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HIGH-VALUE CROPS AS A DEVELOPMENT STRATEGY: EVALUATION OF FIG CULTIVATION WITHIN THE FRAMEWORK OF THE SEMBRANDO VIDA PROGRAM

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Abstract

Protected agriculture has established itself as a viable strategic alternative for diversifying peasant production in rural areas. This study evaluated the cultivation of fig (*Ficus carica* cv. Neza) a high-value fruit, within the framework of the Sembrando Vida program. The objective was to analyze its technical, economic, and institutional viability. The analysis was based on a theoretical framework for public policy evaluation, incorporating the concepts of differentiated policies and entry and exit strategies geared toward the implementation and scaling of productive projects. To this end, a 50 m² pilot module with 60 greenhouse plants was designed at the Chapingo Experimental Field, operated in two staggered cycles per year. Yields of up to 76 t ha^{-1} were obtained, with soluble solids above 17° Brix and firmness greater than 5 Newtons: meeting export quality standards. The economic analysis projected gross revenues of $14,000.00 MXN per module annually, with net margins of $3,500.00 MXN and a benefit-cost ratio of 1.2. The territorial analysis identified the states of Morelos, Puebla, Hidalgo, and the State of Mexico as highly suitable due to their agroclimatic vocation, levels of marginalization, and the institutional presence of the program. It is concluded that the proposed module is technically viable, economically profitable, and institutionally compatible with the guiding principles of Sembrando Vida, particularly those of food self-sufficiency, environmental regeneration, and social inclusion. Consequently, it is recommended to promote their adoption through modular micro-lots to maximize economic benefits for rural communities and strengthen the national strategy for inclusive rural development.

Keywords: protected agriculture, differentiated policies, fig, entry strategy, rural development.

Introduction

Rural development in Mexico faces structural challenges expressed in high levels of poverty and marginalization, low agricultural productivity, and increasing vulnerability to climate change (CONEVAL, 2023; FAO, 2021). Faced with this situation, public policy has sought to reestablish intervention schemes that go beyond addressing insufficient peasant income and, at the same time, strengthen the social fabric and promote environmental regeneration processes. Within this framework, the Sembrando Vida program constitutes one of the most ambitious social and productive policy initiatives in the country, aimed at linking the promotion of agroforestry systems with community inclusion and local capacity building (Secretaría del Bienestar, 2024).

The effectiveness of these rural policies, however, depends on their ability to recognize the heterogeneity of the Mexican countryside. In this sense, the literature on public management emphasizes the relevance of designing differentiated policies, understood as those that adapt their instruments and strategies to the conditions of each social and territorial group (Ortegón, 2008a; Sen, 2000). From this perspective, the contemporary peasantry is characterized by pluriactivity and the need to diversify risks, so any productive innovation must be integrated into modular schemes compatible with local social and economic dynamics (Kay, 2009). In this context, the analysis of high-value crops such as fig (*Ficus carica* cv. Neza) under protected agriculture should not be limited to technical productivity criteria but should also consider their institutional and social compatibility within programs such as Sembrando Vida.

Public policy evaluation provides an appropriate analytical framework for examining such integration, as it distinguishes three key stages: the entry strategy, which refers to crop selection and the design of pilot modules consistent with the program's resources and capabilities; the validation phase, which focuses on measuring technical, social, and economic variables under real-world adoption conditions; and the exit strategy, which defines criteria for territorial scalability and long-term sustainability (Weiss, 1998; Ortegón, 2005). These phases should not be understood as linear processes, but rather as cyclical ones, as feedback is essential for continuously adjusting the technical and social components of the policy.

Within this framework, protected agriculture is defined as a differentiated strategy for productive diversification, combining technical innovation—microclimate control, increased yield and quality—with social relevance—small-scale modules, transferable training within one year, inclusion of women and youth—and environmental advantages—efficient water use, reduced application of agrochemicals. In particular, the cultivation of fig (*Ficus carica* cv. Neza) is emerging as a fruit with high nutraceutical potential, with growing demand in national and international markets and notable adaptability to marginalized contexts (Mendoza *et al*., 2017). These characteristics make it a strategic crop for evaluation within the Sembrando Vida production catalog.

The objective of this study was to evaluate the viability of fig cultivation under protected agriculture as a fruit diversification strategy within the framework of the Sembrando Vida program. To this end, we considered technology transfer, the use of existing community resources and structures—Peasant Learning Centers (PECs), bio factories, and community nurseries—as well as their technical and productive compatibility in marginalized regions with agroclimatic potential. Based on this analysis, we seek to generate evidence that will contribute to the design of differentiated public policies aimed at promoting peasant innovation and strengthening the national strategy for sustainable rural development.

Theoretical framework

The field of public policy evaluation has shifted from approaches focused on regulatory compliance and administrative control to perspectives oriented toward organizational learning, continuous improvement, and strengthening territorial development. This paper adopts an evaluation-for-development approach that integrates three core dimensions: 1) public relevance, 2) territoriality, and 3) policy improvement. Three analytical references are articulated within this framework: i) policy guidelines and cycle (design, implementation, monitoring, and evaluation); ii) evaluative models and criteria; and iii) the territorial and institutional dimension. Ortegón's (2008b) Guide to Public Policy Design and Management, developed within the framework of ILPES/ECLAC, is a seminal reference in Latin America, as it links state capacities, inter-institutional networks, incentives, and evaluation methods throughout the policy cycle (design, negotiation, implementation, monitoring, and evaluation), while emphasizing the importance of performance indicators and cost-benefit analysis in public decision-making.

This framework posits that the quality of a policy depends on its internal coherence—expressed in the theory of change, means-ends congruence, and implementation arrangements—and its external coherence, relative to its alignment with the territorial context, actors, and institutional capacities. Consequently, evaluation transcends the measurement of outcomes to become an explanatory process of how and why an intervention works (or not) in specific territories, and an indispensable feedback mechanism for policy design.

The notion of differentiated policy refers to designs that recognize the socioeconomic, environmental, and cultural heterogeneity of territories and adjust instruments, goals, and implementation paths based on these specificities. In rural Mexico, factors such as peasant pluriactivity, asset diversity (land, water, social capital), gender gaps, and climate variability require policy to be tailored to different contexts (semi-arid, irrigated, rainfed; with and without experience in protected agriculture) to maximize its relevance and effectiveness. In Sembrando Vida, this differentiation is reflected in components such as Agroforestry Systems (AFS), the Milpa Intercropped with Fruit Trees System (MIAF), community nurseries, bio factories, and Peasant Learning Centers (CAC). Within this framework, the compatibility of the protected fig with these components was evaluated, as well as with the inclusion and scalability criteria already defined by the program.

From the perspective of public policy design, the entry strategy involves defining the target population, pilot territories, initial instruments, governance arrangements, and critical assumptions of the theory of change. Ortegón (2005) emphasizes that this phase must explicitly articulate the cause-effect relationship, the coherence of ends and means, and the definition of incentives and institutional capacities necessary for implementation and monitoring, such as agency roles, coordination mechanisms, and learning models, which determine subsequent effectiveness. In some cases, evidence shows attempts to intensify fig cultivation where a lack of experience in technical management or marketing aspects has discouraged adoption and continued cultivation. Hence the importance of validating production processes through applied research before moving toward a scaling strategy.

Applied to this case, the entry strategy was conceived in four components: i) technological validation in small, scalable modules; ii) territorial selection based on agroclimatic criteria, social backwardness, and institutional presence (CAC, technicians, bio-factories); iii) technological and social transfer arrangements (training, nurseries, inputs, technical-social support); and iv) definition of a market strategy (short circuits and collective schemes) that makes economic sense for adoption. These guidelines derive from both the institutional analysis of Sembrando Vida and the documented evidence in the file of the compatibility of fig cultivation with the program.

The exit strategy establishes "graduation" conditions in three dimensions: a) technical efficiency, expressed in the consolidation of standardized management protocols and the achievement of consistent quality; b) economic efficiency, measured by a benefit-cost ratio greater than one, compliance with the break-even point, and access to marketing channels; and c) social and environmental sustainability, reflected in the use of bio-inputs, community organization through CACs, and the inclusion of women and youth in production processes. The technical evaluation report for the protected fig tree reports positive net margins on small areas and effective integration with nurseries and bio factories. These elements allow for a responsible transition from intensive support to a phase of light accompaniment and monitoring, a necessary condition to ensure both sustainability and territorial scalability.

OCDE-DAC and CIPP Criteria

The classic evaluation criteria—relevance, coherence, effectiveness, efficiency, impact, and sustainability—allow for an assessment of the extent to which the innovation package associated with fig cultivation under protected agriculture responds to territorial needs, is aligned with the Sembrando Vida Program, generates the expected results and changes with appropriate use of resources, and demonstrates long-term viability. Additionally, the CIPP (Context-Input-Process-Output) model offers an analytical framework that guides the assessment in four dimensions: Context (conditions of social backwardness and agroclimatic characteristics); Inputs (productive infrastructure such as nurseries, bio factories, and technicians); Process (technology transfer and collective learning in the CACs); Output (yield, production quality, and income generated).

Realist evaluation, based on the mechanisms-contexts-outcomes framework, provides an explanatory approach to what works, for whom, and under what conditions. For example, the combination of high planting density with plastic covers and the organizational expertise of a CAC can favor substantial increases in productivity and quality; while the presence of water limitations, accompanied by insufficient assistance, is associated with risks to productive performance. In turn, contribution analysis allows connecting the intervention (the protected fig module) with the observed outcomes, without requiring a perfect counterfactual, which is particularly useful in multi-component programs such as Sembrando Vida.

The territorial approach conceives development as an endogenous process, in which the coordination of local actors, knowledge, and resources generates added value and social cohesion. According to Ortegón (2005), governance—understood as the capacity for coordination, the existence of networks, and adequate incentives—along with the connection with science and technology, are fundamental conditions for transforming productive structures. This reinforces the importance of institutional capacities and social learning as pillars for sustaining innovations in rural areas.

This territorial assessment analyzed three dimensions: i) agroclimatic conditions; ii) social backwardness; and iii) the institutional presence of Sembrando Vida. Based on this, pilot municipalities were selected, and the innovation module (planting densities, water management, and training framework) was tailored to each context.

Effective technology transfer for fruit crops under protected agriculture requires the integration of four elements: a) modular technology packages compatible with peasant pluriactivity; b) social learning through CAC (Cooperation and Development Cooperation), field schools, and peer mentoring; c) endogenous provision of inputs, such as stake nurseries and local bio-inputs; and d) linkages to markets through short circuits or collective purchases. Evidence from the technical file indicates that greenhouse-grown figs achieve higher yields (≈76 t ha-1) and high levels of quality, which enables attractive incomes for small-scale modules, an essential condition for their adoption.

Compatibility of the protected fig with Sembrando Vida

The cultivation of fig (*Ficus carica* cv. Neza) under protected agriculture shows high compatibility with the program components:

SAF/MIAF: It is integrated as a perennial fruit tree that diversifies income, contributes to carbon capture, and can be harmonized with the milpa calendar through pruning and fertigation adjustments.

Nurseries and bio factories: propagation by cuttings and management with bio-inputs reduce costs and strengthen local technological sovereignty.

CAC and gender approach: The demand for skilled labor in pruning, sorting, and packing opens opportunities for women and young people, provided it is accompanied by gender-sensitive strategies and equitable marketing schemes.

Inclusion and scalability criteria: The modular design (e.g., 50 m^2) allows for starting with small units and expanding as demand grows and capacities strengthen, a critical aspect in territories with water and capital limitations.

Indicators and evaluative hypotheses

For the specific case of fig evaluation in protected agriculture, four types of indicators were considered:

Economic: yield ($kg \cdot m^{-2}$), quality (° Brix, firmness), production costs, benefit-cost ratio (B/C) and break-even point.

Social: participation of women and youth, training hours, CAC governance, marketing agreements.

Environmental: water consumption per kg produced, use of bio-inputs and soil health indicators.

Institutional: coverage of technicians, operation of nurseries and bio-factories, and coordination with the program's Operating Rules.

The central hypothesis holds that, in municipalities with favorable agroclimatic conditions, high social backwardness, and a strong institutional presence, the adoption of protected figs with the support of CACs generates significant improvements in productivity, income, and social organization. These results translate into B/C ratios > 1 and stable commercial quality, conditions that reinforce the viability of this crop as a distinct strategy for Sembrando Vida.

Methodology

This research was designed using a mixed-methodological approach, integrating the technical-experimental validation of fig (*Ficus carica* cv. Neza) cultivation under protected agriculture conditions with an economic, institutional, and territorial analysis aimed at assessing its compatibility and viability as a productive alternative within the Sembrando Vida program. This approach allowed, on the one hand, to examine the yield and quality of the crop in a controlled environment and, on the other, to analyze the feasibility of its adoption in rural communities, considering public policy arrangements and schemes.

Pilot module

A 50 m^2 pilot module was designed, consisting of 60 fig plants (*Ficus carica* cv. Neza), at the Chapingo Experimental Field, under multi-tunnel greenhouse conditions. The modular design responded to the principle of farmer adaptability, considering small areas that could be integrated into diversified production units without displacing staple crops intended for subsistence and dietary supplementation.

The experimental management was structured with a phased production schedule that included two annual cycles of approximately six months each, with the goal of ensuring income continuity. During each cycle, agronomic and quality variables were recorded, including:

Yield per plant and per surface ($kg \cdot m^{-2}$ and $t \cdot ha^{-1}$).

Fruit quality parameters, such as total soluble solids (° Brix), firmness, size and uniformity.

Plant health, measured through the incidence of pests and diseases, as well as the effectiveness of local bio-inputs in phytosanitary management.

The analysis of these parameters validated the hypothesis that fig cultivation under protected agriculture can achieve higher yields than those reported in rainfed systems, while maintaining quality standards compatible with the demands of the fresh fruit market.

Training and technology transfer

A 12-month support protocol was designed, aimed at the comprehensive transfer of knowledge and production practices to participating producers. This program included various training and organizational components, including:

Practical training in pruning, fertilization, and phytosanitary management using bio-inputs.

Specialized harvest and post-harvest workshops, focused on preserving fruit quality and reducing losses.

Community management and organization sessions, coordinated with the Peasant Learning Committees (CAC) as spaces for collective strengthening.

The methodological approach adopted was based on building local capacity, based on the principle that, at the end of the mentoring period, producers will have the necessary skills to independently manage their production module. This strategy responds to the technology transfer objectives set forth in the Sembrando Vida program by promoting social learning, self-management, and sustainability processes at the community level.

Financial analysis

A financial feasibility analysis of the pilot module was conducted to determine its economic viability under small-scale conditions. The study included three main components:

Initial investment, which included the installation of greenhouse infrastructure (metal structure, plastic cover, anti-aphid mesh), the drip irrigation system, as well as the acquisition of seedlings and propagation materials.

Production costs, including labor, acquisition and application of bio-inputs, infrastructure maintenance, and electricity consumption associated with the irrigation system.

Projected income, calculated from the marketable volume per production cycle, considering local and regional market prices.

The module's profitability was assessed using standard economic analysis indicators, such as the benefit-to-cost (B/C) ratio, net margin, and revenue per unit of surface area. A B/C value greater than 1.1 was established as a viability criterion, in line with recommendations for high-value, small-scale crops (FAO, 2021; Mendoza *et al*., 2017).

Institutional evaluation

A documentary analysis of the current guidelines and Operating Rules of the Sembrando Vida program (Secretaría del Bienestar, 2024) was carried out, with the purpose of identifying the degree of compatibility of the protected fig module with its strategic components:

Agroforestry Systems (SAF)

Milpa Intercropped with Fruit Trees (MIAF).

Community nurseries.

Bio-factories of organic inputs.

Peasant Learning Committees (CAC).

The profitability of the module was assessed using standard financial analysis indicators, such as the benefit-cost (B/C) ratio over a 15-year period, the Net Present Value (NPV), the Internal Rate of Return (IRR), and the payback period. A B/C value > 1 was established as a viability criterion, consistent with recommendations for high-value, small-scale crops (FAO, 2021; Mendoza *et al.*, 2017).

Territorial evaluation

Finally, a territorial assessment was conducted to identify priority areas for pilot implementation of fig cultivation under protected agriculture, applying an approach based on climate and social compatibility. To this end, three main sources of information were used:

CONEVAL (2023): index of social backwardness at the municipal level, used to prioritize territories with high levels of marginalization.

SIAP (2023): information on water availability, agricultural land use and complementary crops in the regions considered.

INIFAP Agroclimatic Atlas (2019): identification of semi-arid zones with potential for the establishment of fruit trees under protected agriculture conditions.

The territorial analysis made it possible to guide the incorporation of figs as a sustainable fruit alternative into the program's technical catalog, particularly in semi-arid and agricultural transition regions. In this process, potential municipalities for module validation were evaluated based on three key categories, defined based on public policy objectives and the production system's adoption potential: agroclimatic conditions, level of marginalization, and institutional presence. These categories are presented systematically in Table 1 to support the selection of pilot territories and ensure the relevance of the intervention.

Calculating the score of potential municipalities/states

The score calculation for determining the suitability of a municipality/state is first performed for each category, as shown in Table 2. As a final step in calculating suitability, the three categories are summed. This result should be placed within the range according to the interpretation scale, which will indicate the interpretation of the municipality/state's suitability.

Based on these categories, the impact was focused on those communities with the greatest need for innovative production alternatives. The categories were weighted using an institutional compatibility approach, which not only considers the agronomic suitability for cultivation, but also the existence of a favorable environment for

Table 1. Evaluation of potential municipalities for fig cultivation under protected agriculture.

Evaluated category	Variables considered	Evaluation criteria (score)	Maximum score
1. Agroclimatic conditions **(agro_cond)**	- Average annual solar radiation (kcal/cm²/año)	≥ 450…………………(10) 430–449………………(8) 410–429………………(7) 390–409………………(6) 370–389………………(5) 350–369………………(4) 330–349………………(3) 310–329………………(2) <310……………...…...(1)	10
	- Taverage annual temperature (16-36°C)	20–28 °C…………….(10) 18–19.9 o 28.1–30…..(8) 16–17.9 o 30.1–32…..(6) 14–15.9 o 32.1–34…..(4) <14 o >34…………….(1)	
	- Water availability (irrigation or treated wastewater: planting, 4 l/day 60 days; development, 6 l/day 30-45 days; fruit emission, setting and ripening 8 l/day per plant) the variation in moisture retention depends on the substrate.	- Abundant and reliable [legal well, irrigation and/or treated wastewater]………..…………… (10) Good [well or seasonal irrigation with management possibilities]...(8) Partial [seasonal source, limited catchments]………………………(6) Low [rain dependence]………….(3) Criticism [no viable sources]……(1)	
	- Previous experience in protected fruit growing	Multiple projects/greenhouses operating with trained technicians………………………(10) Specific experiences/producers with a track record……………..…(8) Recent initiatives in piloting……(6) No local experience……………..(2)	
2. Marginalization level **(marg_lev)**	- Social Backwardness Index (CONEVAL)	Very high - national top quartile......................................(10) High -2nd upper quartile………...(8) Medium high..……………………(6) Half…………...…………………....(4) Low/very low…..…………………(1)	10
	- Percentage of rural population	70% rural ………………………(10) 50–70% …………………………(8) 30–49% …………………………(6) 10–29% …………………………(4) <10% ……………………………(1)	
	- Lack of basic services (water, electricity, drainage)	60% lack………..………………(10) 40–59% …………………………(8) 20–39% …………………………(6) 5–19% ………………………….(4) <5% ……………………………..(1)	

Table 1. Continued.

Evaluated category	Variables considered	Evaluation criteria (score)	Maximum score
3. Institutional presence of Sembrando Vida (inst_pres)	- Number of active CACs	consolidated CAC with documented regular activities………….…….(10) Active CACs with regular activities….……………..…………(8) CAC in training…….….….…..…….(6) CAC planned, but not active……………………………...(3) Without CAC……………………..(1)	10
	- Presence of productive and social technicians	≥1 technician per 50–100 families [fam] with ongoing training…..………………………(10) 1 technician per 100–200 fam.....(8) 1 per 200–500 fam ……………...(6) <1 per 500 fam ………………..…(3) No technician…..…………………(1)	
	- Existence of community bio-factories	Bio-factory(ies) operating and supplying inputs…………………(10) Bio-factory(ies) in the implementation phase…………..(7) Plans for a bio-factory without operation………………………….(4) They do not exist…………...……(1)	
	- Experience with previous fruit crops	Several successful fruit projects [documented]……………………(10) Pilot projects with partial results……………………………..(8) Limited experiences…………….(5) No experience…………………...(1)	

Source: Selft-elaborated.

Table 2. Interpretation scale.

Score by category *	Escala de interpretación (Rango)	Aptitud
agro_cond = (A + B + C + D) / 4	25–30 puntos	Alta aptitud, alta prioridad para implementación piloto
marg_ lev = (A + B + C) / 3	18–24 puntos	Aptitud media, requiere fortalecimiento de capacidades antes de implementación
Inst_pres = (A + B + C + D) / 4	10–17 puntos	Aptitud baja, no recomendable en la fase inicial del proyecto
Municipality/State = cond_agro + marg_lev + inst_pres (search range)	<10 puntos	No apto, condiciones técnicas, sociales o institucionales insuficientes.

* Round the result to the nearest integer (min. 1, max. 10).

Source: Selft-elaborated.

cultivation from an agronomic perspective, in a social and institutional context capable of fostering its adoption, scalability, and sustainability. This analysis also allows for the identification of initial intervention areas where fig cultivation can be evaluated as a scalable fruit alternative, with technical support and territorial relevance.

By cross-referencing this information, four states were selected that contain municipalities with potential for community validation, considering their favorable agroclimatic conditions, the institutional presence of the Sembrando Vida program, and the organizational capacity of the communities.

Results

Productivity and fruit quality

The cultivation of fig (*Ficus carica* cv. Neza) under protected agriculture and high planting density (1.25 plants m^{-2}) reached an annual yield of up to 76 t ha^{-1}, far exceeding the national open-air averages (5–6 t ha^{-1}; SIAP, 2023).

Regarding fruit quality, the average soluble solids content was 17.2° Brix, firmness between 5.1 and 5.8 Newtons, and uniformity in color and size were recorded, meeting fresh market and export standards (Piga *et al*., 2008; Mendoza *et al*., 2017). These results confirm the technical and commercial viability of the system under agroecological management.

The proposed pilot modules (50 m², with a density of 1.5 plants m^{-2}) allow for estimated yields of 1,000 kg per year. This production level makes it possible to recover the initial investment and generate a surplus of $60,000.00 MXN, with an IRR of 19% and a B/C ratio > 1, which increases to 1.22 in 100 m² modules and to 1.85 in 500 m² modules. The 50 m² module can multiply producers' minimum income up to five times. Integration with community bio-factories and the use of local materials reduce costs and facilitate the model's replicability under collective marketing schemes, strengthening community networks and boosting local economies (Table 3).

Table 3. Financial profitability indicators.

Fig cultivation	VAN ($ M. N.)*	TIR (%)*	R (B/C) *	PR (Years)
50 m^2 module	60 026.38	19	1.12	7.8
** 100 m^2 module	133,504.77	20	1.22	7.4
**500 m^2 module	793,541.45	23	1.85	6.5

*Project planning horizon: 15 years, with a 12% update rate and a fig sales area of $30.00 MXN per kg1
**Scalable modules with suitable conditions and knowledge appropriation. Source: Prepared by the authors.

The consistency of quality and health across staggered cycles supports the adoption of protected fig as a scalable fruit alternative in rural communities. Overall, the results validate the hypothesis that protected agriculture offers an effective strategy for overcoming productivity and quality limitations associated with rainfed systems, ensuring income stability and socioeconomic relevance within the framework of the Sembrando Vida program.

Documentary analysis of compatibility with the program

In the documentary analysis of compatibility between the protected agriculture fig production model and the public policy guidelines established by the Sembrando Vida program (Secretaría del Bienestar, 2024), a systematic comparison was made between the program's regulatory criteria and the technical, social, and economic characteristics of the protected fig production system. The proposed model aligns with the program's strategic objectives and opportunities for adapting it to the Sembrando Vida production portfolio. The results of this comparison are presented in Table 4.

The findings obtained demonstrate a high degree of congruence between the proposed fig cultivation system under protected agriculture and the structural components of the Sembrando Vida program, considering four key aspects.

First, in terms of productive self-sufficiency, fig cultivation can complement the family food system through its fresh consumption and its processing into derivatives, such as jams and dried fruits, while generating marketable surpluses.

Secondly, regarding the strengthening of the CACs, the introduction of a novel crop, with a high demand for technical learning and possibilities for continuous improvement, which encourages collective work, horizontal transfer of knowledge and peasant experimentation, fundamental principles of the CACs (Sembrando Vida, 2024).

Third, regarding the production of bio-inputs and agroecology, the system adapts to the use of compost, leachates, mycorrhizae, and microorganisms produced in community bio-factories. Since the fig is a rural crop with potential for research and validation under these conditions, it contributes to reducing dependence on external inputs and strengthening local technological sovereignty (Toledo & Barrera-Bassols, 2015).

Finally, regarding family participation and inclusion, crop management is compatible with the participation of women and youth, since it does not require heavy machinery and adjusts to community schedules and rhythms, thus promoting greater productive equity (Secretaría del Bienestar, 2023).

Table 4. Compatibility of the protected fig model with the Sowing Life guidelines.

Public Policy Guidelines (Sembrando Vida)	Description in official documents	Compatibility of the protected fig model	Observations for scalability
Operating rules 2023–2024	They define participation criteria, productive components and obligations of the beneficiaries.	Meets eligibility criteria: family production, technical support, and collective work in CAC.	Requires formal validation in the program's technical catalog.
SAF (Agroforestry Systems)	Association of fruit/timber trees with annual crops for soil diversification and regeneration.	Integrating fig as a perennial fruit tree in SAF for diversification and carbon capture.	Establish integrated fig management in mixed systems to minimize competition for resources.
MIAF (Milpa Intercropped with Fruit Trees)	Agroecological design that combines corn, fruit trees and short-cycle crops.	Incorporating fig as a fruit tree in MIAF under limited irrigation, improving family income.	Adapt pruning and fertigation to the cornfield calendar.
Community nurseries	Produce plants for agroforestry systems managed by CACs.	Propagation of fig by cuttings in community nurseries and reduces the spread of disease.	Train community nursery workers in propagation and sanitary management of cuttings.
Biofactories	Community production of biofertilizers, biofungicides and microorganisms.	Using bio-inputs in bio-factories reduces agrochemicals and costs.	Prepare specific technical sheets for bio-inputs for application in fig cultivation.
Inclusion criteria	Prioritize communities with high and very high marginalization and beneficiaries in the CACs.	Implementable in municipalities with social backwardness and experience in protected agriculture.	Conduct territorial diagnosis for water availability and optimal climate.
Scalability	Replicate the model in territories with technical and social supervision.	Modular and scalable system: start at 50 m^2, grow according to demand.	Scalability conditioned by local inputs, markets and technical capabilities.
Environmental regeneration	Soil restoration, increased biodiversity, and carbon capture.	The evergreen fig promotes ground cover and can be integrated with pollinating plants and hedges.	Incorporate landscape design that combines production and conservation.
Common welfare	Increased income, community strengthening, and reduced inequalities.	Protected fig increases income and improves social cohesion in CACs.	Ensure equitable access to benefits and fair distribution of profits.
Social inclusion	Participation of women, youth and groups in vulnerable situations.	The fig promotes equal participation and leadership of women and youth.	Incorporate leadership, marketing, and product transformation workshops for participating groups.

Source: Selft-elaborated.

Institutional compatibility

The protected fig production model demonstrates a high degree of congruence with the operational guidelines and guiding principles of the Sembrando Vida program

(Secretaría del Bienestar, 2024). In terms of institutional alignment, its affiliation is reflected in various strategic components:

Food self-sufficiency: by complementing basic crops with high-value fruit crops that contribute to the diversification of family income.

Environmental regeneration: supported using bio-inputs from community bio-factories, the reduction of agrochemical use, and the efficient use of water.

Social inclusion: Since its design in small-scale modules facilitates the participation of rural women and youth in both production and marketing.

Common well-being: By integrating into collective work schemes through the CACs, it strengthens the processes of peasant organization and the generation of community learning.

Overall, the protected fig model not only meets technical and economic criteria but also aligns harmoniously with the institutional logic of Sembrando Vida. In this way, it expands the fruit-producing and innovative component of the program and offers a feasible path for scaling up in regions with high levels of marginalization.

Territorial compatibility

The territorial analysis identified priority areas for the validation and adoption of the protected fig model in four states: Morelos, Puebla, Hidalgo, and the State of Mexico. These states meet three strategic conditions that justify their selection:

Favorable agroclimatic vocation, characterized by high solar radiation, availability of water—including sources of treated wastewater—and semi-arid climates conducive to the cultivation of protected figs (INIFAP, 2019).

Significant social backwardness, with highly marginalized municipalities in which the introduction of this crop can serve as a strategic alternative within social inclusion programs (CONEVAL, 2023).

Institutional presence of Sembrando Vida, which is expressed in the coverage of productive technicians, CAC, bio-factories and community nurseries, which provides an institutional platform for the implementation of agricultural innovations.

Based on these criteria, municipalities with ideal agroclimatic conditions, high levels of marginalization, and the institutional presence of the Sembrando Vida program were delimited, which promotes the adoption of this system as a diversification strategy. These factors, together, enhance the adoption of the system as a fruit diversification strategy. For the delimitation, the following were considered: i) the social backwardness index criteria (CONEVAL, 2023), ii) agricultural vocation and agroclimatic potential (INIFAP Agroclimatic Atlas, 2019), and iii) the territorial coverage of the program in terms of CAC, production technicians, and bio-factories (Secretaría del Bienestar, 2024).

Based on the above, four priority regions were identified (Figure 1). In Morelos, the municipalities of Ayala, Jantetelco, and Tepalcingo are most suitable for productive

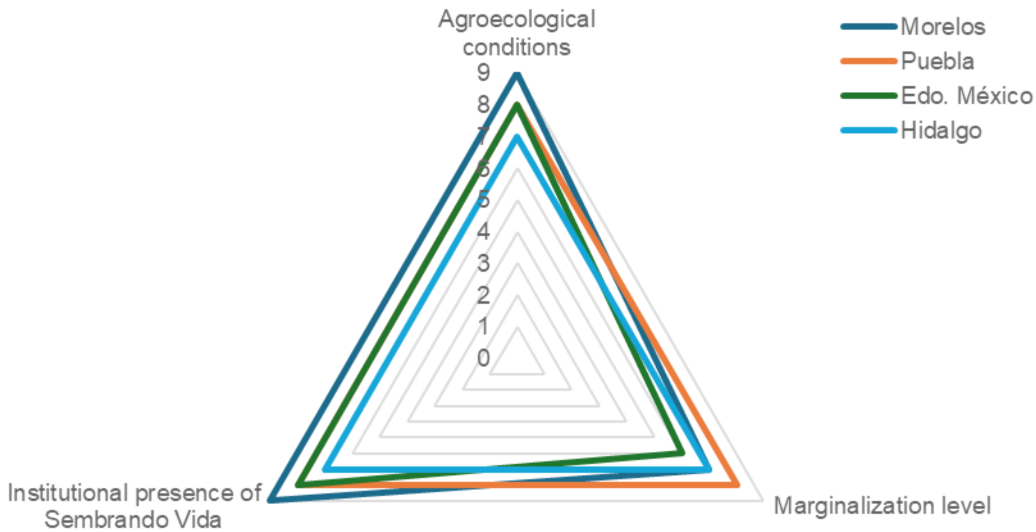

Figure 1. Evaluation of potential states for fig cultivation.

validation of the protected fig, supported by high solar radiation and the availability of treated wastewater (SIAP, 2023; CONEVAL, 2023). In Puebla, the municipalities of Chiautla, Huehuetlán El Grande, and Tehuacán stand out for their dry semi-arid climate, the active institutional presence of social programs, and a nascent fruit-growing vocation, which opens opportunities for the incorporation of productive innovations. In the rural south of the State of Mexico, the municipalities of Tenancingo, Malinalco, and Zumpahuacán are strategic due to their previous experience with protected agriculture and the organization of youth in agricultural activities. In the Mezquital Valley of the state of Hidalgo, the municipalities of Ixmiquilpan, Chilcuautla, and Cardonal constitute territories with a resilient agricultural culture, irrigation infrastructure, and articulated peasant organizations, which favor the incorporation of protected figs into socially inclusive agricultural schemes.

The diversity of identified conditions constitutes a key input for guiding the pilot phase of implementing the fig production system in territories where technical, social, and institutional factors converge to promote a positive and sustainable impact. Initial validation in these areas will generate solid empirical references to support its subsequent scaling to other regional contexts with similar characteristics.

Within this framework, the municipalities of Ayala and Tepalcingo in Morelos; Tehuacán and Huehuetlán El Grande (Puebla); Tenancingo and Zumpahuacán (State of Mexico); and Ixmiquilpan and Chilcuautla (Hidalgo) were recognized as highly suitable areas for establishing pilot modules for protected figs, given the convergence of technical, social, and institutional factors.

Discussion

Entry strategy: technical validation with a sense of development

The agronomic and economic findings of the fig (*Ficus carica* cv. Neza) under protected agriculture, characterized by high potential yields and exportable quality, justify an income for families through pilot modules and pre-defined targeting criteria. In this approach, validation is conceived as a "bridge" between the evidence generated under controlled conditions and its adoption in real-life small-scale contexts, articulating three strategic axes: i) proven technology, supported by high densities, microclimate management, and a controlled environment; ii) territories with enabling conditions, defined by their agroclimatic suitability, high social lag, and the institutional presence of the Sembrando Vida program; and iii) a pre-existing organizational structure (CAC, nurseries, bio-factories, and technical-social support), which reduces coordination costs and accelerates the learning curve.

The relevance of this strategy is documented in the institutional and territorial compatibility analysis, which demonstrated synergies with the SAF/MIAF systems, biofactories, and CACs, in addition to its consistency with the 2023–2024 operating rules and the principles of environmental regeneration and common well-being. In terms of public policy, the design is based on classic management criteria: inter-institutional coordination, reduction of information asymmetries, and provision of appropriate incentives throughout the design, implementation, and evaluation cycle. Latin American public management literature emphasizes that coordination failures and principal-agent problems increase implementation costs and erode effectiveness if not addressed with appropriate governance arrangements. Under this approach, territorial integration expands into existing organizational structures, which reduces these failures and increases the likelihood of adoption.

In operational terms, the validation process was designed to allow technical evidence (productivity, quality, health, costs) to interact with policy criteria (social inclusion, territorial relevance, and scalability). Hence, the municipal selection was based on agroclimatic conditions, levels of marginalization, and institutional presence, as well as the adoption of modules compatible with peasant logic (limited spaces, family labor, and progressive learning). The proven compatibility with Sembrando Vida grants an institutional license for a pilot with rapid replication capacity in areas with active CCS and operating bio factories.

Technology transfer

The agricultural innovation literature agrees that technological adoption is neither linear nor automatic, but rather depends on factors such as contextual suitability, installed capacity, trust, and support (Rogers, 2003; Hall, 2006; Rivera & Alex, 2004). Previous experiences with top-down diffusionist extension have shown low levels of appropriation, misalignment with local timelines and resources, and early abandonment of innovations (Chambers, 1983; Pretty, 1995). To avoid such limitations, transfer here was proposed under a systemic innovation and social learning approach, which articulates co-design of protocols, field demonstration practices, and peer learning in the CACs, integrating bio-inputs from bio-factories and propagation in community nurseries to reduce costs and strengthen local technological sovereignty.

A crucial point lies in the transfer agent. Implementation requires tacit knowledge—fine-grained decisions about pruning, fertigation, ventilation, harvesting, and post-harvest—which can only be effectively transmitted when the technology creators (research/validation teams) coordinate directly with program technicians. This approach reduces information asymmetries, aligns incentives, and shortens the adoption curve, in addition to being consistent with policy-cycle approaches and early-stage technical risk management.

Exit strategy: value addition and micro-batches

The exit strategy is not limited to the marketing of fresh fruit. Adding value at source (size selection, differentiated packaging, dehydration, artisanal confectionery, and jams) allows for higher margins, stabilizes revenue, and reduces exposure to price fluctuations. The intrinsic quality observed (°Brix > 17 and firmness > 5 N) facilitates differentiation processes and the construction of territorial narratives (origin, agroecological practices, traceability), which can be integrated into short marketing channels and, when feasible, into collaborative export schemes.

The micro-lot approach—production and packaging units clearly traceable by CAC, module, or family team—strengthens quality control, comparative learning, and the capture of consistency premiums. International experiences with differentiated products such as coffee show that this model strengthens reputation, enables repeat contracts, and maintains prices above the commodity level (Daviron & Ponte, 2005). In the case of protected figs, consistency in quality parameters represents the main asset for negotiating better commercial conditions, while the aggregation of volumes between CACs guarantees compliance with minimum delivery requirements without sacrificing traceability.

Contributions and challenges

The strategy integrates three pillars of the Sembrando Vida program:

Economical: higher productivity and quality, staggered revenues across two harvest windows, and positive margins in small modules; modularity and use of bio-inputs reduce costs and facilitate organic scaling.

Social: Coordination with CAC, horizontal learning, community savings, and associative processes; participation of women and youth in labor-intensive work, with an impact on empowerment and leadership.

Environmental: perennial management in SAF/MIAF, use of bio-inputs, reduction of agrochemicals, and water efficiency through drip irrigation, with less pressure on the soil.

However, critical challenges remain: i) water availability and management (local sources, reuse of treated water, capture and efficiency); ii) asset security (discrete modular designs, mutual insurance, community monitoring); iii) technical capacity (sequential training, skills certification, on-site mentoring); and iv) marketing (market intelligence, standards, framework contracts, and cold-storage logistics). Evidence indicates that these bottlenecks are mitigated with clear operating rules, institutional coordination, and educational evaluation schemes.

In short, an assessment such as this serves a dual purpose: (1) technical, by demonstrating the system's viability and risks in target contexts; and (2) political, by providing evidence for adjusting existing instruments (catalogs).

Conclusions

The analysis confirms that fig cultivation under protected agriculture represents a viable alternative for diversifying peasant production systems within the framework of the Sembrando Vida program. Experimental validation demonstrated higher yields and quality than open-air systems, along with a favorable benefit-cost ratio even at small scales. This provides evidence that high-value fruit trees can be introduced into marginalized territories as a differentiated production strategy, compatible with the logic of peasant pluriactivity.

The modular design and technology transfer strategy allow innovation to be adapted to heterogeneous contexts, avoiding uniform application and recognizing the agroecological, social, and institutional conditions of each region. This differentiated nature is essential for public policies to generate legitimate and sustainable impacts on the territories (Ortegón, 2005; OECD DAC, 2019).

Likewise, the importance of applied evaluation exercises that identify compatibility and areas for improvement between technological innovations and public programs is highlighted. Evaluation and monitoring not only serve a control function, but also constitute an institutional learning tool that guides investment, scaling, and transfer decisions toward more suitable beneficiaries.

This study shows that public investment in modular schemes can generate more widely distributed economic benefits, in contrast to models concentrated in large areas. The modular approach maximizes social inclusion, strengthens local economies, and contributes to environmental regeneration. The validation of greenhouse figs confirms the relevance of differentiated rural innovation policies: evidence-based entry strategies, technology transfer led by technology developers, and value-added exit strategies with community organization. Only under these principles is it possible to ensure that high-value protected agriculture consolidates itself as an engine of inclusive, sustainable, and territorially differentiated rural development.

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