural subsidies and free trade agreements on third-country agricultural sectors, concluding that these instruments undermine global sustainability. Similarly, Brooks (2014) studied OECD agriculture policies and contended that member states should substitute traditional agricultural policies which distort markets with new approaches including social safety nets and tools to help farmers manage risk. Other authors focusing on PCSD and agriculture have studied natural resources. Harahap, Silveira, and Khatiwada (2017) have examined sectoral policies in Indonesia, including agriculture, and how they negatively impact land allocation while Koff and Maganda (2019) analysed water management and how PCSD approaches can improve the effectiveness of Mexican payment for watershed services programmes.

A proposed analytical contribution of this study is the adoption of PCSD as a framework for the examination of Mexican agricultural policies and their potential links to local practices and sustainability. Huttunen (2015) discusses "experienced policy coherence" and claims that policy level measures in Finnish land governance are viewed by farmers as being incoherent with overall agricultural policies and practices. Larsson (2018) examines the need to practice policy coherence from the bottom-up in defining and implementing waste disposal strategies. Koff et al. (2022) similarly focus on stakeholders and how policy coherence for sustainable development needs to be participative in nature in order to respond to the needs of local communities.

This article applies this framework to Mexico in order to investigate the impact of national programmes on local pineapple systems in Veracruz. Interestingly, Mexico's national sustainable development plan does not mention "Life on Land" (SDG 15) within discussions of development and poverty. Environmental considerations are artificially separated from social questions which is a significant incoherence for sustainable development. (see Koff and Häbel 2022). This study questions whether the normative focus of national agricultural programmes affects practices locally and therefore investigates whether community-based policy frameworks would be better-placed to promote local sustainability in agricultural systems.

2. Methods

2.1. Case selection

This study examines the San Andrés Tuxtla Rural Development District in Veracruz, particularly the municipalities of Isla, Juan Rodríguez Clara, and José Azueta (Figure 1), representing a major source of local employment (by 2015, there were at least 2200 registered producers; Uriza-Ávila et al. 2018). Within the three municipalities, pineapple production is carried out both in ejido and private property lands, and some producers rent land for the activity. Rural Development Districts (RDD) are territories that aggregate several municipalities to coordinate federative federal and municipal programmes for producer organisations and social and private sectors. Moreover, there are diverse groups of producers, including multinational corporations that export pineapples internationally (roughly 1 pineapple for US$5), and small traditional growers who sell pineapples in local markets at low prices (approximately two pineapples for US$1). The concentrated spatial distribution of the crop, in synergy with domestic and international demands, has influenced the local landscape.

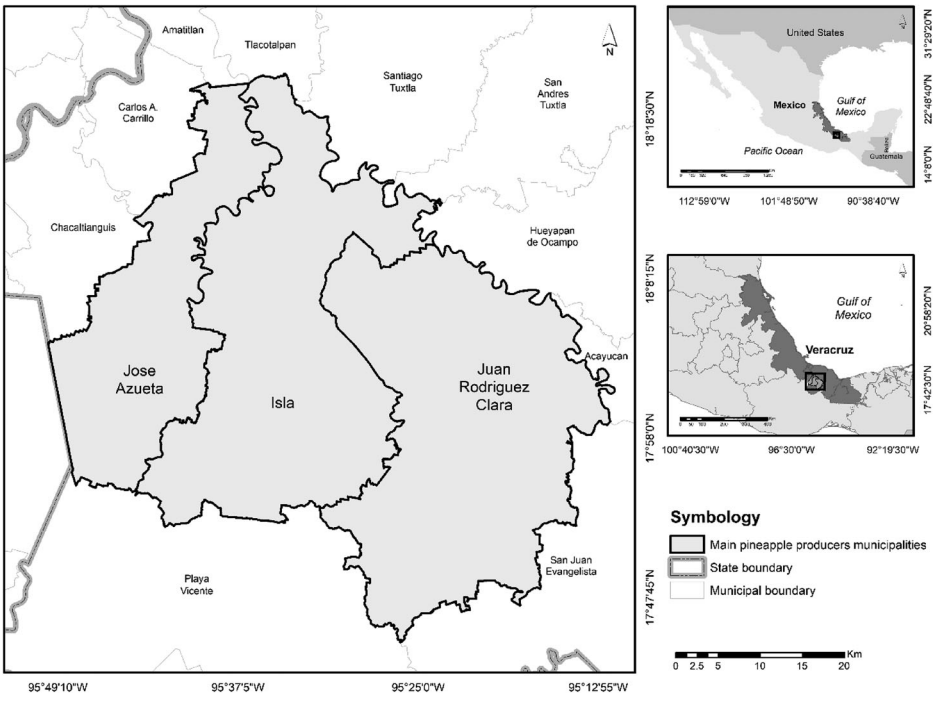

Figure 1. Location of municipalities Jose Azueta, Isla and Juan Rodriguez Clara, in Veracruz, Mexico.

This article questions how agriculture programmes affect socioeconomic conditions and land use through pineapple producers' decisions. In particular, it characterises the production trends and land extent of pineapple cover in the San Andres Tuxtla region. Additionally, it identifies the environmental and economic viability of the crop's production, and describes the social well-being of households in the case municipalities. By limiting the scope of the study to one commodity sector within an identifiable agricultural region and including the perspectives of some big and small producers, this research aims to identify the impacts of national and state agricultural policies on local sustainability. By questioning whether land conservation, agricultural production, and social equity can be pursued simultaneously, this research highlights the trade-offs described above.

What makes San Andres Tuxtla District a critical PCSD case study is the fact that it has formally embraced policy coherence for sustainable development as a guiding policy principle. In 2018, the OECD applauded Mexico: "An explicit commitment of the State towards the 2030 Agenda, backed by an implementation strategy, provides the basis for aligning efforts at federal, state and municipal levels". (OECD 2018, 25). The report underlined two commitments: (1) Leadership at the highest level is helping to lay institutional foundations to ensure that commitment towards the 2030 Agenda transcends government administrations and (2) National planning and budgetary processes provide essential tools for policy integration and coherence (OECD 2018, 26).

The State of Veracruz has also demonstrated a formal commitment to PCSD. It was the first Mexican state to establish a Plan for Sustainable Development which promotes "integral development", including, amongst its priorities, security, modernisation of the public sector, the creation of employment, social inclusion strategies (including gender equality and respect for ethnic communities) and the fight against poverty (Plan Veracruzano Para el Desarrollo 2011–2016; Gobierno del Estado de Veracruz 2011). Veracruz also has established development strategies that integrate economic growth, food security, biodiversity conservation, the use of natural resources, social integration and disaster prevention, which include multi-Secretariat actions (Secretaría de Finanzas y Planeación 2017). In general, the scholarship on policy in Mexico (see Cejudo and Michel 2016) has noted that

Mexican development and sectoral plans are generally well-written but poorly implemented. This often leads to normative coherence within and between policies but incoherence in policy frameworks. For example, the National Agricultural Plans studied here have been poorly implemented which has led to public criticism. By focusing on normative coherence for sustainable development, this study questions whether implementation problems hinder sustainable agriculture or whether this is compounded by more profound normative commitments to unsustainable policy goals.

2.2. Data collection

We used information from satellite imagery, government databases, and interviews with local producers and public authorities. To determine pineapple production at the national, regional and local level, we used statistics generated by the Agrifood and Fisheries Information Service (https://www.gob.mx/siap, SIAP), a body of the Agricultural Secretariat responsible for generating information on the agri-food sector.

To determine the spatial extent and distribution of the pineapple crop, we conducted a supervised land cover classification. First, we conducted a digital delimitation of polygons from different land cover categories within the limits of the San Andres Tuxtla RDD. For the digital delimitation we used Google Earth Pro images (from 2017 to 2019) and ground reference data collected in the field during 2019. A total of 2364 polygons were digitised and divided into six predominant classes: pineapple, urban area/bare land, pasture, tree cover, water and sugarcane. From these, 1427 polygons were used as training samples and 937 for verification of the classified image. Although other crop covers, such as maize, are also present in the area, the small extension and scattered distribution of their plots hindered their classification, therefore we focused on the large and homogeneous covers, such as monocrops.

For the land cover classification of the San Andres Tuxtla RDD, we used four Sentinel-2 satellite images (10 m) from 2019. The selected area of the images were projected in the same coordinate system as the polygons (UTM Zone 15N) to avoid the offset of the vectors on the raster. In order to create multi-band raster images, bands 2, 3, 4 and 8 were combined (through the Composite Bands tool in ArcMap 10.3). These images were subjected to an atmospheric correction (dark subtraction tool, ENVI 5.3), and segmentation (extraction module feature, ENVI 5.3). The classification was carried out through a supervised method using the Maximum likelihood algorithm and the spectral signature. The resulting classifications were joined and validated per municipality. To increase the accuracy of those classes with highest error (i.e. pineapple and bare land) a manual correction was made editing those misclassified polygons taking as reference Google Earth images. To assess accuracy, the validation of each classified image was carried out using a confusion matrix (ENVI 5.3) with verification samples, where the correct and erroneous percentage of pixels for each class were determined for each municipality (Table S1), calculating the Kappa coefficient (from 0 to 1) which is a measure of the difference agreement between the accuracy observed and predicted cover. The closer the Kappa coefficient is to 1, the greater the accuracy achieved in the classification.

To determine the area of pineapple cultivated in ejidos tenure, we used the polygon layer from the national agrarian registry (RAN 2019). For each municipality, we calculated pineapple areas that were within and outside the ejidal polygons and calculated the total percent surface for pineapple production.

To determine the socioeconomic well-being of local communities, we examined socioeconomic data, such as poverty and employment, 14access to services, housing quality, economic indicators by sector, from the Consejo Nacional de 1414Evaluación de la 14Política de Desarrollo Social (CONEVAL), the comité Estatal de Información Estadística y Geográfica de Veracruz de Ignacio de la Llave, the Instituto Nacional de Estadística y Geografía (INEGI) and the Consejo Nacional de Población (CONAPO) databases. Social statistics were gathered for this project at the municipal level. Well-being was analysed through a multi-dimensional approach including socio-economic statistics, access to services, and quality of life (housing, education, consumer goods).

To analyse the potential link between national agriculture policies and local sustainability, interviews were carried out with pineapple producers in order to: (1) provide information on the economic and environmental viability of pineapple-growing as well as the regional perspectives on land change and (2) understand incentive structures and how agricultural programmes have affected producers' decision-making and behaviour. The research team conducted 12 interviews with local producers (three big producers, nine small producers) and six interviews with key authorities from the agricultural sector (three local and three state officials). All producers were representative of the pineapple production region. Due to constraints in timing but mostly insecurity in some regions, we could not extend the sampling (temporally or spatially). Interviewees were focused on the land-use aspect to understand the main reasons behind producers' (big or small) decisions to cultivate pineapple. Small producers were approached through local contacts in the places where they contact intermediaries that commercialise their pineapples and were generally open to answer questions. Big producers were contacted through official channels followed by visits to their farms; they were generally more hesitant to answer, and some declined the invitation. Categories (big or small) were determined based on the amount of land they used for the crop (the plantations of larger producers were in the hundreds of hectares, while those of smaller producers were no more than 10 hectares). Direct quotes from interviews were not included, but a comparative table, included in the annex, shows the replies from all interviews. Given the local knowledge of the region and the quality of the information producers provided, the interviews represent the reality and the extremes of local pineapple producers, particularly on topics related to land use, production and commercialisation, and access to resources. In addition, the demographics reported for producers in Veracruz (Uriza-Ávila et al. 2018) from a sample of 101 producers, reported an average of eleven years of experience and plots with an average area of 4 ha, following a similar pattern to the one found for this study.

Five complementary interviews focused on policy coherence for development were conducted with municipal representatives in Veracruz from Social Development, Tourism, Agriculture, Economic Development and Culture agencies. Interviews were conducted between October 2017 and March 2019 and included topics on land use; harvest and production; environmental issues; programme support and incentives; socioeconomic contexts; production and marketing. These authorities represent local and state officials involved in regional land use planning and agriculture. The number represents well the universe of local and state officials involved in the decision making as well as the detailed plans for the local land use planning, and the production and commercialisation of pineapple. The responses from these interviews linked agricultural policies to practices in the pineapple sector.

Given the pineapple is the most important crop in the region, and this region is the most important for national pineapple production and for the purpose of the study, we believe that although small, the sample represents well the local land use dynamic as well as the main drivers behind the crop extension.

Policy analysis was based on examination of Mexico's national agricultural programme (2017–2030), its sectoral programme for pineapple crops, the two most recent development programmes for the State of Veracruz (2011–2016 and 2016–2018), and municipal development plans for the research cases.

3. Results

3.1. Pineapple cover

According to national statistics, Veracruz is the state with the largest extension of pineapple, representing 73.1% of the crop planting area at the national level for 2020 (Figure 2(a)). From 1980 to 2020 the surface area of the crop increased almost three times (from 9292 to 23,584 ha), the major expansion occurring between 2000 and 2010, at an annual rate of 1431 ha, representing the second fastest growing crop, just after lemons. As with the planting area, Veracruz leads the country in pineapple

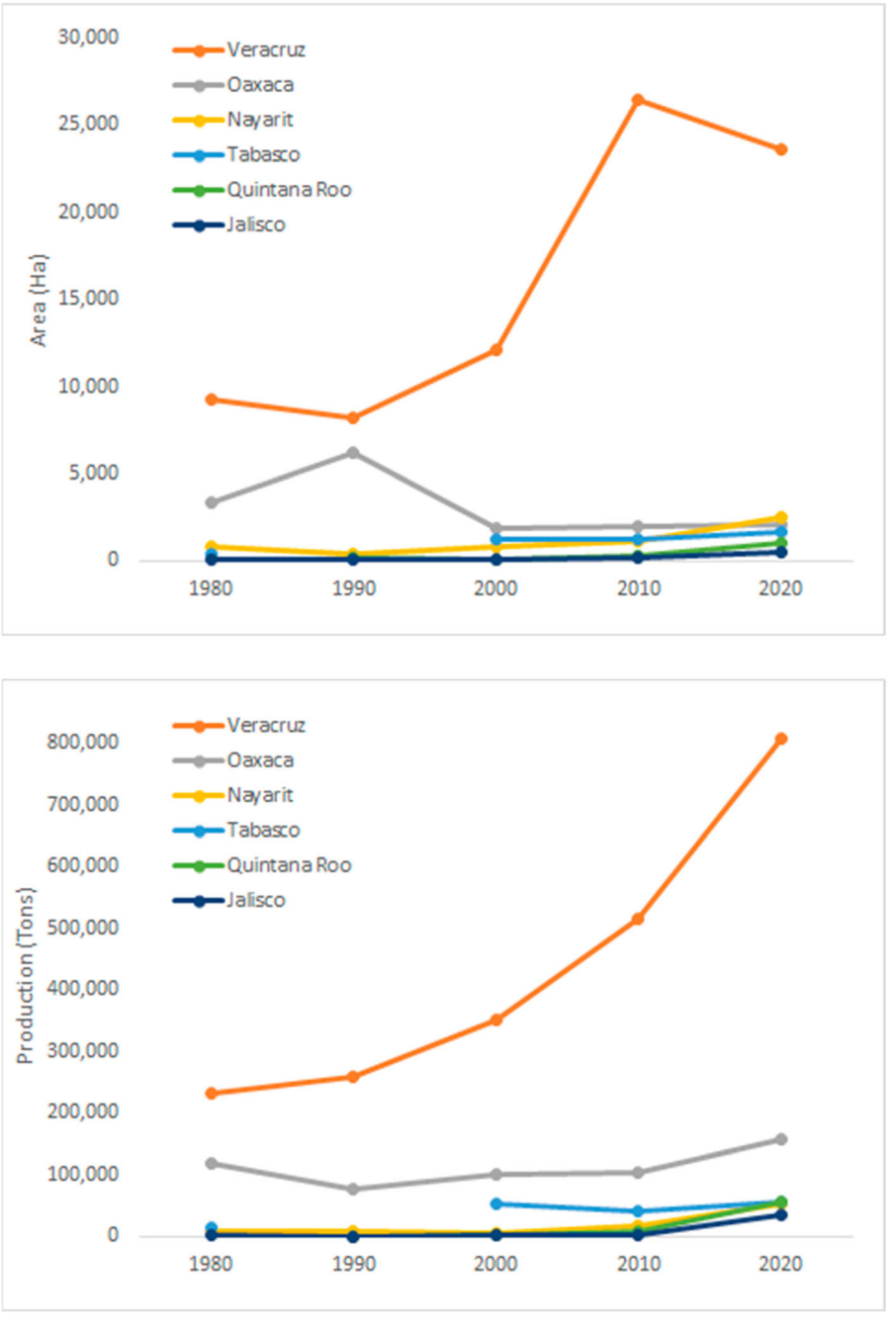

Figure 2. (a) Area (hectares) and (b) production (Ton) of pineapple by state from 1980 to 2020 (Source, SIAP 2020). These states accounted for 96% of the total national production.

production. From *ca* 1.2 million tons of pineapple nationally produced in 2020, 67% (809,292 tons) were from Veracruz (Figure 2(b)).

Prominently, the district of San Andrés Tuxtla contributed to 77.6% of the state production and 51.9% of the national production in 2020. Isla had the largest production (233,511 tons), closely followed by Juan Rodriguez Clara (211,534 tons) and José Azueta (168,726 tons).

Results from remote sensing analysis showed that by 2019, pineapple cover dominated the regional landscape, with more than 120,000 ha, representing almost 50% of the surface from the three municipalities (Table 1), exceeding three times the area reported in national statistics. The second largest cover was pasture followed by sugarcane. Natural vegetation cover barely occupied 12% of the total area.

The area of pineapple cover varied by municipality. The largest extension of the crop was concentrated in Juan Rodriguez Clara (62,653.17 ha), representing more than 60% of the municipality, followed by Isla (48,764.64 ha, 52% of the municipality), and José Azueta (8590.98 ha, 16% of the municipality).

Figure 3 illustrates the spatial distribution of land cover in the three municipalities. Although the pineapple crop was dominant in all three, its distribution varied between them. José Azueta was the municipality with the smallest under pineapple as sugarcane and pasture are also prominent covers. Pineapple occupies a quarter of the municipality and is mostly distributed in its southwest. However, the classification in this municipality was the one with the lowest percent accuracy (76.2%; Kappa Coefficient 0.68) and pineapple cover was confused with pastures (Table S1), so it is likely that its extent was underestimated. Conversely, Isla and Juan Rodríguez Clara are dominated by pineapple cover, with few scattered remnants of natural vegetation. The percent accuracy for the classification in these municipalities ranged between 86.3% for Juan Rodriguez Clara (Kappa Coefficient 0.68) and 84.2% for Isla (Kappa Coefficient 0.73).

In the three municipalities, pineapple cover is distributed both within and outside ejido tenure lands, but the amount varies by municipality. Half of the pineapple cover in Azueta and Rodriguez Clara is within ejido lands (50.3% and 55.4%; respectively), while in Isla only 27.9% of its pineapple cover is distributed in ejidos.

3.2. Land-use and environmental viability of pineapple production

According to the interviews, land characteristics varied greatly among producers (Table S2). The size of the land plots for pineapple growth differs among producers, with big producers reporting between 275 and 600 hectares (457 ha average) while small producers less than 10 hectares (3.5 ha average). All big producers reported owning the land where they grow pineapple, while the small ones reported that they rent (4), use ejido land (communally-owned) (3), and own land (2). The time they have dedicated to producing pineapples varied from 4 to 60 years, being longer for big producers (from 40 to 60, average 50 years). Small ones showed much variability, going from 4 to 48 years, with an average of 19 years. All producers mentioned that before planting pineapple their land was mostly pasture used for cattle. All but one of the producers mentioned that they do not plan to change their production and cultivation practices. However, if they were to change, most would go back to cattle ranching (9) and the rest to milpa. Producers reported that they cultivate pineapple as a family legacy or because it represents an economic option in a region offering few others.

All the producers reported use of agrochemicals, specifically fertilisers (12), and flowering inducers (11). The use of manure was reported (7), while organic production is limited (Table S2). In

Table 1. Area (ha) and percent (%) cover in the three municipalities where pineapple. Values were obtained from a land cover classification using Sentinel-2 from 2019.

	JOSÉ AZUETA		ISLA		JUAN RODRÍGUEZ CLARA	
Landcover	Hectares	%	Hectares	%	Hectares	%
Built/bare	2821.39	5.26	2430.18	2.62	1467.12	1.48
Natural vegetation	6892.55	12.86	11,463.60	12.35	10,856.71	10.93
Pasture	11,457.21	21.37	16,447.16	17.73	22,061.43	22.22
Pineapple	8590.98	16.02	48,764.64	52.56	62,653.17	63.10
Sugarcane	23,066.66	43.03	12,095.42	13.04	1711.80	1.72
Water	782.62	1.46	1585.85	1.71	539.00	0.54

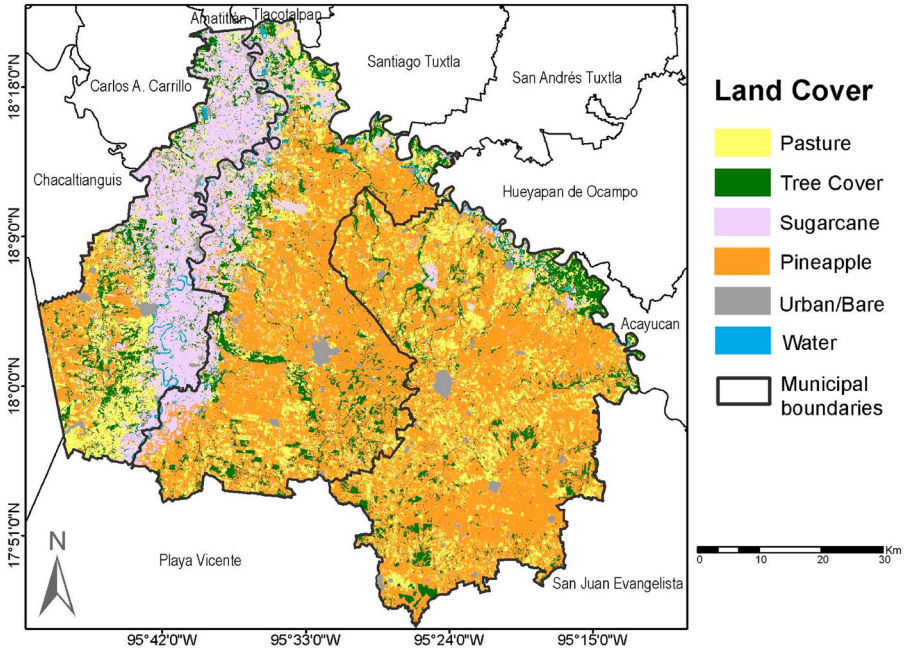

Figure 3. Spatial distribution of the main land covers in Jose Azueta, Isla, and Juan Rodriguez Clara. These are the three most important municipalities of pineapple production in Mexico. Land cover classification was produced using Sentinel-2 satellite images from 2019.

particular, they mentioned growth-accelerating acids, herbicides, fungicides, and flower-inducing hormones. Fertilisers were usually mixtures of nitrogen, potassium, and phosphorus. All big producers reported the use of pesticides. Most of them acknowledge that pineapple production is not sustainable, and the actions they propose to make the sector more sustainable relate to agrochemical management: from the use of organic fertilisers, to waste control and reforestation programmes. Most producers mentioned knowing about environmental or quality certifications and organic production, but not all were interested and only one big producer had achieved organic production. The literature on agricultural policies in Mexico has documented such trends as the government often provides or subsidises chemical fertilisers whereas producers must generally pay for organic ones themselves (see Torres-Jiménez et al. 2020).

3.3. Economic viability of pineapple production

According to interviews, one main challenge regarding the economic viability of the pineapple sector in the RDD concerns disparities between producers. Although all producers reported independent commercialisation, the interviews clearly indicated that parallel markets exist that affect decision-making (Table S3). Most small producers (7) limited their distribution to surrounding areas in Veracruz and only two reported national distribution. Conversely, the large producers all export their pineapples to the US, Canada, Europe and Asia. When asked to name the most significant challenges they face regarding commercialisation, large producers identified the volatility of international prices (specifically discussing crashes). Four of the small producers focused on prices but they also named domestic difficulties, such as lack of government support (2), lack of infrastructure and distribution capabilities (3), and competition disparity with large producers (2).

Responses concerning agricultural subsidies reinforced the perceived differences between the two groups of producers. None of the small producers reported receiving any fiscal incentives or

government subsidies. One small producer reported knowledge of regional corporate loans provided by local private sources, such as the Caja Popular and the Sayula cooperative. However, these loans are not regularly requested or granted. Others reported support for fertilisers but for maize production, not pineapple; nonetheless, these are not direct subsidies. Conversely, the large producers knew of and received subsidies and technical packages from SAGARPA (no mention of specific programmes) for pineapple production and reported fiscal incentives that favoured the expansion of pineapple crops. In addition, large producers also acknowledged receiving communication and advertising aid aimed at extending the commercialisation of their pineapples. When asked about these grants, three of the small producers responded, "these are only for large producers". This response clearly illustrates the dissatisfaction of small producers with imbalanced economic competition, which threatens the economic viability of the local pineapple sector.

All producers agreed that the most important local benefit from the pineapple sector is employment; however, their responses concerning who benefits reinforces the perceived differences between the two groups. The large producers contend that producers benefit from pineapple sales and that locals benefit as well because they (big producers) provide a source of employment. Conversely, the small producers identified sellers (5), the large producers (3), buyers (1) and middlemen (1) as the main beneficiaries of local pineapple production, indicating a generalised sentiment of disenfranchisement. All producers agreed that there are no cooperatives (local or regional) for the commercialisation of the products and that they are not aware of any state or regional master plan to improve or manage pineapple production. Although the interviewees consider that the monoculture of pineapple brings benefits in the producing municipalities, such as job generation and economic spillover, all but one of the producers mentioned that insecurity in the state (threats from criminal groups) has affected production and commercialisation in the RDD, forcing many buyers and producers, to migrate for their physical and economic integrity. This situation highlights the limited integration of security policy in rural development and agriculture strategies.

These findings are complemented by the results of interviews with municipal officials in Veracruz. Amongst the five officials interviewed, four identified "lack of ability to commercialise" agricultural products as the main challenge faced by local producers. Two representatives identified a lack of cohesiveness amongst agricultural producers as a problem and one specifically identified the limited participation of large producers in state agricultural associations as an obstacle to sustainability. Three interviewees recognised that the lack of price regulation undermines the sustainability of state agricultural markets. One official specifically identified commercial intermediaries as those who benefit the most from the current agricultural system.

3.4. Social viability

To understand if local communities have benefited from pineapple production, we analysed the social transformations that have taken place in the case municipalities. As expected, agriculture is the most significant activity in the research cases (Table 2). Agriculture represents half of all employment in Juan Rodriguez Clara and José Azueta, and 40% in Isla. Pineapple production is reported as the most important crop in Isla and Juan Rodriguez Clara and it is second to sugarcane in José Azueta.

Table 2. Employment by sector and agricultural production by crop in Isla, Juan Rodriguez Clara and José Azueta (2015).

	Isla	Juan Rodríguez Clara	José Azueta
Employment in agricultural sector (% working population)	40.3	51.6	54.7
Employment in industrial sector (% working population)	10.9	10.2	11.9
Employment in service sector (% working population)	48.2	36.9	32.6
Value of pineapple production (millions of Mexican pesos)	678,303.9	634,380.7	670,404.69

Sources: *Cuadernillos Municipales 2017* for Isla, José Azueta, and Juan Rodríguez Clara. Xalapa: Estado de Veracruz, 2018.

While the pineapple sector provides employment to these municipalities, it does not necessarily support multidimensional well-being. All three municipalities are characterised by significant social marginalisation. Table 3 shows that Juan Rodriguez Clara and José Azueta have higher degrees of marginalisation. All three municipalities show significant rates of illiteracy amongst inhabitants aged 15 years and over and significant portions of their populations have no more than elementary school education. A vast majority of the employed populations have incomes lower than 10 USD per day, which is the equivalent to only two times the minimum Mexican salary.

Poverty statistics reinforce this picture. Poverty and extreme poverty rates in the research cases are above those for the state of Veracruz and significantly higher than Mexico's national rates (Table 4). Moreover, there is generalised lack of access to basic services (including social security and health) and sufficient food.

These trends document how the expansion of pineapple production and exports have not benefited local communities more generally. The results presented in tables three and four reflect the opinions expressed in interviews with public officials. Three of the five respondents contended that local communities are not adequately prepared to address local sustainability challenges. When asked to identify the most important challenges to agricultural sustainability in the state, three of the five interviewees indicated that the sector is not profitable for communities which has contributed to poverty, thus stimulating out-migration from rural areas.

4. Discussion

Globalised food systems have impacted local communities significantly. In addition, they have affected biodiversity and ecosystem services because they contribute to the extent to which land is converted to monocrops (Chaudhary and Kastner 2016; Kehoe et al. 2017; Zabel et al. 2019). They also impact levels of well-being in agricultural communities because these systems determine revenue distribution, employment, access to state services, and use of strategic resources, which are often the sources of marginalisation or social cleavages (Agnew 2020). These issues have not emerged in a vacuum. The literature cited above illustrates how agricultural policies have undermined sustainability by contributing to monocrop expansion, agricultural pollution, and socio-economic marginalisation (Subercaseaux et al. 2021).

In recent decades, agriculture has caused more transformation to natural systems than any other human activity, which has generated a conflict between demands for resources, food production, and environmental conservation. Understanding the factors that promote and sustain natural ecosystem conversion into agricultural lands will assist in the design of policies aimed at preventing or reducing the degradation of natural systems.

Table 3. Marginalisation statistics for Isla, Juan Rodriguez Clara and José Azueta; 2020.

	Isla	Juan Rodríguez Clara	José Azueta
Degree of marginalisation	Low	Medium	High
Marginalisation index	55.0	54.2	52.5
State Ranking	155	131	82
National Ranking	1407	1182	760
Illiterate population aged 15 years and over (%)	11.0%	12.6%	13.4%
Population of 15 years or more without primary education (%)	51.5%	54.7%	54.4%
Occupants in dwellings without drainage or exclusive sanitary service (%)	2.0%	3.2%	3.4%
Occupants in homes without electric power (%)	1.0%	1.0%	0.8%
Occupants in dwellings without water (%)	2.7%	4.4%	19.2%
Homes with some level of overcrowding (%)	23.2%	20.8%	23.7%
Occupants in homes with dirt floors (%)	5.5%	2.6%	2.6%
Employed population earning 2 minimum wages or less (%)	82.7%	88.7%	89.4%

Source: Compiled by authors from official statistics from CONAPO. Índice de Marginación por Entidad Federativa y Municipio, 2020.

Table 4. Poverty-related statistics for Isla, Juan Rodríguez Clara, José Azueta, Veracruz and Mexico (2015).

	Isla	Juan Rodríguez Clara	José Azueta	Veracruz State	Mexico
Population	48,260	43,531	108,138	8,065,135	119,938,473
Poverty (%)	67.4	71.3	69.4	57.3	43.6
extreme poverty (%)	17.3	15.8	14.0	13.3	7.6
Population living below well-being line (%)	68.9	72.2	70.9	61.2	50.6
Population living below minimum well-being line (%)	25.4	28.3	29.4	25.0	17.5
Lack of access to adequate housing (%)	17.2	16.4	10.2	20.3	12.0
Educational lag (%)	35.3	35.6	35.2	25.4	17.4
Lack of access to health services (%)	17.2	20.1	9.0	18.9	15.5
Lack of access to social security (%)	84.2	86.6	82.1	66.9	55.8
Lack of access to basic home services (%)	35.2	47.1	50.4	40.1	19.3
Lack of access to sufficient food (%)	41.6	42.2	41.3	29.1	20.1

Source: Official statistics from the Consejo Nacional de Evaluacion de la Politica de Desarrollo Social (CONEVAL), 2015.

4.1. Local land use conversion into monocultures and pineapple expansion

According to our results, the case municipalities have been heavily transformed into pineapple, sugarcane, and pastures. This expansion of monocrops, coupled with the sparse and scattered remaining fragments of natural vegetation, have created a homogenised landscape dominated by agriculture. In two municipalities (Isla and Juan Rodriguez Clara) pineapple cover occupied over half of their surface, while it was the third most important cover in José Azueta. More worrisome is that in none of the municipalities did the natural vegetation cover reach 13% of the total surface. In fact, most of the remaining forests correspond to riparian areas, and there are only a few patches of natural vegetation which is highly fragmented . This is relevant considering that the ecological region where this practice is carried out corresponds to the Petén-Veracruz tropical forest, which is one of the most biodiverse but deforested regions in Mexico. The evidence of land use change is that the majority of the surface is dedicated to this cover and a very small proportion remains as natural vegetation. In this region, the only large remnant of natural vegetation is the Sierra de Los Tuxtlas Biosphere Reserve.

Agricultural transformations started decades ago (in fact, all respondents mentioned that before converting their plots into pineapple they had pastures, likely a result from agricultural policies from the 70's that encouraged cattle ranching in southern Mexico). From an ecological perspective, converting from pasture to an intensive monocrop does not provide advantages in terms of biodiversity or ecosystem services. In the last decades some forests were also converted into pineapple fields (Campos-García 2018), which is highly worrisome given the limited remaining forest in the region. In addition, it has been reported that some consequences of this practice include erosion due to excessive tillage, high planting densities and more abundant harvests, reducing soil fertility, that leads to higher amounts of inorganic nitrogen, and phosphorus (up to 200% more in pineapple-growing areas compared with undisturbed areas), which increases acidification, and soil and water pollution (Zetina, Rebolledo, and Uriza 2005).

Many factors have influenced the regional expansion of the agricultural frontier, such as the favourable climatic and topographic conditions (i.e. high precipitation and flat lowlands). However, the specialisation in pineapple production has likely been due to access to agricultural mechanisation and national programmes targeting agricultural production and international market consolidation/expansion (SAGARPA 2017a). In this way, market demands and policies guiding pineapple production have affected the presence of natural vegetation and influenced the replacement of other crops. These trends are expected to continue because they are promoted by agricultural policy. The 2017–2030 National Agricultural Plan (NAP) (SAGARPA 2017a) aims to improve competitiveness of Mexico's agriculture in global markets and the two questions that underline the plan's structure overtly ask: (1) How can we produce better? and (2) How can we

sell better? In this regard, the plan focuses more on policy coherence for production and sale than it does on sustainable rural development.

Pineapple sector strategies focusing on Veracruz reinforce this vision. SAGARPA's regional policies on Veracruz and more specifically on the RDD all focus on competitiveness, production and commercialisation. These measures include, generating new products for post-harvest application aimed at increasing the shelf-life of pineapples, promoting alternative methods to manage organic products and biological controls, planting pineapple varieties (MD2) that have higher demand in international markets, increasing crop density, and stimulating the use of covers to improve the quality and health of pineapple crops (SAGARPA 2017b, 10). State government activities have also been characterised by this approach. For example, the government of Veracruz, SAGARPA, the Humid Tropics Program and private investors committed to a 609.4 million Mexican pesos (USD 47.7 million) investment in 2012 in a state of the art pineapple packaging centre for exports to the U.S., Canada and Europe (FreshFruitPortal.com 2012).

4.2. The economic viability of pineapple production

Similar to land cover, the decision-making of producers in the pineapple sector has been significantly affected by policy strategies. International markets are drivers of pineapple expansion. According to FAO, the world production of pineapple is concentrated in Costa Rica, Brazil, the Philippines, Thailand, and China (FAO 2019). From these, Costa Rica is by far the leading exporter (71% of world production), particularly to the USA and the EU which are the main global consumers of pineapples. While Mexico is an important producer, only 7.6% of its production is exported (FAO 2019), suggesting most of its production is for national consumption. Despite producers in the region varying from large to small, programmes have singularly favoured larger producers, who have innovated their production systems (such as the induction of flowering, fertilisation, land preparation and irrigation), reducing losses, and facilitating their entry into national and global markets. For example, multinational stores such as Walmart sell the MD2 honey pineapple at US$0.99 per kg, while in the local market the smaller producers sell the same product for US$0.20 to US$0.40 per kg. This has exacerbated the inequalities between producers, highlighting inequitable policies, and a lack of planning for land resources. This tendency has been supported by national agricultural strategies, specifically the national agriculture plan for pineapple that identifies policy tools aimed at "maximising" and "encouraging" sales and exports in the sector. In the first category, the plan focuses on new certifications for fresh and packed pineapples for international markets, updates for technological packages, standardising the production of MD2 pineapples for the purpose of export, designing new technologies for canning that do not harm pineapples, developing new approaches to production that avoid soil erosion and promote lower water use, strengthening commercial enterprises aimed at lowering the influence of export intermediaries, and promoting pineapple consumption (SAGARPA 2017b, 9). In the second category, priorities include diversifying pineapple varieties produced in Mexico and expanding the types of products and sub-products made from fresh and canned pineapples (SAGARPA 2017b, 9). Of these priorities, only the focus on the role of intermediaries targets the well-being of small producers. In terms of commercial strategies, this plan aims to maximise international sales by consolidating exports to the US, Canada, and EU member states, expanding markets in Switzerland, South Korea and Japan and developing new markets in Turkey (SAGARPA 2017b, 7). These priorities privilege large producers who can invest in certification and export, relegating small producers to sales in local informal sectors where price regulation and financial support is absent. Given this lack of support for production and commercialisation, and the low local market prices for pineapple, it is surprising that most small producers mention they will continue this activity. In part this is because local environmental conditions are optimal for pineapple growth, which does represent a source of income, even if small. However, most small growers interviewed highlighted their wish to maintain a family legacy more than economic viability of their activities. This shows the relevance of cultural factors for regional land use.

4.3. Social well-being in pineapple producing communities

Due to the expansion of pineapple crops, exports and sales have generated a local perception of wealth in the RDD, especially in the case municipalities but has this wealth benefited local communities? Three indicators are especially pertinent from the statistics presented above: (1) above-average poverty levels, (2) the elevated percentage of workers earning less than two minimum wages (the equivalent of 10 USD per day) and (3) the significant rate of inhabitants living in homes characterised by overcrowding. These statistics in turn show: (1) a general lack of economic wealth, (2) the low salaries for work offered to local inhabitants, contributing to unsustainable livelihoods and (3) challenging social conditions created by a lack of circulation of wealth as many in the community cannot invest in appropriate housing. Other prominent challenges exist in these communities as well. For example, like other parts of Mexico, insecurity is an issue in the RDD. Large growers can invest in private security which protects their lands and products. Local inhabitants cannot afford such costs which leaves them vulnerable. During interviews, some respondents claimed that local gangs have stolen crops from small producers going to Xalapa, the state capital of Veracruz, where these products are sold informally on the streets.

In general, the National Agricultural Plan (NAP) recognises the need to address these challenges. The NAP notes that "Development depends on funding for access to quality education, the generation of income, support for the creation of employment and mechanisms for sufficient social protection". (SAGARPA 2017a, 18). In addition to poverty reduction and social inclusion, the NAP also addresses climate change, disaster prevention, security and conflict prevention, competition for natural resources and science and technology innovation. Similarly, the plan asserts that one third of all food produced in Mexico is wasted at some point in the supply chain, mostly during the harvest or post-production stage due to insufficient infrastructure, thus calling for more effective public investment (SAGARPA 2017a, 18). The problem with the NAP is not that it explicitly ignores the needs of small producers. However, the emphasis on "productivity, profitability and competitiveness in order to combat poverty and promote a more balanced regional development" (SAGARPA 2017a, 7) in the country is not coherent with those needs. In fact, increased economic production does not translate into social sustainability. Despite limited economic viability, pineapple producers cannot change activities because of a lack of alternative economic opportunities. Interestingly, virtually all producers expressed no intention to change their productive activities.

5. Conclusions

This article has examined the impact of Mexico's agricultural programmes on local sustainable development in pineapple producing communities. Local cases illustrate the destructive impacts of extensive monocultures in terms of sustainable development as they affect land cover, establish parallel economic markets benefitting export-oriented large producers at the expense of small growers and they generate wealth that does not necessarily benefit local communities as evidenced by persistent social marginalisation. The interviews conducted with growers indicate how agricultural programmes have contributed to this situation as they highlight how subsidies focused on productivity, export and commercialisation benefit large growers and promote environmentally damaging land use transformations.

The article analysed these trends through a policy coherence framework. PCSD was introduced globally in order to prioritise sustainability. Unfortunately, most governments, like Mexico, focus on establishing "coherence" without necessarily defining meaningful sustainability objectives. The analysis presented above shows how policy coherence has been adopted as a national coordination mechanism without strong normative bases in favour of local sustainability. The national agricultural programme has simply fostered "business as usual" agricultural practices, such as expansion of monocrops like pineapple through provision of subsidies to growers which distort markets.

A prime example is the "Sembrando Vida" social programme, which is part of Mexico's National Development Plan. This programme aims to promote sustainable rural poverty reduction through both income and technical support aimed at stimulating production of traditional crops. In 2019, the Mexican government selected Veracruz as one of the states to be included in the programme. Beneficiaries receive 5000 pesos per month (approximately USD 250) in income support as well as financial subsidies for land transformations focused on agroforestry production (including plants, inputs, tools, etc.). Sembrando Vida's overall objective of planting more than one million hectares of trees was reached in 2020 (Secretaría de Bienestar 2021). In Veracruz alone, the programme has planted 84 million 593 thousand fruit and timber trees (Gobierno del Estado de Veracruz 2021). While these statistics seem to indicate an increase forest cover, programme evaluations have shown how Sembrando Vida has actually contributed to loss of biodiversity (Cotler, Manson, and Nava-Martínez 2020) as it has promoted the expansion of monocrops. Moreover, reports from Los Tuxtlas have indicated that small farmers are burning and cutting down trees in order to enter this subsidised programme (Azamar-Fonseca 2019).

What is most problematic is the fact that these local environmental costs do not seem to be accompanied by long-term socio-economic benefits for local agricultural communities, including those studied in this article. Like many Mexican social and environmental programmes, there do not seem to be any mechanisms to promote the emergence of economically sustainable local markets. Sembrando Vida's focus is the planting of trees and fruit production. There is no investment in sustainable infrastructure, sustainable distribution networks or the commercialisation of sustainable products in local markets. Without this vision of policy coherence for local sustainability, growers will remain dependent on economic subsidies for viable livelihoods because this agricultural system lacks mechanisms for transformative change.

Many countries, including Mexico have formally embraced policy coherence in national programmes. However, economic growth remains the normative reference for development in these policies, so coherence supports markets more than communities or ecosystems. As such, agricultural production in sectors like pineapple, remains privileged at the expense of local environmental, economic, and social sustainability.

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