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Public Policies for the Development of Agroecosystems Resilient to Climate Change

Mikery-Gutiérrez, Mildred J.[1]; Pérez-Vázquez, Arturo[1*]; Martínez-Dávila, Juan P.[1]; Ruiz-Rosado Octavio[1]; García-Albarado, J. Cruz[2]

[1]Colegio de Postgraduados, Veracruz Campus. Carretera Federal Xalapa-Veracruz km. 88.5, Tepetates, Manlio Fabio Altamirano, Veracruz, México. C. P. 91700. [2]Colegio de Postgraduados, Córdoba Campus. Carretera Córdoba-Veracruz km 348, Manuel León, Amatlán de los Reyes, Veracruz, Mexico. C. P. 94946.

***Corresponding author**: parturo@colpos.mx

ABSTRACT

Objective: To analyze public policies in Mexico to cope climate change in agriculture that allow a chieving the development of resilient agroecosystems.

Design/Methodology/Scope: The analysis of research on resilience to climate change in the agricultural and rural sectors, as well as the literature on public policies formulated to face climate change in the agricultural sector (2013-2019 period).

Results: There are multiple resilience sources for agroecosystems. Policies may be oriented toward the identification of such sources and strengthening capacities depending on different scales and contexts. There is a possibility of considering factors associated to the evolution of these systems in order to employ adequate strategies that allow the coordination between political levels.

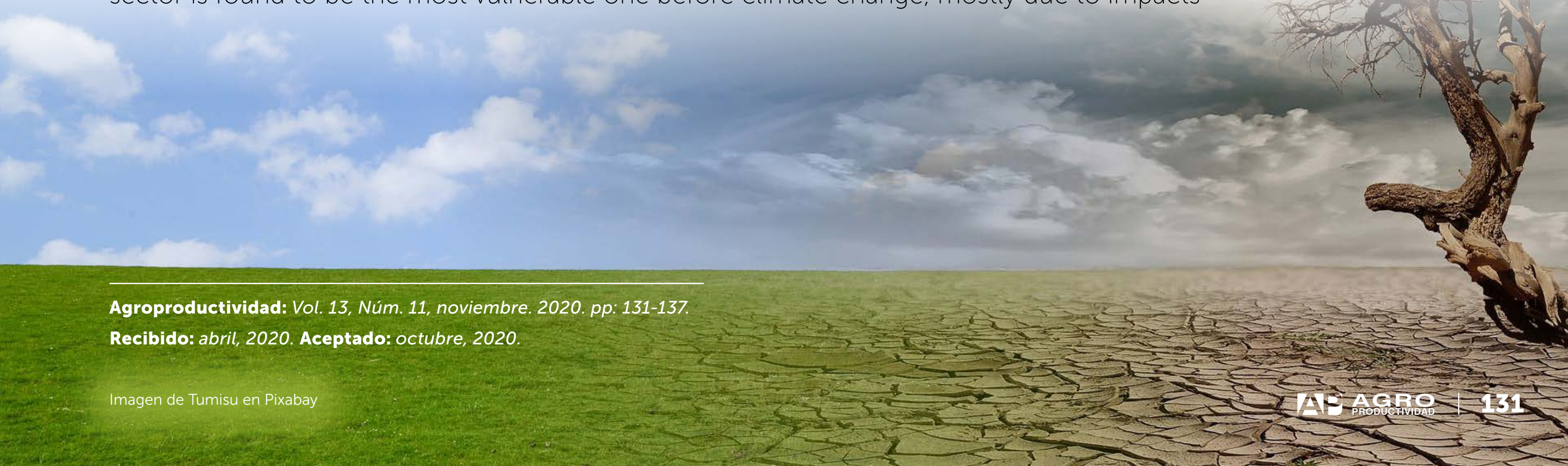
Study Limitations/Implications: This is theoretical essay limited to the analysis of literature published by 2019.

Findings/Conclusions: Public policies demand the integration of the perspective of the complex agricultural system dynamics and multiple resilience sources at different scales and contexts to articulate the development of agroecosystems resilient to climate change.

Keywords: political dynamics, rural development, agricultural system.

INTRODUCTION

Climate change is one of the most challenging issues facing humanity (Urry, 2015). Both scientists and policy-makers have debated at the IPCC (*Intergovernmental Panel on Climate Change*) about potential effects of climate change and what would be the mitigation and adaptation strategies before a complex scenario of impacts differentiated by vulnerability levels with regard to this phenomenon. The agri-food sector is found to be the most vulnerable one before climate change, mostly due to impacts



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in performance, prices of basic commodities and imports and exports (Lobell *et al.*, 2008). Therefore, a minimization in vulnerability of agroecosystems is sought upon increasing the capacity of adaptation in order to be resilient to the changing circumstances of contemporary life and, in particular, climate change (Altieri *et al.*, 2015). The study and development of resilience of agroecosystems has been proposed worldwide to face the effects of climate change in agriculture. This way, the resilience concept acquires relevance as an analysis focus of proposals that will face potential climate events (Folke, 2006; Anderies *et al.*, 2013); this may also be used as a tool for designing and managing agroecosystems (Altieri *et al.*, 2015). This would allow elucidating paths that would improve the response before stressing or unexpected events before the increasing complexity and interdependence of several critical networks of society. This way, resilience management goes beyond risk-management in order to address the complexities of big integrated systems and the uncertainty of future threats, especially those related to climate change (Linkov *et al.*, 2014). Therefore, the objective of this work was to analyze public policies in Mexico to cope climate change in agriculture that allow attaining the development of resilient agroecosystems.

MATERIALS AND METHODS

The literature published during the 2013-2019 period on research on resilience to climate change or natural disasters in the agricultural and rural sectors was reviewed together with that which referred to public policies formulated to face climate change in the agricultural sector, from the international and national context. The information gathered was systematized through the identification, classification and grouping of research that has proposed strategies for the development of resilience at a level of agri-food systems, agricultural systems, agroecosystems and rural communities. This was compared to national policies that may contribute on the attainment of such strategies in agroecosystems.

RESULTS AND DISCUSSION

Research on Climate Change Resilience of the Agricultural Sector

Several definitions were found for the concept of resilience, even for the same agricultural-rural study field. This indicates that there is no single resilience research framework, which shows the influence of dominant paradigms in accordance with the scientific communities that employ such concept. To this respect, two main theories were distinguished: ecology and social-ecological systems (SES) from which the definitions of resiliency most employed in the agricultural-rural sector emerge. From the ecology perspective, Holling (1973) defines resilience as "the persistence of relations within a system and it is a measure of capacity of these systems to absorb changes of variables of state, conduct, parameters and yet prevail." As for the agroecosystem domain, Cabell and Oelofse (2012) define it as "the capacity that a system has to self-organize and its ability to adapt to stress and change after a disturbance."

From the SES perspective, it is considered that ecosystems are attached to a society. This is why the proposed definition of social-ecological resilience is "the capacity that social-ecological systems have to absorb recurrent disturbances, in order to withhold structures, processes and essential feedback" (Adger, 2006). In this focus, a system analysis tends to incorporate specific values such as cultural diversity. From this theory, SES are defined as a framework of relations around resources necessary for human life, where social and environmental variables interact. Therefore, from this viewpoint, agriculture is understood to be a complex and adaptive system in which different cultural, political, social, economic, ecological and technological components interact (Resilience Alliance, 2007). This focus is not centered on system components, but rather on its relations, interactions and feedback. This is congruent with the complex adaptive system (CAS) theory it is supported on together with the more current focus to understand the contemporary agricultural dynamic from its complexity (Preiser *et al.*, 2018; Jagustović *et al.*, 2019). CAS characterizes systems composed by agents in interactions, described in terms of rules that are changed or adapted in the measure in which the system accumulates experience. Therefore, in agroecosystem resilience, the coherence and persistence thereof depends on multiple interactions between the parts, the addition of several elements, as well the capacity to adapt or learning (Holland, 2006). Due to the foregoing, from the CAS focus, agroecosystem resilience is defined as the capacity to recover the function after an event that generates stress, disturbance or collapse in the system. In this case, recovering a function refers to the system being capable of producing some type of food. The change that all living systems experience through time is assumed, reason why no returns to previous characteristics or structures are not modeled. The maintenance of the function, which may persist without the need of keeping past structures is modeled instead. And even under the assumption of behavior with high degree of complexity, non-linearity and non-predictability, these systems are not as predictable due to adaptive cycles that exist in their dynamics. The "adaptive cycle" metaphor has its origin in the ecological perspective posed by Holling (1996). This has been applied to SES and the study of the evolutionary nature of CAS through the panarchy concept. It explains the hierarchical structure in which SES follow never-ending adaptive cycles of growth, accumulation, re-structuring and renewal. The identification of these cycles and the scales thereof is useful for the strengthening of system resilience and its path toward sustainability (Holling, 2001). For Folke (2006), the SES study challenge resides in the understanding of their feedback related to the vulnerability in the system and those that strengthen resilience. The adaptive cycle model conceived by Holling (1986) is a powerful and useful metaphor of the system dynamics, which includes four stages: 1) Phase "r" of rapid exploitation and growth, 2) Phase "K" of preservation and steady state or balance, 3) Phase "Ω" of collapse and liberation, and 4) Phase "α" of system re-organization or re-structuring. This widens the traditional succession logistic curve (r→K), to explicitly include collapse and re-organization phases (Figure 1). Also, as the systems are in constant motion through adaptive cycles in numerous temporary and spatial scales, each conservation phase will also reach its end (Walker and Salt, 2006).

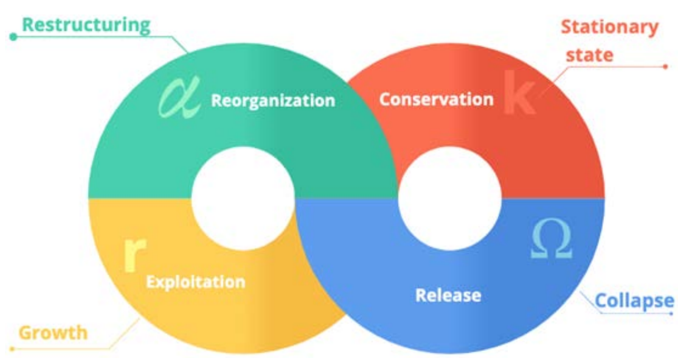

Figure 1. Illustrative scheme of adaptive cycle dynamic stages. Source: Self preparation of the version proposed by Holling (1986).

Strategies for the Development of Agroecosystems Resilient to Climate Change

Some coincidences were found in the recommendations or strategies for increasing resilience proposed in the analyzed research. Table 1 retakes the adaptive cycle model proposed by Holling (1996) and the possible strategies to be employed are distributed according to the state the agroecosystem passes by (Darnhofer *et al.*, 2010). It is important to consider the variability of vulnerability in strategies, both at a spatial level and through social groups. Vulnerability may be understood as the level of damage susceptibility by the exposure to stresses related to environmental and social changes and the lack of adaptation capacity (Adger, 2006). Each agroecosystem will have a unique level of resilience to climate change, which will depend on a series of factors; the most vulnerable will be those that are more exposed or sensitive to disturbances, with limited response capacity and a lesser recovery capacity (Bohle *et al.*, 1994).

At a spatial level, the biophysical vulnerability refers to physical conditions of landscape and how humans or biological diversity are affected which social vulnerability is defined according to the political, social, and economic conditions of society (Appendini and Liverman, 1994). Kelly & Adger (2000) break down social vulnerability into vulnerability of individuals or households, and collective vulnerability (national, regional or community), while Reilly and Schimmelpfennig (2000) differentiated

Table 1. Main strategies for increasing resilience of agroecosystems or rural communities for each stage the SES is in.

Stage	Strategy
Growth (r)	Utilize the advantages of successful activities that are well adapted to the current environment, compensate the stress through the transfer of more resources to successful activities (specialization) and utilize scale economies.
Balance-Development (k)	The stress or disturbance is absorbed without need for changes. The agroecosystem develops sufficient buffering capacity to cope the crisis.
Collapse-Adjustment (Ω)	The disturbance requires some adjustment at the level of production unit, such as new production methods or crops, introduction or suppression of activities, among others.
Reorganization-Transformation (α)	The disturbance requires the re-alignment of resources that diversify the traditional agricultural domain: agritourism, therapeutic agricultural practices, power production, among others.

between the vulnerability of the sector, regional economy and famine vulnerability. This shows the importance of considering analysis or impact scales and the context of public policy design. Generalizing strategies to reduce vulnerability or increase resilience in the agricultural sector is not possible, as this is characterized by a set of manifestations dictated by the rationality of the produce and social group he/she belongs to, in a given context, influenced by public policies and macroeconomic conditions. Nevertheless, it is possible to distinguish general lines for developing resilience at a social level, associated to a resilient human development, which will influence on better decision-making by the producer before unexpected o stressing events. This evidences the need to link adaptation principles to current and future challenges, at the level of policy and territorial governance (Folke *et al*., 2016). Economic re-structuring may also intensify the effects of climate change upon marginalizing production conditions. Also, in order to improve the understanding of the future of agriculture and associated sectors, the joint impacts of globalization and climate change, *i.e*. how the impacts of each process may exacerbate or compensate between themselves, as proposed with the double exposure concept (O'Brien & Leichenko, 2000).

Public Policies for the Resilience of Agroecosystems to Climate Change

The term resilience is present in the statements of organizations at a world level, associated to the economic development of societies, both in rural and urban regions (Simmie & Martin, 2010). Relevant coincidences were found among the policies dictated by the United Nations Organization (UN), the World Bank (WB) and the Food and Agriculture Organization (FAO) with those of the National Development Plan (PND) 2013-2018 (Presidency of the Republic, 2013), the 2019-2024 National Development Plan (Presidency of the Republic, 2019) and the General Law of Climate Change (DOF, 2012), associated to agreements and treaties subscribed for the mitigation of and adaptation to climate change. They refer to the need of climate change-resilient agriculture and populations. The UN, by means of the United Nations Development Program (UNDP, 2018) and FAO (2018), derive policies aimed at "generating and increasing resilience of rural communities and primary activities performed therein."

Sustainable development is another element related to resilience, present in policies at all levels; it gets relevance according to the construction assumed for resilience. In the rural domain, a more resilient agroecosystem will be that which has greater capacity to remain through time and contributes to its sustainability (Cabell and Oelofse, 2012). The 2013-2018 National Development Plan that allows generating greater certainty in the primary sector through risks management and climate prevention upon fostering the sustainable utilization of the nation's natural resources. This policy is more oriented to the acquisition of insurance for agricultural production than to the development of social-human and biophysical capacities to face the effects of climate change, as suggested by the research in resilience as key and basic elements for the improvement of decision-making, biophysical potential management and vulnerability before phenomena such as climate change. The enactment of the General Law of Climate Change in 2012, and 2018 review thereof, which sets forth the importance of generating climate change adaptation and vulnerability reduction measures, aspects associated to resilience both in populations and ecosystems, stands out in climate change matters. Nevertheless, the exclusion of most policies associated to resilience in the agricultural and rural sectors is observed in state plans. As an example, in the 2016-2018 Veracruz Development Plan (PVD), the policies that relate more to resilience are associated to the rural environment and the attention for indigenous peoples to improve their income and eradicate food poverty, which are only part of the series of factors that integrate agroecosystem resilience. Also, policies for improving income and eradicate food poverty for such plan are of assistentialist type, with the handing of groceries and financial support for vulnerable populations. This action is far from what Cabell & Oelofse (2012) have acknowledged with regards to resilience, climate change and territorial development. The former underline the importance of the development of response and self-management capacities by society, and the part of territorial governance as a key indicator for the increase in socio-ecological resilience (Folke *et al*., 2006). On the other hand, the 2019-2024 Veracruz Development Program refers to the Sustainable Development Goals (SDGs) proposed by the UN (2015), although it does not develop a systemic perspective to address problems and strategies for the agricultural sector or the environmental domain, as proposed by the UN. It omits the resilience subject, when the SDG sustainable city and community objective demands planning and management to attain inclusiveness, security, resilience and sustainability. Also, goal 1 of Objective 13 of SDG "Strengthening resilience and the capacity of adaptation to risks related to climate and natural disasters" was ignored. Nevertheless, the 2014-2018 Special Climate Change Program (PECC) does specify the objective of increasing the resilience of population and productive sectors, as well as increasing resilience to the effects of climate change (INECC, 2014). In this context, even though national policies address the resilience subject for the population and productive sector before the effects of climate change, this is not addressed in the Veracruz state. Also, there is an evident lack of institutional coordination at different political levels to develop public policy instruments that allow addressing resilience, not only as a need, but from a complex system thinking where processes such as resilience and sustainability are inter-related with human, social, cultural, environmental, climate, economic, technology and political domains. Relations between elements of these domains or subsystems are those that will determine the maintenance of agroecosystems. The development of this focus allows understanding agricultural practices and addressing them in terms of co-production; *i.e.*, the finding, interaction and co-evolution in course of social and natural processes, the spatial heterogeneity and temporary non-linear fluctuations; this is why the continuous contextualization of processes and their characteristics is required (Wilson, 2008).

IPCC (2012) and Cutter (2016) suggest not to generalize strategies for improving resilience, in view of the variability of the main resilience factors before disasters at different scales, sectors and contexts. For Cutter (2016), in urban areas resilience is boosted mostly by the economic capital, while the community capital is the main booster of resilience before disasters in rural areas. Also, physical and social impacts of climate change are not to be deemed to be homogeneous due to the spatial variability in components of resilience before disasters in rural areas (IPCC, 2012). Global circulation models project spatial differences in the magnitude and direction of climate change, and even within a region that experiences the same characteristics of climate change (INECC, 2016); it is more likely that impacts vary more in ecosystems, sectors or social groups more vulnerable to climate change (Ge *et al*., 2016). The mechanisms that underlie to resilience to climate change work and interact at different scale levels (Dhar & Khirfan, 2017) and impacts from one scale level to another (activity, agroecosystem, community, region, landscape, State), are to be considered and therefore the interactions and synergies between these levels will have a strategic importance (Renting *et al*. 2009).

Also, it is acknowledged that the type of policy will affect the options of farmers and it needs to understand the evolution of motivations of the involved actors and their ever changing social and political environment (Herzfeld & Jongeneel, 2012). Human beings are "stakeholders" or decision-makers in the change of land use. Janssen & Van Ittersum (2007) discuss several models of bioeconomic farms, the objective of which is to incorporate key factors in decision-making processes by farmers and increase the efficacy in the perception of risk. The differences in results or motivations of decision-making processes may be incorporated in public policies stratified by producer typology, scenarios or others, in accordance with differentiated levels of agronomic, economic, environmental efficiency, the relations between agroecosystem strategies and biodiversity or landscape patterns (Schmitzberger *et al*., 2005). Also, attention must be paid to the option of generating parallel markets for non-basic agricultural products (OECD, 2001; Huylenbroeck *et al*., 2007). Finally, performing a more integrated policy-territory-development analyses that allow the interaction of sciences that complement each other in order to improve our understanding and action on complex phenomena such as climate change resilience that allow overcoming the current political-administrative obstacles is suggested.

CONCLUSIONS

Several research works suggest the existence of multiple resilience sources for agroecosystems. Accordingly, public policies should be focused on identifying such sources and strengthening capacities at different scales and contexts, depending on such sources. Greater coordination between government agencies that allow articulating resilience policies between ministries and programs, as well as at the level of states and municipalities, is required. The variety of responses to climate change may be self-induced or the result of deliberate political processes, therefore, managed policies may be crucial in the resilience capacity. The design of resilience policies should be based on the understanding of the dynamics of complex adaptive systems for the nature of social-ecological dynamic processes.

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