

Mitigating carbon emissions in urban developments: Study case in Mexico

Corona, R.* and Mendoza, A.

Procesos y Sistemas de Información en Geomática, SA de CV.

<http://www.sigeomatica.com/>

+52 (55) 53980333, email: rogeliocoronan@yahoo.com.mx

Abstract

Currently the carbon emission mitigation action plans are challenged by different aspects. On the one hand, there is energy consumption based on existing knowledge with respect to producing, reducing and finding new technological alternatives. On the other hand, there is the need to reconcile different political, economic, technological, social and environmental aspects. No to mention that in developing countries there is a lack of money and information, which makes a real challenge in the implementation of carbon mitigation projects. Taking these factors into account, the Mexican government through FONATUR has taken the first step by promoting the mitigation of carbon emissions in a denominated Megaproject Costa Pacífico in Sinaloa. Our study proved to be a good alternative in developing countries for estimating carbon emissions base line in mega-projects, mitigating it by local carbon sequestration, and projected them under different economic investment scenarios to distinguish the best alternative to improve mitigation to climate change under a constraints on the flow of investment.

I. Introduction

There is a plethora of scientific evidence that suggests that the climate is changing due to human activities which modify directly the concentration of the greenhouse gases (GHG) in the atmosphere. The global increases in CO₂ concentration are due principally to fossil fuel use and land use/cover change (LUCC), while those of methane and nitrous oxide are primarily due to agriculture. (IPCC, 2001). Not only are LUCC related to changes of forests to agricultural lands, but also to changes to urban areas. Under this context, the construction sector is responsible of 30–40% of global GHG emissions (Van Bodegom et al., 2009). Energy supply and transport sectors have increased their GHG emissions, since 1970, by more than 145% and 120%, respectively. Moreover, GHG emissions of LUCC and forestry have augmented by close to 40%, while the residential/commercial sector have shown an increase with values of 26% and 27%, respectively (Rogner et al., 2007). It is relevant to notice that, tourism is one of the world's fastest growing industries which has complex impacts on socio-ecological systems (Maksin & Milijić, 2010). It is important to notice that those impacts are intricate because they depend on different strategies of implementation and management of tourism's projects that could contribute to mitigate to climate change and promote the development of socio-ecological systems. Moreover, according to Zanetti and Casagrande (2009) there is an important subsector (residential) which can generate some of the greatest energy savings in the construction process and development related to tourism. These savings are of great interest, if we consider that it is expected that global energy use and supply will continue growing, and more than 80% of it would be based on fossil fuels (Van Bodegom et al., 2009).

During the last decade, Mexico had suffered an ongoing transformation of the tourist planning. Concepts such as energy saving, mitigation by using increasing carbon stocks are being incorporated from the early stages of planning just in recent years. Moreover, integration of the spatial dimension of biophysical and socio-economic characteristics, which are recognized as an important key of tourism projects, were not really taken into account. Under this perspective, in our research isolation of buildings and shade effects of construction and structures, local wind direction, micro-topography, vegetation distribution and canopy have been considered as basic properties for promoting the reduction of energy consumption and the mitigation of carbon emissions. Furthermore, we recognize that at this scale it can be promoted physical integrity (local environmental conditions, and maintain high quality landscapes), preserve and increase forest carbon stocks and local biodiversity. For these reasons, the main objective of our research is to show how all of these approaches and data can be joined for promoting an urban sustainable development in a developing country mega project.

Based on what was mentioned before, the Mexican Federal Government through the National Fund for the Development of Tourism (FONATUR; Fondo Nacional de Fomento al Turismo) has taken the challenge to promote the first attempt in Mexico to promote an urban development where carbon emissions and stocks were estimated for promoting not only social and economic development but also for promoting the mitigation to climate change and bioconservation of local native species. The project was denominated Integral Planned Center (IPC) Costa Pacífico in Sinaloa State. This IPC is a mega-project which compasses different land uses like: residential, commercial and tourist under a sustainable development planning. The IPC aims to provide housing to 95,000 people, of which nearly 40% are tourists and the rest are local inhabitants. It covers nearly 2,400 ha and it is extended over 12 km of coastal plain.

II. Methods

Study area

The climate is semiwarm and subhumid with an annual average temperature in between 24° and 25°C with a maximum of 36° to 40°C and a minimum of 8° to 12°C. The average precipitation is between 800 to 1,000 mm which is concentrated in summer. The natural vegetation covers just 10% of the total area (9% with tropical dry forest (TDF) and 1% of mangrove), 11% of secondary TDF and 79% of introduced vegetation (30% palm tree land, 11% shrubland and 49% grassland).

II.1 Energetic carbon emissions reduction

To enable impact assessments and informed decisions, the estimation of a baseline approach was necessary. Firstly, it was indispensable to evaluate the development master plan (number of rooms per land use, buildings heights, spatial distribution, etc). Under the assumption of the use of dirty technology, non bioclimatic designs and full occupancy, the energetic consumption base line was estimated for each land use. Secondly, the responsible elements of the major energetic consumption were identified. Thirdly, different available technologies and bioclimatic designs were evaluated in order to select the most plausible and economically accessible for promoting reduction of energy consumption. Subsequently, projections of energy consumption on equivalents of CO₂ (CO_{2-e}) and carbon sequestration

were generated under three different economic investment scenarios. Finally, two other activities were evaluated (1) technologies for producing renewable energy according to site conditions and (2) the estimation of organic waste production for calculating the potential to generate biogas. For comparative purposes, all the data was transformed to CO_{2-e} per year.

II.2 Forest carbon stock

In June 2010 plots of (10m x 10m) were established and georeferenced (n=66). In each plot, the species were identified and the diameter at breast height (d.b.h.) was measured for each individual ≥ 1 cm. The diameter was used to estimate aboveground tree biomass through the use of allometric equations reported by Brown et al., (1989) for these species. Then, biomass was transformed to CO_{2-e}. Finally, to spatialize the carbon stocks satellite imagery and field samples were integrated by statistical modeling using R 2.15.1 (2012). By this procedure we were able to identify the forest patches with the most important carbon stocks. The master plan and carbon stock distribution were integrated in order to identify the most promissory spots for carbon stock conservation and compensation.

Even though it is recognized that planting trees in species-rich woodlands, thickets, savannas and grasslands can increase their carbon density, it has a great cost to biodiversity (Putz and Redford 2009 and 2010). Our approach was to promote reforestation not only to sequester carbon but also for contributing to biodiversity conservation based on a proper selection of vegetation species and densities by taking into account the characteristics of each site condition. From those approaches three different projections of ecological restorations were performed and carbon sequestration were estimated.

II.3 Complements

Different recommendations for saving fuel were done by promoting urban mobility on foot, bicycle and promote the usage of public transportation. Location of parking lots, sceneries views and green fines were evaluated as key tools for promoting the reduction of number and usage of cars, being the first attempt in Mexico to promote this kind of element in new urban developments.

III. Results and discussion

III.1 Energetic carbon emissions reduction

The base line showed a maximum consumption of non-renewable energy of 2,053 GWh per year (77.9 KWh per day in room hotels and 297.8 KWh per day in residencies). This consumption is mainly distributed in hotels in 90% for air conditioning, 4% for illumination and 5% for refrigerator. Residences for the same concepts are expected to spend 95%, 2% and 1%, respectively. Finally, road illumination is expected in 4.2 KWh per day. Under these estimations three different saving approaches were developed for saving energy (Table 1). It is important to notice that air conditioning is not only the one that show the major energy consumption, but also, it is the one that can save the most by applying different bioclimatic designs and energy efficiency systems.

Table 1. Estimation of saving energy in percentage based on three different economic investment scenarios per land use.

Consumption	Land use	Acceptable	Good	Optimum
Air conditioning	Residences	43.4	58.6	71.3
	Hotel	57.9	68.5	71.4
Refrigerator	Residences	3.6	4.2	4.8
	Hotel	4.2	4.8	5.4
Illumination	Residences	58.0	68.8	78.4
	Hotel	69.2	76.6	83.2
Others		1.8	2.1	2.4

The estimation of urban development organic waste was in between 0.5 to 0.8 Kg per person per day (30 to 46 GWh per year) can be produced. Based on this estimation, a biogas generation as a source of energy is a good alternative to reduce non renewable energy consumption. It means that if this quantity is transformed to the current price based on KWh cost, it is expected to save between 4 to 7 million dollars per year. Complementary to this, on roofs photovoltaic panels will be installed.

III.2 Forest carbon stock

In the nearly 2,000 ha of green areas available, it was estimated a reforestation with minimum of 1.4 trees per 100 m² which means a stock of carbon between 20 to 54 Gg C. Moreover, it is expected carbon storage of 1.5 GgC by considering green façades (40% in residences and 30% in hotels) and green roofs (50%).

III.3 Projections in terms of CO₂ emissions

In Figure 1 can be seen different projections of carbon emissions and carbon sequestration contrasted with the consumption base line estimated in terms of CO_{2-e}. The projections show an increase from the year 2012 to 2022 when is expected that the urban development will conclude, and keeping the energy consumption stable for the coming years. The carbon sequestered shows an exponential growth, because of the fast increment of the first stages. Taking this approach into account, it is possible to distinguish, in terms of cost-benefits, the best action plan for mitigating carbon emissions and technological investments. For example, applying the highest investment on forest and technology it can be expected that by the year 2030 the CO_{2-e} emissions can be compensated, while investing only on vegetation would take longer (2055-2060).

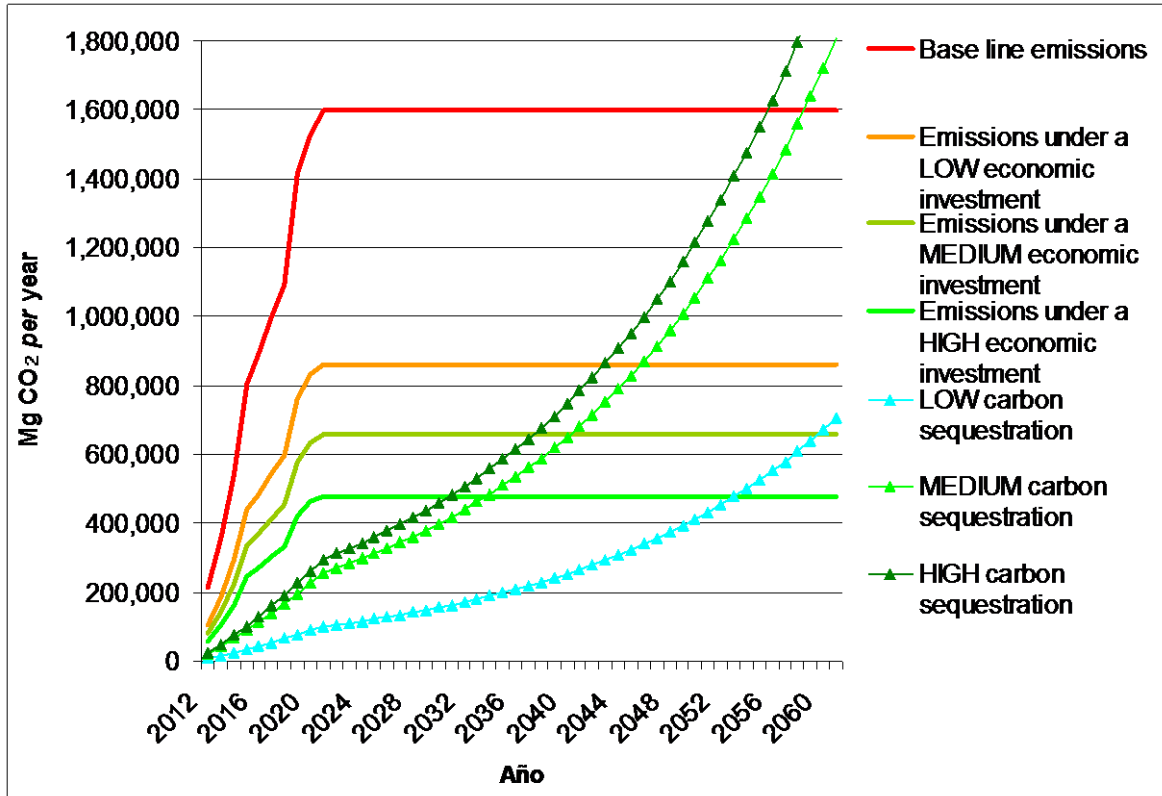


Figure 1. CO₂-e estimations of base line and under three different scenarios of energy consumption and carbon sequestered.

IV. Conclusion

This study shows the incorporation of biophysical and socio-ecological characteristics should be taken into consideration from the beginning of the projects planning. The incorporation of these factors can be positively influenced not only the economic development of communities but also the bioconservation and the mitigation to climate change. For instance, this study presents that nearly 50% of the energy can be saved by the implementation of bioclimatic designs and energy efficiency. Nearly, 30% of the energy can be obtained by renewable sources and the rest can be compensated by sequestering carbon on vegetation stocks. Based on our results, this approach proved to be a good way for future urban mega-developments planning under a perspective of climate change mitigation in developing countries. It is worth pointing out that the use of tools and the spatial analysis approach can create the best alternatives for landscape planning, by taking into account the main areas suitable for environmental and biodiversity conservation and for mitigation actions. In addition, it is relevant to notice that even though many technological advances in modeling in energy consumption at fine scales have been developed, those are expensive and difficult to escalate into mega-projects because of these reasons the approach showed in this study takes its value. As a final point, it should be said that fine scale analysis cannot substituted a coarse scale analysis. On the contrary, both approaches should be considered as complementary during different stages of the project, when the economic investment allows it.

V. References

- Bonino, E., **2005**. Changes in carbon pools associated with a land-use gradient in the Dry Chaco, Argentina. *Forest. Ecology and. Management*, 223: 183-189.
- Brown, S., Gillespie, A. y Lugo, A., **1989**. Biomass estimation methods for tropical forest with applications to forest inventory data. *Forest Science*. 34(4): 881-902.
- Dumanski, J., **2004**. Carbon sequestration, soil conservation, and the Kyoto Protocol: summary of implications. *Climatic Change*, 65: 255-261.
- Houghton, R., **1996**. Converting terrestrial ecosystem from sources to sinks of carbon. *Ambio*, 25: 267-272.
- IPCC (Intergovernmental Panel on Climate Change)., **2001**. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Technical Summary. WMO-UNEP. Cambridge: Cambridge University Press.
- Kauffman, J., & Uhl, C., **1990**. Interaction of anthropogenic activities, FIRE, and rain forests in the Amazon Basin. In Goldammer, J.G. (ed.); Fire in the tropical biota: ecosystem process and global challenges. Ecological Studies 84. Springer-Verlag, New York. Pp.117-133.
- Maksin M., Milijić S., **2010**. Strategic planning for sustainable spatial, landscape and tourism development in Serbia. *SPATIUM International Review* No. 23: 30-37.
- Nabuurs, G.J., O. Masera, K. Andrasko, P. Benitez-Ponce, R. Boer, M. Dutschke, E. Elsiddig, J. Ford-Robertson, P. Frumhoff, T. Karjalainen, O. Krankina, W.A. Kurz, M. Matsumoto, W. Oyhantcabal, N.H. Ravindranath, M.J. Sanz Sanchez, X. Zhang, **2007**. Forestry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Putz, F.E. and Redford, K.H., **2009**. Dangers of carbon-based conservation. *Global Environmental Change*, 19: 400–401.
- Putz, F.E. and K.H. Redford., **2010**. Tropical forest definitions, degradation, phase shifts and further transitions. *Biotropica* 42:1, 10-20.
- Rogner, H.-H., D. Zhou, R. Bradley. P. Crabbé, O. Edenhofer, B.Hare (Australia), L. Kuijpers, M. Yamaguchi., **2007**. Introduction. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Van Bodegom, Arend Jan, Herman Savenije and Marieke Wit (eds)., **2009**. *Forests and Climate Change: adaptation and mitigation*. Tropenbos International, Wageningen, The Netherlands. xvi + 160 pp.
- Zanetti E, y E. Casagrande., **2009**. Social housing in Curitiba, Paraná State, Brazil in Van Bodegom, Arend Jan, Herman Savenije and Marieke Wit (eds). *Forests and Climate Change: adaptation and mitigation*. Tropenbos International, Wageningen, The Netherlands. xvi + 160 pp.