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Determinant Indicators for Assessing the Adaptive Capacity of Agricultural Producers to Climate Change

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Abstract: Assessing adaptive capacity to climate change is a complex task since it is a multidimensional component. There has been considerable discrepancy between the dimensions or elements that compose it. This study aimed to analyze the relevant dimensions and indicators that allow estimation of the adaptive capacity to climate change and to propose a set of indicators that will enable their application to assessment at the level of agricultural producers. A systematic review of scientific literature on evaluating or measuring adaptive capacity to climate change was carried out. Subsequently, the indicators were analyzed and selected through a coincidence analysis and were calibrated through a multicriteria evaluation with relevant actors in the southern Mexico, state of Chiapas. In total, 329 indicators were identified and analyzed. As a result, 19 indicators were selected and then grouped into six dimensions: economic resources, human resources, infrastructure for production and marketing, institutionality, social capital, and natural resources. These represent the 14 specific dimensions with the greatest potential to contribute to the estimation of adaptive capacity to climate change. The dimensions and indicators can be applied to assess the adaptive capacity of farmers in Mexico at a national or regional scale and specifically by producer types.

Keywords: agricultural adaptation strategies; adaptive capacity indicators; adaptive capacity components; determinants of adaptive capacity; farmers' adaptation

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1. Introduction

The IPCC has confirmed a 1.1 °C increase in global average temperature, with climate change affecting all regions of the world in different ways [1–3]. Agricultural activity is at a crossroads; on the one hand, it has been identified as a driver of climate change [4,5] and, at the same time, it is the activity most affected by these changes. At the biological level, there is evidence of alterations in phenological processes, yields and crop quality; at the economic level, it leads to increased production costs and higher food prices; and at the social level, it exacerbates inequality, poverty, involuntary migration and food insecurity [1,3,6–15]. However, agriculture is the key to contributing to the achievement of the United Nations' Sustainable Development Goals, mainly in the eradication of hunger and food security for a growing world population projected to reach 9 to 10 billion by 2050 [4,16].

Adaptive capacity has gained relevance in the political and scientific agenda in the last two decades, as it is considered a necessary condition for achieving successful adaptation to climate change [17]. At the political level, it is a transcendent issue for the fulfillment of the Sustainable Development Goals; for each country, it is a relevant issue for the design of institutional frameworks of environmental policy and in the planning of nationally determined contributions.

At the scientific level, some research has theoretically explored the concept of adaptive capacity (AC) in relation to vulnerability and adaptation to climate change [18–20]; other authors have studied adaptive capacity in specific sectors, for example in urban and peri-urban areas [21,22], in rural communities [23,24], in the agricultural sector [25–27], and at the institutional level [28]. More recently, some studies have sought to determine the dimensions and elements that make it up [17,21,29–31].

Assessing adaptive capacity to climate change is complex as it is a multidimensional component. There has been considerable discrepancy between the dimensions and the elements that compose it; in this sense the estimation methods have evolved [32,33]. Techniques based on the evaluation of secondary data sources [18,34,35] or techniques based on inductive theory approaches [28] have been used. Most studies have proposed indicators and dimensions based on the sustainable livelihoods approach [24,28,29,31,36,37], which helps us to understand AC as a complex iterative process and allows the analysis of the complex socioecological processes occurring within AC, in addition to the complexities of human–environmental systems undergoing change [25,37,38]. Another advantage of this approach is that it is people-centered and allows the development of standardized measures of AC at the national level [36]. Some recent studies suggest that adaptive capacity should not only consider the availability of assets, but also the willingness and ability to convert resources into effective adaptive action [39,40]. However, no mechanisms to measure these factors have been presented.

Mexico is considered particularly vulnerable to climate change and is one of the priority regions for promoting adaptation to climate change. Improving adaptive capacity positively affects the resilience of a system and would contribute to reducing vulnerability to climate change [34]. According to the Nationally Determined Contributions (NDC) [41] and the Climate Change and Agri-food Production Agenda, it is a national priority to carry out a diagnosis of the climate change adaptation capacity of the agri-food sector [42], but how heterogeneous is this sector? At what level should this assessment be carried out? So far there are very few studies that have assessed adaptive capacity at a national, regional or local scale for Mexico [22,31,43,44], and the research that has been done has focused on adaptive capacity at the level of a municipality or for a specific region.

Estimating the capacity and potential of people to cope with and adapt to climate change is a major challenge, especially when it comes to people whose livelihoods are highly dependent on natural resources or who inhabit marginalized lands, as is the case of smallholder farmers in Mexico [3,45] (IPCC, 2018; Mexico-INECC, 2015). In this sense, it is of political and scientific interest to estimate the adaptive capacity of farmers, considering that there is a great diversity of producers, from those engaged in subsistence family farming to business producers involved in exporting products. In Mexico, at least nineteen types of agricultural producers have been identified and classified, based on their common characteristics and similar challenges in terms of coping with climate change (Supplementary Material S1). In this sense, the objective of this study was to assess and select the dimensions and indicators with the greatest potential for estimating the capacity to adapt to climate change at the scale of agricultural producers in Mexico.

2. Materials and Methods

A systematic review of the scientific literature on the assessment or measurement of adaptive capacity (AC) to climate change was carried out. Although it is not a new topic, there are relatively few publications on the subject and there is no standard method for measuring it. The available information on the measurement or assessment of adaptive capacity to climate change was analyzed based on the following questions: 1. What methods have been used to estimate adaptive capacity to climate change? 2. Considering that AC is multidimensional, what are the dimensions that should be considered in the assessment of AC to climate change? and 3. What are the indicators that contribute to the assessment of AC to climate change?

The scientific repositories Web of Science, Science Direct, Google Scholar, and some publishers such as MDPI, Nature, Springer and Elsevier were searched. The search period was limited to the last decade (2012–2021) and only scientific articles in English and Spanish were considered. The following keywords were considered in the search: "capacidad adaptativa al cambio climático/adaptive capacity to climate change", "evaluación de la capacidad adaptativa al cambio climático/assessment of adaptive capacity to climate change", "evaluación y capacidad adaptativa al cambio climático/assessment and adaptive capacity to climate change", "medición y capacidad adaptativa al cambio climático/measurement and adaptive capacity to climate change", "Capacidad adaptativa al cambio climático y México/adaptive capacity to climate change and Mexico". Only studies that assessed adaptive capacity based on the construction of indicators or indices were selected.

An Excel database was created to organize the information in a deductive manner: estimation method, dimensions and indicators used by the authors for the study of adaptive capacity. With this information a coincidence analysis was performed, based on the comparison of indicators and dimensions of each study and on the grouping of these by similarity (indicators that measure the same variable). From this analysis, the most frequently used dimensions and indicators were selected for the assessment of adaptive capacity to climate change.

The indicators were calibrated through interviews with 10 decision-makers or relevant actors in the agricultural sector of the Comiteca-Tojolabal Plateau region, Chiapas. Using the technical criteria for a comprehensive assessment of the indicators [46], it was determined at what level the indicators fulfilled each of these attributes: clarity, relevance and monitoring. Clarity implies that the name of the indicator is self-explanatory and there is no doubt as to what it seeks to measure. Relevance consists of verifying that the most important elements are related to some fundamental aspect of measuring adaptive capacity to climate change. Monitoring refers to the fact that the indicator has the possibility of being estimated in a given time and that its variables are measurable. To carry out this multi-criteria evaluation, the experts gave a score from 0 to 2 (where: 0 means "does not meet the criterion"; 1 means "moderately meets" and 2 means "fully meets the criterion"). Subsequently, the average score of the group of decision-makers was estimated and the weighted sum was calculated, assigning equal weight to each criterion. The following formula was used (1):

$$SP_i = \sum_{k=1}^{n} w_i \times v_{ik}, \quad (1)$$

where SP_i: Weighted sum of indicator i; w_i: Weight assigned to criterion i and v_{ik}: Performance value of indicator i in criterion k.

3. Results

Twenty original studies from the last decade (2012–2021) on dimensions and indicators of adaptive capacity to climate change were analyzed. The studies were conducted in regions or countries located in five continents: the Americas, Europe, Asia, Africa and Australia. In most of the studies, the selection of indicators was based on expert judgment or key actors, who rated them and then, with weighted sum or factor analysis, obtained the final score [24,26,29,47–50]. Other authors used qualitative methods, such as an analysis of the perception of agricultural producers as a case study [25,36,43,51] (Table 1 and more details can be seen in Supplementary Material S2).

Table 1. Summary of the most relevant information about the 20 studies analyzed (2012–2021).

Author	Method	Level/Sector	Synthesis
Juhola, S. and Kruse S., 2013	An aggregate index was designed from a set of variables and a weighted average was calculated at the dimension level. The Delphi method is used, and it is qualified using government data and statistics.	Pan-European assessment of adaptive capacity and an assessment of the adaptive capacity of the tourism sector in the European Alps	5 dimensions 15 indicators Source: Prepared by the authors based on Greiving et al., 2011
Defiesta and Rapera, 2014	Through a process of analytical hierarchy and expert judgment, the indicators were weighted.	Agricultural sector	5 dimensions 19 indicators Source: Prepared by the authors
Lam et al., 2014	A vulnerability index was designed by combining the different variables representing the three dimensions using an arbitrary weighting scheme. To validate the derived vulnerability index, a regression analysis was performed between the actual damage data (dependent variable) and the predictor variables representing the three dimensions of vulnerability. The weights were revised according to the resultant regression coefficients, and the vulnerability index was recalculated and compared.	Coastal hazards in the Caribbean Region	3 dimensions 6 indicators Source: Prepared by the authors based on Yusuf y Francisco, 2009; Brito y Arenas, 2009
Chen, 2014	Descriptive data analysis was performed for all indicators. Correlation analysis and cluster analysis were used to determine the relationships between the different components of the AC index.	China's adaptive capacity to climatic variability and climate-related disasters, both at a national level and in a regionally	5 dimensions 46 indicators Source: Prepared by the authors based on Graedel et al. (2012)
Ruiz Meza L. E., 2015	Participatory methodology: interviews and participatory research workshops were used.	Adaptive capacity of small-scale coffee farmers to climate change impacts (Chiapas, Mexico)	3 dimensions 18 indicators Source: Prepared by the authors based on Wehbe et al., 2005
Lockwood, 2015	They developed psychometric scales for these dimensions and tested their internal consistency (reliability) and validity (how well the measures define the construct) using factor analysis.	Agricultural landscape in Australia	4 dimensions 14 indicators Source: Prepared by the authors
Nhuan, 2016	They developed a survey based on the indicators approach to assess AC. Household survey data were processed using descriptive statistical methods, principal component analysis (PCA) and multiple linear regression analysis.	The adaptive capacity of urban households: The case of Da Nang city, Central Vietnam	6 dimensions 17 indicators Source: Prepared by the authors

Table 1. *Cont.*

Author	Method	Level/Sector	Synthesis
Araya-Muñoz et al., 2016	They created a general framework of indicators, standardized, and aggregated using fuzzy logic, and performed a sensitivity, uncertainty, and correlation analysis to assess robustness, using fuzzy overlay in ArcGIS 10.	Assessing urban adaptive capacity to climate change (Chile)	6 dimensions 17 indicators Source: Prepared by the authors based on Acosta et al., 2013
Abdul-Razak Majeed and Kruse Sylvia, 2017	Validation of determinants and indicators through interviews with experts. Ranking for each determinant and indicator was determined by the average of the ranking scores assigned to each one by all the experts.	Adaptive capacity to climate change of smallholder farmers (Northern Region of Ghana)	6 dimensions 22 indicators Source: Prepared by the authors based on 22 authors
Li Mengping et al., 2017	Pearson's correlation analysis to test the complementarity and substitution between indicators. Standardized regression coefficient and factor analysis to integrate complementary capital indicators, and a contribution rate of each factor was used to calculate the AC.	Adaptive capacity of apple farmers to drought events by impact of climate change (Loess Plateau, China).	6 dimensions 13 indicators Source: Prepared by the authors based on Bryan et al., 2015; Huai, 2016a; Sharp, 2003
Monterroso R. A. and Conde C., 2017	Standardization and normalization of the variables of each indicator. An AC index was estimated for each municipality and the final range of values was divided into five groups according to the geometric distribution of the frequencies of values.	Assesses the adaptive capacity of Mexican municipalities to address climate change	4 dimensions 19 indicators Source: Prepared by the authors
Holland, 2017	An AC index was created, the variables were selected through interviews with 109 experts and 3 indicator validation workshops were held.	Mapping adaptive capacity and smallholder agriculture (Central America)	5 dimensions 14 indicators Source: Prepared by the authors
Hoan N., 2019	Qualitative methods: it was based on rating motivation and abilities (MOTA). An AC index was designed based on farmers' motivation and abilities and semi-structured interviews were conducted to assess the perception, motivation and capacity of farmers.	Assessing the adaptive capacity of farmers under the impact of saltwater intrusion by effect to climate change (Vietnamese Mekong Delta)	3 dimensions 6 indicators 14 sub indicators Source: Prepared by the authors based on Fogg, 2009
Zanmassou Y. et al., 2020	Five groups of indicators were created based on the five capitals, the data were normalized and two weighting schemes were used to combine the indicators in a composite index: equal weighting and expert judgment. In order to analyze the consistency of the uncertainty, a Monte Carlo simulation was performed.	Assessment of smallholder farmers' adaptive Capacity to climate change (Benin, Africa)	6 dimensions 22 indicators Source: Prepared by the authors based on 11 authors

Table 1. *Cont.*

Author	Method	Level/Sector	Synthesis
Matewos T., 2020	Mixed research: qualitative and quantitative data were collected. Cross-sectional household surveys, key informant interviews and focus group discussions were used to collect relevant data.	Local adaptive capacity to climate change in drought prone (districts of rural Sidama, Ethiopia)	5 dimensions 14 indicators Source: Prepared by authors based on Ludi et al., 2011
W. Chepkoech, et al., 2020	They conducted an expert online rating survey (n = 35). The Kruskal-Wallis H test and a *t*-test were used to test the independence of AC scores and the access to existing resources.	Adaptive capacity of smallholder African indigenous vegetable farmers to climate change (Kenya)	5 dimensions 20 indicators Source: Prepared by authors based on Abdul-Razak and Kruse (2017), Defiesta and Rapera (2014), Eakin and Bojorquez Tapia (2008).
Abbas Khan N. et. al., 2020	Data were acquired through a farm-level survey, and the variables obtained were grouped into three clusters. Principal component analysis was applied as an exploratory analysis. The data were normalized and weights were assigned to each variable according to expert judgment and the AC Index was calculated.	Mapping rice farmers' adaptive capacity of Agricultura (rice farmers)	3 dimensions 11 indicators Source: Prepared by the authors based on Sendhil R. et al., 2018
Choden, 2020	Households selected through simple random sampling were surveyed on perception of changes in climate and on available capital assets. A factor analysis was performed using Varimax with Kaiser normalization rotation and a Principal Component Analysis (PCA).	Assessment of adaptive capacity to climate change at household and village-levels. (Nikachu, Bután)	6 dimensions 19 indicators Source: Prepared by the authors
Putri, 2020	Through interviews with key informants selected through purposive sampling and an AC index was created.	Community adaptive capacity (Semarang, Indonesia)	5 dimensions 7 indicators Source: Prepared by the authors
Parveen, 2022	A tree of decision criteria was built, the criteria were standardized on a 0–1 scale range and finally a climate change vulnerability assessment was conducted.	Climate change vulnerability assessment: a case study in the Indian	3 dimensions 10 indicators Source: Prepared by authors based on 10 authors

In total, 329 indicators grouped into nine different dimensions were identified: economic resources, human resources, infrastructure for production and marketing, institutionality, social capital, natural resources, basic services, housing infrastructure and flexibility. The studies propose from six to 22 indicators to measure adaptive capacity to climate change. This depends on the focus of the study, where the largest number is for agricultural producers. Fourteen specific dimensions were identified that may show greater relevance for estimating AC (Figure 1).

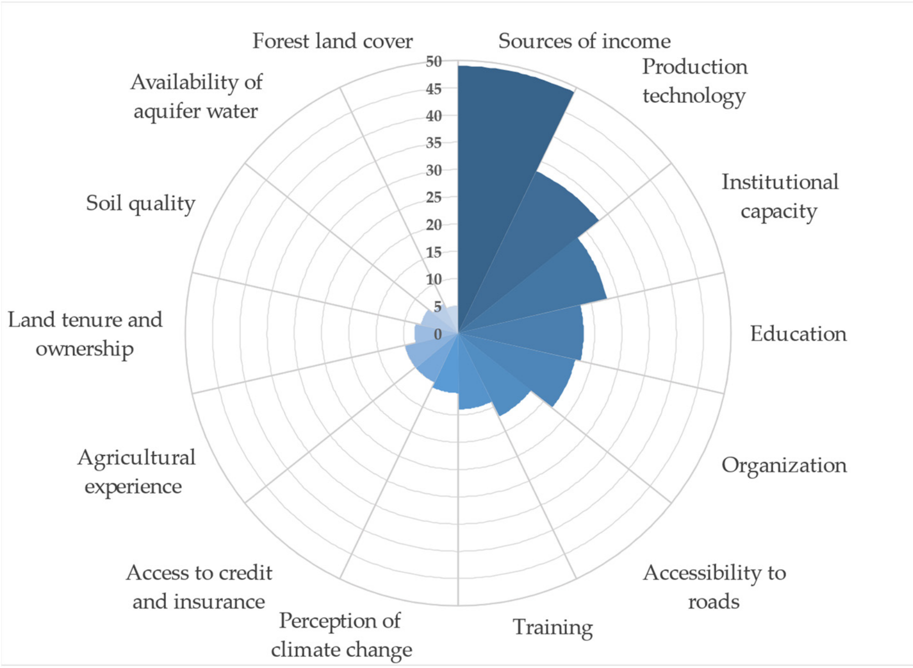

Figure 1. Specific dimensions identified from the coincidence analysis. Source: Based on the studies cited in Table 1.

As a result of the coincidence analysis (frequencies), 19 indicators were selected, calibrated and then grouped into six dimensions: economic resources, human resources, infrastructure for production and marketing, institutionality, social capital and natural resources. These represent the 14 specific dimensions with the greatest potential to contribute to the estimation of adaptive capacity to climate change (Figure 2).

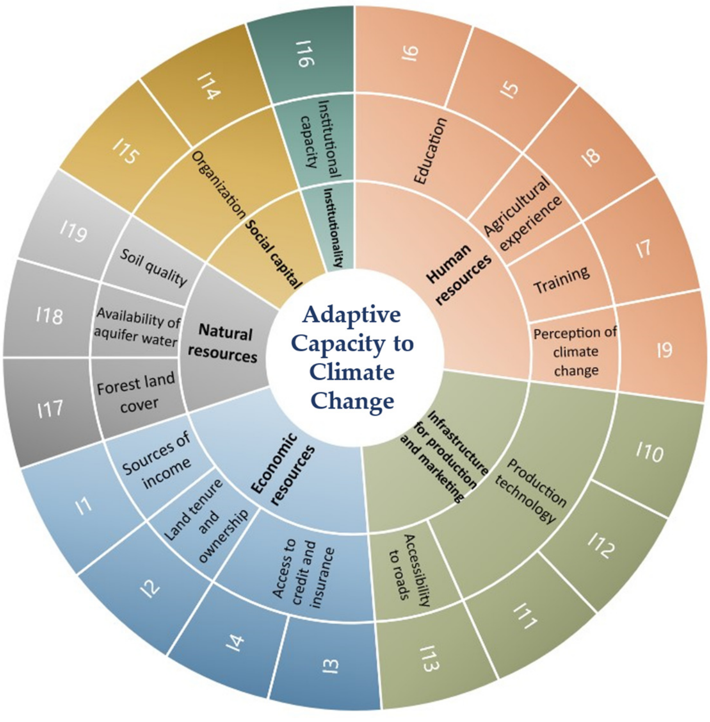

Figure 2. 6 Dimensions, 14 Specific dimensions and 19 Indicators, grouped together. Source: Prepared by the authors.

According to the calibration process, considering the three criteria evaluated, all indicators obtained a high weighted average (1.63–2.00). Ten of the 19 indicators fully met the criteria of clarity, relevance and monitoring (score = 2.00); five indicators obtained a score very close to full compliance with the criteria (1.87–1.97) and the remaining four obtained weighted scores between 1.63 and 1.83 (Table 2).

Table 2. Weighted values obtained for each indicator.

Indicator	Clarity	Relevance	Monitoring	Weighted Sum Value
I1. Percentage of farmers with various sources of income in the study region	2	2	2	2
I2. Percentage of farmers with ownership rights to their plot(s) in the study region (locality, municipality)	2	2	2	2
I3. Percentage of farmers with access to credit or financing in the study region	2	1.8	1.9	1.9
I4. Percentage of farmers who have agricultural insurance in the study region	2	1.6	1.9	1.83
I5. Percentage of farmers (head of household) who can read/write in the study region	2	2	2	2
I6. Proportion of farmer household members (aged 6 to 24 years) currently attending school	2	2	2	2
I7. Proportion of farmers who have received technical assistance or training in the last 5 years	2	2	2	2
I8. Number of years (average) of experience in agricultural production of farmers in the study region	2	2	2	2
I9. Percentage of farmers who have experienced changes due to climatic events (in their production unit or in the study area)	1.7	2	2	1.9
I10. Percentage of farmers in the region with irrigation technology for agricultural production	2	2	2	2
I11. Percentage of people in the region with machinery to carry out agricultural activities	2	1.9	2	1.97
I12. Proportion of farmers in the region that have information and communication technology for productive activities	2	1.9	2	1.97
I13. Degree of accessibility to paved roads in the region (locality/municipality)	2	2	2	2
I14. Farmers in the study region (locality, municipality) participating in a primary sector organization	2	2	2	2
I15. Farmers in the region (locality, municipality) who participate in a social or community organization	2	2	2	2
I16. Degree of institutional capacity of the municipality/state to cope with climate change	2	2	1.5	1.83
I17. Forest cover of the study region (locality/municipality)	2	1.9	1.7	1.87
I18. Availability of water per capita in the state	2	2	1	1.67
I19. Degree of soil quality in the study region	2	2	0.9	1.63

It should be noted that of the four indicators that obtained the lowest score, in three of them it was due to the difficulty of monitoring, and for this reason the weighted sum value is lower.

Based on the results of the calibration process, Table 3 shows the final list of proposed indicators (relevant information in Table S3).

Table 3. Proposed indicators for assessing adaptive capacity to climate change.

Dimension	Specific Dimension	Indicator
D1. Economic resources	**SD1.** Sources of income	**I1.** Percentage of farmers with various sources of income in the study region
	SD2. Land tenure and ownership	**I2.** Percentage of farmers with ownership rights to their plot(s) in the study region (locality, municipality)
	SD3. Access to credit/insurance	**I3.** Percentage of farmers with access to credit or financing in the study region
		I4. Percentage of farmers who have agricultural insurance in the study region
D2. Human resources	**SD4.** Education	**I5.** Percentage of farmers (head of household) who can read/write in the study region
		I6. Proportion of farmer household members (aged 6 to 24 years) currently attending school
	SD5. Training	**I7.** Proportion of farmers who have received technical assistance or training in the last 5 years
	SD6. Agricultural experience	**I8.** Number of years (average) of experience in agricultural production of farmers in the study region
	SD7. Perception of climate change	**I9.** Percentage of farmers who have experienced changes due to climatic events (in their production unit or in the study area)
D3. Infrastructure for production and marketing	**SD8.** Technology for production	**I10.** Percentage of farmers in the region with irrigation technology for agricultural production
		I11. Percentage of people in the region with machinery to carry out agricultural activities
		I12. Proportion of farmers in the region that have information and communication technology for productive activities
	SD9. Accessibility to roads	**I13.** Degree of accessibility to paved roads in the region (locality/municipality)
D4. Social capital	**SD10.** Organization	**I14.** Farmers in the study region (locality, municipality) participating in a primary sector organization
		I15. Producers in the region (locality, municipality) who participate in a social or community organization
D5. Institutionality	**SD11.** Institutional capacity	**I16.** Degree of institutional capacity of the municipality/state to cope with climate change
D6. Natural resources	**SD12.** Forest use	**I17.** Forest cover of the study region (locality/municipality)
	SD13. Water	**I18.** Availability of water per capita in the state
	SD14. Soil	**I19.** Degree of soil quality in the study region

4. Discussion

The results confirm that there is no standard method for assessing adaptive capacity. The scientific community has proposed several methods to approach a systemic assessment; however, they are heterogeneous, ranging from methods involving modeling or mapping with the use of geographic information systems to semi-structured interviews and ethnographic research [52]. The most common method focuses on the identification of determinants or dimensions, and the construction of indicators or composite indices, and although it has been criticized for a lack of spatio-temporal validity, it provides a broad spectrum to have a baseline and monitor the potential of people to cope with climate change and their adaptation strategies.

Despite the heterogeneity of methods, conditions and territories, some common determinants were identified that allow the estimation of adaptive capacity to climate change. The significance of the six dimensions and 19 indicators selected and validated is discussed below.

Economic resources. The economic factor of farmers is decisive for achieving adaptive capacity and is largely related to the diversification of income sources or livelihoods [50,53,54]. According to some studies, households that receive income from various sources have greater security to make decisions and face the challenges and impacts resulting from changes in climate and allow them to develop adaptation strategies [55]. In contrast, people with limited options for earning income have been shown to be more vulnerable [56]. In this regard, the literature suggests that smallholder farmers or subsistence-based ones who rely solely on primary activities are often people with very low adaptive capacity [1,25,50].

In the agricultural sector, land tenure plays an important role since it is the basis for planning primary activities; it allows producers to make decisions and long-term changes in the management of the production unit [57]. Land tenure favors the adaptive capacity of individuals, particularly of farm families [31]. This component is essential for obtaining some supports, financing, agricultural insurance or some type of subsidy. According to Holland [26], not having secure land tenure limits the capacity to adapt to climate change and social changes.

Human resources. The studies reviewed in this research share the position that education and capacity building of individuals or communities have a direct relationship with improved adaptive capacity [7,24,25,29,31,36,37,47,48,50,51,58–61]. The higher the level of education of household members, the greater the access to knowledge and information about environmental issues and the more heightened the perception of climate change impacts [25]. Formal education empowers rural communities and is an important aspect to consider when it comes to managing resilient agricultural production strategies [62]. Furthermore, education is an indispensable element to achieve innovation processes in the agricultural sector [63].

There is evidence that education is an essential factor and is related to several processes that can generate actions to improve adaptation to the impacts of climate change [54]; for example, for the definition of the agricultural calendar, for the development of markets, for crop diversification and rotation, for the fostering of effectively organized communities or groups of producers, and for the systematization of agricultural activities and the achievement of profitability in the production units [24,37,43,47,49,50]. Some studies have also shown that the cultural aspect is related to the conservation of natural resources and allows symbiosis between humans and the environment [64].

Human capital also considers traditional knowledge: the traditions, beliefs, and worldview of indigenous and rural communities, which are often part of climate change adaptation strategies [65]. The experience of the farmers is important and can favor the capacity to adapt to climate change, since it allows them to have a more comprehensive level of perception and can generate a knowledge wave at the local level. In addition, farming experience is one of the significant determinants in technology adoption [66] and farmers' perception of climate change and climate variability has a significant influence on the implementation of successful adaptation strategies [67].

Infrastructure for production and marketing. There is sufficient evidence to affirm that the availability of technology and infrastructure for carrying out primary activities is an advantage and contributes to having a high adaptive capacity, in addition to facilitating the adoption of technologies and new strategies for adapting to climate change [68]. Farmers with better infrastructure conditions tend to be less vulnerable and suffer less from the impacts of climate change. As part of the infrastructure in the agricultural sector, road accessibility is an essential element for the development of productive and commercial activities, with some studies showing that it influences the improvement of adaptive capacity.

Institutionality. The existence of formal and informal institutions in a region or community plays a relevant role [69], as they can positively or negatively influence the adaptive capacity of individuals and communities, and the success of adaptation processes; it really depends on the power relations and the level of interaction that exists between them [70]. Adaptive capacity has a broad relationship with multiple factors, including politics and institutionality [71]. It is essential that there is good governance to focus institutional efforts in a prioritized manner, oriented towards the most vulnerable groups of people or groups with greater production risks due to climate change (in the case of the agricultural sector) [72–74].

Social capital. Networks or organizations within a community contribute to improving adaptive capacity, strengthen ties in the face of a social or climatic emergency [47,50,55,56,75] and improve the willingness of farmers to generate climate change adaptation strategies or to seek government support [56]. Some studies have shown that farmers follow the actions of their neighbors and trust each other for information. When a farmer-to-farmer extension strategy is implemented, peer-to-peer knowledge replication is more likely [50,67].

Natural resources. This is the basis for building other capitals, sustains all forms of life and contributes to climate regulation [76,77]. The combination of fertile soils and adequate rainfall is essential for developing agricultural activities. The quality of these resources will depend on the production environment of each farmer: the higher the degree of soil quality, the better its adaptive capacity, and the adaptation actions to be implemented will involve fewer challenges compared to a farmer with degraded soil.

Forests are key resources for the supply, quality and amount of water in both developing and developed countries [78]. The availability of and access to natural resources, such as water and forest resources, increase people's capacity to respond to climate change and environmental variability [79]; however, there is evidence that ensuring the rational and diversified use of the landscape requires that people have other potentialities, such as formal and traditional knowledge, availability of economic resources and, of course, the perception of climate change and the will to act and make use of the skills and resources they have. According to Soares and Sandoval [80], any adaptation strategy must consider the effective, efficient and equitable use of natural resources, otherwise the effects of climate change may have a negative impact on people's livelihoods.

The results of this study showed low scores for the indicators related to natural resources; however, it is considered that the elements of this dimension are indispensable for measuring adaptive capacity and for the development of climate change adaptation strategies. These indicators are useful for the assessment of adaptive capacity to climate change; however, as recommended by Juhola and Kruse [48], it is necessary to adjust each indicator according to the objective of the AC measurement and the level at which the assessment is intended to be carried out.

5. Conclusions

This study has been able to identify the dimensions and aspects with the best potential for estimating adaptive capacity, derived from a coincidence analysis and a validation process. Nineteen indicators are proposed that allow empirical categorization of adaptive capacity to climate change. The results are useful for estimating adaptive capacity at the producer-type level or at the community (or specific region) level; however, the success of the estimation will depend on the information that is available at the level that needs to be measured. Measuring the capacity of people, especially farmers, to adapt to climate change allows us to identify the level of potential in the field to cope with the effects of climate change. This is an issue that should be addressed as soon as possible, in order to identify—among so much heterogeneity—which and where are the agricultural producers with the least capacity to adapt, and to propose strategies for adapting to climate change with the support of institutions. For Mexico, it would be important to estimate the adaptive capacity of each type of farmer—once the results of the 2022 agricultural census are available—and to carry out a strategic planning exercise that allows the prioritization and focus of the distribution of public resources on those producers with the least adaptive capacity to climate change.

Supplementary Materials: The following are available online at https://www.mdpi.com/xxx/s1. Table S1: Agricultural producers type identified by the authors; Table S2: Synthesis of the studies selected and analyzed for assessing the capacity to adapt to climate change; Table S3: Definition of terms used in the article.

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