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Agriculteurs et artisans transformateurs, l'autre facette des filières d'huile de palme / Smallholders and artisanal millers: the least known actors of the global oil palm sector.
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ARTICLE DE RECHERCHE / RESEARCH ARTICLE

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Diversity and profitability of oil palm smallholders in the southeastern Mexican states of Campeche and Tabasco

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Abstract – Smallholders in southeastern Mexico face significant pedoclimatic constraints, including an uneven annual rainfall distribution and poorly workable soils. Consequently, they originally focused on extensive cattle rearing and food crops. Oil palm cultivation was introduced in the states of Campeche and Tabasco in the late 1990s *via* a federal rural development programme targeting family farmers. This article examines how smallholders have adopted oil palm cultivation and assesses the economic impacts of this shift. Technical-economic surveys were conducted in these states involving 47 oil palm producers and 8 interested farmers. Coexisting with agro-industrial estates and large cattle farms in the process of diversification, we differentiated two main types of smallholders: those specialising in oil palm cultivation and larger producers (>50 ha) who diversified into oil palm while remaining cattle ranchers. Our results show that oil palm cultivation is economically more attractive than alternatives such as cattle rearing, maize cultivation or agricultural wage labour. The study area can be divided into three agroecological zones with varying palm oil production potentials, influencing technical practices and economic performance. We identified three types of oil palm cropping systems based on input and labour use: the "extensive", the "intermediate", and the "intensive" ones. In a context of volatile palm oil prices, our results indicate that the "intermediate" system yielded the highest labour and per-hectare productivity, in all agroecological zones. All smallholder oil palm farms generated high revenues and positive cash balances, enabling self-financed expansion of at least two hectares annually.

Keywords: family farming / agricultural microeconomics / adaptive strategies / Elaeis guineensis

Résumé – Diversité et performances économiques des systèmes éléicoles des petits producteurs des États de Campeche et Tabasco, au sud-est du Mexique. Les agriculteurs du sud-est du Mexique sont confrontés à des contraintes pédoclimatiques marquées, notamment une répartition annuelle inégale des pluies et des sols difficiles à travailler. Les agriculteurs se consacraient initialement à l'élevage bovin et aux cultures vivrières. Le palmier à huile a été implanté dans les États de Campeche et Tabasco à la fin des années 1990 avec un programme fédéral de développement rural destiné aux petits producteurs. Nous examinons comment ces agriculteurs ont adopté cette culture et analysons le résultat économique de cette décision. Des enquêtes technico-économiques ont été menées auprès de 47 producteurs de régimes de palmier et de 8 agriculteurs intéressés par cette culture. Co-existant avec des plantations agro-industrielles et de grandes exploitations bovines en cours de diversification, nous avons différencié deux types de petits producteurs : ceux qui se sont spécialisés dans la culture du palmier et ceux qui, disposant de surfaces supérieures à 50 ha,

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ont adopté le palmier tout en restant éleveurs. Nous montrons que la culture du palmier est économiquement plus intéressante que l'élevage bovin, la culture de maïs ou le travail salarié agricole. Les palmeraies étudiées se répartissent dans trois zones agroécologiques présentant des potentiels de production contrastés, impactant les conduites techniques et les performances économiques. Nous distinguons trois types de systèmes de culture de palmier à huile, selon le degré d'usage des intrants et du travail : « extensif », « intermédiaire » et « intensif ». Dans un contexte de prix volatils de l'huile de palme, nos résultats montrent que les productivités du travail et par hectare du système de culture « intermédiaire » sont les plus élevées, dans l'ensemble des zones agroécologiques. Toutes les exploitations éléicoles familiales génèrent des revenus suffisants et des soldes de trésorerie positifs, permettant ainsi d'assurer l'autofinancement d'au minimum deux hectares de palmeraie par an.

Mots-clés : agriculture familiale / microéconomie agricole / stratégies adaptatives / Elaeis guineensis

1 Introduction

The oil palm (*Elaeis guineensis*) is a perennial specie native to the Gulf of Guinea and is cultivated for the extraction of oil from its fruit. This crop has been present in Mexico since the 1950s in the state of Chiapas, then later expanded to Campeche (1997), Tabasco and Veracruz (1998). According to the Mexican Federation of Oil Palm (FEMEXPALMA), in 2020 around 117,000 hectares of oil palm were planted, almost half being located in the state of Chiapas. In Mexico, about 95 per cent of production is managed by smallholders who own less than 20 ha of oil palm (FEMEXPALMA, 2021).

The southeastern Mexican states of Campeche and Tabasco have moderately to highly favourable climatic conditions for the cultivation of oil palm, with varying levels of adequate rainfall and water deficit duration (Chikhaoui, 2019). Oil palm smallholdings were mostly established under a federal program of productive conversion (Mata Garcia, 2014). This program, along with a second initiative launched in the 2010s, promoted this crop among family farms that managed extensive livestock and/or food crops such as maize, rice, beans, and chili peppers. Unlike the widespread deforestation in Southeast Asia (Indonesia and Malaysia), and the oil palm development in the state of Chiapas, this crop did not result in significant direct deforestation in the study area (Camacho-Valdez *et al.* 2022; Castellanos-Navarrete 2023). In Campeche and Tabasco, most of the oil palm was planted on land previously deforested for extensive cattle rearing or food crops (Hernández-Rojas *et al.*, 2018; Isaac-Márquez *et al.*, 2021).

The aim of this paper is to provide a better understanding of the Mexican oil palm sector and smallholders' strategies, using agrarian diagnosis and farm-level economic analysis (Cochet and Devienne, 2006; Jouve and Tallec, 1994; Mazoyer and Roudart, 1997). This is in response to doubts expressed by smallholders regarding their ability to reinvest in oil palm. The agrarian diagnosis is used to describe the technical practices of oil palm farms in the states of Campeche and Tabasco, and to evaluate their profitability in comparison to other local agricultural alternatives (cattle and food crops). This approach helps identifying why farmers in the same region have different types of production systems and diverse strategies, allowing us to hypothesise about prospects for the future of family farms (Cochet and Devienne, 2006).

The output of the local history is the coexistence of a range of highly specialised oil palm farms and diversified farms combining oil palm, cattle raising, and food crops as their main traditional activities. Across this diversity, we observed different degrees of intensification partly dependent on agroecological conditions and on the economic capacity of the farms. This social and environmental heterogeneity provides an opportunity to address the following questions: i) How does oil palm cultivation contribute to the economic wellbeing of smallholders? ii) How do different types of farmers decide their level of intensification in their oil palm plots? iii) Which livelihood choice seems to be the most efficient when oil palm prices fluctuate? iv) In terms of sustainability, does the replanting of oil palm present difficulties similarly to most tree crops? v) Because the economic performance of oil palm seems overwhelmingly superior to that of cattle raising, how can we explain the persistence of the latter? vi) Does diversification limited to two main livelihood activities offer efficient risk management, and how? Globally, in accordance with microeconomic theory, we seek to analyze how the search for maximization of returns, either by specialization or/and intensification, influence the crop system and the sustainability of the farms.

2 Methodology

According to the agrarian diagnosis methodology, the research followed a three-phase approach. First, a landscape reading and historical analysis (based on individual life histories of retired and current farmers, other senior citizens and literature research) of the study area were conducted to identify current farming systems (farms and practices diversity). Second, semi-structured interviews focused on the diversity of the farm's production and their technical management were conducted in 2023 with a sample of 55 farmers interested in oil palm cultivation. Of these farmers, 47 were oil palm producers and eight farmers were planning to plant this crop.

This work enabled us to draw up a typology of oil palm farms, based on a typology developed by Marzin *et al.* (2015), that differentiates farms by type of labour (hired or family), capital ownership (held by the family or external) and legal status. This typology distinguishes between: i) family business farms, ii) family farms, iii) managerial enterprises, and iv) capitalist firms. The categories of "family business farms" and "family farms" were combined in a single category named "oil palm smallholders". The category "managerial enterprises" corresponds to what is called "large private ranches" in the study area. The capitalist firms are represented by industrial oil palm corporations.

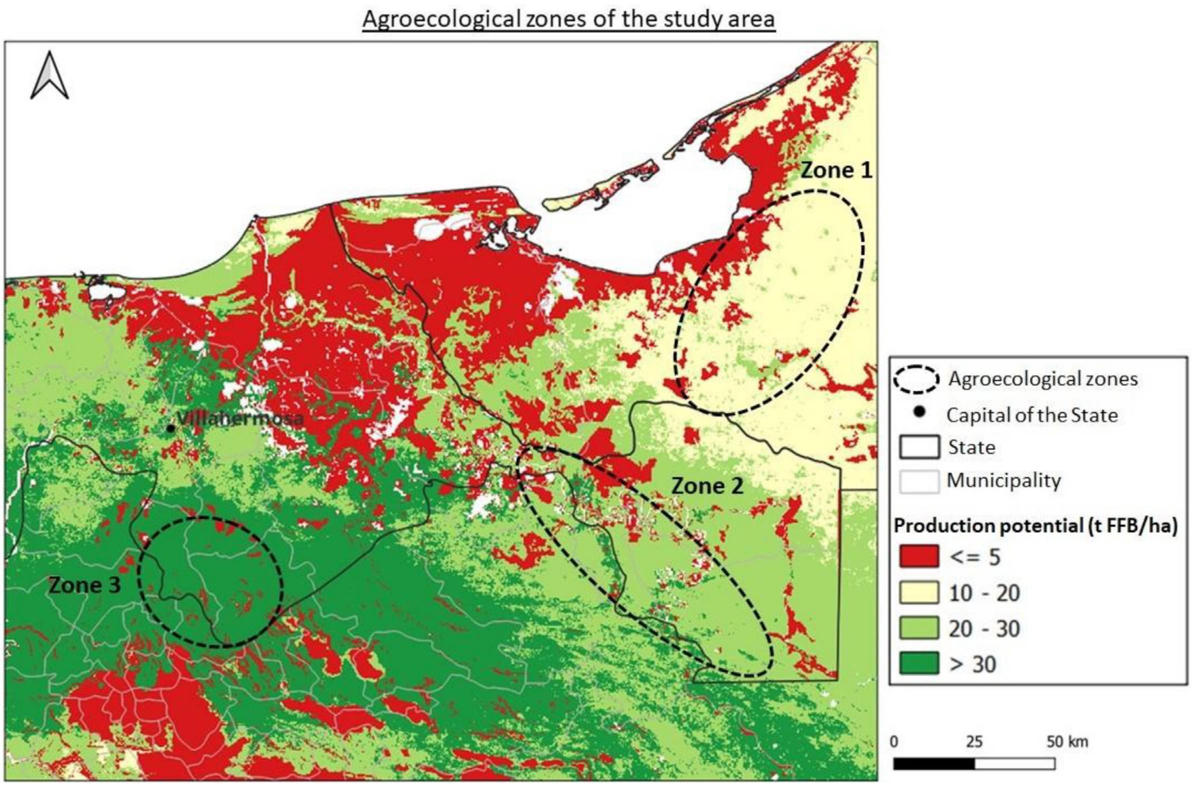

Figure 1. Agroecological zones of the study, according to the oil palm production potential in the states of Campeche and Tabasco. Production potential based on data collected and processed by Chikhaoui (2019). Map by A. Jolivot (CIRAD), 2023

Figure 1. *Figure 1. Zones agroécologiques de l'étude, selon le potentiel de production du palmier à huile dans les États de Campeche et Tabasco. Carte réalisée en 2023 par A. Jolivot (CIRAD) à partir des données collectées et traitées par Chikhaoui (2019).*

The respondents are distributed across three different agroecological zones defined by their environmental conditions (minimum, maximum and average temperatures, annual rainfall, annual duration of water deficit and soil type): i) Zone 1 with a limited potential for production of oil palm Fresh Fruit Bunches (FFB) (yields <20 t FFB/ha/year); ii) Zone 2 with a suboptimal potential (yields <30 t FFB/ha/year); and iii) Zone 3 with an optimal potential (yields> 30 t FFB/ha/year) (Figure 1). A key difference between the three agroecological zones is seasonality, which translates into a season of high FFB production and a season of low FFB production. During the low production season, some holdings in zone 1 might not be harvested due to lack of production or temporary inaccessibility caused by inundations of roads or plots.

Based on the 55 farmers, we built a typology of cropping systems (oil palm and maize) and cattle rearing systems (CRS). Three oil palm cropping systems (CS) were defined according to the level of input use and labour: "extensive", "intermediate" and "intensive" CS. Each oil palm CS was modeled based on 13-year-old palms (average age of oil palm holdings in the sample), in the mature production phase (regarded as average production from 8 to 20 years), with a planting density of 143 palms/ha planted in staggered rows. Given data limitations, it has not been possible to estimate production, labour, and economic returns at each stage of the development of this crop over the complete lifespan. The type of planting material used was assumed to be the same, to illustrate the homogeneity encountered in the study area. The Fresh Fruit Bunch (FFB) yields of the extensive and intermediate oil palm CS used in the model are an average of yields estimated by the farmers. We compared the monitoring of FFB production by 10 farmers to the yields estimated by farmers during interviews and thus confirmed the accuracy of their answers. As few smallholders applied the intensive CS, it was based on technical pathway projections (operations, inputs and labour) and yield estimates, based on interviews with three plantation managers working on large private estates and three local experts.

The profitability of CS and CRS was estimated using economic survey data, using economic indicators defined by Penot *et al.* (2010), based on Carles (2004), including gross margin per hectare and work profitability. Gross margin (GM) is equal to gross income (annual production × average annual price) minus operating expenses (inputs and hired labour) and is used to calculate the economic return of the activity. The gross margin/ha (GM/ha) was used to compare the cropping and livestock systems. Most smallholders employed paid workers; even relatives were paid as employees. Family labour is an unpaid member of the family who works on the farm, but their labour is not allocated in the costs. Return on household labour was calculated as net farm income divided by the number of working days for all members of the family and was used to estimate the economic return per family member. This indicator was calculated for smallholders and was not relevant for managerial enterprises or corporations, as they do not use family labour. Net farm income is the sum of all gross margins from all cropping and livestock systems, minus fixed costs and financial costs. Total net income is the sum of net farm income and off farm income. After deducting annual family expenses from total net income, the cash balance represents potential investment capacity. The farmers have their own plans of how to use the annual cash balance to for either increased farm investment or higher household spending.

Two prices per tonne of FFB were used: a low price equal to the price paid to producers in September 2023 and a high price corresponding to the weighted average price for 2022, which was considered a high-price reference year by farmers and experts.

We analyzed the technical and economic performance of smallholders' farms, identifying subtypes based on the type of oil palm cropping systems and the agroecological zone, on a reduced sample size of 35 smallholders' farms with reliable data.

Average net total income, cash balance (net total income minus family expenses), and potential self-financed oil palm area funding capacity, were used to compare the farm models and assess the economic capacity to invest in farm activities. Cash balance is the money remaining after covering usual family expenses (*e.g.* food, healthcare, clothing, school fees and other daily expenses). Family expenses were estimated by respondents and their spouses during interviews. This balance can potentially be used for investment on the farm, for any other activity, or to increase family consumption of goods and services within household to enhance livelihood. The cash balance indicates the self-financing capacity, to replant aging oil palm.

The potential self-financed oil palm area is the cash balance divided by the cost per hectare of a new oil palm plot (estimated by palm experts and producers at €2,000 per hectare in 2023 in the study area). Data will be presented in € with the following exchange rate exchange rate: €1 =MXN$20. After the interviews and data processing, the technical and economic models and the results of the analysis were validated by most of the interviewed producers during feedback meetings organised in each study location in September 2023.

Other agricultural activities were observed in the study area (large-scale banana estates in the state of Tabasco, fruit orchards, poultry, and small-scale porcine production in most of the localities), but we did not include them in the analysis because either they did not appear in our sample of farms, or they represented an insignificant contribution to family income.

3 Results

3.1 Oil palm farm diversity

Based on the total area of the farm and the diversification with cattle rearing, we defined four types of oil palm farms, with two subtypes of smallholder farms:

i) **Smallholder farms specialised in oil palm**: These farms operate on smaller areas (<50 ha) and have converted pastureland to oil palm, relying primarily on oil palm for their agricultural income. They did not expand their land due to limited opportunities for land purchase.

ii) **Smallholder farm diversified with cattle rearing**: These farms have added oil palm cultivation to their main commercial activity of cattle rearing. They often benefited from remittances from family members working in the USA during the 1990s and 2000s, which allowed them to purchase additional land and expand their holdings to as much as 100 hectares for some farms in the sample.

All smallholders cultivate food crops for home consumption and from time to time sell the surplus, mainly corn, sometimes in association with local squash (*Cucurbita argyrosperma Huber*) and beans. All the smallholders operate independently of oil palm firms and may or may not participate in professional agricultural organizations (such as associations or cooperatives).

iii) **Large private ranches**: These farms have recently diversified cattle operations by converting part of their pastures to oil palm estates, with production areas ranging from 100 to 800 ha.

iv) **Industrial corporations**: These firms acquired large tracts of land, ranging from 2,500 to 7,000 ha, to establish oil palm plantations and usually possess their own oil extraction mills.

Most of the mills relied on their estates for FFB supply as well as a network of smallholders with which they had business relationships (whether formalised through a contract or not). Smallholdings might be over 200 km from a mill, whereas large ranches were usually located close to mills (less than 50 km). However, the public road network was in good shape and well maintained, and long distances did not discourage the planting of oil palm. Intermediaries managed FFB logistics and collection in the localities of smallholders, with the help of local farmers (often also oil palm smallholders). They set a price monthly, based on the price at the mill gate, their transportation costs and the profits they wanted to make. These middlemen assumed the risk of quality loss in the event of delays of FFB delivery to the mill. Indeed, farmers were paid when they delivered FFB at the collection point. There were one or two local middlemen buying oil palm FFB in competition with no evidence of collusion in each locality we visited. In some of them, middlemen contracted by mills also entered the competition to buy FFB at the farm gate. Price setting is directly linked with factory price.

3.2 Profitability of oil palm cropping systems

Oil palm management varied according to the type of oil palm farm. Three major oil palm cropping systems (CS) were identified, differentiated according to the degree of input use: "extensive", "intermediate", and "intensive". For each CS, yields differed according to the agroecological zone that resulted in FFB production potential (limited, suboptimal and optimal). In some smallholdings, the number of months of harvest might be reduced due to very low production or inaccessibility of the plot. As a result, each CS produced a range of annual yields depending on the locality and the accessibility of the holding (Table 1).

Table 1 reveals that the extensive CS type was only present in agroecological zone 1, which had limited FFB production potential. This was the result of a technical adaptation to the low potential, with limited intermediate costs and labour to

Table 1. Characterisation of the three oil palm cropping systems (CS) according to agroecological zones
Tableau 1. *Tableau 1. Caractérisation des trois systèmes de culture (SC) de palmiers à huile selon les zones agroécologiques.*

Type of oil palm CS	Extensive		Intermediate				Intensive		
Agroecological zone	1	1	2		3	1	2	3	
Oil palm theoretical potential associated with the area	Limited		Limited	Suboptimal		Optimal	Limited	Suboptimal	Optimal
Low harvest duration (months)	3	8	8	8		6	8	8	6
Low harvest frequency	Every month		Every 20 days				Every 15 days		
High harvest duration (months)	2	4	4	4		6	4	4	6
High harvest frequency	Every 15 days		Every 10 days				Every 7 days		
Annual yields (t of FFB/ha/year)	4	6	13	16	20		17	23	30
Pruning	None		1 time/year				1 time/year		
Fertilization	None		1 time/year: 1.5 kg of NPK/palm				4 times/year: 6 kg of NPK/palm + Empty Fruit bunches (EFB)		
Weeding	1 time/year with machete		2 times/year with strimmer				2 times/year with the tractor on the harvesting roads + 2 times/year around the palms with strimmer and herbicide		
Type of labor	Family and employees		Family and employees				Employees		

adapt to poor economic capacity of smallholders (lack of cash flow to buy inputs), and to improve profitability per hectare and return on labour (Figure 2).

Under conditions of a high FFB price, intensification in terms of inputs and labour led to a higher gross margin (GM)/ha for agroecological zones 2 and 3 (suboptimal and optimal production potential). On the other hand, in zone 1, where production potential was limited, intensification did not translate into a gain in GM/ha. Under high and low price conditions, it was the intermediate CS that produced the highest GM in all the zones.

When the FFB price was low, GM/ha decreased for all cropping systems and in all zones, but the largest fall was in intensive CS where gross output decreased drastically, while operating expenses, which were already high compared to other CS, remained unchanged. The eventual no correlation between FFB and fertiliser price fluctuations was observed.

Considering only technical labour for oil palm (excluding time involved in management, administration, and sale), moderate intensification (from extensive to intermediate CS) resulted in a higher value of the family workday (return on labour) regardless of the agroecological zone, especially when the price per tonne of FFB produced was high. Intensive systems were excluded because their labour force was composed solely of hired workers.

In conclusion, intensive CS were the most profitable CS per hectare for agroecological zones 2 and 3, with suboptimal and optimal production potential in conditions of high palm oil price, but less profitable than the intermediate CS in conditions of low palm oil price. Intermediate systems were also less sensitive to market fluctuations, indicating greater economic resilience than intensive systems.

3.3 Profitability of oil palm cropping systems compared to other cropping and cattle rearing systems

The four most common cropping and livestock systems, other than oil palm, are presented. Two maize monoculture systems were modeled: i) cropping system (CS) type 1: maize associated with squash; and ii) CS type 2: maize not associated with other crops. Two cattle rearing systems (CRS) were modeled: i) type 1 cattle rearing system (CRS): sale of weaned calves (7 months); and ii) type 2 CRS: sale of fattened young bulls (19 months).

3.3.1 Gross margin per hectare (GM/ha)

In conditions of high oil palm price, oil palm was the most profitable agricultural activity per hectare compared to the other local agricultural alternatives (Figure 3). When the FFB price was low, except for extensive and intensive CS in agroecological zone 1, oil palm CS remained more profitable per hectare than maize CS and cattle rearing systems (CRS). Although calf fattening slightly increased the gross margin per hectare, cattle rearing remained by far the least profitable agricultural activity per hectare, in periods of low and high FFB prices because of the large number of hectares used for livestock.

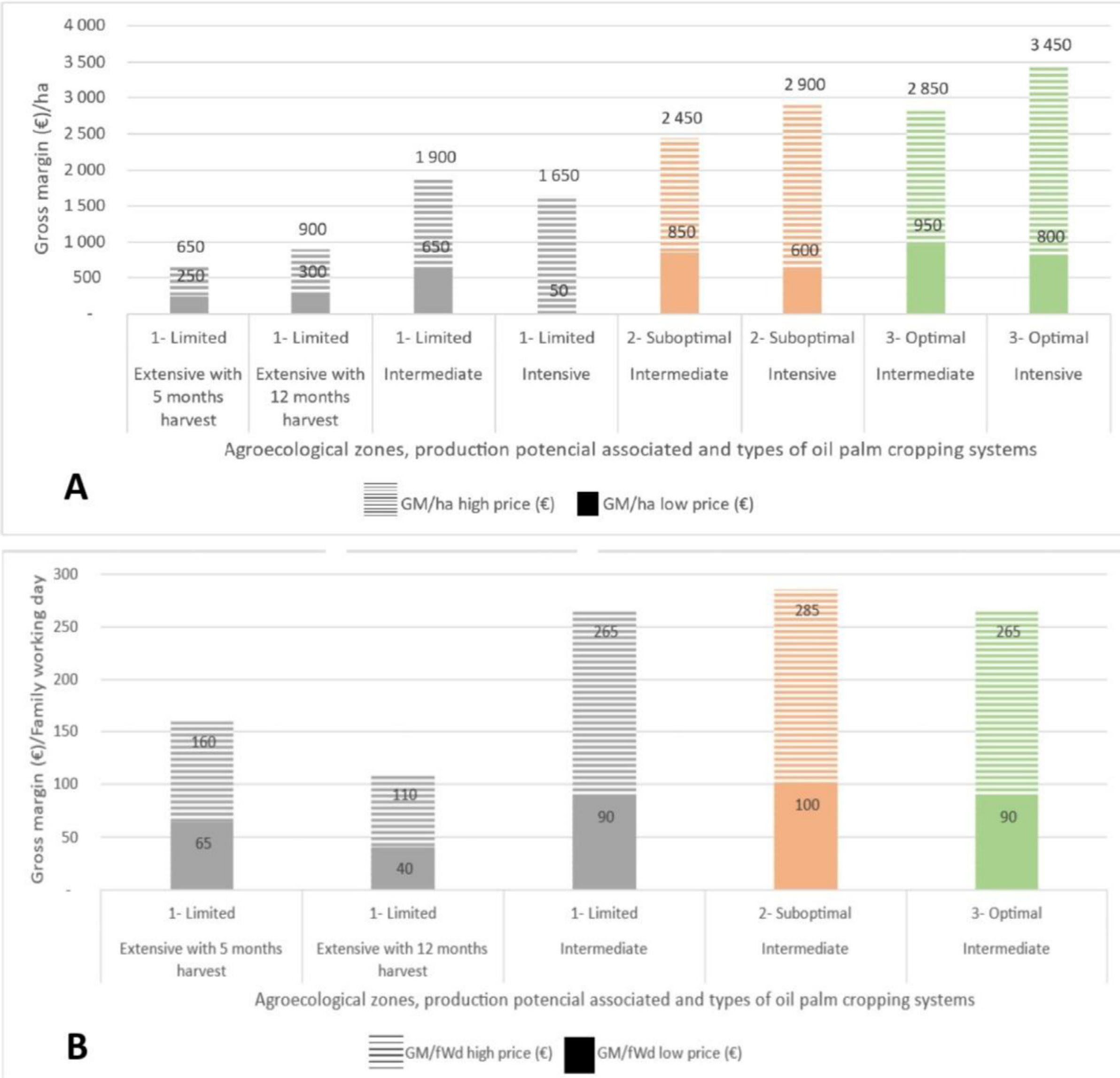

Figure 2. A) Gross margin per hectare according to the oil palm cropping system, the production potential associated with the agroecological zone and the FFB price. B) Return on labour for family workers according to the oil palm cropping system, the production potential associated with the agroecological zone and the FFB price

Figure 2. *Figure 2. A) Marge brute par hectare en fonction du système de culture du palmier à huile, du potentiel de production associé à la zone agroécologique et du prix de la tonne de régimes de fruits frais. B) Valorisation de la journée de travail familial en fonction du système de culture du palmier à huile, du potentiel de production associé à la zone agroécologique et du prix de la tonne de régimes de fruits frais.*

Another alternative was *Sembrando Vida*, a national agroforestry program promoted by the federal government. By dedicating 2.5 ha to an agroforestry cropping system (designed under specific technical conditions), the farmers involved received a monthly subsidy (€250 per month, equivalent to €3,000 per year for the first two years), which was more than twice the gross margin of oil palm CS (€1,200 per hectare) in conditions of low FFB price. Only 34% of the smallholders in the sample were involved in this program, which was not intended for all the studied communities. Since the end of government support for the palm oil sector in 2019, the government subsidies for this program competed with oil palm when FFB prices were low.

3.3.2 Return on labour

When the FFB price was high, oil palm was the most profitable agricultural activity in the different agroecological zones in terms of gross margin per family labour-day; the most extensive oil palm CS generated twice the gross margin per family labour-day compared to maize CS and CRS type 2 with feedlot (Figure 3). In a period of low FFB price, intermediate

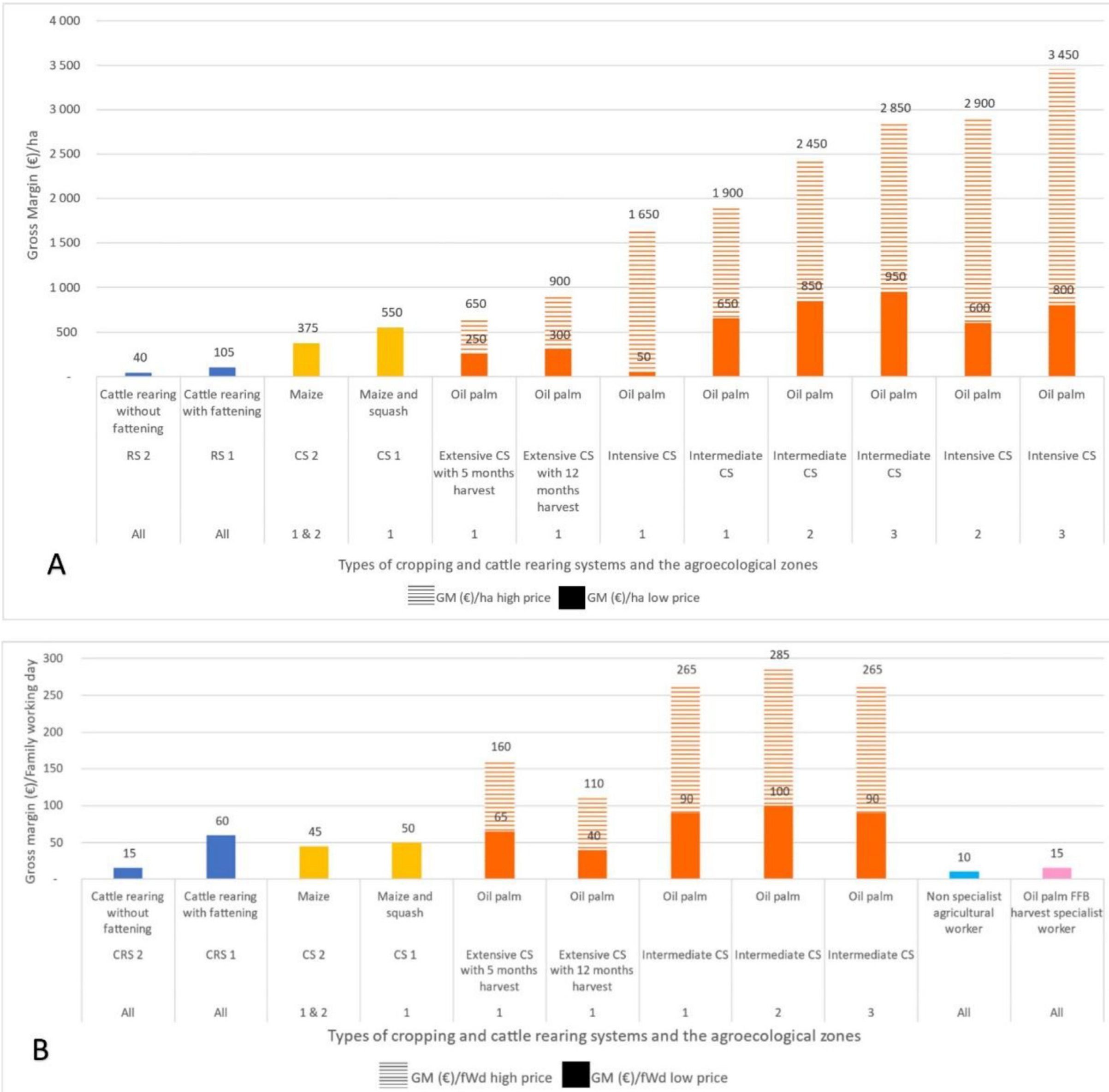

Figure 3. A) Ordered by increasing value, the gross margin per hectare according to the cropping or rearing system, the oil palm production potential associated with the agroecological zones and the FFB price. B) Valuation of family working day if remunerated, according to cropping or rearing systems, the oil palm production potential associated with the agroecological zone and the FFB price. fWd= family working day with one working day corresponding to 6 hours

Figure 3. *Figure 3. A) Par ordre croissant, la marge brute par hectare selon les systèmes de culture ou d'élevage, le potentiel de production du palmier à huile associé à la zone agroécologique et le prix de la tonne de régimes de fruits frais. B) Valeur de la journée de travail familiale si elle était rémunérée, en fonction des systèmes de culture ou d'élevage, du potentiel de production du palmier à huile associé à la zone agroécologique et du prix de la tonne de régimes de fruits frais. fWd = journée de travail familiale avec une journée travaillée correspondant à 6 heures.*

oil palm CS remained more competitive than other agricultural activities or agricultural wages; it represented at least twice the daily farm wage (10€/day for a non-specialist agricultural worker or 15€/day for an oil palm FFB harvest specialist worker). Interestingly, even with fattening, cattle rearing could not compete with oil palm in terms of labour returns.

3.3.3 Profitability at the farm level

Profitability was assessed in terms of total net farm income and cash balance, including off-farm income (Table 2).

As expected, net income was highly influenced by the combination of land area and its location under particular agroecological conditions. Cattle farms in zone 3 generated the

Table 2. Average annual profitability and annual family expenses for smallholder oil palm farms in 2022, with a high FFB price
Tableau 2. *Tableau 2. Rendement économique moyen et dépenses des ménages pour les exploitations familiales de palmiers à huile en 2022, avec un prix élevé par tonne de régimes de fruits frais.*

Types of oil palm farm	Smallholders' farms specialized in oil palm		Smallholders' farms with oil palm and cattle rearing		
Agroecological zone and oil palm production potential associated	*1 – Limited*	*3 – Optimal*	*1 – Limited*	*2 – Suboptimal*	*3 – Optimal*
Total area (ha) – sample average (min-max)	*28.5 (9.5-45)*	*18 (8-28.5)*	*89 (40-100)*	*63.5 (25-143.5)*	*48 (23-61.5)*
Oil palm area (ha) – sample average (min-max)	*11 (8-16)*	*14 (5.5-24)*	*14 (10.5-17)*	*15 (5-44)*	*19 (13-25)*
Type of oil palm CS	*Extensive*	*Intermediate*	*Intermediate*	*Intermediate*	*Intermediate*
Annual yields (t of FFB/ha/year) – sample average (min-max)	*5 (3-7)*	*22 (17-28)*	*13 (10-14)*	*16 (10-23)*	*17.5 (17-18)*
Net farm income (€)	8000	40000	30000	39000	49000
Off-farm income (€)	2000	1000	2000	3000	7000
Total net income (€)	**10000**	**41000**	**32000**	**42000**	**56000**
% of off-farm income to total net income	20%	2%	6%	7%	13%
Total net income (€)/ha	**400**	**2300**	**400**	**700**	**1200**
Annual family expenses (€)	4400	3800	6800	6800	7000
Cash balance (€)	**5600**	**37200**	**25200**	**35200**	**49000**
Oil palm area that could be replanted with self-financing (ha)	3	19	13	18	25

highest total income, followed by farms specialised in oil palm in zone 3 and farms with cattle in zone 2. Farms specialised in oil palm in zone 1 had the lowest total income. In terms of total net income per hectare, it was the oil palm specialised farms in zone 3 that had the highest total income per hectare, almost twice that of livestock-based farms in the same zone. Farms in zone 1, whether or not they included livestock, had comparable incomes per hectare.

In a situation of low FFB price, farms with cattle in zone 2 generated the highest total net income compared to farms with cattle in zone 3 (Table 3). The smallholders' farms specialised in oil palm in the zone with limited production potential had extensive oil palm CS, whereas the others had intermediate CS, due to less favourable environmental conditions than in zone 3 and the lack of cattle-derived income. As expected, specialised farms were more exposed to a decline in oil palm prices. It is worth noting that the total net income of the specialised oil palm farms in zone 3 (optimal production potential) decreased by 68% with the fall of the FFB price. The diversified farms, with oil palm and livestock, had their total income halved because of the drop in FFB prices. Farms specialised in oil palm in zone 1 (limited production potential) were less affected by the price change but remained the lowest income farms even during low-price periods.

Farms with higher incomes also recorded higher cash balances. Cattle farms in zone 3 had the highest cash balance, while in low price years, it was cattle farms in zone 2 that had higher cash reserves. With high prices, the best-performing farms could replant 11 to 25 hectares of oil palm, while the farms with the lowest cash balances could afford replanting of a three-hectare oil palm plot. Under low-price conditions, the best-performing farms could renew five to eleven hectares of oil palm, while farms with the lowest cash balances could renew two to three hectares of oil palm.

Very few growers had started to replant their ageing oil palm plots of the first planting program, which were 25 years old in 2023, corresponding to the end of the economic lifespan of oil palm (palms over 25 years old reach heights that make harvesting impractical). All oil palm farms had sufficient capital to self-finance the establishment or renewal of at least two hectares of oil palm per year, if they allocated all available cash reserves. Even if the estimated planting costs did not include the costs of maintenance of immature plots during the second and third years following planting, when no FFB production occurs, this is an interesting indicator of the potential sustainability of oil palm cultivation. It demonstrates that even the smallest-scale and most extensive smallholders, and in conditions of low prices, can stagger renewal of oil palm (0.5 ha/year for 12.5 ha oil palm area), with the exception of farmers with less than five hectares and low yields (below 6 tonnes of FBB/ha/year).

4 Discussion

This paper demonstrates that oil palm increases the income of smallholders in the states of Campeche and Tabasco, as observed in other oil palm-growing regions worldwide, such as Cameroon (Tabe-Ojong *et al.*, 2023), Indonesia (Chrisendo *et al.*, 2022; Feintrenie *et al.*, 2010; Sayer *et al.*, 2012) and the South Pacific (Cramb and Curry, 2012). Oil palm delivers

Table 3. Total net income, cash balance and theorical financial capacity to replant oil palm area through self-financing, according to the type of smallholder farm and FFB prices
Tableau 3. *Tableau 3. Revenu net total, solde de trésorerie et superficie théorique de palmier à huile pouvant être rénovée avec autofinancement selon le type d'exploitation familiale et les prix de la tonne de régimes de fruits frais.*

Types of oil palm farm	Smallholders' farms specialized in oil palm		Smallholders' farms with oil palm and cattle rearing		
Agroecological zone and palm oil production potential associated	*1- Limited*	*3- Optimal*	*1- Limited*	*2- Suboptimal*	*3- Optimal*
Type of oil palm CS	*Extensive*	*Intermediate*	*Intermediate*	*Intermediate*	*Intermediate*
Annual yields (t of FFB/ha/year)	*5*	*22*	*13*	*16*	*17.5*
Total net income with high FFB price (€)	10000	41000	32000	42000	56000
Total net income with low FFB price (€)	7000	13000	16000	28000	26000
Net income reduction in low price conditions	30%	68%	50%	33%	53%
Cash balance with high FFB price (€)	108000	740000	502000	708000	977000
Cash balance with low FFB price (€)	64000	188000	224000	440000	389000
Area that could be replanted with self-financing with high FFB price (ha)	3	19	13	18	25
Area that could be replanted with self-financing with low FFB price (ha)	2	5	6	11	10

benefits through job creation and household income stability, in line with the results of Rosas Urióstegui *et al.* (2018) regarding the specific case of Mexico. This aligns with farmers' positive attitudes regarding oil palm production in Campeche, as described by Cifuentes-Espinosa *et al.* (2023).

Intensification of the oil palm cropping system does not systematically translate into increased GM and profitability of the farm. This is confirmed by Tabe-Ojong *et al.* (2023) and Darras *et al.* (2019), who indicate that FFB production may be more profitable through less labour-intensive and environmentally friendly cropping systems.

This study confirms that fertilisers are used by smallholders as a key input in managing oil palm cultivation in the study area, in a strategy of resilience to economic uncertainties. This has been observed frequently in other oil palm regions of the world and for other commercial crops (Hoffmann *et al.*, 2019; Kenfack Essougong *et al.*, 2020; Mettauer *et al.*, 2021; Nkongho *et al.*, 2014; Schnitkey *et al.*, 2021). It is likely that, under conditions of low oil palm price and high input price, specialised farms in agroecological zone 1 will move on to more extensive CS with five months of harvesting, making greater use of family labour and increasing the profitability per tonne of FFB produced. In this context, it is also likely that specialised farms in agroecological zone 3 will decrease their use of fertilisers, which is the second most important input cost for the farms, converting to an extensive oil palm CS.

Our results show that smallholders have the financial capacity to replant their aging oil palms, which accords with Ruf and Burger's (2001) argument that oil palm is among the easier perennial crops to replant. So, what is preventing them from replanting one of their main agricultural sources of income, and their most profitable one? Cifuentes-Espinosa *et al.* (2023) highlight some of the reasons stated by smallholders: i) difficult access to seedlings – there are few nurseries in the study area, and the delivery of seedlings takes six months to a year after ordering, which implies anticipation from the farmers; ii) producers' inertia in the face of the end of public subsidies and the absence of a public program to support replanting. To date, producers have received support during the planting phases, and, given the need for training that they have expressed, it is possible that they do not feel capable of replanting their palm plots without technical and financial support.

Part of the solution might be for farmers to stagger replanting of palm smallholdings as has been tried in Papua New Guinea (Curry *et al.*, 2019). This would cause less disruption to oil palm production and smooth out investment costs over several years. This practice makes it possible to intersperse annual food crops continuously or over a long period (depending on the total area of the plot and the staggering method chosen), as shown by Feintrenie *et al.* (2010) for coconut-based agroforestry systems and Nake *et al.* (forthcoming) for oil palm in Papua New Guinea. This method guarantees economic stability, allowing renewal to be carried out with high-quality planting material and fertilization.

The agroecological conditions in most of the study area are unsuitable for many agricultural commodities, particularly in Campeche, where extended and hard droughts limit seasonal crops to short-cycle ones, and high temperatures are not suitable for cash crops such as cocoa or coffee. This natural context partly explains why maize and livestock are the main agricultural products of the study area. When telling their life stories, smallholders described how they tried various crops which were unsuccessful and unprofitable, until they diversified with oil palm. These accounts are supported by the work of Pajamandy (2023) who showed that the possibilities for agricultural diversification are severely constrained by inadequate or complex marketing channels. This can be explained by the fact that the southeastern states of Mexico are isolated and under-industrialised, due to successive policies that place them at a comparative disadvantage and inhibit their economic development (Dávila *et al.*, 2002; Ramírez *et al.*, 2020). Maize is the local staple food and has great cultural value in Mexico, and more specifically in the Yucatan Peninsula (Moo Xix *et al.*, 2018; Schmook *et al.*, 2013), which is probably why maize is still cultivated by smallholders despite its low gross margin/ha.

Maize and livestock production are highly sensitive to extended droughts, which occur frequently but unpredictably in the study area. When the first rains arrive late in the season, maize cannot be cultivated in association with squash. Shortages and irregular rainfall at the end of the year make it unprofitable to sow a second round of maize. When droughts are severe and extended, livestock herds might suffer significant losses, with as much as 50% of animals lost due to the lack of accessible surface water and pasture. Oil palm demonstrates greater resilience to climate variability. A longer drought will translate into a decrease in FFB production but will not lead to a loss of palms or investment. Even if it is not very lucrative and is climate sensitive, livestock production still plays an important role in smallholders' farms. It historically allowed a large part of the land to be developed and appropriated with little labour investment, and it has a functional role, as it generates cash to buy inputs for oil palm. Diversification of agricultural activities is an element of livelihood security, especially when prices fluctuate (as in the case of palm oil), which was confirmed by our results. Smallholders might choose to specialise in oil palm or to maintain livestock as part of a diversified farming strategy, depending on their financial resources and access to land. In the case of livestock farming, the savings obtained from the sale of animals and the possibility of converting pastures to oil palm facilitate the establishment of oil palm plots. In the absence of livestock farming, off-farm income is used for the establishment of oil palm plots and for facilitating the management of annual cash flows.

5 Conclusion

We used a case study of small-scale oil palm growers in southeastern Mexico to explore how smallholders, in an heterogenous, isolated and poorly suitable agricultural region, maximise their agricultural productivity in the context of price volatility. Four main types of oil palm farms were defined and analyzed in the states of Campeche and Tabasco: (i) smallholder farms specialised in oil palm; (ii) smallholder farms with cattle rearing; (iii) large cattle farms in the process of diversifying into oil palm; and (iv) agro-industrial oil palm estates. As reflected in this typology, some farms combined oil palm cultivation with cattle rearing, while others, which were smaller in size, sold their herds to specialise in oil palm cultivation, due to better returns on land and labour. Some large cattle ranches were also beginning to diversify their agricultural activities with oil palm.

The typology of the farms was linked to the agroecological zones in which they were located and their capacity to adapt their farm management strategies. They did so according to the agroecological zone and Fresh Fruit Bunch (FFB) price to achieve the most efficient economic results. Three main oil palm cultivation systems were identified according to the degree of input use. The intensive cropping system (CS) was the most profitable per hectare for zones with suboptimal and optimal production potential. However, in the context of fluctuating oil palm prices, the intermediate CS was more resilient in all agroecological zones, in terms of the value of FFB production and the value of the family working day. This finding aligns with the basic marginalist return approach: maximised use of inputs does not coincide with the economic optimum threshold. Flexibility in production costs through adjustment of CS patterns gives to the famers the ability to adapt to any change, including a drop in palm oil price. Further work with agro-industrial estates applying intensive CS, in each of the agroecological zones, would confirm or refute the hypothesis of economies of scale from a given surface area, which could make intensive CS more profitable.

This case study also confirms the usually very good returns on labour for oil palm. Oil palm cultivation remained much more financially attractive than the local agricultural wage rate for daily labour (opportunity cost) in both conditions of high and low palm oil prices. In periods of low price, the value of a family work day in the less competitive oil palm CS represented at least twice the daily agricultural wage. Further investigation will be necessary to describe the employment patterns by agroecological zone and farm type. It is possible that in the area with limited production, the seasonality of oil palm fruit production could create precarious jobs on smallholdings. Oil palm cropping was economically attractive compared to other agricultural activities in the area (cattle rearing or maize cropping). In addition, all oil palm farms might be able to self-finance the replanting of oil palm plots. This shows that it is not the combination of many crops that minimises price risk and maximises the income of farmers, but the choice of a limited number of crops. However, the area of oil palm that farms could self-finance for replanting is purely theoretical in a sense that most farmers will never use all their cash balance for 100% agricultural investment. It will be more difficult for smaller, low-yielding farms to replant their oil palm plots than for larger farms. It depends on the farmer's savings capacity and ability to plan a financial investment in planting or replanting.

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References

Camacho-Valdez V, Rodiles-Hernández R, Navarrete-Gutiérrez DA, Valencia-Barrera E. 2022. Tropical wetlands and land use changes: The case of oil palm in neotropical riverine floodplains. *PLOS ONE* 17 (5): e0266677. https://doi.org/10.1371/journal.pone.0266677.

Carles R. 2004. *Compte et résultats de l'entreprise agricole*. Paris (France): Editions France agricole, 319 p.

Castellanos-Navarrete A. 2023. Un monocultivo de frontera: Historia de la palma africana como proyecto de modernidad capitalista en el sur de México (1948- 2018). *Journal of Latin American Geography* 22: 1–26. https://doi.org/10.1353/lag.0.0196.

Chikhaoui E. 2019. Évaluation du potentiel de production durable du palmier à huile au Mexique. Mémoire de fin d'étude, Master 2 Géomatique, Université de Toulouse, France, 80 p.

Chrisendo D, Siregar H, Qaim M. 2022. Oil palm cultivation improves living standards and human capital formation in smallholder farm households. *World Development* 159: 106034. https://doi.org/10.1016/j.worlddev.2022.106034.

Cifuentes-Espinosa JA, Feintrenie L, Monzón-Alvarado C, Schmook B, Mesa-Jurado MA. 2023. Oil palm growers' prospects for sustainable oil palm production. A case study from Campeche, Mexico. *Agricultural Systems* 212: 103780. https://doi.org/10.1016/j.agsy.2023.103780

Cochet H, Devienne S. 2006. Fonctionnement et performances économiques des systèmes de production agricole : Une démarche à l'échelle régionale. *Cahiers Agricultures* 15 (6): 28. https://doi.org/10.1684/agr.2006.0028.

Cramb R, Curry GN. 2012. Oil palm and rural livelihoods in the Asia-Pacific region: An overview. *Asia Pacific Viewpoint* 53 (3): 223–239. https://doi.org/10.1111/j.1467-8373.2012.01495.x.

Curry GN, Nake S, Tilden G, Koczberski G, Pileng L, Germis E. 2019. *Maintaining Household Food and Income Security amongst Oil Palm Smallholders: the One Hectare Replant Trial, Bialla, West New Britain Province, Papua New Guinea*. Perth (Australia): The Sustainable Livelihoods Group; Dami (Papua New Guinea): The Oil Palm Research Association. http://hdl.handle.net/20.500.11937/76752

Darras KFA, Corre MD, Formaglio G, Tjoa A, Potapov A, Brambach F, *et al.* 2019. Reducing fertilizer and avoiding herbicides in oil palm plantations—ecological and economic valuations. *Frontiers in Forests and Global Change* 2. https://doi.org/10.3389/ffgc.2019.00065.

Dávila E, Kessel G, Levy S. 2002. El sur también existe: Un ensayo sobre el desarrollo regional de México. *Economía Mexicana Nueva Época* XI: 205–260.

Feintrenie L, Jean O, Frank E. 2010. How to take advantage of a new crop? The experience of Melanesian smallholders. *Agroforestry Systems* 79: 145–155. https://doi.org/10.1007/s10457-010-9285-z.

FEMEXPALMA 2021. *Anuario estadístico 2021*. http://femexpalma.com.mx/femexpalma.ftp/anuario_estadistico_2021.pdf)

Hernández-Rojas DA, López Barrera F, Bonilla Moheno M. 2018. Preliminary analysis of the land use dynamic associated with oil palm (*Elaeis guineensis*) plantations in Mexico. *Agrociencia* 52: 875–893.

Hoffmann M, Cock J, Samson M, Janetski N, Janetski K, Rötter RP, *et al.* 2019. Fertilizer management in smallholder cocoa farms of Indonesia under variable climate and market prices. *Agricultural Systems* 102759. https://doi.org/10.1016/j.agsy.2019.102759.

Isaac-Márquez R, Bojórquez G, Ayala Arcipreste M. 2021. Palma de aceite, reconversión productiva y respuestas campesinas en el uso del suelo. *Tropical and Subtropical Agroecosystems* 24. https://doi.org/10.56369/tsaes.3505.

Jouve P, Tallec M. 1994. Une méthode d'étude des systèmes agraires par l'analyse de la diversité et de la dynamique des agrosystèmes villageois. *Cahiers de la Recherche-Développement* 39: 43–59. https://agritrop.cirad.fr/387956/.

Kenfack Essougong UP, Slingerland M, Mathé S, Vanhove W, Tata Ngome PI, Boudes P, *et al.* 2020. Farmers' perceptions as a driver of agricultural practices: Understanding soil fertility management practices in cocoa agroforestry systems in Cameroon. *Human Ecology* 48 (6): 709–720. https://doi.org/10.1007/s10745-020-00190-0.

Marzin J, Daviron B, Rafflegeau S. 2015. Family farming and other forms of agriculture. In: Sourisseau JM, ed. *Family Farming and the Worlds to Come*. Dordrecht (The Netherlands): Springer, pp. 71–89. https://doi.org/10.1007/978-94-017-9358-2_5.

Mata Garcia B. 2014. *Palma de aceite en México: política gubernamental e innovación tecnológica*. Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria, Mexico. http://biblioteca.diputados.gob.mx/janium/bv/cedrssa/lxii/pal_ace_mex.pdf

Mazoyer M, Roudart L. 1997. Pourquoi une théorie des systèmes agraires? *Cahiers Agricultures* 6: 91–595. https://revues.cirad.fr/index.php/cahiers-agricultures/article/view/30057.

Mettauer R, Baron V, Turinah Demitria P, Smit H, Alamsyah Z, Penot E, *et al.* 2021. Investigating the links between management practices and economic performances of smallholders' oil palm plots. A case study in Jambi province, Indonesia. *Agricultural Systems* 194: 103274. https://doi.org/10.1016/j.agsy.2021.103274.

Moo Xix FJ, Jimenez Pat NF, Huchin Chan J. 2018. La calabaza Chihua (Cucurbita Argyrosperma Huber) del Estado de Quintana Roo, como producto potencial para la comercialización (Vol. 3) Universidad Nacional Autónoma de México y Asociación Mexicana de Ciencias para el Desarrollo Regional A.C, Coeditores. http://ru.iiec.unam.mx/4301/.

Nake S, Curry GN, Koczberski G, Germis E, Bue V, Tilden GM, *et al.* (forthcoming). Social, technical and institutional innovation: Smallholders' responses to population and land pressures on the oil palm schemes in Papua New Guinea. *Cahiers Agricultures*.

Nkongho RN, Feintrenie L, Levang P. 2014. Strengths and weaknesses of the smallholder oil palm sector in Cameroon. *OCL* 21 (2): 2. https://doi.org/10.1051/ocl/2013043.

Pajamandy O. 2023. Estudio de salidas comerciales y servicios ecosistémicos para especies vegetales que pueden asociarse con la palma de aceite en sistemas agroforestales en los estados de Campeche y Tabasco, México (marzo-junio 2023). [Informe de práctica, Institut Agro, Montpellier, Francia], 47 p.

Penot E, Olivier H, Rakotondramanana. 2010. Annexe 2 : Les bases de calculs économiques pour l'évaluation des systèmes SCV. In: *Manuel pratique du Semis direct sur Couverture Végétale permanente (SCV). Application à Madagascar*. pp. 479–506. https://open-library.cirad.fr/files/2/34__Manuel_SCV_Mada_Annexe_2_calculseco.pdf.

Ramírez A, Lamoyi Bocanegra CL, Martínez Prats G. 2020. Análisis de la competitividad de la región sureste de México. *Revista Inclusiones*: 128–153.

Rosas Urióstegui IFR, Fernández JMP, Fernández LAP, Van der Wal JC. 2018. The effect of oil palm on income strategies and food security of households in rural communities in Campeche, Mexico. *Acta Universitaria* 28 (2): 2. https://doi.org/10.15174/au.2018.1553.

Ruf F, Burger K. 2001. Planting and replanting tree crops: Smallholders' investment decision. In: *The Future of Perennial Crops*, Yamoussoukro. 33 p. https://www.researchgate.net/publication/242269471.

Sayer J, Ghazoul J, Nelson P, Klintuni Boedhihartono A. 2012. Oil palm expansion transforms tropical landscapes and livelihoods. *Global Food Security* 1 (2): 114–119. https://doi.org/10.1016/j.gfs.2012.10.003.

Schmook B, van Vliet N, Radel C, Manzón-Che M de J, McCandless S. 2013. Persistence of swidden cultivation in the face of globalization: A case study from communities in Calakmul, Mexico. *Human Ecology* 41 (1): 93–107. https://doi.org/10.1007/s10745-012-9557-5.

Schnitkey G, Paulson N, Swanson K, Zulauf C. 2021. Management decisions relative to high nitrogen fertilizer prices. *Farmdoc Daily* 11 (147). https://origin.farmdocdaily.illinois.edu/2021/10/management-decisions-relative-to-high-nitrogen-fertilizer-prices.html.

Tabe-Ojong MPJ, Molua E, Nanfouet M, Mkong C, Kiven V, Ntegang V. 2023. Oil palm production, income gains, and off-farm employment among independent producers in Cameroon. *Ecological Economics* 208: 107817. https://doi.org/10.1016/j.ecolecon.2023.107817.

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