Climate action plan for the city of La Paz, Baja California Sur, Mexico: a tool for sustainability

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Abstract

As a result of its coastal location and severe water scarcity condition, the city of La Paz, Baja California Sur, Mexico, is extremely vulnerable to the impacts of climate change. The purpose of this paper is to present the main findings of the Climate Change Action Plan for the City of La Paz and Neighbouring Areas (PACCLAP): first, the vulnerability to climate change and the adaptation measures suggested; and second, the local greenhouse gas emissions inventory and the recommended mitigation measures. In this study the methodology specified in UNEP (2008) was applied, Methodology for Assessment: GEO Cities. Manual for Application, Version 3; UNEP (2009), Training Manual on Vulnerability and Adaptation to Climate Change for Geo Cities, UN-Habitat (2010), Planning for Climate Change: A Resource Guide for Urban Planners and UNEP (2011) IEA Training Manual, Climate Change Vulnerability and Impact Assessment in Cities. The greenhouse gas emissions inventory (LGHGEI) was carried out following the revised 1996 Intergovernmental Panel on Climate Change's guidelines for greenhouse gas inventories (IPCC, 1997a; IPCC, 1997b; IPCC, 1997c). The main results show that the water scarcity is the principal vulnerability for the city, followed by the sea level rise; and that the transport sector must be the priority in the mitigation strategy. The proposed climate actions (e.g. catch of surface water in dams, reduce leakage losses in the water system; efficient fuel use; and, emissions mitigation trough grid connected systems) are directly related to the Municipality Development Plan, thus making the PACCLAP a valuable instrument to support current and future decision makers in the formulation of public policies to foster the sustainability and improve the wellbeing of the local society.
Keywords: climate action, adaptation, mitigation, sustainability, Mexico.

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1 Introduction

The Climate Action Plan for the city of La Paz originates as a complementary study to the Emerging and Sustainable Cities Initiative (ESCI) of the Inter-American Development Bank in which the city of La Paz, Mexico takes part. The ESCI seeks to help participating cities to identify the main challenges and the actions of short and medium term that allow guide their development towards greater sustainability. One of these challenges is the climate change in the first place, since the city is a main source of greenhouse gas emissions, which inventory allows to outline the actions to their mitigation, and, in the second place, due to the vulnerability to climate impacts on the key economic sectors and society of the city of La Paz (temperature variation, change of the coastline, saline intrusion into groundwater aquifers, hydro-meteorological hazards, severity and redistribution of rainfall and drought, streambeds change, desertification, reduced availability of water for human and productive use, impacts on human, animal and plant health).

2 Context of La Paz city

La Paz city is the capital of BCS and is the seat of the municipality with the same name. The municipality has a population of 253,077 inhabitants and the 93.6% is concentrated in the towns along the coast. To the city of La Paz and surrounding areas the coasts of the Sea of Cortez are of great importance for the development, given that the activities that support the local people include maritime trade, fishing, tourism and services. However, agricultural activities are also developed in the valleys [1, 2].

The city concentrates most of the government agencies, educational institutions and health centers in the state of Baja California Sur. From 1950 to 2010 the population of La Paz has steadily increased on average 4.5% annually [3], which shows a community in motion by migration but also represents a challenge to achieve planning urban growth that promotes sustainable development.

The rapid population growth has led to a change in the city environment due primarily to the generation of waste, growth of the vehicle pool and deforestation [4]. Likewise, poor urban planning has caused several pollution problems and increased greenhouse gas emissions (GEI).

The boundaries of the study area of this Plan of Action on Climate Change are shown in the map in Figure 1. Surrounding areas were included because of their influence on economic and social life of the city, as are particularly relevant in sectors such as transport and farming and fishing activities.

In the context of this study, the city is considered as an "urban ecosystem" [1, 5, 6]. It is studied from the perspective of natural resources management, and includes, therefore, surrounding areas that have a relation of mutual dependence with the city. The characteristics of the city of La Paz are the following: desert climate, coastal area, semi-arid zone, medium economic potential (most of the economic growth is on account of services, while the development of industry and agriculture is facing the strong constraint of water scarcity), high social development, medium size and medium population growth rate (4.5% annual).

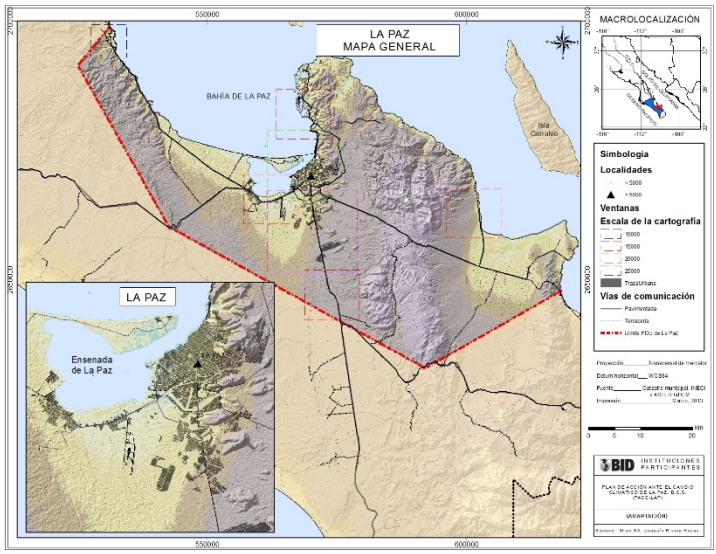

Figure 1: Map of La Paz city and surrounding areas: area of study.

3 Research process and results

The research was conducted in two main modules: adaptation and mitigation, to cover the most important aspects for the city of La Paz related to the climate change. The components developed along the process were the following: 1) Vulnerability and adaptation; 2) Mitigation.

In this study was applied, in a general manner, the methodology specified in UNEP [5–7] and UN-Habitat [8].

The methodology assumes that sustainable development creates new demands regarding the impact assessment and structuring of response measures. In this regard, it is considered of importance: recognize the interaction between environmental conditions and human activities; take into account gender and intergenerational equity; promote the participation of the inhabitants of La Paz in decision-making.

3.1 Vulnerability and adaptation

3.1.1 Current situation and impacts of climate change on the environment and social welfare in La Paz

The extreme vulnerability of the city of La Paz resulting from its geographic location and specific conditions, with main real and potential impacts of climate change, is recognized in the plan. By threatening water resources, causing stronger cyclones and floods, accelerating desertification, and negatively impacting biodiversity and marine and terrestrial natural populations, global warming increases the costs to maintain levels of comfort and security that allow

undertaking productive activities and everyday life. These impacts have negative consequences on society and economy of the city: productive activities such as tourism, services, fishery and agriculture have to spend an increasing portion of its budget to counteract them; while other sectors such as livestock face higher production costs due to the lack of fodder because of water stress. Meanwhile, the population is affected by increased electricity costs, greater risks to public health and in extreme cases; and the local government faces greater pressure on its functions of attention to the inhabitants and economic sectors.

It should be noted that water stress is the greatest vulnerability for the city of La Paz. Nowadays the total amount of groundwater concession exceeds the sum of the water that is recharged annually to the two main aquifers of the study area (La Paz y Los Planes). The overexploitation of the aquifer of La Paz is recognized since the 1970s [9, 10], and the demand is increasing two times in the next 23 years due to population growth. The water consumption analysis in relation to temperature changes indicates that daily consumption rises 5.4 liters per person per each degree centigrade over the maximum temperature [11].

Besides this threat, climate study shows potential increases in average sea temperature of about 1°C in the medium term as well as the extension of the summer (average temperatures of 27°C) to the months of October and November [4, 12]. These phenomena will foster the intensification of cyclones and, in addition, its season could be extended, as it occurs during El Niño phenomenon, and generate more natural disasters [13]. The rise in sea level, according to data reported in this study between 5.4–17.7 cm minimum and maximum respectively in 2030, and between 9–29.5 cm in 2050; is added and interacts with the magnitude of the storm surge, which may influence toward increasing these dimensions. The effects of this interaction in the long term will be of consideration for the city of La Paz and its surrounding areas, where the vulnerability index is high and the return period of hurricanes is small. This is because of the location of the poorest and most vulnerable populations, critical infrastructure [14] and main economic activities.

A deforestation rate of 1,939 hectares of sarcocaule scrub, 7.57 hectares of mangroves and 11 hectares of vegetation in marshes and coastal dunes, was estimated for the period 2005–2012, increasing the degree of unsustainability [15]. Deforestation in the region of La Paz has been caused primarily by the development of agricultural activities and residential uses.

In agriculture, the increase in temperature and decrease in rainfall [16] will result immediately in increased water demand for each crop because of greater levels of evapotranspiration and soil salinization. Similarly, the increase in water demand would imply a higher energy cost. Moreover, in times of drought yields of some crops may decrease [17], for example, 14% in corn and 9% in sorghum. Also in periods of abnormal rainfall affectations of crops can be expected: 23% in corn and 15% in sorghum.

Tertiary activities generate the greatest contribution to the State GDP, representing 69.50% in 2009 [18]. By itself, the trade sector represents the sector with the greatest contribution to State GDP, with 19.1%. Slightly less than a half of the employed population is employed in the retail trade sector, construction,

hotels and restaurants. Climate change may affect some of the commercial establishments located in areas at risk of flooding because of a rise in sea level and streambeds change due to higher rainfall. Also disruption of roads by heavy floods can affect the flow of supplies for a harmonious functioning of the trade sector.

In La Paz there are 347 establishments directly or indirectly devoted to tourism [19]. From 2008 to 2012 there was an average of 20,762 tourist arrivals. From the total of tourists received in La Paz 79% are national, while the remaining 21% are foreigners [20]. It is of importance to mention the influx of foreigners for full or part time residence, as well as the construction of marinas [21]. Tourism is the economic activity that although it belongs to the tertiary sector is highly vulnerable to climate impacts. This activity can be affected by the increase in average temperatures, which would make little attractive to tourists a greater period of the year (low season). On the other hand, some beaches could be affected by the rise in average sea levels.

3.1.2 Adaptation responses

To face the growing water scarcity there are a lot of technical methods to increase the supply, three of which have greater importance for the area of study: desalinization, reuse of treated wastewater and surface water catch in dams and reservoirs. These three alternative sources currently increase the supply of natural water in only about 20%. In this connection, the following may be anticipated: (a) the reuse of treated wastewater is not a viable option for a substantial increase in water due to its relatively low volume and, in addition, most of this resource is already given in concession for irrigation; (b) due to their high costs, desalination of brackish or salt water cannot replace the deficit expected in the near future; (c) the catch of surface water in dams, reservoirs or infiltration ponds represents the most viable option for La Paz, because of cost and efficiency; (d) for the city of La Paz there is also great potential for saving water by reducing leakage losses in the water system and through a more efficient consumption.

It is important to limit by legal means the human use of soil, water and vegetation, and animal resources present in areas of high diversity and high susceptibility to climate change.

It is also essential to promote actions and campaigns to minimize loss of vegetation cover in the region, working together the various levels of government, civil society organizations, media and schools. The disappearance of woody vegetation and scrub not only modifies the composition of the resident animals communities, but local biogeochemical cycles, altering soil water retention and the recycling of nutrients essential for the functioning of ecosystems.

It will be necessary to promote adaptability of agricultural crops, seeking transformation towards those that are more resistant to sudden temperature changes, have a short life period, demand less water volume and are more profitable.

In the fisheries sector is relevant to open formal programs supported by scientific and technological information, which can diversify or change the capture of target species through the replacement of some existing procedures of artisanal commercial fishing, as well as investing municipal and private enterprise

resources to carry out monitoring of the levels of catch and effort conducted in capturing sports-worthy fish species.

It is important to plan for future tourism development projects taking into account the average elevation of sea level and the potential flood areas because of high rainfall in hurricane season, as well as to plan the construction of new health and education institutions in areas not threatened by sea-level rise. The Urban Development Plan (UDP) must take into account, related to the growth of the city, the possible involvement of deforestation and affectation of groundwater recharge areas.

3.2 Mitigation

As a first step to formulate recommendations aimed at reducing the greenhouse gas emissions (GHGE) of the study area, an inventory was carried out for years 2005 through to 2010. On this basis, the emissions in a business-as-usual (BUA) scenario for GHGE were calculated covering a period up to year 2030. This scenario provided a reference baseline to compare the effects of the GHGE mitigation recommendations. The results obtained in this process are presented next.

3.2.1 Inventory and baseline

The local greenhouse gas emissions inventory was carried out following the revised 1996 Intergovernmental Panel on Climate Change's guidelines for greenhouse gas inventories [22–24]. These guidelines cover six categories: Energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, and waste.

In the estimation of the city's emissions, the best resolution data available were used (state, municipal, local). For cases where available data did not correspond to the city itself, proxy indicators were calculated to enable an estimation of the actual city data.

The results of the inventory show that the emissions are dominated by the Energy category with more than 90% of the combined total.

The 2030 baseline under the BAU scenario was generated considering the official population growth projections from CONAPO (Mexico's National Population Council) for the whole state. This assumed a scenario where emissions increase proportionally to population growth only. Likewise, it was assumed that the city's population growth is proportional to the state's population. With this in mind, the emissions baseline was estimated using a per capita emissions factor resulting from averaging the per capita emissions for years 2005–2010. The baseline obtained is presented in Figure 2.

3.2.2 Mitigation recommendations

The largest share of emissions for La Paz and surrounding areas corresponds first, to transport, and second, to electricity generation. It was then these categories that mitigation recommendations were primarily focused on.

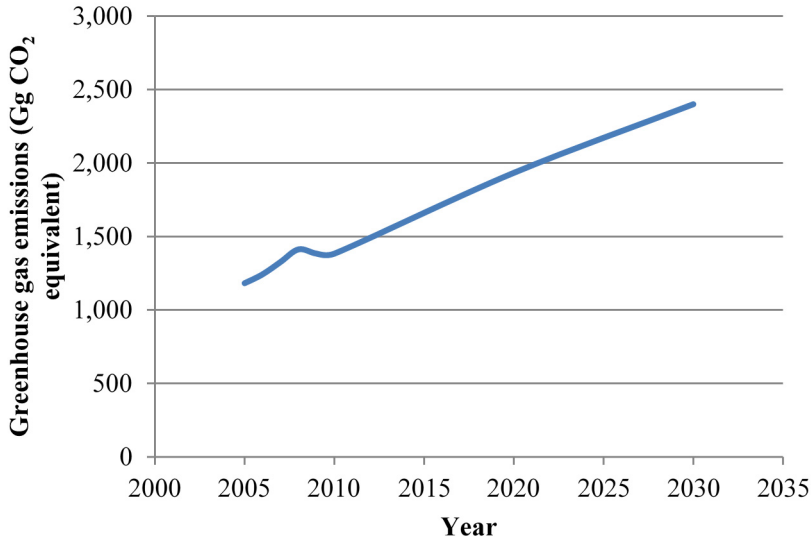

Figure 2: Greenhouse gas emissions baseline to 2030.

3.2.2.1 Transport As of 2010, transport infrastructure in the municipality of La Paz comprised 1,704 km of highways and roads, 1,019 km of which are actually paved or have some kind of seal. There are also three mayor ports and one of the three international airports in the state.

Regarding the vehicle fleet, BCS is the state with the largest number of motor vehicles per person in Mexico. This number has grown rapidly in the last decade and for 2008 this number equalled 78 vehicles per 100 inhabitants, considerably higher than the national mean of 26.5 vehicles for 100 inhabitant [25]. It is not surprising then that between 2005 and 2010 approximately 75% of transport fuels consumed in the state correspond to gasoline and diesel fuel. This impacts on the state's and local transport emissions, which are dominated by these two fuels.

Japan has shown a clear improvement [26, p. 124]. A fleet renovation program to achieve fuel efficiency improvements similar to those found in the countries mentioned above (1.2% annual improvement) could have an important effect on terrestrial transport GHGE (gasoline and diesel fuel accounted for 79% of transport GHGE during 2010). This program should not only consider old-for-new replacements but also provide incentives to replace internal combustion engine vehicles with different technologies such as plug-in hybrids and electric ones, especially in light of the large local potential for renewable electricity generation. If the program started in 2015, a 20% emissions reduction from terrestrial transport could be achieved by 2030.

However, in this proposal it is of utter importance not to overlook the great ease that prevails in the region to purchase and import into Mexico second hand vehicles coming from the United States without undergoing a proper road worthiness inspection that guarantees good environmental and mechanical

performance of the vehicles entering the country. Consequently, if implemented, this program should be very carefully devised so as to avoid substitution of current vehicles with others in similar conditions. It seems therefore necessary to find a suitable procedure that ties up the vehicle fleet renovation with fuel efficiency goals and controls as well as with operation condition of the replacement vehicles. This may require reforms to the actual Transport Law to enforce a strict mechanical, road worthiness and vehicle emissions inspection for people to maintain their vehicle registration and be allowed to circulate on the roads, especially for imported, second hand vehicles.

Local culture also plays a very important role in the use of motor vehicles, particularly regarding private vehicles and the (low) use of public transport. In this area, environmental education and direct work with people can have large contributions to change current local transport paradigms and, in turn, translate into GHGE reductions.

In addition, the development of new residential areas located along the city's access roads (radial growth) increases transport distances and encourages the use of private motor vehicles. This also results in higher emissions. An alternative urban growth model could also aid in the reduction of transport GHGE.

Finally, one more option to reduce local transport emissions (with the associated benefits for public health and life quality in general) is the use of alternative ways of transport like cycling or walking.

3.2.2.2 Electricity Electricity generation in LAPSA had the second largest emissions volume after transport with an average of 0.89 kg CO_2 equivalent per kWh of electricity consumed (average for 2005–2010). This factor is significantly above the national average for 2010 (0.58 kg CO_2 equivalent per kWh [27, p. 271]. The high emission factors found locally are explained by the fuels used in electricity generation, heavy fuel oil no. 6 (bunker fuel) and diesel oil, which result in greater emissions than other fuels (e.g. natural gas, low-sulphur diesel fuel) or non-combustion generation technologies used elsewhere in the country (hydro, geothermal, nuclear).

Amongst the options to mitigate the electricity generation GHGE in La Paz three categories can be identified: improve the efficiency of the technology currently in use to achieve a lower carbon intensity of the electricity generated; introduce other fossil-fuel-based generation technologies with cleaner fuels than those currently in use; and introduce generation technologies based on renewable energy that do not result in GHGE during operation.

Regarding the first category, the combined average efficiency of all power stations in BCS (mostly internal combustion engines and steam turbines) for 2010 was estimated at 38%. Given the technologies used, significant efficiency improvements are not viable.

Regarding the second category, combined cycle gas turbines could significantly improve generation efficiency. These plants have efficiencies in the range of 55%, which would undoubtedly contribute to reduce the electricity generation emissions due to both, using a cleaner fuel and a more efficient process. However, natural gas is not currently available in the state nor is there any

infrastructure in place to handle it. Present plans and program [28] consider starting generation with natural gas in the mid-term future. Likewise, an electrical connection with the rest of the country (the state grid is at present isolated from the national grid) is also under consideration. However, both these options are very capital intensive and their results regarding GHGE reductions would be available in the mid and long-term future.

From the GHGE mitigation standpoint in the short term, an option with higher potential to achieve significant reductions is through the generation based on clean, local and renewable energy sources. For La Paz, solar energy has the largest potential.

4 Final remarks

Due to its geographical location and coastal and arid conditions, the city of La Paz, Baja California Sur is extremely vulnerable to the adverse effects of global climate change on the use of natural resources, as well as on their productive activity and social and economic dynamics. Among the main potential impacts of climate change in the state are included the warming that threatens water resources and generates damage associated with coastal flooding; the presence of stronger cyclones; change in the course of streams; the loss of vegetation and soils leading to accelerated desertification; adverse impacts on biodiversity; negative impact in major economic sectors (fishery, tourism and agriculture); and increasing human vulnerability (disadvantaged social groups, employment, housing and health).

Nevertheless, the city of La Paz has great potential to enhance its sustainability, reduce its vulnerability and improve the welfare of the population. Evidence of this are the advances in conservation actions, high public awareness and the existence of specialized human capital.

It is very important to note that both, mitigation and adaptation actions, have significant side effects directly related to the sustainable development of the city: to establish effective policies for the management of scarce water resources; to improve public transport (routes and vehicle fleet); to protect vulnerable groups (because of their geographical location as well as because of their economic activities); to ensure a continued development in changing conditions of the main economic activities (fisheries and tourism), as well as to reduce dependence on these highly vulnerable to climate variability activities; to optimize the human, animal and plant health, among others.

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