

## Article

# Contributions to Sustainable Development in Coastal Communities of the Gulf of Mexico While Assessing Climate Change: A Case Study

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**Abstract:** The sustainable development of the coastal watersheds can contribute to facing climate change. This research aimed to identify the climate change adaptation measures contributing to the sustainable development: environmental, social, and economic, applied to a local project that promoted an integrated environmental management of coastal watersheds, “The Coastal Watershed Conservation Project in the Context of Climate Change (C6)”. The study used a quantitative evaluation framework and analysis of variance that considered the Sustainable Development Goals (SDGs) of the Agenda 2030. The data was collected from project reports and key actors of the 29 interventions executed by 24 local civil society organizations in the Mexican Tabasco and Veracruz communities in the coastal Gulf of Mexico. The results indicate that the adaptation actions implemented through the C6 project contributed to sustainable development with the highest contribution in the social aspect (41%), followed by environmental (27%), economic (16%), peace (10%), and partnership (7%). Therefore, it can be concluded that local civil society organizations created strategies according to the local needs to face climate change and, at the same time, to improve sustainable development in their communities.



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**Keywords:** SDG evaluation framework; climate change adaptation; Mexico; coastal communities

## 1. Introduction

### 1.1. Reference Framework

Climate change makes maintaining healthy ecosystems and socioeconomic structures challenging due to the collateral effects this phenomenon is causing, such as increased global temperatures, changing precipitation patterns, rising sea levels, and intensifying natural hazards. Therefore, adaptation to climate change requires considering any system's vulnerability (whether economic, social, or environmental) [1]. That is why the appropriate framework to approach climate change should be through sustainable development [2–5]. In this regard, the United Nations Development Program (UNDP) on Sustainable Development 2030 Agenda centers not only on the concept of sustainability but also on the struggle against climate change and the need to act, considering the mutual impact of both concepts [4,6]. In this sense, the vulnerability of the ecosystems needs to be assessed considering its related components, such as exposure, sensitivity, and lack of feedback and adaptation.

*Exposure* refers to the type and degree to which a system can be affected by significant climate variations, like tropical storms, floods, or landslides [7]. *Sensitivity* is the degree to which one system may be affected, positively or negatively, due to variability or climate change. *Adaptability and responsiveness capacity* is a system's capacity to resist or respond successfully to climate change. Therefore, the vulnerability of a system occurs when it has high exposure, high sensitivity, and low capacity to adapt to changes. For this reason, the system should reduce its exposure and sensitivity or increase its adaptive capacities to mitigate its vulnerability [8–13].

Considering the previous definitions, we can state that the adaptation to climate change is the adjustment of the ecological, social, or economic systems to respond to the effects of climate variability, that is to say, the adjustment process to the actual or projected climate and its impacts to moderate the damages or take advantage of the beneficial opportunities of climate change [14]. Adaptation involves implementing changes, practices, or structures to reduce climate-related risks. Interventions or actions can perform these adaptations to reduce the vulnerability to climate change and improve the capacity of communities to adapt to it.

Adaptation to climate change also implies carrying out actions that guarantee the security of the population, its belongings, the ecosystems, and environmental services based on observed or projected climate change impacts. These necessities and adaptation options may be divided into four categories: (i) physical, structural, and environmental needs: solutions based on nature (adaptation and risk disaster reduction based on ecosystems); technological and service options; (ii) social needs: educational, informative, behavioral, and community-based adaptations; (iii) institutional needs related to economic subjects, laws, political regulations, government programs, and governance; and (iv) needs for information, training, and resources [15].

## 1.2. Climate Change in the Context of Mexico and the States of Veracruz and Tabasco

According to the Mexican government, the climate change scenarios for the Gulf of Mexico towards the end of the 20th century show that the temperature will change by +3° Celsius (°C), and precipitation will diminish by less than 10% [16]. Besides, due to its geographical location, the country has been continuously affected by hydrometeorological phenomena that have caused continuous natural and socioeconomic disasters [17]. This situation places the country under constant challenges to maintain its natural and socioeconomic resources. In this sense, studies like the one from Buenfil Friedman [16] observed that the coastal zone of the Gulf of Mexico is highly vulnerable to climate change, which will have repercussions on its natural and economic resources.

Some of the territories most affected by climatic conditions are the states of Veracruz and Tabasco. Veracruz is the State with the most disaster declarations in Mexico, with 375 harmful events caused by hydrometeorological phenomena from 2002 to 2023. Following Veracruz, the State of Tabasco occupies second place in the number of disaster declarations by floods, with 30 [18], and it had the most significant economic impact of excessive rainfall from 2000 to 2012 [19]. Besides, Veracruz and Tabasco have had the highest risk indexes due to floods associated with hurricanes or intense rains [16].

The climate variations in Veracruz from 1980 to 2018 indicate that average temperatures had risen between 3 and 6 °C in some sites of the center region of the State [20]. In general, the climate scenarios for this State indicate an increase of mean temperatures between 0.6 and 1 °C in 2030 and 1.2 to 1.8 °C (2050). Regarding precipitation, a diminishing of 11% is forecast for the month with less rain. These conditions might increase the magnitude of the impacts of natural disasters [17].

In the case of Tabasco, at the state level, the average annual temperature increased by 0.9 °C between 1961 and 2010, with fluctuations of −0.6 to 2.5 °C between state regions.

Also, for the same period, there was an increase in the anomaly of the average annual total precipitation of 0.5%, with fluctuations in the regions of  $-12.1\%$  to  $10.2\%$  [21].

### 1.3. Problematic and Justification

In this context, Mexico has promoted actions in different states of the Mexican Republic to reduce the impact of climate change, such as a national plan to integrate the management of watersheds [22]. In this regard, there was a project financed by the World Bank to promote the integrated environmental management of selected coastal basins to conserve biodiversity, contribute to climate change mitigation, and improve sustainable land use. This project was named “Conservation of Coastal Basins in the Context of Climate Change (C6)”. Its execution was implemented through local civil society organizations that promoted actions to face the effects of climate change in their territories and to increase the communities’ capacity to adapt to climate change [23]. The C6 project was executed in the Veracruz and Tabasco Mexican states between 2015 and 2018. Still, there are questions about its impacts on key aspects like:

- How did climate change adaptation actions contribute to local sustainable development?
- Which aspects of sustainable development were most affected?
- Can sustainable development and climate adaptation be evaluated using specific regional indicators?

However, very few studies have been published on these types of studies in the country. According to the research platform Dimensions [24], a search using the keywords “evaluation framework” and “coastal communities” revealed that 2094 documents were found by May 2025. From these documents, only six belong to Mexican researchers or researchers working for a Mexican institution, indicating a lack of research in these areas for the country.

This research used the C6 project as a case study to answer the above questions. Therefore, this work examines the relationship between climate adaptation measures under Mexico’s C6 project and sustainable development in the Gulf of Mexico’s coastal areas. The goal is to identify how these measures impact environmental, social, and economic sustainability and provide a foundation for future project evaluations from territorial and regional focuses (through hydrological basins).

## 2. Materials and Methods

### 2.1. Theoretical Methodological Framework

This research considers interventions for climate change adaptations executed by civil society organizations working with local inhabitants. The actions considered non-formal education about climate change, training on eco-technology management, and sustainable production practices [25].

To evaluate the support for sustainable development, starting from the application of adaptation interventions to climate change, we considered the international policy established in the Sustainable Development Goals (SDGs) 2030 Agenda, which is a set of strategies to improve health and education, reduce inequality, and incentive economic growth while tackling climate change and working to preserve our oceans and forests [26].

Therefore, this analysis aimed to identify the relationship between the climate change adaptation actions performed by civil society organizations and their contribution to the SDGs and build a methodology that might visualize the interaction between sustainable development and climate change.

Accordingly, we take into consideration that sustainable evaluation may be achieved through three mechanisms: (1) through a list of sustainability indicators, (2) through evaluation methodologies based on sustainable indices, which include several indicators, and (3) through flexible evaluation frameworks [27].

## 2.2. Indicators for the Evaluation of Sustainable Development

The indicators and indices are used to evaluate achievements, objectives, and impacts, and, in the case of sustainability, they focus on three dimensions: environmental, economic, and social. They are tools that bring objectivity to measuring and understanding sustainable development. Therefore, they need to be multi-disciplinary, based on socio-cultural assessments, and adapted to the context of their application [28].

## 2.3. Evaluation Frames of Sustainable Development and Adaptation to Climate Change

According to Galvan Miyoshi, Masera, and Lopez Ridaura [29], the evaluation frames for sustainable development may be directed to objectives or be systematic. Those oriented to objectives consider systems' general aspects such as conservation of resources and biodiversity performance, economic viability, efficiency, and intergenerational security, among others. These systemic frames focus more on functions and dependence on the different aspects of sustainability. This research used a framework oriented to objectives, specifically through the 17 SDGs.

## 2.4. Conservation Project of the Coastal Basins in the Context of Climate Change (C6)

The C6 project was conceived to promote the coastal basins' role in mitigating climate change by promoting sustainability in the watersheds [23] (Figure 1). The implemented actions were focused on preserving biodiversity and improving soil conservation. The direct beneficiaries were the local coastal basin communities and the social civil organizations that worked with them, rendering technical assistance, training, and financial support. The C6 project was executed in the states of Veracruz and Tabasco, both located in the Gulf of Mexico, with a territorial approach in six hydrological basins: (1) Tuxpan, (2) Antigua, (3) Jamapa, (4) Huazuntlan, (5) Temoloapa, and (6) Usumacinta [22,30,31]. The number of total beneficiaries was 4483 inhabitants.

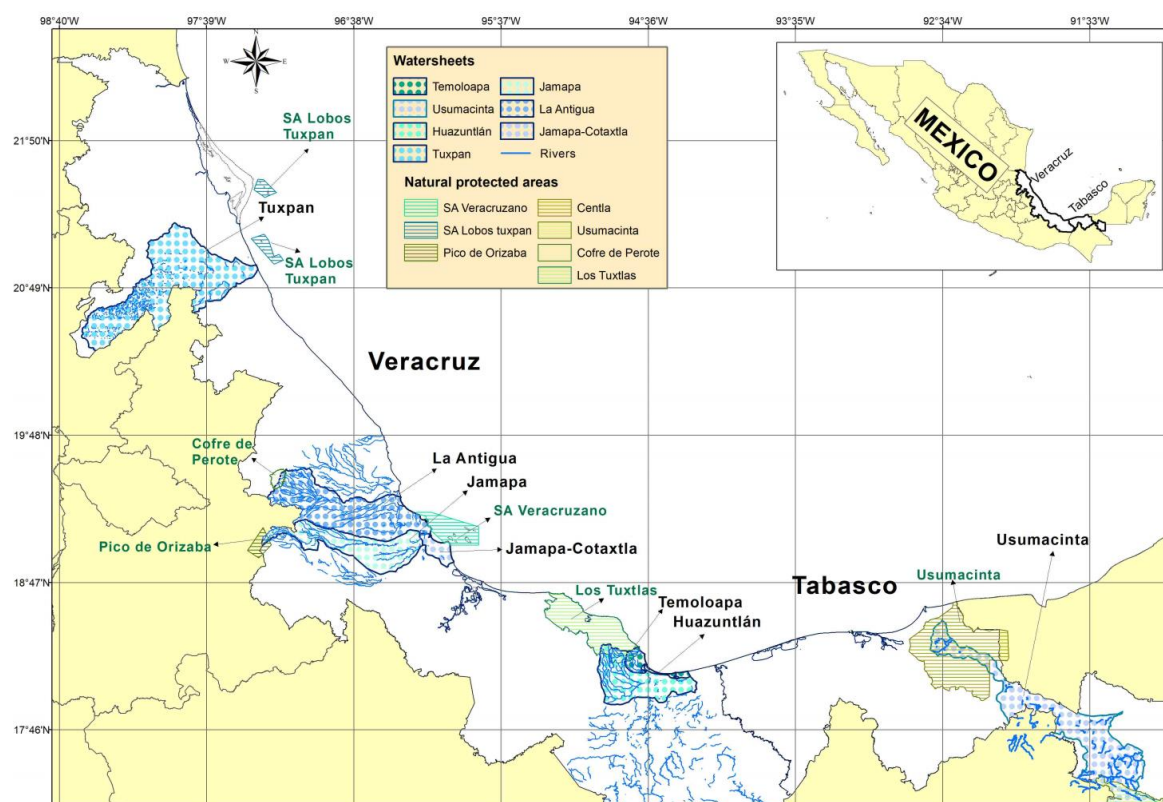


**Figure 1.** Geographical location of the C6 project. Source: developed by the first author with geographical information from the Mexican National Institute of Statistics and Geography [32].

The civil society organizations executed 29 interventions in the agricultural ecosystems, forests, and seven natural protected areas; 24 interventions corresponded to local civil organizations, one to a regional civil organization, and one to a national civil organization, which intervened in the five watersheds. The watershed characteristics are shown in Table 1, and Figure 1 shows the watershed locations, the permanent rivers, and the natural protected areas where the C6 project was executed.

**Table 1.** Characteristics of the coastal basins involved in the C6 project.

| Characteristics                                | Basins  |            |         |                      |            |
|------------------------------------------------|---------|------------|---------|----------------------|------------|
|                                                | Tuxpan  | La Antigua | Jamapa  | Huazuntlán-Temoloapa | Usumacinta |
| Watershed surface (km <sup>2</sup> )           | 6755    | 2176       | 3918    | 562                  | 4883       |
| Community area <sup>‡</sup> (km <sup>2</sup> ) | 2702    | 778        | 1179    |                      |            |
| Percentage of plant cover                      |         |            |         |                      |            |
| Natural cover                                  | 27%     | 28%        | 14.5%   | 10%                  | 61.2%      |
| Transformed surface                            | 73%     | 72%        | 85.5%   |                      | 36%        |
| Percentage of soil uses                        |         |            |         |                      |            |
| Agriculture                                    | 42.90%  | 50.45%     | 57.4%   |                      |            |
| Livestock                                      | 28.90%  | 19.85%     | 26.3%   |                      |            |
| Forestry                                       | 0.04%   |            |         |                      |            |
| Human settlements                              | 0.80%   | 1.32%      | 1.2%    |                      |            |
| Number of direct beneficiaries                 | 1407    | 872        | 953     | 893                  | 358        |
| Percentage of water bodies                     | 0.50%   | 0.07%      | 0.6%    |                      |            |
| Total inhabitants                              | 537,960 | 316,983    | 521,621 |                      | 201,548    |
| Direct interventions                           | 6       | 7          | 5       | 6                    | 4          |
| Intervention along the five basins             |         |            |         | 1                    |            |

<sup>‡</sup> Community area refers to the area belonging to the community inhabitants; +1 corresponds to the national civil organization intervention. Sources: Data compiled from INECC-FGM [22,31,33], BIRF [23], Robles and Pacheco [34], March and Castro [35], Peralta-Carreta et al. [36], and (H) Cotler-Ávalos [37].

## 2.5. Selection of Key Informants

The key actors selected were the project coordinators or persons responsible for executing the projects at the local sites. These key actors were also selected based on their willingness to be interviewed and respond to our questions. The regional civil society organizations from the interviews were taken were Agroprodotores Forestales de Zacualpan SPR de R.L, Agua y Monte de Pajapan A.C., AMECORENA A.C, Articulación Territorial A.C., Asesoría Social Productiva A.C., Conecta Tierra A.C., Cooperativa Ambio S.C. de R.L., DECOTUX A.C., Espacios Naturales y Desarrollo Sustentable A.C., Fundación Pedro y Elena Hernández A.C., Gente Sustentable A.C, Global Water Watch A.C, Gruta del Río Jamapa S.C. de R.L. de C.V., IMDESOCO A.C., INANA A.C., Productores de Alimentos para las Zonas Rurales de Mexico S.C., Pronatura Veracruz A.C., Sembrando Semilla Sagrada A.C. y SENDAS A.C; the regional civil organization was the Fondo Golfo de Mexico A.C., and the national civil organization was the Fondo Mexicano para la Conservación de la Naturaleza.

## 2.6. Selection of the Evaluation Framework and Analysis Indicators

Identifying the contribution of sustainable development through adaptation interventions applied in the Gulf of Mexico was executed through an evaluation framework oriented to the 17 SDGs [4,29,38]. Each SDG had indicators associated with the 2030 Agenda Goals, which helped relate to the results of the interventions adapted to climate change performed in each case study. The indicators considered the risk management indicators within the adaptation of the “Tracking Adaptation and Measuring Development” (TAMD) frame [39]. The indicators to be used in this investigation are shown in Table 2 and were

selected based on one study of the Program of the United Nations for Development 2016 (UNDP) [40], which shows the results of the climate change programs and project portfolios executed in more than 140 countries with an amount of 2800 million dollars in donations. There they state that 37% of those resources was for adaptation, 30% for mitigation and 33% in actions for transversalities and forests. It is also highlighted that around 39% of those projects have contributed to SDG 1, 45% to SDG 7, 100% to SDG 13, 42% to SDG 16, and 38% to SDG 17.

**Table 2.** Selected indicators according to the Sustainable Development Framework for Agenda 2030.

| SDG                                        | Indicator                                                                | Targets for the 2030 Agenda                                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. No Poverty                              | Resilience livelihoods (1.5)                                             | To build the resilience of people with low incomes and those in vulnerable situations, reduce their exposure and vulnerability to climate-related extreme events and economic, social, and environmental disasters.                                                                                                                                             |
| 2. Zero Hunger                             | Double the productivity and incomes of small-scale food producers (2.3)  | To double the agricultural productivity and incomes of small-scale food producers, focusing on women, indigenous peoples, family farmers, pastoralists, and fishers, including equal access to land, other productive resources and inputs, knowledge, financial services, markets, and opportunities for value addition and non-farm employment.               |
| 3. Ensure Healthy Lives                    | Reduce illnesses and deaths from hazardous chemicals and pollution (3.9) | To substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination.                                                                                                                                                                                                                       |
| 4. Quality Education                       | Education for sustainable development (4.7)                              | To ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including education for sustainable development and sustainable lifestyles, human rights, gender equality, promoting a culture of peace and non-violence, and appreciation of cultural diversity and culture's contribution to sustainable development. |
| 5. Gender Equality                         | Ensure full participation in leadership and decision-making (5.5)        | To ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life.                                                                                                                                                                                             |
| 6. Clean Water and Sanitation              | Implement integrated water resources management (6.5)                    | To implement integrated water resources management at all levels, including through transboundary cooperation.                                                                                                                                                                                                                                                  |
| 7. Affordable and Clean Energy             | Increase the percentage of renewable energy (7.2)                        | To substantially increase the share of renewable energy in the global energy mix.                                                                                                                                                                                                                                                                               |
| 8. Decent Work and Economic Growth         | Promote policies to support job creation and growing enterprises (8.3)   | To promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity, and innovation, and encourage the formalization and growth of micro, small, and medium-sized enterprises.                                                                                                                       |
| 9. Industry, Innovation and Infrastructure | Develop sustainable, resilient, and inclusive infrastructures (9.1)      | To develop quality, reliable, sustainable, and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, focusing on access for all.                                                                                                                                                   |
| 10. Reduce Inequalities                    | Promote universal, social, economic, and political inclusion (10.2)      | To empower and promote the social, economic, and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion, or economic or other status.                                                                                                                                                                              |
| 11. Sustainable Cities and Communities     | Reduce the adverse effects of natural disasters (11.5)                   | To significantly reduce the number of deaths and people affected and decrease the direct economic losses relative to the gross domestic product caused by disasters, including water-related disasters, focusing on protecting the poor and people in vulnerable situations.                                                                                    |

Table 2. *Cont.*

| SDG                                         | Indicator                                                                                                | Targets for the 2030 Agenda                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12. Responsible Consumption and Production  | Responsible management of chemicals and waste (12.4)<br>Substantially reduce waste generation and (12.5) | To achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, and significantly reduce their release to air, water, and soil to minimize their adverse impacts on human health and the environment; reduce waste generation through prevention, reduction, recycling, and reuse. |
| 13. Climate Action                          | Strengthen resilience and adaptive capacity to climate-related disasters (13.1)                          | To strengthen resilience and adaptive capacity to all countries' climate-related hazards and natural disasters.                                                                                                                                                                                                             |
| 14. Life Below Water                        | Protect and restore ecosystems (14.2)                                                                    | To sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience and taking action for their restoration to achieve healthy and productive oceans.                                                                                         |
| 15. Life on Land                            | Conserve and restore terrestrial and freshwater ecosystems (15.1)                                        | To ensure the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and their services, particularly forests, wetlands, mountains, and drylands, in line with obligations under international agreements.                                                                          |
| 16. Peace, Justice, and Strong Institutions | Strengthen national institutions to prevent violence, combat terrorism, and crime (16.8)                 | To strengthen relevant national institutions, including through international cooperation, for building capacity at all levels to prevent violence, combat terrorism, and crime.                                                                                                                                            |
| 17. Partnerships for the Goals              | Enhance the global partnership for sustainable development (17)                                          | Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology, and financial resources to support the achievement of the Sustainable Development Goals in all countries, particularly developing countries.           |

Source: Information obtained from the United Nations [38].

Identifying the contribution of sustainable development as a result of adaptation interventions to climate change was done by examining the contribution to the indicators in each of the 17 SDGs. This analysis did not pretend to evaluate the C6 project and its contribution to sustainable development, but identifies the contribution to the SDGs and the dimensions of sustainability from there. This research could be the first approach to determine the relationship between climate change adaptation actions and actions that lead to sustainable development.

In this research, we considered a literature review to select a frame based on ONU [41], Mozas Moral [42], Pérez et al. [43], Bórquez Polloni and Lopicich Catalán [44], Canaza-Choque [45], and Rijnhout y Meymen [46] (Figure 2), to identify the SDGs into five areas: persons (social), planet (environmental), prosperity (economic), peace and partnerships (alliances) for the goals.

Pérez et al. [43,47,48] share the idea that two more dimensions—peace and partnerships—should be considered to establish the programs, projects, and actions that contribute to the SDGs in the three dimensions of sustainable development. Therefore, this research analysis was conducted using the classification of the 17 SDGs in the three dimensions of sustainable development, plus peace and alliances as a base (Figure 2).



**Figure 2.** Sustainable Development dimensions and their corresponding Sustainable Development Goals of the C6 Project.

## 2.7. Data Collection and Analysis

The primary data collection was made directly from the reports of the C6 project [23], The Mexican Gulf Fund [31,49], the advance reports of the interventions made in the communities for 2015, 2016, 2017, and 2018, and the Mexican Fund for the Conservation of Nature and Gulf of Mexico A. C [50]. This research also considered data on evaluating capacities from the civil society organizations involved in executing actions to address climate change [23] and the civil society organizations' role in adapting to climate change [30].

To identify the contribution of the interventions performed through the C6 project to the SDGs, we analyzed the contribution from the interventions and their adaptive actions to the environmental, social, and economic dimensions of sustainable development through descriptive statistics with the frequencies related to the variable amount of interventions for each dimension: (1) environmental (planet), (2) social (persons), (3) economic (prosperity), (4) peace, and (5) (alliances), for each watershed: (1) Tuxpan, (2) La Antigua, (3) Jamapa, (4) Huazuntlan-Temoloapa, and (5) Usmacinta (Equations (1)–(6)).

$$ISDG_n = \sum i \quad (1)$$

where:  $ISDG_n$  represents the number of interventions contributing to one of the 17 SDGs, and  $\sum i$  represents the sum of each dimension's interventions.

Equation (2) indicates the sum of the social dimension.

$$\text{SocialD} = \frac{ISDG_1 + ISDG_2 + ISDG_3 + ISDG_4 + ISDG_5}{\sum_{n=1}^{17} ISDG_n} \quad (2)$$

Equation (3) indicates the sum of the economic dimension.

$$\text{EconomicD} = \frac{ISDG_7 + ISDG_8 + ISDG_9 + ISDG_{10} + ISDG_{11}}{\sum_{n=1}^{17} ISDG_n} \quad (3)$$

Equation (4) indicates the sum of the economic dimension.

$$\text{EnvironmentalD} = \frac{\text{ISDG}_6 + \text{ISDG}_{12} + \text{ISDG}_{13} + \text{ISDG}_{14} + \text{ISDG}_{15}}{\sum_{n=1}^{17} \text{ISDG}_n} \quad (4)$$

Equation (5) indicates the sum of the peace dimension.

$$\text{DPeace} = \frac{\text{ISDG}_{16}}{\sum_{n=1}^{17} \text{ISDG}_n} \quad (5)$$

Equation (6) indicates the sum of the dimension alliances.

$$\text{DAlliances} = \frac{\text{ISDG}_{17}}{\sum_{n=1}^{17} \text{ISDG}_n} \quad (6)$$

Besides this ponderation, a one-way analysis of variance (ANOVA) was executed to identify differences in the number of interventions by watershed, and a two-way ANOVA to determine the differences between watersheds by SDG and the number of interventions. Before the analysis, a normality test with the Shapiro-Wilk method was applied. These tests failed ( $p < 0.001$ ) for the one-way ANOVA. Therefore, a Kruskal-Wallis analysis of variance on Ranks was executed. For the two-way ANOVA, the normality test passed ( $p = 0.137$ ), and the equal variance test passed ( $p = 0.1000$ ); therefore, a parametric test and the Holm-Sidak method were applied for the multiple comparison testing. A 0.05 significance level was used for these analyses with the program SigmaPlot 11.0 version.

### 3. Results

#### 3.1. Adaptation Actions to Climate Change in the C6 Project

The core adaptation actions to climate change implemented by the social civil associations through the interventions made on the C6 project were:

- Management of agroecosystems and forest conservation, restoration, and sustainable management (intercropped crops and generation of riparian corridors);
- Management of habitat and corridors around nature-protected areas;
- Conservation of forest fragments suffering deforestation pressure;
- Live fences, restoration of soils, sustainable coffee growing, and native bees conservation;
- Interinstitutional coordination activities (networks, forums, and learning activities) with different actors;
- Installation of plant nurseries with seed banks for endangered species and creation of networks;
- Agroecological modules;
- Reforestation actions;
- Design of Action Plans for the Integrated Management of Watersheds (PAMIC) for the Tuxpan, La Antigua, Jamapa, and the Gulf of Mexico basins.

These actions responded to the communities' necessities to prepare the agricultural and climate systems for climate change and use the ecosystems as natural barriers to confront the extreme hydrometeorological phenomena.

#### 3.2. Contribution of the C6 Project to the SDGs and Sustainable Development

In this section, we will present the contributions of the interventions referred to other SDGs, which might be identified as additional benefits and collateral contributions to the project. Figure 3 shows the 29 adaptation interventions to climate change performed in the five territories. These interventions supported 14 of the 17 DSGs. There were 24 interventions

to SDG 13, 20 to SDG 15, and seven to SDG 6. The collateral SDGs that received significant support were SDG 4, with 26 interventions; SDG 1, with 24; and SDG 16, with 23.

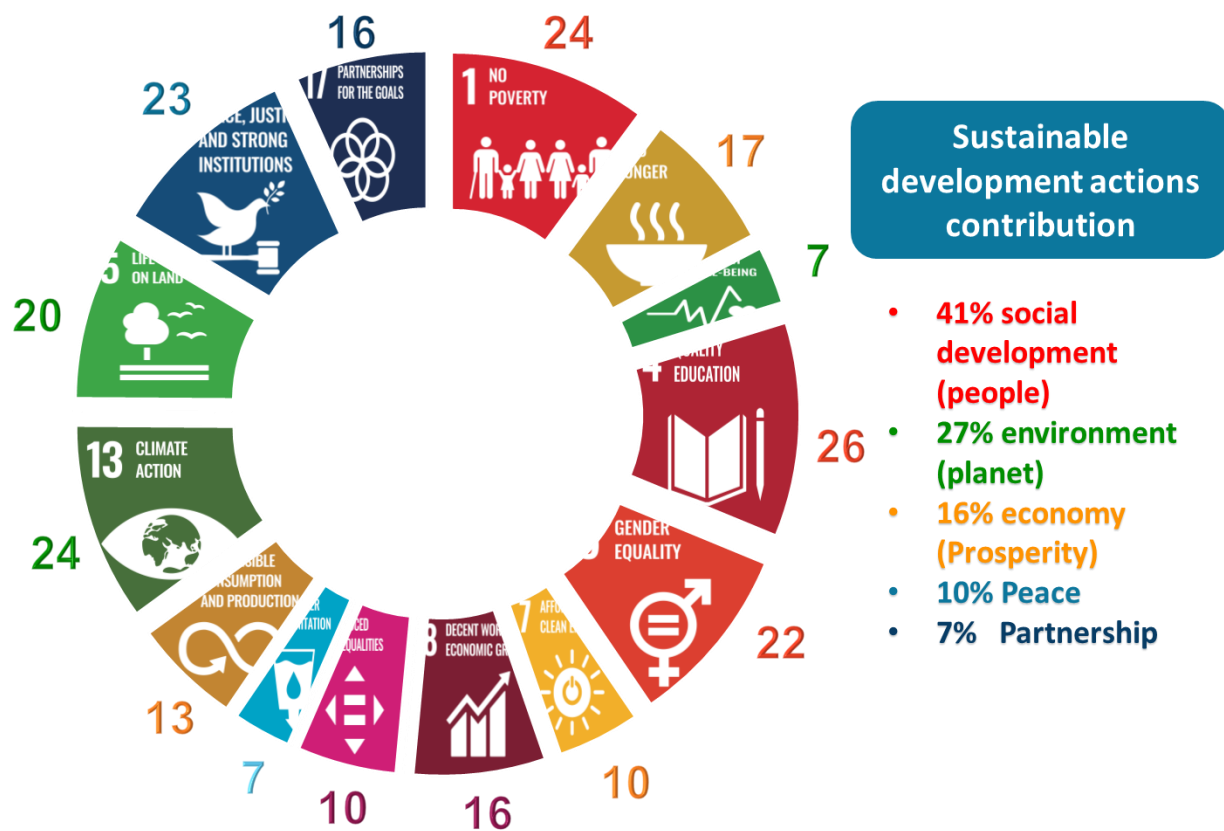


**Figure 3.** Percentages of contributions to the Sustainable Development Goals of the project C6. The numbers above and below the squares represent the percentages.

Considering the SDGs' environmental, economic, and social dimensions, the social dimension (persons) was the one with the most actions supported since 41% of the total actions performed are related to SDGs 1, SDG 2, SDG 3, SDG 4, and SDG 5 (Figure 3). The results of the social dimension are 1.5 times superior to those of the environmental dimension (planet) and 2.5 times superior to the contribution to the economic dimension (prosperity).

### 3.3. Identification of the SDGs in the Social Dimension, Peace, and Partnerships

When comparing the dimensions of sustainable development on the five hydrological basins where interventions were performed through the C6 project, we observe that on the social dimension, the Tuxpan basin had the highest climate change actions (CCAs) (47%). These social SDGs were SDG 1 (end of poverty), SDG 2 (zero Hunger), SDG 3 (Health and well-being), SDG 4 (Quality education), and SDG 5 (Gender Equality). This watershed was the one that reported the highest number of hectares (155 Ha) of agriculture through good practices and with the most significant amount of efficient technologies to reduce the contamination of closed spaces through the installation of 769 wood-saving stoves.

In the peace dimension, 100% of the interventions performed in the Jamapa and Usmacinta watersheds were through actions aimed at SDG 16 (peace, justice, and solid institutions) supported by local institutions.

Regarding partnerships or alliances, the watersheds of La Antigua and Usmacinta were the ones that mainly contributed to SDG 17 (alliances to achieve the objectives). In the case of La Antigua, the alliances that supported the interventions were: (1) the Coalition of the Bioregion Organizations Jamapa and La Antigua (COBIJA), (2) the Monitoring

Community Water networks, (3) the melipona honey growers and beekeeping networks, and (4) the Biodiversity Nurseries network.

### 3.4. Identification of the SDGs in the Economic Dimension

When comparing the five watersheds, the actions performed on the Huatzuntlan-Temoloapa watershed were the ones of higher support to the economic dimension, with a 21% total of actions contributing to the following SDGs: SDG 7 (accessible and not contaminant energy), SDG 8 (decent work and economic growth) and SDG 10 (reduction of inequalities). Referring to SDG 7, this watershed recorded the highest quantity of biodigesters installed (87). Within the frame of SDG 8, the highest number of honey modules were installed (59), together with the highest intercrop fruit-corn modules (38). Additionally, this watershed was where the largest indigenous population was involved (9957 persons).

### 3.5. Identification of the SDGs in the Environmental Dimension

The highest environmental actions were executed in the Jamapa and La Antigua watersheds, corresponding to SDG 6 (clean water and sanitation), SDG 12 (responsible production and consumption), SDG 13 (climate actions), and SDG 15 (life on land ecosystems). In terms of SDG 12, it was in the Jamapa watershed where most of the demonstratives' modules of agroecological coffee were installed (79 modules). In the Antigua watershed, the highest amount of organic maneuver modules was implemented (250 modules). For SDG 15, the highest number of species favoring connectivity between vegetation fragments was established in the La Antigua watershed. (4810.86 Ha). Figure 4 shows the contribution to the SDGs by watershed.

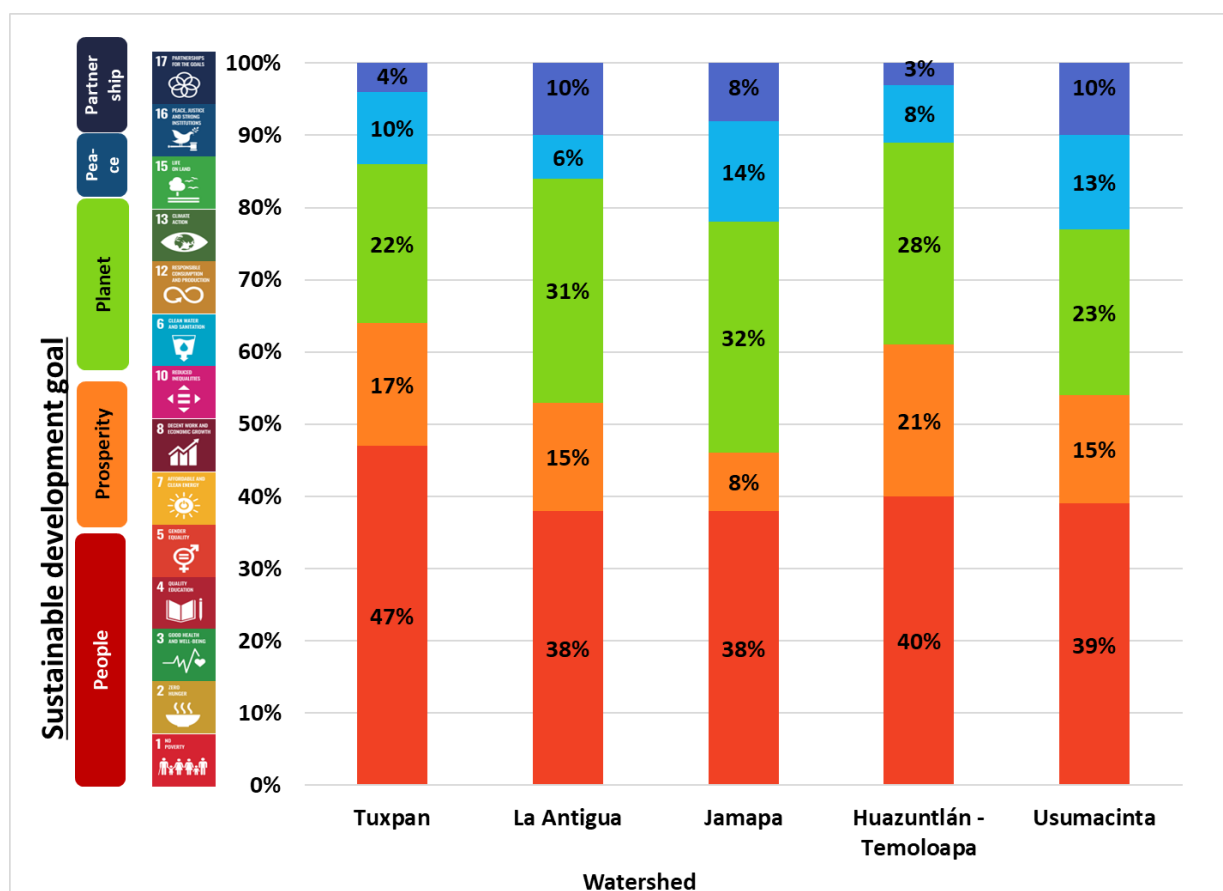


**Figure 4.** Percentage of the contribution to the Sustainable Development Goals obtained by the C3 project actions, with the interventions executed by each basin.

Table 3 shows the identified number of interventions by dimension and SDG. There, it can be seen that DGDs 8, 10, and 14 have no interventions. SDG 14 (life below water) was not found because, in this project, there were no interventions considering aquatic plants or animals. Therefore, we could not identify this SDG. SDG 9 (Industry, Innovation, and Infrastructure) was not accounted for because this project did not work with industries. SDG 11 was not accounted for because this project did not work in any city or small villages, since it was centered on field producers and farmers.

**Table 3.** Number of interventions by SDG and dimension in the watersheds.

| Dimension  | Sustainable Development Goal                | Tuxpan | La Antigua | Jamapa | Huazuntlán-Temoloapan | Usumacinta |
|------------|---------------------------------------------|--------|------------|--------|-----------------------|------------|
| Persons    | 1. No Poverty                               | 6      | 5          | 4      | 5                     | 4          |
|            | 2. Zero Hunger                              | 5      | 2          | 1      | 6                     | 3          |
|            | 3. Ensure Healthy Lives                     | 2      | 1          | 2      | 2                     | 0          |
|            | 4. Quality Education                        | 6      | 5          | 4      | 6                     | 5          |
|            | 5. Gender Equality                          | 5      | 5          | 3      | 6                     | 3          |
|            | 7. Affordable and Clean Energy              | 2      | 2          | 2      | 3                     | 1          |
| Prosperity | 8. Decent Work and Economic Growth          | 3      | 5          | 1      | 4                     | 3          |
|            | 9. Industry, Innovation and Infrastructure  | 0      | 0          | 0      | 0                     | 0          |
|            | 10. Reduce Inequalities                     | 4      | 0          | 0      | 6                     | 2          |
|            | 11. Sustainable Cities and Communities      | 0      | 0          | 0      | 0                     | 0          |
|            | 6. Clean Water and Sanitation               | 1      | 3          | 2      | 1                     | 0          |
| Planet     | 12. Responsible Consumption and Production  | 1      | 4          | 3      | 5                     | 0          |
|            | 13. Climate Action                          | 5      | 3          | 5      | 6                     | 5          |
|            | 14. Life Below Water                        | 0      | 0          | 0      | 0                     | 0          |
|            | 15. Life on Land                            | 4      | 5          | 2      | 5                     | 4          |
| Peace      | 16. Peace, Justice, and Strong Institutions | 5      | 3          | 5      | 5                     | 5          |
| Alliances  | 17. Partnerships for the Goals              | 2      | 5          | 3      | 2                     | 4          |

### 3.6. Relationships Between Basins and Sustainable Development Goals

The one-way ANOVA for the number of interventions by watersheds did not find significant differences in the number of SDGs per watershed ( $H = 5.98$ ;  $p = 0.20$ ). This result means that there is no prevalent SDG between watersheds. The two-way ANOVA found differences between groups ( $p = 0.004$ ). The power of the test for the watersheds was 0.80, while the power for the SDGs was 1.00. The watersheds that differed were Huazuntlan and Jamapa ( $t = 3.604$ ;  $p < 0.001$ ) and Huazuntlan and Usumacinta ( $t = 3.316$ ;  $p < 0.002$ ; Figure 5). Figure 6 shows the differences between SDGs.

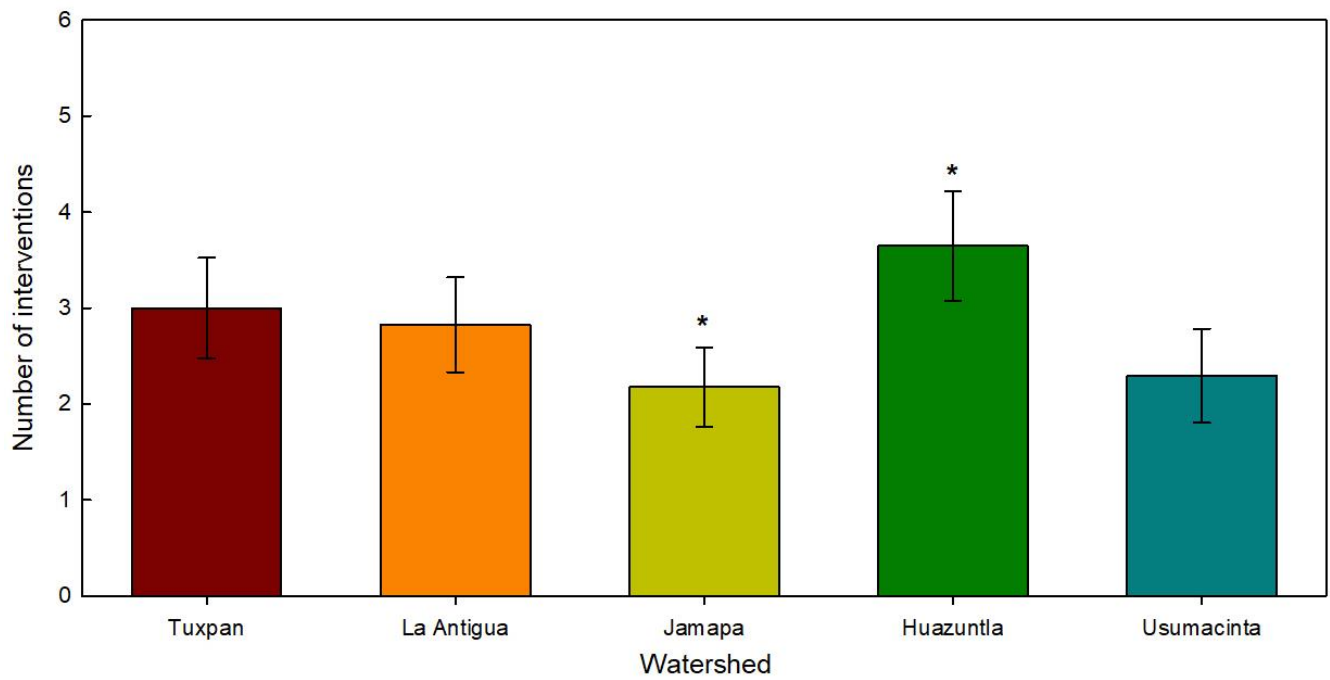


**Figure 5.** Number of interventions by watershed. The vertical bars indicate the standard error of the mean. The asterisk (\*) indicates statistical differences between groups ( $p < 0.01$ ).

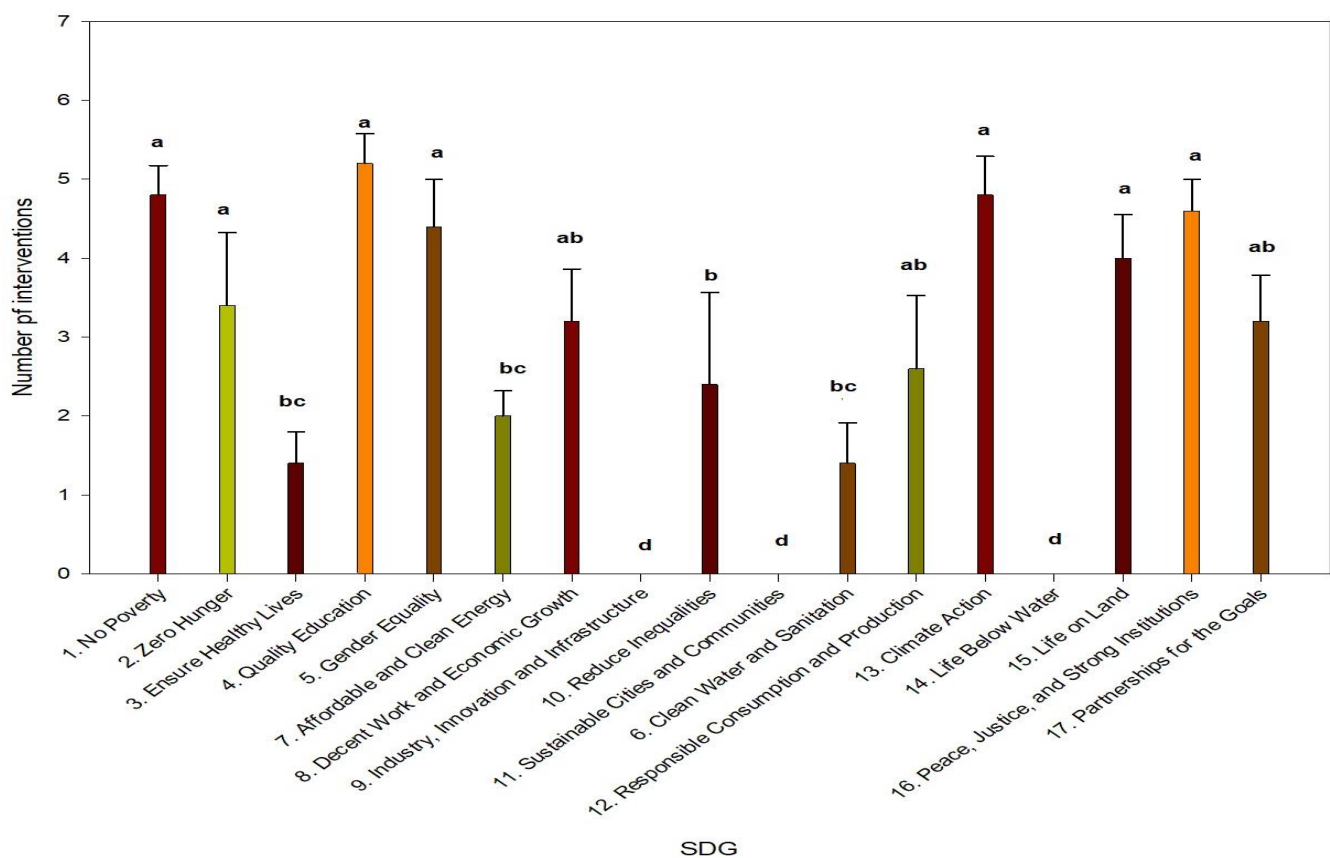


**Figure 6.** Number of interventions by SDG. The vertical bars indicate the standard error of the mean. Different letters represent statistical differences between groups ( $p < 0.05$ ).

## 4. Discussion

### 4.1. Contribution of the C6 Project to the Sustainable Development

In terms of the C6 project, through climate change adaptation interventions performed by the Civil Societies Organizations in the watersheds of La Antigua, Jamapa, Huatzuntlan-Temoloapa, and Usmacinta, the actions executed in the watersheds contributed to the sustainable development because the communities implemented activities and technologies that may allow to continue their social and economic growth and, at the same time, they will try to reduce the vulnerability to climate change scenarios, such as increase of temperature, reduction or excess of rain, and their impacts [31,50].

### 4.2. Contribution of the C6 Project to the Social Dimension

The CCAs performed through the C6 project contributed more significantly to five SDGs within the social dimension (end of poverty, zero hunger, health and well-being, quality education, and gender equality). This result could be explained because adaptation needs are related to social systems to reduce poverty and inequality, improve the conditions of life resources and subsistence strategies, and access to education and information. These actions were performed because the social sector must be considered to achieve consensus on the need and benefits of the CCAs to reduce short- and long-term disasters [51]. For example, in the case of the Tuxpan basin, which was the one that most contributed to the social dimension compared to the other basins, this can be explained by the need to improve the health in the population of the high basin by using wood stoves at the same time that the pressure on the natural vegetation in the forests is reduced [22]. Besides these actions, there is also the necessity to perform sustainable agriculture since rainfed agriculture, such as orange cultivation, has generated intense pressure on the basin [22].

### 4.3. Contribution of the C6 Project to the Environmental Dimension

In the environmental dimension, the CCAs performed within the C6 frame contributed to four of the five SDGs since physical actions were performed to (1) keep the ecosystemic services, (2) reduce the vulnerability to climate change in water scarcity situations, (3) stop the loss of biodiversity, and (4) diminish the damages caused by the frequency and seriousness of natural disasters [52–54]. In the case of the Antigua and Jamapa basins, which contributed the most to the environmental dimension, the actions performed in the Jamapa basin responded to the agricultural sector (shadow coffee plantations) [50]. In La Antigua's case, the activities were intended to maintain natural coverage, favoring connectivity between vegetation fragments.

### 4.4. Contribution of the C6 Project to the Economic Dimension

In a minor but still relevant proportion, the CCAs performed within the C6 project frame contributed to the economic dimension by three of the five SDGs in this dimension. This result is significant since a successful adaptation should help the livelihoods and the production means to be more resilient to climate change and reduce vulnerability through the sector mobility of those in poverty [55,56]. Besides, climate change involves different aspects of the economy and society, such as production, finances, work, consumption, and politics, to set up production changes and consumption and promote more sustainable lifestyles [57]. Furthermore, since the population with fewer economic resources has a double inequity: poverty and climate change, climate change adaptation actions must be placed at the center of decisions for this population affected by inequalities [58]. The particular case of the Huazuntlan-Temoluapa basins in the C6 project was the one that most contributed to the economic dimension compared with other basins due to the need

to generate income through entrepreneurship with environmentally friendly solutions to reduce pressures on the ecosystems.

The resultant information from this research was contrasted with the Determined Contribution at the National Level (DCNL) for Mexico (2020) [59], which refers to the adaptation component (composed of five axes and 27 action lines). In this respect, the action lines of the adaptation component contribute to the social dimension in the following proportion: 27% to the economy, 44% to the environment, 3% to peace, and 2% to Alliances. Thus, the DCNL contributed mainly to the environmental dimension, and the C6 project, even if it is a project that faces climate change, primarily contributed to the social dimension. It is essential to mention that the DCNL for Mexico, besides considering climate change, also promotes sustainable development, aligning both policies [60].

#### 4.5. Contribution to the Sustainable Development Goals by Adaptation Actions to Climate Change

Since the appearance of the Action Plan *Transforming our world: the 2030 Agenda for Sustainable Development*, with its 169 goals and 17 Sustainable Development Objectives as an international agenda to lead countries to sustainable development [41], the 17 SDGs have become a conceptual and a normative reference frame under which environmental, social and economic policies are designed. An essential aspect of the SDGs is that their general terms give the possibility of considering different actions and adapting them as a reference frame to identify other actions in local contexts [47]. However, this same characteristic has been criticized by those who think the SDGs are ambiguous, rhetorical, idealistic, and of short viability [44,48].

The support for sustainable development through the execution of climate change adaptation actions to climate change can be observed in Objective 1 of the *Special Climate Change Program 2021–2024* (SCCP) [61], referred to: “Reduce the population, ecosystems, and biodiversity vulnerability to climate change, as well as the productive systems and the strategic infrastructure through the impulse and strengthening of the adaptation processes and increase of resilience”. In this project, this situation is related to 10 of the SDGs divided into these dimensions: environmental (5), social (2), economic (1), Peace (1), and Alliances (1).

Authors like Gómez-Gil [48], Díaz-Barrado [47], and Pérez et al. [43] expressed that the SDGs integrate and balance the three dimensions of sustainable development in such a manner that if a project supports the SDGs in different dimensions, then it is contributing to sustainable development. Such identification was possible by analyzing the change factors (interventions) and the impacts on the systems (measured through the selected indicators). This situation can be explained by Yim [5], who reveals that climate change’s economic, social, and environmental aspects are widely interlinked with sustainable development considerations since climate change actions and sustainable development share many of the objectives of reducing vulnerability. These considerations also agree with what authors like Simonet and Fatoric [62] and Vranic and Milutinovic [63] mention: the CCAs are tangible applications of sustainable development to adopt a better quality of life. Therefore, adaptation strategies have become a practical way to achieve sustainable development.

For Mexico, the current policy to confront climate change is directed by the Mexico National Level Determined Contribution Actualized Version 2020 (MNLDC) [59] and the Special Program for Climate Change 2021–2024 (SPCC) [61]. In these documents, the 27 action lines of the MNLDC and the objectives of the SPCC are closely related to the 17 SDGs due to the synergy between the climate and sustainable development agendas (2030 Agenda).

In some cases, the adaptation actions executed through the C6 project directly supported only one indicator. For instance, the indicator of *resilience to climate change* was

achieved in the case of agriculture and cattle under the application of sustainable practices. However, we could also consider that it impacts SDG 2 (zero hunger) since agriculture and cattle are directly connected to food. This indicator exemplifies that applying different actions through the adaptation focus may help fulfill the other SDGs.

Therefore, although the C6 project was conceived to support only three SDGs: SDG 6 (clean water and sanitation), SDG 13 (climate action), and SDG 15 (life on land), the results of this research show that the actions performed in the communities contributed to 14 SDGs. According to authors like Pérez et al. [28], this additional support is a collateral result.

#### 4.6. Contribution of the C6 Project to the Partnerships Dimension

In the C6 project, more than half of the interventions were involved in some alliance to empower its action potential to confront climate change, which confirms what Velasco [64] and Monterroso and Conde [12] affirmed on the importance of having alliances to access information, training, share knowledge and widen the impact of the actions. These results are also explained because those actions are part of the social capital of the civil society organizations [65,66]. These organized interventions in the communities enabled them to widen their knowledge in other areas [65], helped them to increase their adaptation capacity to climate change, and, thus, transferred them to the communities [67,68].

The results of this research demonstrate the effects that civil society organizations have on the communities to achieve capacities of adaptation to climate change and, at the same time, how these interventions have incidence in the natural and social systems so that they may adapt to this phenomenon and also to the 17 SDGs leading towards sustainable development. As Garro-Gil [69] indicated, the interventions performed in any territory should be studied from an open-view approach to capture all relations and effects in the whole system. Table 4 summarizes the specific contributions to the SDGs, considering the evaluation reports of the C6 project.

**Table 4.** Relationship between adaptation actions executed by the C6 project and the SDGs.

| Dimension             | SDG                                | Indicator                                                | Actions Executed in the C6 Project                                                             |
|-----------------------|------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------|
| Social (People)       | 1. No poverty                      | Resilient livelihoods<br>Food safety                     | Permanent employment generation<br>Family orchards                                             |
|                       | 2. Zero hunger                     | Resient agricultural practices                           | Sustainable agriculture practices<br>Sustainable livestock farming                             |
|                       | 3. Good health and well-being      | Technologies to reduce contamination                     | Installation of wood-saving stoves                                                             |
|                       | 4. Quality education               | Non-formal and informal education                        | Non-formal and informal education workshops on land conservation                               |
|                       | 5. Gender equality                 | Climate change measures with a gender perspective        | Actions to include gender perspectives                                                         |
| Economic (Prosperity) | 7. Affordable and clean energy     | Implementation of clean energy devices                   | Biodigesters and photovoltaic cells                                                            |
|                       | 8. Decent work and economic growth | Entrepreneurship with environmentally friendly solutions | Vanilla modules<br>Cacao modules<br>Honey modules<br>Intercropping corn and fruit tree modules |
|                       | 10. Reduced inequalities           | Integration of indigenous people.                        | Actions for the involvement of the Indigenous population                                       |

Table 4. Cont.

| Dimension              | SDG                                         | Indicator                                                          | Actions Executed in the C6 Project                                                                 |
|------------------------|---------------------------------------------|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Environmental (Planet) | 6. Clean water and sanitation               | Water resource management with a climate change approach           | Rainwater harvesting systems and dry toilets                                                       |
|                        | 12. Responsible consumption and production  | Agroecological practices<br>Proper residue disposal.               | Agroecological coffee practices<br>Organic biofertilizers<br>Actions to enhance local capabilities |
|                        | 13. Climate action                          | Adaptive capacities                                                |                                                                                                    |
|                        | 15. Life on land                            | Environmental conservation<br>Sustainable forest management.       | Creation of forest species nurseries<br>Soil and water bodies restoration                          |
| Peace                  | 16. Peace, justice, and strong institutions | Strengthen national and local institutions.                        | Actions to strengthen the local governmental institutions                                          |
| Alliances              | 17. Partnerships for the goals              | Coordination between key actors to execute climate change actions. | Formation of networks between civil society organizations and government institutions              |

Source: Table elaborated by the authors with the information from the C56 project reports [8–13] and the SDGs [26].

#### 4.7. Relationships Between Basins and Sustainable Development Goals

The differences found in the watersheds Jamapa and Huazuntlán-Temoloapan can be explained because, in Huazuntlán-Temoloapan, the highest number of interventions were executed (62), while in Jamapa, the lowest number of interventions were executed (37). In the dimension of prosperity, the lowest percentage of interventions was executed in Jamapa (8%) compared to Huazuntlán-Temoloapan. These results directly relate to the number of civil society organizations working there. Regarding the SDGs, SDG 13 (climate action) stands over SDGs 3, 7, 9, 11, and 14 because the primary focus of the C6 project was climate change actions. According to Vranic and Milutinovic [63], climate change adaptation and sustainable development policies are mainly performed in isolation. However, as stated in the present research, coordination between institutions to achieve the climate change policy may impact SDGs in different percentages.

Lessons learned by the C6 project will help guide new actions to increase the adaptive capacities in the communities, as stated in Article 11 of the Paris Agreement [70]. We also have to highlight what the UN (2020) [54] indicates about considering all the challenges humanity has had regarding development.

To complement the evaluation of the impacts of the C6 projects at the regional level, we also recommend another methodology, like the HUELLA, which considers satellite imagery and quasi-experimental designs [71]. However, we need more information than the reports we used in this research to perform this evaluation. Therefore, we recommend these activities as future steps for similar projects.

Considering other research, our research is a pioneer in evaluating the 17 SDGs in five watersheds. There is one that analyses sustainability indicators and climate change for 10 Latin American countries in coastal zones [72]. Still, it only considers socioeconomic variables, finding that the strategies differ between countries because each has different policies. Thus, this study can be applied to other watersheds to complement the analysis of their climate change adaptation actions.

## 5. Conclusions

The evaluation frame used in the C6 project allowed for linking the climate change actions performed with the indicators for each of the SDGs of Agenda 2030.

Through this analysis, we could demonstrate that the C6 Project contributed to the SDGs considered in the project design and other SDGs not included as part of the project.

Considering the five hydrological watersheds of the states of Veracruz and Tabasco, the most outstanding contribution of the C6 project was in the social dimension, followed by the environmental and economic aspects.

When performing the analysis of the different intervention territories (hydrological watersheds), the one in Tuxpan contributed mainly to the social dimension, the watershed Huazuntlan-Temoloapa to the economic dimension, and the ones from Jamapa and La Antigua to the environmental dimension. In contrast, La Antigua and Usumacinta contributed to the Alliances dimension. This result has to do with the natural vocation of the usage of the soil, the natural and transformed vegetation coverage, the principal agriculture and livestock sector activities, and, in general, the characteristics of the population, as, for instance, the presence of the Indigenous population, as well as the characteristics of the civil society organizations that supported the communities to implement their actions.

For countries like Mexico, where economic resources in coastal communities are scarce, we recommend working with civil society organizations at the national and local levels, since these organizations know the complexity of the sites and have experience working with the people and their resources.

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