

Traffic Light System Methodology (TLSM): a versatile methodology for the diagnosis, monitoring, and auditing of the agroecological transition of oil palm (*Elaeis guineensis* Jacq.) agroecosystems in Mexico

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Citation: Marroquín-Agreda, F. A., Pohlan-Hermann, A. J., Salazar-Centeno, Dennis, J., & Toledo-Toledo, E. (2025). Traffic Light System Methodology (TLSM): a versatile methodology for the diagnosis, monitoring, and auditing of the agroecological transition of oil palm (*Elaeis guineensis* Jacq.) agroecosystems in Mexico. *Agro Productividad*. <https://doi.org/10.32854/famxgt14>

Academic Editor: Jorge Cadena Iniguez

Associate Editor: Dra. Lucero del Mar Ruiz Posadas

Guest Editor: Daniel Alejandro Cadena Zamudio

Received: June 12, 2025.

Accepted: September 13, 2025.

Published on-line: September XX, 2025.

Agro Productividad, 18(9) supplement. September. 2025. pp: 3-12.

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ABSTRACT

Objective: To describe and identify the relationships of Good Agricultural Practices (GAP) and verify the versatility of the Traffic Light System Methodology (TLSM) for the diagnosis, monitoring, and auditing of 13 agroecological objectives, as well as its scales of application at different levels for the agroecological transition.

Design/methodology/approach: The process included the results of various field practices carried out during the First International Diploma in Agroecological Oil Palm Production. Document analysis and group discussions were conducted to identify the transition of agricultural and food systems and the development of agricultural resilience at three scales of application and four out of the five levels for the transition to sustainable food systems.

Results: The versatility of the TLSM in oil palm agroecosystems was confirmed for the diagnosis, monitoring, and auditing of the implementation of agroecological principles, across its three scales of application and at least four of the five levels of the agroecological transition.

Limitations of the study/implications: The application of the methodology in another agroecological palm system.

Findings/conclusions: The 13 pillars of GAP analyzed through the TLSM address 12 of the 13 agroecological principles necessary for the transition of agricultural and food systems to achieve global food and nutrition security and to develop agricultural resilience through climate change adaptation, along with their corresponding application scales and four of the five levels for the transition to sustainable food systems. The TLSM proves to be suitable for diagnosing, monitoring, and auditing the implementation of agroecological principles in oil palm agroecosystems.

Keywords: Good agricultural practices, agroecological principles, application scales, transition levels, oil palm.



INTRODUCTION

Agroecological approaches combined with various innovations have gained prominence in scientific, agricultural, and political discourse in recent years, suggesting pathways to transform agricultural and food systems that address environmental degradation and biodiversity loss. A profound transformation is thus needed to confront the challenges of persistent malnutrition and rural poverty, further exacerbated by the growing consequences of climate change (CSA 2025; GIZ 2023; Wezel *et al.*, 2020; HLPE, 2019). Pohlen *et al.* (2023) propose that Good Agricultural Practices (GAP) in oil palm (*Elaeis guineensis* Jacq.) agroecosystems should lead to an agroecological transition of these systems, based on strategic planning. These authors summarize that the Traffic Light System Methodology (TLSM) is a transparent and precise tool aimed at all actors in the oil palm production sector, whether smallholders, medium, or large producers. Its purpose is to diagnose, monitor, and audit the state of the art of GAP as a key component in agricultural enterprise management. This methodology comprises 13 pillars, which are described and analyzed in Chapter III of the Manual for Oil Palm Producers in Mexico (Marroquín *et al.*, 2023). A total of 13 principles were defined by Wezel *et al.* (2020), based on literature that views agroecology as a science, a set of practices, and a social movement (HLPE, 2019). These principles align well and are complementary to the 10 elements of agroecology developed by FAO (2018). The first seven principles correspond to the agroecosystem scale and the first three levels of the transition toward sustainable food systems proposed by Gliessman (2007), while principles 9 through 13 relate to the food system, with principle eight serving as the central axis. The dialectical interactions between the Sustainable Development Goals, the 2030 Agenda, planetary boundaries, and GAP outcomes in oil palm agroecosystems through the TLSM are analyzed in Marroquín *et al.* (2024) and Salazar *et al.* (2023). This qualitative research aims to describe and identify the relationships between the results of the 13 pillars of GAP analyzed through the TLSM during the First International Diploma in Agroecological Oil Palm Production in Soconusco, Chiapas, as presented in the Manual for Oil Palm Producers in Mexico, and the 13 agroecological principles for the transition of agricultural and food systems to achieve global food and nutrition security and to develop agricultural resilience through climate change adaptation, with their respective application scales and the five levels of transition toward sustainable food systems. Another objective is to confirm the versatility of the Traffic Light System Methodology for diagnosing, monitoring, or auditing the 13 agroecological objectives and their application scales across the different levels of the agroecological transition.

MATERIALS AND METHODS

This study complements the one published by Marroquín *et al.* (2024), which originated from the preparation of various classes and sessions during the “International Diploma in Agroecological Oil Palm Production in Soconusco, Chiapas, Mexico,” where the state of Chiapas, the history of agriculture in the Soconusco region, and the TLSM were described.

Methodological Approach, Scope, and Design

The methodological approach consisted of utilizing the results of various field practices conducted during the “First International Diploma in Agroecological Oil Palm Production,” which enabled a qualitative and participatory analysis of the 13 pillars of the TLSM and their relationship with the five levels for the transition to sustainable food systems and the 13 agroecological principles for the transformation of agricultural and food systems toward achieving global food and nutrition security and developing agricultural resilience through climate change adaptation.

The methodological perspective is qualitative and was based on document analysis and discussion groups. Four focus group discussions were held with the 42 producers who participated in the international course on agroecological oil palm management conducted at the Autonomous University of Chiapas. The scope of this qualitative methodological perspective is correlational, with a non-experimental design.

Pillars and Components of the Traffic Light System Methodology in Oil Palm Agroecosystems

The identification and utilization of the 13 pillars and their 55 components provide a scientific-practical analysis of the processes involved in the agroecological transition of oil palm agroecosystems (Table 1).

Table 1. Pillars of the TLSM in oil palm agroecosystems with their respective components (Marroquín *et al.*, 2023).

Pillar	Component
Pillar 1. History and organization of the agroecosystem by plot or lot	Lack of mapping or georeferencing
	Absence of soil analysis for heavy metals
	Climate and carbon footprint
	Topography or location
	Infrastructure
	Management of the stages of the oil palm production life cycle
Pillar 2. Origin of seeds and cultivars	Non-certified or non-elite seeds and/or plants
	Insufficient quality of pre-germinated seeds
	Bag size and substrate quality
	Cultivars
Pillar 3. Establishment of the nursery and quality of the seedlings	Presence of pests and diseases
	Pruning the root system
	Suitable plants for transplanting
	Well-nourished plants
	Irrigation and drainage for the pre-nursery and nursery
Pillar 4. Agroecological soil management	Slopes greater than 15 degrees
	Erosion exists
	Runoff prevention and good drainage
	Accumulation of organic matter (OM) and carbon within the soil

Table 1. Continues...

Pillar	Component
Pillar 5. Oil palm transplantation and crop establishment systems	Establish strip palm grove systems and combine them with intercropping strips
	Take advantage of different existing strata and their diversity
	Oil palm transplantation
Pillar 6. Management of oil palm systems and associated crops	Forest felling, monoculture, and ecological footprint
	The use of protective equipment is not guaranteed
	Management of systems with associated crops
Pillar 7. Weed management	Herbicides restricted by importing countries
	The use of protective equipment is not guaranteed
	Over-application rates
	Number of applications per year
Pillar 8. Nutrition or fertilization management	Inadequate storage conditions
	Use of dirty containers
	Relationship between fertilizer type and Need = Knowledge of the phenology of the oil palm
	Application rates
Pillar 9. Pest and disease management	Inadequate storage conditions
	Use of dirty containers
	Products not permitted by importing countries
	Lack of guaranteed use of protective equipment
	Over-application rates
Pillar 10. Irrigation, water footprint, drainage, associated crops and diversification	Irrigation with contaminated water
	Absence of strategies to reduce the water footprint
	Agroforestry systems
	Diversification of production and services in the short, medium, and long term
Pillar 11. Management of sanitation pruning and cleaning of oil palm	Lack of guaranteed use of protective equipment
	Sanitary and weed control in the oil palm
	Recycling of pruning waste
Pillar 12. Management of Harvest and Primary Transport of Fresh Fruit Bunches (FFB)	Inadequate means of transportation
	Inadequate tools and techniques for harvesting bunches
	Inadequate timing for transporting bunches to the field
	Organization and pace of harvesting bunches
Pillar 13. Social and Corporate Responsibility (SCR): social support, training and capacity building, agricultural and accounting records	Minors allowed to work
	Absence of agricultural and accounting records
	Poor food and housing quality
	Social security and safety are not guaranteed Labor
	Bonuses, Transportation, and Tours
Training and Training	

Description of the 13 agroecological principles for the transition of agricultural and food systems

The 13 agroecological principles proposed by Wezel *et al.* (2020), along with their scales of application, are summarized by plot (P), agroecosystem (A), and food system (FS). Details are presented in Table 2.

Description of the levels of agroecological transition

The following is a summary of the five levels for the transition toward sustainable food systems proposed by Gliessman (2007):

Table 2. Principles and scale of application of the 13 proposed agroecological principles (according to Wezel *et al.*, 2020).

Principle	Scale of application
1. Recycling: Preferably use locally renewable resources and close nutrient and biomass resource cycles as much as possible.	P and A
2. Input reduction: Reduce or eliminate dependence on purchased inputs and increase self-sufficiency.	A and FS
3. Soil health: Ensure and improve soil health and function to enhance plant growth, particularly through organic matter management and improving soil biological activity.	P
4. Animal health: Ensure animal health and well-being.	P and A
5. Biodiversity: Maintain and enhance species diversity, functional diversity, and genetic resources, and thus maintain the overall biodiversity of the agroecosystem over time and space at the field, farm, and landscape scales.	P and A
6. Synergy: Enhance positive ecological interactions, synergies, integration, and complementarity among agroecosystem elements (animals, crops, trees, soil, and water).	P and A
7. Economic diversification: Diversify agricultural incomes by ensuring farmers have greater financial independence and opportunities to add value, while enabling them to respond to consumer demand.	A and FS
8. Knowledge co-creation: Enhance co-creation and horizontal knowledge sharing, including local and scientific innovation, especially through farmer-to-farmer exchanges.	A and FS
9. Social values and diets: Build food systems based on the culture, identity, tradition, and social and gender equity of local communities that provide healthy, diversified, seasonally and culturally appropriate diets.	A and FS
10. Justice: Support decent and robust livelihoods for all actors involved in food systems, especially small-scale food producers, based on fair trade, fair employment, and fair treatment of intellectual property rights.	A and FS
11. Connectivity: Ensure proximity and trust between producers and consumers by promoting fair and short distribution networks and reintegrating food systems into local economies.	A
12. Land and natural resource governance: Strengthen institutional arrangements for improvements, including the recognition and support of family farmers, smallholder farmers, and peasant food producers as sustainable stewards of natural and genetic resources.	A and FS
13. Participation: Promote social organization and greater participation in decision-making by food producers and consumers to support decentralized governance and adaptive local management of agricultural and food systems.	FS

1. Increase input use efficiency to reduce the reliance on costly and environmentally harmful inputs.
2. Substitute conventional inputs and practices with agroecological alternatives.
3. Redesign: diversification through integrated plant and animal systems.
4. Re-establish a more direct relationship between food producers and consumers.
5. Build a new global food system based on equity, participation, and justice to enable the transformation of agroecosystem

Presentation and analysis of results

The results are presented in a matrix or double-entry table that associates or relates each TLSM pillar with the 13 agroecological objectives (D: Directly addressed, I: Indirectly addressed, : Not addressed), along with their corresponding scale of application (P: Plot, A: Agroecosystem, and FS: Food System at the family, local, and international levels) and the levels of agroecological transition (1, 2, 3, 4, and 5).

RESULTS AND DISCUSSION

The 13 Pillars for the Diagnosis, Monitoring, and Auditing of GAP in Oil Palm Agroecosystems through the TLSM (Table 3) address 12 of the 13 agroecological principles proposed by Wezel *et al.* (2020), representing 92.3% of these principles. Principle 12, related to “land and natural resource governance” (Tables 2 and 3), is the only agroecological principle not covered by the TLSM pillars in oil palm agroecosystems in Soconusco, Chiapas, Mexico, corresponding to 7.7%. Based on these results, it is essential that Pillar 13 (Social and Corporate Responsibility) of the TLSM (Table 1) includes an additional component to diagnose, monitor, and audit “the recognition and/or support of family farmers, smallholders, and peasant food producers as sustainable managers of natural and genetic resources,” which certifies the diagnosis, monitoring, and auditing of the social, corporate, and environmental responsibility of oil palm growers. With the inclusion of this component in Pillar 13 of the TLSM, all 13 agroecological principles proposed by Wezel *et al.* (2020) will be addressed, directly and/or indirectly, which are vital for the transition of agricultural and food systems, achieving global food and nutrition security, and developing agricultural resilience through climate change adaptation, as they are connected to the five levels for the transition to sustainable food systems proposed by Gliessman (2007). The TLSM pillars most strongly related or associated, directly and/or indirectly (Table 3), with the 13 agroecological principles are Pillar 1 (history and zoning of the agroecosystem by plot or lot), Pillar 10 (irrigation, water footprint, drainage, agroforestry systems, and diversification), Pillar 6 (management of oil palm systems and associated crops), Pillar 4 (agroecological soil management), Pillar 5 (transplant systems for oil palm and establishment of associated or intercropped crops), Pillar 7 (weed management), Pillar 8 (nutrient or fertilization management), and Pillar 11 (pruning management and sanitation of oil palm), which cover 7, 7, 6, 5, 5, 5, 5, and 5 agroecological principles respectively. These eight TLSM pillars represent 61.5% of the total, and collectively address, either directly or indirectly, 11 agroecological principles, which equates to 84.6% of the total (Table 3). From this, it can be inferred that these eight TLSM pillars contribute most significantly to the

diagnosis, monitoring, and auditing of the implementation of agroecological principles in the transition of oil palm agroecosystems in Soconusco, Chiapas, Mexico.

The pillars 2 (origin of seeds and cultivars), 9 (pest and disease management), and 13 (social and corporate responsibility) each include, directly and/or indirectly, four agroecological principles (Tables 1, 2, and 3), while Pillar 3 (nursery establishment and seedling quality) encompasses three agroecological principles (Figure 1). The only pillar that includes, indirectly, two agroecological principles is Pillar 12 (harvest management and primary transport of fresh fruit bunches).

The most represented agroecological principles, directly and/or indirectly, within the TLSM pillars are Principle 5 (biodiversity), Principle 6 (synergy), and Principle 3 (soil health), found in 11, 11, and 9 TLSM pillars respectively (Tables 1, 2, and 3). These three principles significantly enhance the resilience of agroecosystems (HLPE, 2019; Tittonell, 2019). Additionally, the findings confirm that soil health is closely linked to biodiversity and species synergies, which are manifested in various forms of symbiosis (mutualism, commensalism, parasitism) interactions between two or more biological species. This relationship fosters the rehabilitation and improvement of soil health and quality in oil palm agroecosystems, making it feasible to reduce inputs (Principle 2) and promote social values and diets (Principle 9) that support healthy food systems at family, local, and international levels. These two principles are addressed, directly or indirectly, in seven and eight TLSM pillars respectively (Tables 1, 2, and 3). Recycling (Principle 1) reusing local renewable resources and closing nutrient and biomass cycles as much as possible is addressed, directly

Table 3. Pillars of the Traffic Light System Methodology (TLSM), Agroecological Principles Proposed by Wezel *et al.* (2020), and the Five Levels for the Transition Toward Sustainable Food Systems Proposed by Gliessman (2007).

Pillars TLSM	Agroecological principles														D/T ratio	Scale of application	Level for agroecological transition
	1	2	3	4	5	6	7	8	9	10	11	12	13				
Pillar 1	-	-	I	-	I	I	-	D	I	D	D	-	-	3/7	A	1 and 4	
Pillar 2	-	I	-	-	D	I	-	-	I	-	-	-	-	1/4	P, A and FS	1 and 3	
Pillar 3	-	-	-	-	I	I	-	-	D	-	-	-	-	1/3	P and A	1	
Pillar 4	D	I	D	-	D	I	-	-	-	-	-	-	-	3/5	P and A	1	
Pillar 5	-	-	I	-	D	I	D	-	D	-	-	-	-	3/5	P, A and FS	1 and 3	
Pillar 6	I	I	I	-	D	I	I	-	-	-	-	-	-	1/6	P, A and FS	1 and 3	
Pillar 7	-	I	I	-	D	I	-	-	D	-	-	-	-	2/5	P, A and FS	1	
Pillar 8	-	I	I	-	D	I	-	-	D	-	-	-	-	2/5	P and A	1	
Pillar 9	-	-	I	-	D	I	-	-	D	-	-	-	-	2/4	P, A and FS	1	
Pillar 10	I	I	D	I	D	D	D	-	-	-	-	-	-	4/7	P, A and FS	1 and 3	
Pillar 11	D	I	D	-	I	I	-	-	-	-	-	-	-	2/5	P and A	-	
Pillar 12	-	-	-	-	-	-	-	-	-	-	I	-	I	0/2	FS	1	
Pillar 13	-	-	-	-	-	-	I	-	D	D	-	-	D	3/4	P, A and FS	1 and 5	
D/T ratio	2/4	0/7	3/9	0/1	7/11	1/11	2/4	1/1	6/8	2/2	1/2	0/0	1/2				

D: Directly addressed, I: Indirectly addressed, -: Not addressed, T: Total, P: plot or field; A: Agroecosystem, FS: Food system; levels of agroecological transition (1, 2, 3, 4, and 5).

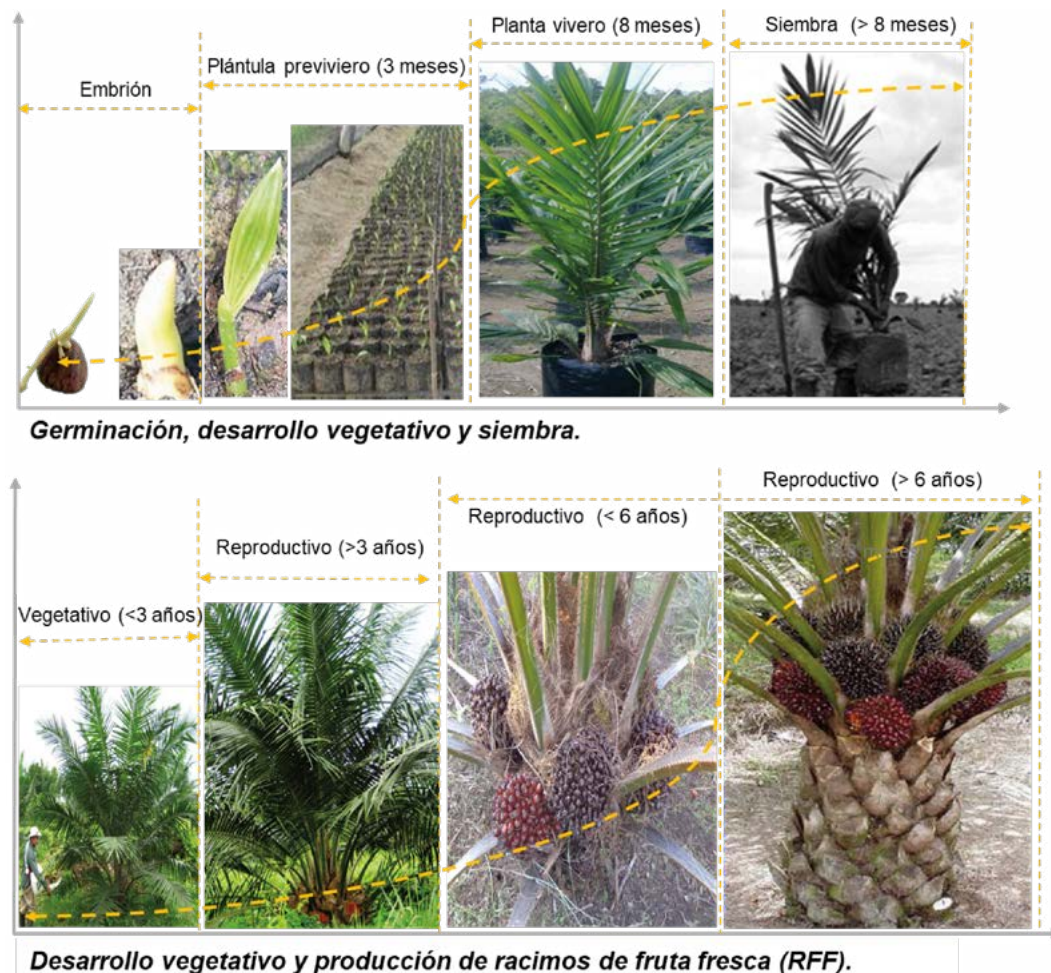


Figure 1. Stages of the vegetative and reproductive life cycle of oil palm plants (own elaboration).

or indirectly, in four TLSM pillars (Tables 1 and 3): Pillars 4, 6, 10, and 11. Similarly, Principle 7, linked to economic diversification to enable oil palm producers to respond to consumer demand, is addressed in Pillars 5, 6, 10, and 13. Animal health (Principle 4) is indirectly addressed in Pillar 10 (irrigation, water footprint, agroforestry systems, and diversification), particularly in systems integrating poultry and small livestock (oxen, buffalo, pigs, and sheep). Co-creation of knowledge (Principle 8) is directly addressed only in Pillar 1 (history and zoning of the agroecosystem by plot), which includes infrastructure components to ensure basic services and connectivity that enable active interaction across social networks, platforms, and information and communication technologies among producers, agricultural collaborators, and oil palm product consumers at local, national, and international levels. These results suggest that the primary levels of application of the 13 TLSM pillars are at the agroecosystem (A) and/or plot (P) scale, since the agroecological principle of justice, connectivity, and participation mainly refers to the food system (FS) level. Thus, the three scales of application of the 13 agroecological principles proposed by Wezel et al. (2020) are covered by the TLSM pillars (Table 3). 84.6% and 92.3% of the

TLSM pillars correspond to the plot (P) and agroecosystem (A) levels respectively (Table 3), reaffirming this inference. The food system (FS) level at local or international scales is diagnosed, monitored, and audited in 61.5% of TLSM pillars.

Four out of the five levels for agroecological transition proposed by Gliessman (2007) are included in the 13 TLSM pillars (Table 3). Notably, Level 1 (increase input efficiency to reduce reliance on costly and harmful inputs) is the most represented, with 92.3% of pillars addressing it (Table 3). Only Pillar 11 (management of pruning and sanitation in oil palm) does not address any transition level.

The only transition level not directly addressed by the 13 TLSM pillars is Level 2 (replace conventional inputs and practices with agroecological alternatives). However, oil palm farmers who produce their own biostimulants, organic fertilizers (solid and/or liquid), and plant-based products and incorporate them in agroecological soil management (Pillar 4), fertilization (Pillar 8), and pest and disease control (Pillar 9) fulfill Level 2 criteria.

Level 3 (Redesign) is represented in 30.7% of TLSM pillars: Pillar 2 (nursery establishment and seedling quality), Pillar 5 (transplant systems and establishment of associated/intercropped crops), Pillar 6 (oil palm and intercropped systems), and Pillar 10 (irrigation, water footprint, agroforestry systems, and diversification).

Levels 4 (reconnecting producers and consumers) and 5 (building a new global food system based on equity, participation, and justice) are included in Pillar 1 (history and zoning of the agroecosystem) and Pillar 13 (social and corporate responsibility), respectively.

The 13 TLSM pillars and their components reaffirm the proposal by Pohlen et al. (2023) that Good Agricultural Practices (GAP) in oil palm agroecosystems (*Elaeis guineensis* Jacq.) must lead to an agroecological transition rooted in strategic planning (mission, vision, objectives, principles, and actions), including:

- An economic plan covering labor, administrative activities, and risk management.
- An agro-environmental plan with practices, technologies, management methods, and scheduling to regenerate and improve the environment (recarbonization, restoration of soil health, internal and external biodiversity promotion, and nutrient cycles C, N, P, K).
- A compliance plan ensuring adherence to laws, human and labor rights, training activities, and risk management.

In summary, the application of the TLSM in oil palm agroecosystems additionally supports the diagnosis, monitoring, and auditing of the implementation of agroecological principles across all three application scales and addresses at least four of the five levels for agroecological transition, thereby confirming the versatility of this methodology.

CONCLUSIONS

The 13 pillars of GAP analyzed through the TLSM in oil palm agroecosystems in Soconusco, Chiapas, Mexico, address 12 of the 13 agroecological principles essential for the transition of agricultural and food systems toward achieving global food and nutrition security and developing agricultural resilience through climate change adaptation,

including their respective scales of application and four of the five levels for the transition to sustainable food systems. The versatility of the TLSM in oil palm agroecosystems was confirmed for the diagnosis, monitoring, and auditing of the implementation of agroecological principles, across its three application scales and within the five levels of agroecological transition for these agroecosystems.

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