Alfredo Ortega-Rubio *Editor*

Mexican Natural Resources Management and Biodiversity Conservation

Recent Case Studies

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Chapter 18
Community Adaptation to Climate Change and Biodiversity Conservation in Natural Protected Areas: The Case of El Vizcaíno Biosphere Reserve, Mexico

Alba E. Gámez, Antonina Ivanova, and Eduardo Juárez

Abstract Climate and economic change put pressure on the use of natural resources, which in turn increases the vulnerability of ecosystems and human communities. This makes social participation essential for biodiversity conservation. This chapter addresses community perceptions on adaptation to climate change in El Vizcaíno Biosphere Reserve (REBIVI), in Baja California Sur (Mexico), one of the largest natural protected areas in Latin America. Workshops with local producers and community representatives show the need to increase knowledge on climate change issues and strengthen institutional and legal capacities to facilitate the implementation and monitoring of adaptation actions. At the same time, experiences already in place in REBIVI (such as whale watching, mangrove recovery, and bighorn sheep hunting) demonstrate that a responsible use of biodiversity can contribute both to conservation and community welfare and provide grounds to pursue alternative economic and social ways to relate to nature. Yet, economic growth models and the community members' heterogeneous capabilities to better adapt to climate change and strengthen their capacities for action need to be taken into account if both human welfare and conservation are to be effectively promoted.

Keywords Community adaptation · Climate change · El Vizcaíno Biosphere Reserve · Mexico

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18.1 Introduction

The environmentally adverse effects of contemporary economic growth on life—and the economy itself—have given rise to the acceptance of mitigation and adaptation mechanisms in policy agendas worldwide. The role of natural protected areas (NPAs), as clearly defined geographical spaces managed to achieve long-term conservation of nature with associated ecosystem services and cultural values (Dudley 2008), has become even more important in the context of global change. Relevant to this are local inhabitants' economic practices and living standards since the lack of income alternatives, lifestyles, and inequality are among the most common factors that constrain the implementation of adaptation and mitigation options and, in turn, strongly influence vulnerability to climate change and the emission of greenhouse gases (IPCC 2014:94–95).

Recognizing that improving community resilience to climate change in NPAs can initiate productive processes that both strengthen development opportunities and lead to improved biodiversity conservation. Seventeen climate change adaptation programs targeting populations in NPAs have been advanced in Mexico, one of them in El Vizcaíno Biosphere Reserve (REBIVI). REBIVI is located in the municipality of Mulegé, Baja California Sur (BCS), in northwestern Mexico; with an area of 2,546,790 hectares (ha), it is one of the largest NPAs nationwide (INE-SEMARNAT 2000). This space hosts high biological diversity, which includes endemic species. However, the challenge is to match biodiversity conservation with natural resource consumption by foreign investors and local communities. Situated in an arid region, REBIVI is currently subject to pressure from climate and economic change, which increases the vulnerability of human communities and ecosystems in the area. In addition to this, Mulegé shows higher rates of social marginalization in the state when compared to the other four municipalities in Baja California Sur, which further aggravates both conservation and development concerns.

This chapter addresses local residents' perceptions on adaptation to climate change in REBIVI and offers insight on how biodiversity can lead to community welfare in this NPA. After this introduction, the chapter is organized as follows. The first section refers to the relevance of community participation regarding conservation, especially in a context of climate change, and focuses on methodologically grounded proposals that strengthen adaptation practices in vulnerable regions. The second part presents an overview of the challenges and sources of climate change vulnerability in REBIVI. A third section reviews the results from the workshops carried out in REBIVI with local producers and community representatives during 2017, which involved the scientific community, decision-makers, and rural communities to identify adaptation measures to reduce ecosystem and human vulnerability. A fourth part advances three examples of economic diversification as adaptation that also serve as biodiversity conservation mechanisms: whale watching, bighorn sheep hunting, and mangrove recovery. A final section presents some concluding thoughts and recommendations to advance the notion that actively promoting alternative economic and social ways to relate to nature can contribute both to conservation and community welfare.

18.2 Community in Conservation and Adaptation to Climate Change

Social participation is essential for biodiversity conservation and this is particularly clear in climate change conditions. The Intergovernmental Panel on Climate Change (IPCC) defines *adaptation* in human systems "as the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (IPCC 2012:5). Moreover, the IPCC underlined the argument that adaptation is imperative in order to address impacts resulting from the warming due to past emissions. Thus, since adaptation plays an important role in conservation, an integrated ecosystem-community approach is needed to pursue effective conservation strategies.

Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (Jimenez Hernández 2016; CBD 2015). As one of the possible elements of an overall adaptation strategy, ecosystem-based adaptation uses sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase resilience and reduce the vulnerability of ecosystems and people that are confronted with the adverse effects of climate change.

EbA can generate significant social, economic, and cultural co-benefits, contribute to the conservation of biodiversity, and build on the traditional knowledge and practices of indigenous peoples and local communities—including the important role of women as custodians of local knowledge. In addition, healthy, well-managed ecosystems have climate change mitigation potential, for example, through the sequestration and storage of carbon in healthy forests, wetlands, and coastal ecosystems (GIZ 2016).

Community-based adaptation (CbA) has been defined as "a community-led process, based on communities' priorities, needs, knowledge and capacities, which should empower people to plan for and cope with the impacts of climate change" (Dodman and Mitlin 2013). It refers to an evolving yet distinct set of principles and practices that consistently target the most vulnerable populations and focus on activities with the greatest direct impact (Girot et al. 2016). This targeting and focusing, embedded in participatory situational analysis and action-planning processes, distinguishes it from development "business-as-usual" (Wamsler et al. 2016), which is often top-down and does not focus on the most vulnerable.

Adaptation strategies are generated through participatory processes that build on existing cultural norms and address the underlying causes of poverty that render some people especially vulnerable to the impacts of climate change. Influenced by this notion, the Global Environmental Facility Trust Fund and the United Nations Development Programme financed climate change adaptation programs (CCAP) for NPAs, which are derived from the Global Resilience Project. This project aims to reduce the direct and indirect adverse impacts of climate change on globally important biodiversity and human communities.

In Mexico, the project additionally sought to consolidate the institutional framework to implement the objectives of the Strengthening Management Effectiveness and Resilience of Protected Areas to Safeguard Biodiversity Threatened by Climate Change project (Resilience Project). Behind this was the recognition that a precautionary approach was in order to address the threats posited by climate change to the protected area system. In this context, it is important to increase the preparedness of NPA authorities and other stakeholders to address such a challenge (GEF 2012).

Such effort implies a prioritization of adaptation measures to climate change according to a multicriteria analysis of the adaptation measures of the Strategic Adaptive Axes as a support tool in the decision-making process (Zorrilla and Kuhlmann 2015). Multicriteria analysis is used to facilitate decision-making, so that different or even contradictory points of view may intervene. This is especially useful in planning, because it allows integrating different criteria in a single framework of analysis, according to the intervention of the participants.

Part of the information in this chapter results from the development of REBIVI's climate change adaptation program (CCAP-REBIVI) (Ivanova 2017), which was financed during 2016–2017 by the United Nations Environment Programme through Mexico's National Commission of Protected Natural Areas. Seven participatory community workshops (PKW) were held in January, February, and April 2017 with representatives from seven communities selected according to their population size, economic relevance, and geographical location. These representatives were Guerrero Negro, Vizcaíno (Villa Alberto Alvarado), San Francisco de la Sierra, San Ignacio, Santa Rosalía, Punta Abreojos, and Bahía Asunción.

The objective of the workshops was to gather the observations and comments of REBIVI inhabitants to enrich and further specify the strategies and lines of action of each Strategic Adaptive Axis by social groups, main stakeholders, and government agencies that would be responsible for their implementation and follow-up (Zorrilla and Kuhlmann 2015). In addition, as part of the PKW activities, the participants prioritized the actions of each Strategic Adaptive Axis based on a multicriteria analysis. Representatives from the municipal, state, and federal levels of government, nongovernmental organizations, community members and producer associations (ranchers, fishermen, farmers), and educational institutions participated in this exercise.

Workshop attendees were organized into five working groups, each with a facilitator (member of the research team) and a rapporteur: (a) water, (b) fisheries and biodiversity, (c) agriculture and livestock, (d) tourism, and (e) environmental education and research. Those Strategic Adaptive Axes had been previously defined in meetings of the research team with public officials of REBIVI and the Natural Protected Area Commission (which is in charge of the Resilience Project in Mexico). After the facilitator of each thematic group presented the work dynamics, participants were asked to write each idea or piece of information on a sheet of paper, from which the facilitator synthesized the information (eliminating repetitions). This exercise resulted in the creation of adaptation measures for each strategic sector. The discussion took place in two stages:

(a) Stage I. Assessment of climate change impact and identification of adaptation measures

At this stage, the impacts of climate change were identified by the assistants (e.g., drought, flooding, sea level rise, etc.). Then the level of each impact was ranked between 0 and 3 (0, no impact; 1, minimal impact; 2, considerable impact; 3, high impact). Then the consequences of the impact were defined (e.g., drought affects crops, sea level rise affects the coastal infrastructure, etc.). Next, participants defined the most appropriate adaptation strategies according to each impact. Once the adaptation strategies were formulated, there was discussion about whether or not any governmental institutions or civil society organizations received support for their implementation (e.g., financing, capacity building, and environmental education).

(b) Stage II. Prioritization of adaptation measures identified in stage I

The prioritization was performed according to the multicriteria methodology. The PKW participants discussed the following six criteria, ranking each of them from 0 to 3:

- Importance for the community
- Contribution to conservation
- Care for vulnerable population
- Resilience enforcement
- Community participation
- Institutional support (government and/or civil society organizations)

Then, each group of answers was discussed. Subsequently, the ideas were debated until consensus and possible solutions to the problem were identified. The results of these workshops are presented below, in the third section.

18.3 Livelihood Impacts of Climate Change in Mexico's El Vizcaíno Biosphere Reserve

In the region covered by REBIVI, three areas with different characteristics can be identified. The first corresponds to the sierras, the second to the plains that make up the basins of El Vizcaíno, and the third to the area of coastal lagoons, which exhibit high rates of biodiversity and conservation. Primary economic activities form the basis of community life in REBIVI; however, production patterns are far from homogeneous insofar as high-tech agriculture coexists with subsistence agriculture and livestock. In addition, small-scale coastal fisheries differ from export-oriented high-value fisheries, such as abalone and lobster, which are produced by fisheries cooperative societies. Further, federal government co-investment with the Mitsubishi Corporation in open-air salt mining makes Guerrero Negro, and thus REBIVI, one of the most important salt producers in the world, exporting over eight tons of salt per year.

Along with the production of salt, fishing, and alternative tourism (mostly derived from whale watching and hunting), agriculture is one of the most important economically productive activities carried out in this NPA. The municipality of Mulegé is the second most important agricultural region of Baja California Sur, and most agricultural areas are located in REBIVI (where agriculture is currently allowed in the portion identified as "area of sustainable use of natural resources"). This zone coincides with the lowlands, since most of the existing mountain ranges in the NPA are considered "restricted use zones" (INE-SEMARNAT 2000).

Considering the value of its production, Mulegé is the second agricultural center of BCS, after the municipality Comondú. Of a total of 115 companies or agricultural fields in the state in 2015, 22.61% are located in the municipality of Mulegé. Most of the 27 agricultural companies that operate in the REBIVI's buffer zone and in the subzone of sustainable use of natural resources rent land to ejidos.[1] In general, those firms operate with greenhouses or some type of protected agriculture. Production conditions related to favorable climate, soil (López Méndez et al. 2013), and sanitary conditions, as well as closeness to the United States' market, among other factors, make this type of production highly cost-efficient. It is also cost-efficient because the limiting resource, water, is relatively inexpensive.

Almost all El Vizcaíno agricultural valley surface is devoted to horticulture, with the exception of 288 ha that are destined for the cultivation of fig trees in Ejido Díaz Ordaz. Fig production is exported almost entirely to Hong Kong and Korea. The yield of fig trees begins to show a downward trend (GBCS 2016a, b). Agriculture in the municipality of Mulegé is highly industrialized, leading to a profitability of approximately 500 thousand pesos per hectare (or seven times more than any other agricultural region in the state). This high value of agricultural production places Mulegé, and consequently REBIVI, as the second most important agricultural region in the state with 23.8% or 50 million dollars in the 2013–2014 agricultural cycle.

For the 2014–2015 agricultural cycle, the most important production in the municipality and in REBIVI was vegetables, followed by organic vegetables and fruits, the latter with a higher value per volume produced. Of vegetables, the most important products are tomatoes, which contribute 91.94% and 85.25% of that section in the 2014 and 2015 cycles, respectively, and chilis with 7.98% and 13.81%, in each case (GBCS 2016b). However, BCS has experienced examples of water overexploitation from agriculture in other regions (such as the Santo Domingo

[1] Ejido is a form of land tenure in Mexico that combines communal ownership with individual use. Changes to the ejido system in the early 1990s allowed the privatization and sale of ejido land under the argument this would address problems related to the lack of productivity and farmer impoverishment; yet, with some exceptions and despite their great productive potential, ejido members face increasing challenges related to low investment, clientelism, poverty, and migration, among others. For an updated ejido situation in Mexico, see Morett-Sánchez and Cosío-Ruiz (2017).

valley), and the abovementioned level and patterns of production place heavy stress on water availability and quality in REBIVI, a concern shared by local communities in coastal and valley areas.

According to the most recent data (2015), the municipality of Mulegé comprises 43% of the state surface and a population barely above 67,000 inhabitants (or 8.7% of the state's total). This translates to a density of 2.1 inhabitants per square kilometer, which is lower than the state's average density (10 in./km^2) and far from the national average (61 in./km^2). Five localities hold most of the population: Guerrero Negro, Santa Rosalía (site to the municipality's political powers), Villa A.A.A. Arámburo (or Vizcaíno), H. Mulegé, and Bahía Tortugas. The average level of education in the municipality of Mulegé is 7.9 years, the lowest in the state. In addition, although the municipality is ranked with a low level of marginalization at the national level, it has the highest in the state: nearly 30% of people who are 15 or older have not completed primary education; 32% lived in overcrowded households; and 34% did not earn enough to escape poverty (GBCS 2015).

Most localities are isolated among themselves and also in relation to La Paz, the state capital, which is 780 km away from Guerrero Negro (the population center that borders to the north with the state of Baja California). The long and deserted transpeninsular highway, which ends in the Mexico-United States border, connects the Mulegé's most populated towns and cities, but dirt roads are the only means to access the most remote areas. Although this inhibits human interactions, it also favors ecosystem conservation—except in those areas where water overexploitation and scarcity have become an issue.

Employment in agricultural activities is not included in the economic censuses although its importance in demographic and social terms is recognized; this contrasts with fisheries, whose level of occupation is relatively even as shown by the low number of inhabitants in REBIVI's coastal areas. The growth of agricultural activities has spurred new population centers composed of migrant communities, especially from the states of Baja California, Oaxaca, Sinaloa, Guerrero, and Veracruz. In this way, about a quarter of population in Mulegé is settled in eminently agricultural communities (Ibid: 7).

When using greenhouses, the most productive season is extended up to 8 months. The number of employed persons (day laborers) varies, thus fostering a floating population of large proportions. Baja California Sur's migrant agricultural population, which is drawn from mostly indigenous communities in southern Mexico, was estimated at approximately 25,000 in 2015. These workers receive no labor benefits. Twenty percent were subcontracted by intermediaries who charge the employer a daily quota for each worker, while 80% were workers who lived almost permanently in the camps owned by agro-export companies. Approximately half of those migrant day laborers were located in Mulegé (BCS Noticias 2014; UABCS 2015). Considering that marginalization and poverty greatly exacerbate human vulnerability and ecosystem deterioration, the need for more sustainable models of production is evident in REBIVI.

18.3.1 Threats to the Primary Sector of the Economy in REBIVI Due to Climate Change

Fishing is highly relevant for the coastal communities in REBIVI. In spite of the relatively low number of inhabitants, these communities greatly contribute to the economy of Mulegé. Changes in temperature and ocean acidification have modified fish and marine resource populations, thus altering patterns of production in BCS (Ivanova and Gámez 2012). Particularly along the Pacific coast, revenues from exporting highly priced products (and a more entrepreneurial approach) have resulted in the development of highly qualified people who have the skills to monitor not just marine conditions but also markets and processes related to pursuing economic alternatives and business opportunities.

However, as in relation to agriculture, the fishing community is heterogeneous, and even those members that are economically advanced face environmental, social, and economic challenges. Some fishing cooperatives in REBIVI have developed means to adapt to the changing environment and have started aquaculture initiatives so they are not entirely dependent on climate variations. In other cases, such as in Punta Abreojos and La Bocana, a timid but informed incursion in tourism is underway. Reconversion to or income complementation with whale watching tourism—as in Laguna Ojo de Liebre and Laguna San Ignacio—has meant an improvement in many locals' conditions, as developed below, since whale populations are abundant (Urbán et al. 2010). However, sea level rise and storms endanger households, along with fishing and social infrastructure. This makes it imperative to develop ways to cope with extreme events and reduce risks associated to climate change.

Many of the extensions identified as areas of sustainable use of natural resources are located in the central part of the peninsula. Being away from the coasts, those areas would not be so exposed to the effects of sea level rise. However, there will be impacts to agriculture due to other climate change effects, such as droughts and rainfall pattern variations. In addition, in the agricultural colonies located in the Reserve, social, health, and human rights conditions are deficient (Sánchez 2014; Molina 2011), which increase the vulnerability of social groups such as day laborers, on whom agricultural production is based. These aspects can be aggravated without an adequate prevention that includes comprehensive multidisciplinary programs.

Activities that entirely depend on water, such as agriculture, are among the most vulnerable to climate variations (Magaña et al. 2012). In a scenario of climate change, one of the possible effects in arid regions is that droughts last longer. Temperature increase in Mexico's arid regions can cause the availability of water to decrease up to 30% due to a higher evapotranspiration, a condition that would lead to a large part of the vegetation to a state of hydric stress. In most of the Reserve, an increase of less than 1 °C is forecast in the coming years. However, from 2045 to 2069, temperatures are expected to rise throughout the region (RCP 4.5) and higher than 4 °C in a RCP 8.5 scenario in some of the agricultural production areas (the central plains, to the west of Marasal and Ejido G. Díaz Ordaz), as well as in the entire eastern part of the sierra. In general, a decrease in rainfall is

expected throughout the region, especially in the central plains, which will become more arid (Ivanova 2017).

Under these conditions, increasing crop areas in REBIVI would create a complex situation, even if the availability of water remains stable. Mexican legislation established an extraction limit of 250 million cubic meters or mm^3 per well, equivalent to the irrigation of 100 ha; in Vizcaíno, the extraction was 60 L per second or 60 ha of irrigation. However, water scarcity conditions led to the establishment of an extraction limit of 175 million cubic meters for irrigation, which gave way to high-tech irrigation to maintain the same cultivated area. Currently, the agricultural areas of Mulegé have an extraction of 75 mm3 of drip irrigation that covers an area of 120 ha (Ivanova 2017).

As in the case of BCS, REBIVI is a natural greenhouse that offers unbeatable conditions for the production of vegetables. This includes soil conditions that result in high-quality cultivated products, high demand from foreign—especially American—markets, the consequent availability to and from the foreign investment, climatic conditions that offer stability with respect to temperature variations, and a geographic location that favors the absence of pests (López Méndez et al. 2013). The current high price of vegetables in the international market does not suggest the need for productive reconversion, at least not in the short term, so that the exacerbation of climate conditions will imply a greater demand for this resource. Another likely threat in this scenario is the higher incidence of pests. In recent times only small areas of agricultural production have been affected, but this situation could vary due to the effects of climate change (SAGARPA 2016).

Indirectly, social phenomena such as migration, marginalization, and gender inequality will undoubtedly increase in a climate change scenario and will probably have negative effects on local communities. In addition to the threat from climate change, stress on economic activities will likely result in the displacement, deportation, and relocation of migrants that can undoubtedly cause greater pressures for conservation, particularly in a climate change scenario. Women day laborers, in spite of harvesting just like men, generally have lower incomes and other family and social responsibilities and roles, since under conditions of marginalization, it is usually their responsibility to carry water, prepare food, and take care of their children and work cleaning (Sánchez 2014). All of the above activities require water and, faced with the threat of less availability of this vital liquid, will undoubtedly suffer more severely the effects of various phenomena.

18.4 Community Perceptions Toward Climate Change in El Vizcaíno Biosphere Reserve

There was no precise definition in the workshops by the participants regarding priority sites for conservation in REBIVI although, in general, concern for flora and wild fauna was expressed. In Guerrero Negro, attendees showed awareness about the existence of cave painting conservation initiatives, but this was primary in

relation to a sense that the benefits of this conservation were not distributed sufficiently. Potential for exploitation of palm trees (*Washingtonia robusta*) is recognized. Regarding priority species for conservation, the peninsular pronghorn was highlighted, much to the appreciation of those who participated in the workshop, because it does not receive sufficient support in comparison with livestock and agriculture.

In Guerrero Negro, the most important activity is open-pit salt mining and services. However, due to the proximity to the town of Vizcaíno, where there is an extensive agro-export activity, there is a marked recognition of the environmental problems that this type of agriculture represents in a desert region such as REBIVI. Most of the families have their personal crops for family consumption, but they recognize the importance of integrating the communities' needs in the hydraulic works. They also attached importance to the effective regulation of sanitary conditions to prevent the introduction of pests that result from improper production practices.

During the discussion, participants in the workshop highlighted their interest in learning more about the effects and remediation measures in a climate change context, as well as access to technological improvements and changing crop patterns. The incidence of extreme temperatures is a cause of affliction, because crops are lost with frost, and more water is lost due to having to replant them. In this sense, it is worth noting open manifestations regarding timely and reliable information availability on climate and water quality, as well as developing research with a view to other types of crops and/or products with greater added value. The elements of definition and prioritization of adaptation measures in the workshop were, in order of importance, the scarcity and poor quality of water, the appearance of pests, drought, and extreme temperatures. As in Vizcaíno-San Francisco de la Sierra, technological improvement, training, and climate information were prominent elements as adaptation measures, but greater emphasis was placed on the need for producers to be better organized to jointly promote the water saving, as well as access to credits.

In Vizcaíno, the workshop was held with residents of Vizcaíno and San Francisco de la Sierra. The comments varied by the influence of the origin of the participants: agricultural those of the first and ranchers those of the second site. Considering that the planting in the Vizcaíno area comes from the extraction of the aquifers, the lack of rain or the greater heat automatically implies a greater use of water. Thus, the elements of greatest impact were the appearance of pests and diseases, drought, increased solar radiation, and frost. Interestingly, the presence of rains during the hurricane season (summer-fall) causes concern because they produce erosion and are a vector for diseases. One element to point out is that sprinkler irrigation is in place and workshop participants stressed the need to improve irrigation systems to make better use of water.

The town of Vizcaíno depends on the promotion of extensive agriculture for export to the United States; the largest proportion of agricultural activity in the Reserve is concentrated in that area. This type of agriculture has promoted very rapid economic growth due to the presence of agro-export companies in Vizcaíno,

subsidiaries of parent companies based in states such as Baja California and Sinaloa, which have a high level of investment by foreigners. The sowing periods are, on the one hand, from January to June and, on the other, from August to December. These agricultural cycles determine the flows of the population, to the extent that there is a contingent of laborers from other states of the country that is employed in agriculture. Thus, the population is made up of inhabitants who have been settled there for a few decades, by a large floating population and by a more recent wave of people who settle on the site more permanently. The population increase linked to agricultural growth causes environmental problems due to the lack of drainage and proper handling of rubbish, since there are no adequate sites for the management of the population's waste, nor of the residues of the agricultural fields (plastics, fertilizers, etc.).

Day laborers have a significant economic impact in the area. When harvest season arrives, the sales of local businesses increase significantly. On the other hand, in terms of income, the ranchers earn between 8 and 10 thousand pesos a month in total, which, after expenses, are reduced to about 4 thousand; they do not have a close relationship with agro-export companies. Meanwhile, ejido members receive a more stable and higher income (10 thousand pesos per month) from Exportadora de Sal, S.A., the salt mining company. A prominent element noted in the workshop was the absence of social and economic conditions for young people to return or stay in Vizcaíno and surrounding areas. Additionally, although groups from different cultural origins shape Vizcaíno, social programs to promote cultural awareness and understanding are scarce, and attachment to the community is not encouraged.

Other issues in REBIVI relate to bad grazing practices in open fields, which are worsened by droughts, produce erosion, and lead to social disputes. Workshop participants argued that if regulations were correctly applied, those problems would be avoided. Due to extreme temperatures (heat and frost), export producers make use of more pesticides, but this means not complying with export-related regulations and increased losses (sunburn and frost damage agricultural production and make sales in the US market unviable). Growers complained that the absence of rain increased pests that attack crops, which became food sites given the scarcity of native vegetation. Also, since REVIBI is a protected area, regulations prevent locals from harvesting palm tree leaves in ravine areas that could be sold for thatching and could help prevent vegetation fires; thus, without a proper management program, reforestation programs were questioned.

One element that was highlighted was the need for the authorities to train people regarding what they can do and how to do it within REBIVI. Because of their lack of knowledge, people misuse resources or simply sell their rights to land and water. Although the issue is not directly related to the effects of climate change, the progressive sale of water rights to agro-exporting companies by farmers—in the absence of other economic opportunities and a lack of a long-term vision—is a general concern. This leads to their impoverishment and, on the environmental side, to erosion, water scarcity, and soil pollution as the agricultural frontier and production volumes are expanded.

Regarding the combined EbA and CbA approach applied during the field study and consulting, a combination of activities was prioritized by REBIVI community members, as follows:

- Promote livelihood resilience (productive activities diversification):
  - Develop ecotourism activities that could generate income for the community, while protecting biodiversity.
  - Promote aquaculture or seek new fishery resources.
  - Use hardier seed varieties and high-tech irrigation.
- Conserve or restore coastal wetlands, mangrove forests, and/or woodlands.
- Take a holistic approach to watershed management.
- Employ "natural solutions" to reduce hazards (e.g., protecting or restoring mangroves to reduce the risk of sea level rise and coast erosion).
- Minimize disaster risks and, thus, the impact of hazards, particularly on the most vulnerable groups and individuals.
- Strengthen local civil society and government institutions' capacities so that they can more effectively support communities and individual adaptation efforts.

Lastly, with the participation of local actors and decision-makers, on July 14, 2017, REBIVI's Scientific Subcommittee on Climate Change and Exotic Species prioritized and validated the actions agreed upon in the seven community workshops. This included consideration of issues such as the identification of monitoring strategies, conservation objectives, gender inclusion, and equity and women's empowerment. The final conclusion was that inclusive mechanisms of education, training, and access to better technologies could generate productive and economic conditions. Such changes could lead to greater access to training and the development of skills to improve general standards of living, as well as the empowerment of women through their inclusion in productive work and in making decisions about their own future.

As seen, EbA and CbA projects embrace activities that are both community- and ecosystem-focused. These commonalities are most apparent when they are put into practice. The following case studies illustrate some of the benefits of the combined appliance of EbA and CbA approach to adaptation and resilience building. These alternative activities, which have already been developed, enhance both livelihoods and ecosystem functionality in REBIVI and match results from the workshops. Ecosystem conservation and social welfare in REBIVI would undoubtedly benefit from developing more eco-friendly economic alternatives, increasing knowledge on climate change issues, and strengthening institutional and legal capacities to facilitate the implementation and monitoring of adaptation actions.

18.5 Economic Diversification as Adaptation and Biodiversity Conservation

As mentioned before, three experiences of economic exploitation of biodiversity are provided in this section: whale watching, mangrove reforestation, and bighorn sheep hunting. All of them are led by communities in REBIVI, thus setting examples of how conservation can be central to community adaptation and welfare.

18.5.1 Gray Whales

Laguna Ojo de Liebre (LOL) is located in the central part of the Baja California peninsula, in the Pacific Ocean. UNESCO inscribed LOL on the World Heritage list in 1993, and it is the breeding area for the gray whale (*Eschrichtius robustus*), which every year travels 9000 kilometers from the Bering and Chukchi seas in the Arctic to the coasts of the peninsula of Baja California. Among gray whale populations in the world, this one remains the healthiest and most abundant (Urbán et al. 2010) and can be closely observed and is friendly with humans. Ecotourism at Ejido Benito Juarez in LOL and by small and medium enterprises in Laguna San Ignacio (Fig. 18.1) has contributed to raising the living standards of the local population and has promoted environmental protection and minimum impact practices, in addition to providing environmental education to its visitors (Valle Padilla and Cariño Olvera 2010).

Fig. 18.1 Gray whale watching in Laguna Ojo de Liebre (Ekaterine Ramírez 2012)

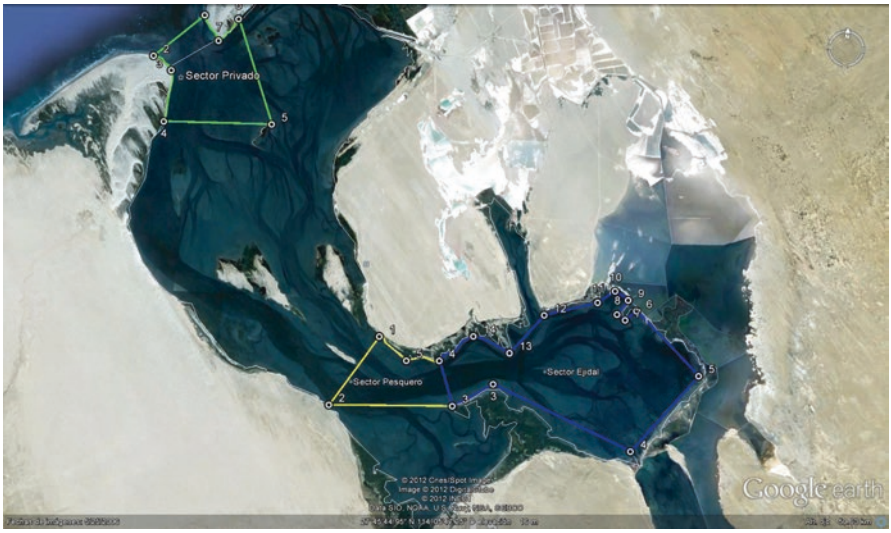

Fig. 18.2 Delimitation of Ejido Benito Juárez' gray whale watching area in LOL (in blue). (Adapted from Google-INEGI 2012)

Gray whale watching zones in LOL are pursued by private enterprises, fishing cooperatives, and ejido member sectors. The latter come from Ejido Benito Juárez, which is located 3 km off the federal highway by asphalt road and 17 km from Guerrero Negro city. Approximately 50 families live in Ejido Benito Juárez; their quality of life is good and income is enough to cover their needs. Agriculture used to be the main economic activity, and most families still have backyard gardens with fruit trees, vegetables, and magueys for their own consumption. In the past 12 years, they began to supplement their income mainly with gray whale tourism in LOL (Fig. 18.2).

Over time, this activity became their main source of income, enhancing not only their standard of living but also the ecosystem's conservation and the adaptation to climate change.[2] This has only been possible through collaboration and coordination in public, private, and social sectors, as well as cross-sectoral support and international cooperation. Moreover, as one community member stated: "to preserve biodiversity in the Reserve, support from the people who live in it is obviously needed." [3]

Ejido Benito Juárez is relatively new, and its members went through a peculiar process to become a community ecotourism company. The colonization in the Vizcaíno valley goes back to the end of the 1960s when, by presidential decree and

[2] Ekaterine Ramirez-Ivanova's personal communication with Noé Alcalá Giménez and Emma Velázquez Alcalá by Ekaterine Ramírez-Ivanova, Centro de visitantes/Casa de la Ballena Mexicana, Laguna Ojo de Liebre, Guerrero Negro, Baja California Sur, February 12, 2012.

[3] Antonina Ivanova's personal communication with Celerino Montes, Taller Participativo Comunitario del proyecto "Programa de Adaptación al Cambio Climático de la REBIVI," Guerrero Negro, January 3, 2017.

according to agrarian reform legislation, land was made available to people from other regions in Mexico.[4] Settlers from Guanajuato, Jalisco, and Zacatecas founded Ejido Benito Juárez in 1971. Coming from a purely agricultural tradition, they found themselves in arid lands; ever since, water scarcity and climate change impacts have increased their agricultural activities' vulnerability.

REBIVI's Management Plan (INE-SEMARNAT 2000) explicitly regulates the priority local communities have in developing ecotourism. Although UNESCO lists LOL as a World Heritage Site, sustainable economic activities can be developed in REBIVI's buffer zone since 1988 (Ramírez et al. 2015). Therefore, during the whale-breeding season, all human activity is prohibited in the lagoons except for whale watching (ecotourism) and research activities (INE-SEMARNAT 2000).

Federal government institutions were crucial to devise conservation mechanisms and community participation. REBIVI officials helped promote ecotourism through meetings with community members to make them aware of the advantages of gray whale watching. Local inhabitants were not interested at first, but after several attempts they became convinced of the benefits of whale watching to increase their income.[5] Ecotourism also became a business opportunity for some private companies located in Guerrero Negro. Nowadays, both REBIVI officials and ejido residents deem this as an economically profitable activity, which meets the sustainability objectives emphasized by the management program of REBIVI and is a valuable tool for climate change adaptation.

18.5.2 Mangrove Recovery in Campo Delgadito

Campo Delgadito is located in the southern part of Laguna San Ignacio, in the longitude 113.059167 and latitude 26.608056. This REBIVI community is an example of conservation of some of the mangroves found further north in the Mexican Pacific. The inhabitants there are dedicated to traditional fishing, organized under cooperative ownership. There are three fishing production cooperatives (*Sociedades Cooperativas de Producción Pesquera*): Cooperativa Cadejé, September 19, and Mujeres del Delgadito. The first two are dedicated to the extraction of scales, ax callus, Pismo clam, and lobster.

Mangroves are of great importance for climate change adaptation and mitigation. They are trees or shrubs that develop in the intertidal (the area where waves break at high and low tides) and provide many environmental services (SEMARNAT 2012; Wildcoast 2014, 2016a). This ecosystem protects the coast from erosion by limiting the impact of sea level rise and is also a carbon sink that absorbs almost three times more carbon dioxide than green forests.

[4] Ekaterine Ramírez-Ivanova's personal communication with Irma González López and Celerino Montes, Dirección de la Reserva de la Biósfera El Vizcaíno, Guerrero Negro, BCS, February 10, 2012.

[5] Ekaterine Ramírez-Ivanova's personal communication with Irma González López and Celerino Montes, Dirección de la Reserva de la Biósfera El Vizcaíno, Guerrero Negro, BCS, February 10, 2012.

Fig. 18.3 Climate change effects on mangroves, Campo Delgadito (Antonina Ivanova 2017)

As fisheries are affected by changes in climate, overexploitation of resources, pollution, and bad practices, mangroves of Laguna San Ignacio are considered key to conservation and the locals' economy and food security (CONANP 2016). Mangroves play an important role in keeping water free of pollutants and reducing pressures from high temperatures (Wildcoast 2016b), and inhabitants of Campo Delgadito recognize that mangroves protect their community from hurricanes, storms, and floods. Fishermen get most of their products from the open sea, but they acknowledge that mangroves play an important role as food banks and protection sites for the species they capture: without mangroves fishing would not be possible, since mangroves protect both fish and shellfish.[6] However, in recent years, mangroves have been adversely affected by climate change (Bautista González 2014): In Campo Delgadito, a high mortality of white mangrove has recently been noted (Fig. 18.3), due to the proliferation of some species of algae that surrounds its roots and dries them.[7]

David Borbón and his family (see Fig. 18.4) have dedicated themselves to reforesting red mangroves by planting propagules (see Fig. 18.5) under natural conditions (without the use of greenhouses). The activity has been successful insofar as for the last 3 years, the area has been repopulated with 30,000 new plants and 10,000 more propagules were introduced during 2017. Also, a group of young people and women in the community permanently participate in cleaning new plants (Montaño

[6] Antonina Ivanova's personal communication with David Borbón Ramírez, Campo Delgadito, Laguna Ojo de Liebre, BCS, September 24, 2017.

[7] Antonina Ivanova's personal communication with David Borbón Ramírez, Campo Delgadito, Laguna Ojo de Liebre, BCS, September 24, 2017.

Fig. 18.4 David Borbón and his family, Campo Delgadito (Antonina Ivanova 2017)

Fig. 18.5 Growing mangrove propagules in Campo Delgadito (Antonina Ivanova 2017)

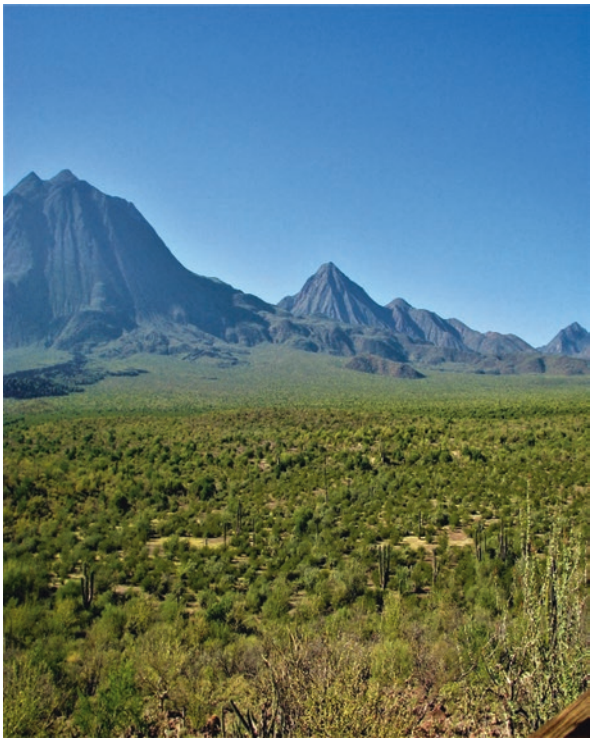

Fig. 18.6 Volcán de las Tres Vírgenes (Eduardo Juárez 2017)

2017), as well as in the monitoring and surveillance them; children have been invited to observe and engage in those activities. Thus, environmental education has been promoted at the community level, based on mangrove reforestation.

To further strengthen this activity, the Borbón family seeks to learn more about mangroves, strengthening ties between El Delgadito's community and research institutions. This unprecedented initiative could be strengthened by further support from government and civil society organizations and be disseminated as a successful example of community-based conservation of natural resources and environmental education.

18.5.3 Bighorn Sheep: Management Units for Wildlife Conservation at Ejido Bonfil

Another emblematic example of resource management in REBIVI is bighorn sheep (*Ovis canadensis weemsi*) hunting. The Official Mexican Standard (NOM) 059-ECOL-1994 considers this species as subject to special protection, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) includes it in Appendix II. The largest distribution of bighorn sheep

within the Reserve is located in 217,000 out of the 519,000 ha that make up Nuevo Centro de Población Ejidal Lic. Alfredo V. Bonfil (NCPE Bonfil), particularly in the area of Volcán de las Tres Vírgenes (Fig. 18.6) and the Reform sierra (INE-SEMARNAT 2000).

In 1995, NCPE Bonfil's community began the bighorn sheep hunting program from a Unit for the Conservation, Management and Sustainable Use of Wildlife (UMA Bonfil). The purpose was to build a mechanism that would allow, on the one hand, the generation of economic resources to improve the living conditions of the local population and, on the other, the development of self-sustaining practices in the long term. To this end, they implemented three measures based on the recognition that the future of cynegetic activity depends on better conservation practices. The first is monitoring and surveillance that involves REBIVI's staff and local inhabitants; the second is expressed in the habitat and wild sheep population management program; and the third integrates environmental education, both for UMA Bonfil administrators and hunters.

18.5.3.1 Resource Management and the Logistics of Hunting

The cynegetic activity begins with a helicopter monitoring NCPE Bonfil hunting zone every 3 years to determine the 8–9-year-old male population; this is deemed as old, since the average life of a sheep is 10 years.[8] Then, the Secretary of Environment and Natural Resources and the National Commission for the Knowledge and Use of Biodiversity issue the number of permits for the season. Authorized permits are offered at auctions usually held in the United States (Las Vegas and Sacramento). After the sale and reception of logistical information, staff from UMA Bonfil picks the hunters up at an agreed location, usually the airport of Loreto, BCS. From that moment, all costs are absorbed by the UMA administration.[9] UMA Bonfil also provides support for the migration process and firearm registration. Once the administrative requirements are completed, hunters are taken to the camp, where comfortable cabins and a restaurant with regional meals are provided. The hunter has 10 days to get his/her prize. Even if the objective has not been achieved, she/he loses the right granted by the permit and must buy a new permit at a future auction.

Hunting rates are very high. The expedition consists of approximately 12 people (backpackers, interpreter, guides, and cook), and on average a hunter gets his prey in 4 days. After locating the prey, the hunter is informed about the approximate score it has, which depends on the antlers taking's size (length and thickness). This aspect is key to the hunter because the higher the score, the better the piece's value. In addition, better-quality hunting pieces imply that future permit prices may

[8] Eduardo Juárez' personal communication with Zootechnical Engineer Carlos Enrique Zambrano Romero, head of special projects of Ejido Alfredo V. Bonfil, Baja California Sur, on October 23, 2017, at Tres Vírgenes UMA.

[9] Eduardo Juárez' personal communication with Francisco Javier Romero Juárez, sheep hunter and guide of Tres Vírgenes UMA, on November 22, 2017.

increase. The hunter is only interested in antlers and skins, which are later shipped abroad after basic treatment (salted leather). Since 1996 an average of four permits has been granted per season, which has generated about 3.5 million dollars during the 22-year length of the hunting program. At that time, there was an overall population of 100, and most recent census estimates (2014) count over 250 individuals. This has allowed the inhabitants of NCPE Bonfil to internalize a new way of understanding conservation and the use of their surrounding resources.

18.5.3.2 Conservation and Hunting

This resource management model has made bighorn cattle numbers rise and has generated resources to improve the economic conditions of community members. All the income obtained from the sale of the permits is invested in the community; once the operating expenses of the project have been deducted, 50% is used for conservation, and the remaining money to improve local social conditions. A trust manages the economic resources generated by the program, and all financial decisions are taken in the plenary session of a technical committee, formed by federal, state, municipal, and ejido authorities.

However, as in similar cases (Paterniti 2017), controversy surrounds trophy hunting. On the one hand, it is argued that hunting goes against the basic principles of conservation but, on the other hand, that it allows conservation of the general conditions of the ecosystem, strengthens the inhabitants' interrelationships and trophic networks, guarantees the conservation of bighorn sheep, and provides services for the survival of other species. In addition, community members argue that UMA Bonfil's surveillance keeps unregulated poachers away; additionally, given the economic benefits of hunting, cattle owners voluntary removed their flock from the areas of contact with bighorn sheep, avoiding competition for food and disease transmission.

Bighorn sheep hunting has been practiced in UMA Bonfil over the course of 22 years, while the wild population has remained balance (Fig. 18.7). So, it seems that conservation and trophy hunting can coexist, insofar as the financial resources generated from the hunting activity have improved this and other species' habitat, as well as the general living conditions of local inhabitants.

However, and despite this, there are areas of opportunity not yet explored:

- The discussion about hunting could be solved with the participation of conservation organizations that could pay for permits, but without actually going through with the actual hunting. This would avoid or at least reduce the cynegetic activity, favoring an ecological balance.
- The frequent conflicts of consanguinity of the species in small herds without contact with other populations could be solved with the professionalization of UMA Bonfil's members in bighorn sheep management and biology: (a) creating a sperm bank and exchanging semen with other centers, temporarily confining the females and performing artificial insemination with the exchanged semen,

Fig. 18.7 Bighorn sheep hunting visiting center in UMA Bonfil (Eduardo Juárez 2017)

and (b) expanding the population census not only to locate suitable males, but to have information on the juveniles and their development.

- The local community could diversify its economic activities still using the bighorn sheep, through the generation of products that could raise the level of knowledge on this species and, in general, on environmental education. One source of financing could be international foundations interested in the conservation of biodiversity and development of audiovisual and printed materials, for instance.

18.6 Conclusions

From January to April 2017, seven communities were included in a study to analyze their member's perceptions on climate change, community adaptation mechanisms, and how these factors affect conservation in the Mexican natural protected area Reserva de la Biosfera El Vizcaíno-REBIVI. The workshops included REBIVI's staff as well as government officials and representatives from social organizations. Five of those communities are on the state's mainland, Guerrero Negro, Vizcaíno, San Francisco de la Sierra, Santa Rosalía, and Ejido Alfredo V. Bonfil, where agriculture or livestock are the main economic activities. Two of these communities are placed on the coast, Bahía Abreojos and Bahía Asunción, and both are fishing communities. Economic activities in REBIVI are mainly agriculture, fisheries, open-air salt mining, and services related to attending the small urban populations in the

area. Whale watching, cave painting tourism, and hunting have become a source of economic diversification for some communities, although they are still incipient in the area.

Agricultural activity in REBIVI is heterogeneous. On the one hand, intensive, industrialized export agriculture is performed in the Vizcaíno valley based on foreign investment and migrant laborers; this export targets the United States as the market for the fruits and vegetables harvested in REBIVI. A second segment, mostly formed by Alfredo V. Bonfil ejido members, exports dates and figs. Finally, backyard agriculture mainly for self-consumption predominates in the mountain areas. Regarding livestock, the production of cattle for milk and meat is marketed locally or is a means of subsistence for the population of small ranches distributed along the Reserve.

The concentration of agricultural activities in the Vizcaíno valley and Ejido V. Bonfil, as well as the dispersion of livestock activities in the mountain area in the context of the wide geographical extension of REBIVI, complicates efforts to determine rates of vulnerability in and for the Reserve. Thus, although the adverse effects of climate events, such as droughts and hurricanes, are common throughout REBIVI and make all producers vulnerable, the geographical position of the towns and productive activities makes a difference with respect to the degree of their impact; this is also influenced by the level of income and the real capacities of these populations to prevent or recover from such effects. Thus, climate change exacerbates vulnerabilities already present. For example, it can affect income as is the case of mountain rancher, or, alternatively, it can impact health as with the case of agricultural day laborers, who face extreme events in disadvantageous conditions.

Hurricanes, drought, pests and diseases, and extreme temperature (heat, frost) are the main sources of vulnerabilities and impacts based on the information from the workshops. In a region with high water stress, drought stands out as an element of vulnerability that affects the yields of intensive agricultural activity. However, considering that aquifers are the source and current production rhythms are not hindered, uncertainty (and vulnerability) is more general to all of the population of the Reserve given water shortage, as are the effects of this type of agriculture on the conditions and health of soil, air, and human and wildlife in REBIVI.

Regarding adaptation measures, better infrastructure and technology, research and training, and organization and awareness of production practices were advanced. Among the actions with most potential are the following: less conversion of forests to agriculture, the development of highly efficient agricultural practices, the selection of more specific crops for arid conditions, and a more efficient use of water. All are important aspects to consider in REBIVI to improve agricultural practices in a framework of environment conservation and to guarantee production and suitable living conditions for the local population in the long term.

In this sense, interinstitutional work is key. Currently, information that would be useful for making progress on challenging issues is dispersed in institutions and government agencies. It would be highly relevant to improve regulatory schemes based on (1) responsible public policy, (2) the participation of specialists from academic institutions, and (3) the development of an agricultural culture that includes

technical elements in production and research on the social and economic dimension of agriculture. In this regard, there is a clear need to develop and promote more information to aid better government and individual decision-making, as well as to enforce existing regulations. Also, although most of the Mulegé municipality population lives inside REBIVI, the lack of knowledge about the ecosystem and value of this protected area was notorious. This makes it important to channel resources to REBIVI's staff to make their conservation programs known in the region.

Adaptation was the focus of the workshops, but mitigation measures in REVIBI to cope with the expected threats of climate change were also devised and included the application of more advanced technology to reduce greenhouse gas emissions, agrochemicals, and waste from agriculture; protection against erosion; integrated management and fire control practices; diseases and pests outbreak controls; and improvement of production practices. Conditions must be sought to stop the increase of agricultural land, based on the fact that the limiting factor is water supply, which in principle is not expected to increase. Soil maintenance and recovery, and reforestation activities to prevent the advance of agricultural borders, were proposed as well.

The wide territory covered by REBIVI and its low human population density make this protected area a valuable case study in terms of its potential for ecosystem conservation and bettering its inhabitants' quality of life. Workshops showed awareness of the problems communities face and some possible solutions to accomplish those goals. In that sense, successful examples of economic diversification as adaptation through a responsible exploitation of biodiversity have been pursued, and, yet, even those positive experiences face important challenges. This means that both human welfare and conservation need to be placed in the wider context in which economic growth models are put forward. It is also imperative to consider the vulnerability and heterogeneous capabilities community members have in order to better adapt to climate change and strengthen their capacities for action.

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