

Call for submission on human settlements and adaptation

According to the Vancouver Declaration on Human Settlements, human settlements can be defined as the totality of the human community – whether city, town or village – with all the social, material, organizational, spiritual and cultural elements that sustain it.¹ During SBSTA 44, Parties highlighted that those making submissions should “bear in mind the unique challenges and scale differences in urban, rural and remote settlements, in particular in small island developing States and least developed countries.”² During SBSTA 46, Parties further underscored their interest in collecting information related to rural and coastal settlements, particularly remote settlements.³

We thank you in advance for filling out this template with concise, evidence-based information and for referencing all relevant sources. There are 5 sections in the template: please fill the sections that are relevant to the work of your government or organization. As you will see on the last page of the document, more detailed information on case studies, tools/methods and other knowledge resources for dissemination through the Adaptation Knowledge Portal is welcome, but optional.

Name of the organization or entity:

WayCarbon, prepared in partnership with the Municipality of Belo Horizonte.

Type of organization:

Please choose as appropriate:

- | | |
|---|---|
| <input checked="" type="checkbox"/> Local government/ municipal authority | <input type="checkbox"/> Regional center/network/initiative |
| <input type="checkbox"/> Intergovernmental organization (IGO) | <input type="checkbox"/> Research institution |
| <input type="checkbox"/> National/public entity | <input type="checkbox"/> UN and affiliated organization |
| <input type="checkbox"/> Non-governmental organization (NGO) | <input type="checkbox"/> University/education/training organization |
| <input checked="" type="checkbox"/> Private sector | |

Location

City: Belo Horizonte

Country: Brazil

Scale of operation:

- | | |
|---|--|
| <input type="checkbox"/> Global | <input type="checkbox"/> Regional |
| <input checked="" type="checkbox"/> Local | <input type="checkbox"/> Subregional |
| <input type="checkbox"/> National | <input type="checkbox"/> Transboundary |

City(ies)/Country(ies) of operation (if appropriate):

Belo Horizonte / Brazil

¹ See: <https://unhabitat.org/the-vancouver-declaration-on-human-settlements-from-the-report-of-habitat-united-nations-conference-on-human-settlements-vancouver-canada-31-may-to-11-june-1976/>

² FCCC/SBSTA/2016/2, paragraph 15(b)(ii).

³ FCCC/SBSTA/2017/L.7, paragraph 13.

1. Assessing sensitivity and vulnerability to climate change

Description of relevant activities/processes or research:

Please describe the activities or processes that your entity has implemented to assess sensitivity and/or vulnerability to climate change in human settlements. In case your organization carried out research on such activities/processes, please describe them.

Vulnerability Assessment to Climate Change in human settlements: a Case Study in Belo Horizonte, Brazil

Belo Horizonte is one of the major cities in Brazil and, as other cities in Latin America, it faces climate change-related challenges. In order to assist the city in the understanding and preparation for climate related impacts, WayCarbon worked in partnership with the municipality in the assessment of its climate vulnerability. In this context, following the implementation of Belo Horizonte's Policy for Climate Change Mitigation, Belo Horizonte City Hall developed, from July/2015 to June/2016, a study called "Assessment of the vulnerability to climate change of the municipality of Belo Horizonte", taking two scenarios into consideration: one for the year 2016 and another with projections for 2030 using downscaled climate models. The study looked at the following potential climate impacts, listed by the Municipal Secretariats, based on the relevance and frequency of historical climate-related events observed in the municipality: (i) floods; (ii) landslides; (iii) dengue fever and (iv) heat waves. As such, the study is a technical foundation for the development of the future Plan for Adaptation and Resilience of Belo Horizonte and is seen as the first step to its accomplishment. This assessment of climate change vulnerabilities offers strategic information for decision-making, supporting the mitigation of potential threats through the design of proactive measures, according to the specificities of the several regions of the city.

Description of relevant tools/methods:

Please describe the tools and/or methods that have been developed and/or used to assess sensitivity and/or vulnerability to climate change.

The goal of the study was to assess the vulnerability to climate change in the municipality of Belo Horizonte, considering the current scenario (2016) and climate projections for the year of 2030. The study follows the methodology delineated in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007). The Vulnerability Index encompasses available information on exposure to changes in climate, socio-environmental sensitivity to these changes, and the system's capability to deal with and adapt to new conditions.

The calculation of each index and the choice of the most appropriate variables to characterize them relied strongly on the local context of social, economic and bio-geographical attributes, on the availability of quality data, and on the priorities selected collaboratively by the Municipal Secretariat of Environment and other secretariats in Belo Horizonte City Hall.

The biggest challenges regarding climate change identified in Belo Horizonte are the impacts from landslides, floods, dengue fever and heat waves. All explanatory variables chosen to characterize the effects and the adaptation capacity were georeferenced and standardized to make them spatially comparable and aggregable in a weighted composite climate vulnerability index. The choice of weights for each variable was based on literature review and the results of model calibrations based on historical events.

Vulnerability for each potential impact (landslide, flood, dengue fever and heat waves) was calculated using the Model of Vulnerability Evaluation (MOVE). MOVE is an integrated computational platform that uses spatial and statistical analysis to assess vulnerabilities and risks associated with climate change, applicable to different areas into the public and private sectors, on multiple scales and under different

climate scenarios. This model was developed by WayCarbon under a research program⁴ funded by FINEP⁵, FAPEMIG⁶ and CNPq⁷.

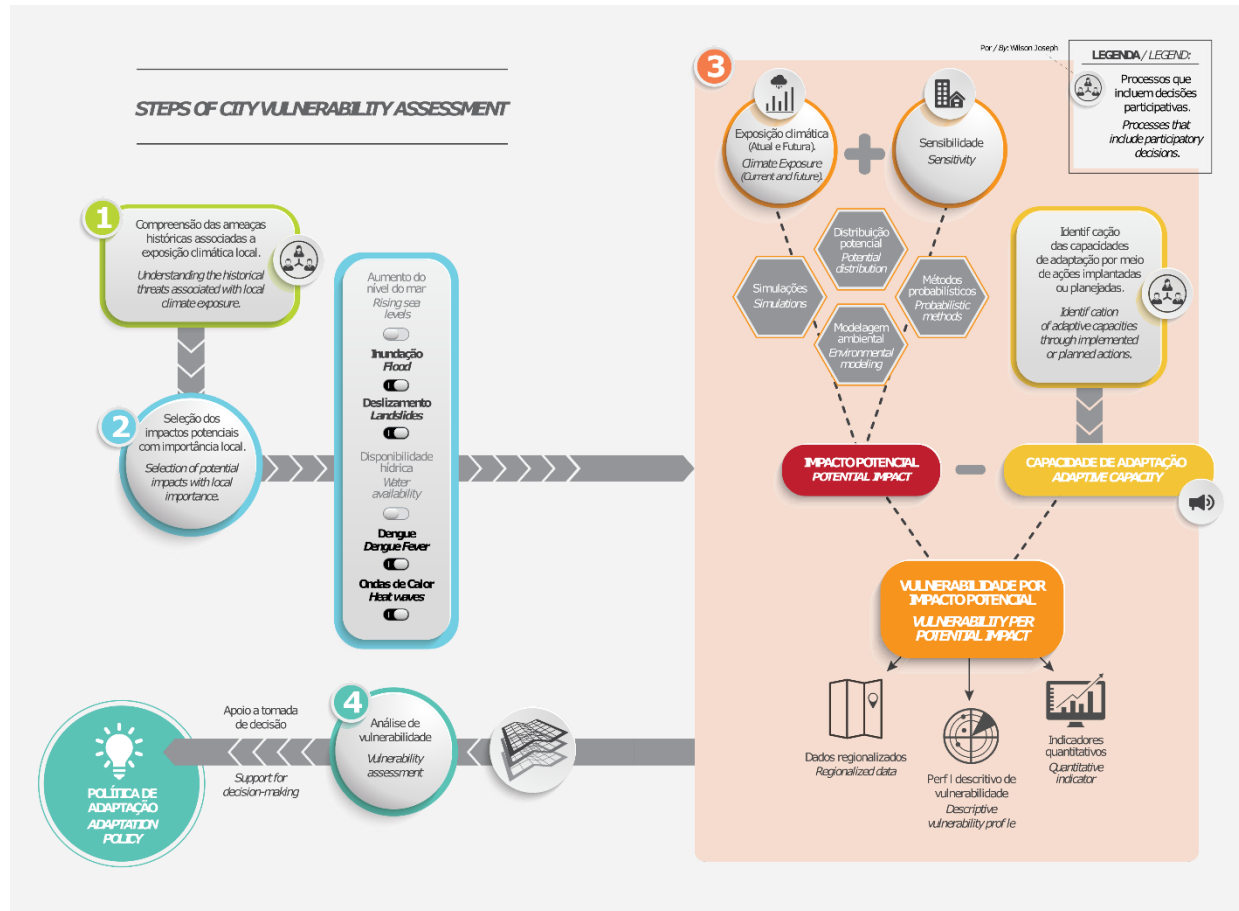


Figure 1. Steps of city vulnerability assessment.

A spatial approach is essential to identifying regions where the impacts of climate change are more relevant, creating vulnerability hotspots. These hotspots are considered priority areas and, thus, have their attributes analyzed with a greater level of detail. This greater level of detail allows for a better understanding of the causes of high vulnerability areas and offers answers to “how” and “where” to intervene with adaptive measures. Information generated by the study allows the breakdown of components of the Vulnerability Index, making it possible to understand the level of relevance of a specific impact. For instance, different locations may be subject to the same climate exposure, of the same nature, frequency and intensity. These locations may, as well, have similar biophysical sensitivity characteristics, with similar landscape and geology, but have different assets identified. The presence of assets at risk is what should direct the decision-making system toward an adaptive intervention. Therefore, under equivalent impact scenarios, it is necessary to evaluate the importance and relevance of what is at risk: people, cultural assets, infrastructure or industries.

To build each index, results of the most updated regional climate model, from the National Institute for Space Research (Model ETA-HadGEM2-ES - CPTEC-INPE) were used, on a 5 km scale. Emission scenario RCP 8.5, considered pessimistic, was chosen. RCP 8.5 takes into consideration the rapid increase in methane emissions and the strong dependence on fossil fuels, besides slow technological development

⁴ <http://www.finep.gov.br/apoio-e-financiamento-externa/programas-e-linhas/descentralizacao/tecnova>

⁵ <http://www.finep.gov.br/>

⁶ <http://www.fapemig.br/>

⁷ <http://cnpq.br/>

and no changes in policies to reduce GHG emissions. In this scenario, atmospheric concentrations of CO₂ are higher than 1000 ppm and the global average temperature increase is between 2.6°C and 4.8°C, by the end of the 21st century. Sensitivity and adaptive capacity data were selected according to specific input variables for each impact and made available by the City Hall. Results were aggregated for discussion based on 9 (nine) administrative city regions as follows: Barreiro, Center-South, East, Northeast, Northwest, West, Pampulha and Venda Nova.

Key outcomes of the activities undertaken:

Please provide information regarding the outcomes of the activities/processes described above, and do not hesitate to add qualitative assessment and/or quantitative data to substantiate the information.

The composite vulnerability index for Belo Horizonte was calculated through a weighted average of all the vulnerability indexes for each impact, namely: flood, landslide, dengue fever and heat waves. For a better understanding of the most vulnerable locations, hotspots with vulnerability indexes higher or equal to 0.58 were selected. This value represented, in the study, the areas with the highest indexes. It was possible to identify the most vulnerable areas of the municipality in which interventions shall be focused, giving support to decision-making.

Belo Horizonte is located in a region in which climate and the future consequences of climate change are divided into two broader areas: North and South. As such, there is an overall tendency for the Northern region to be more impacted by temperature increases than the Southern region, which enhances the probability of dengue fever and heat waves. The South area has a greater biophysic sensitivity to landslides due to its geological and geomorphological nature. Floods are distributed throughout the municipality with their intensity varying according to the characteristics of the river basins, and the intensity and frequency of rainfall. In this respect, Belo Horizonte has well defined areas that requires specific interventions as an answer to potential climate impacts. The North, Northwest and East regions are the ones with the highest vulnerability indexes, with the North experiencing the largest variation in climate vulnerability into the future projection (2030). ON the other hand, the Northwest region will observe the largest expansion of vulnerable areas, and an intensification of occurrence of all impacts. Finally, the Barreiro region will face the smallest increase in high vulnerability areas. In 2030, it is expected that the number of neighborhoods at high vulnerability will grow by 60% (sixty percent) totaling 331 (three hundred and thirty-one) neighborhoods out of the 486 (four hundred eighty-six) in the municipality. The Northwest, West and Northeast regions are the ones with the largest increases in number of vulnerable neighborhoods. It is worth mentioning that most neighborhoods in the North, Northwest and East regions have hotspots. The Barreiro region, although having few hotspots both in the current and the 2030 scenarios, will see a three-fold increase in the number of vulnerable neighborhoods. In the case of Belo Horizonte, the occurrence of climate change vulnerability hotspots in regions of highly social vulnerability is noticeable, as reflected in low incomes, inappropriate land use and precarious housing. Thus, the vulnerability identified in the analysis is representative of the low adaptive capacity of such regions, as they face more barriers in responding to pressures and potential damages. Broadly speaking, priority areas for allocating adaptive measures are the ones in or near to vilas and favelas, as shown in the list of the top 10 (ten) main vulnerability hotspots.

Climate models simulated for 2030 show that there will be, overall, an increase in exposure to floods across the municipality and that these events will tend to be more intense, with heavier and concentrated rainfall, and more likely to cause losses and damages. Increasing resilience in Belo Horizonte through improvements in infrastructure, warning systems and macro drainage works to reduce flooding is extremely important to reduce such vulnerability. The vulnerability analysis for landslides indicates that the phenomenon is influenced by different issues according to region. The area located on the border of the Quadrilátero Ferrífero (South of Belo Horizonte, Curral and Rola Moça Mountain Ranges) presents, generally speaking, a high vulnerability due to its declivity and geology. On the other hand, vulnerabilities observed for the North region are more influenced by a deficit of adaptive capacity, specially regarding

the low number of warning systems such as the Centers for Rainstorms Warning (Núcleos de Alerta de Chuvas - NAC). The North area of Belo Horizonte is more critical in terms of dengue fever vulnerability than the South area because of climate and socioeconomic characteristics. Humidity, an increase in the minimum temperature and the number of warm nights are the main climate factors encouraging the survival of the vector *Aedes aegypti* in the municipality. When analyzing dengue fever vulnerability proactive measures such as socio educative ones, campaigns to exterminate reservoirs and to monitor infected mosquitoes are recommended. Actions in response to epidemics must be reinforced, such as fighting the mosquito, expanding health infrastructure and improving protocols for diagnosis. Vulnerability related to heat waves is focused on regions in which the socioeconomic indicators are lower, especially in the North area of Belo Horizonte, where adaptive capacity, such as access to health centers and programs, is weaker.

Climate Change Vulnerability Assessment of Belo Horizonte

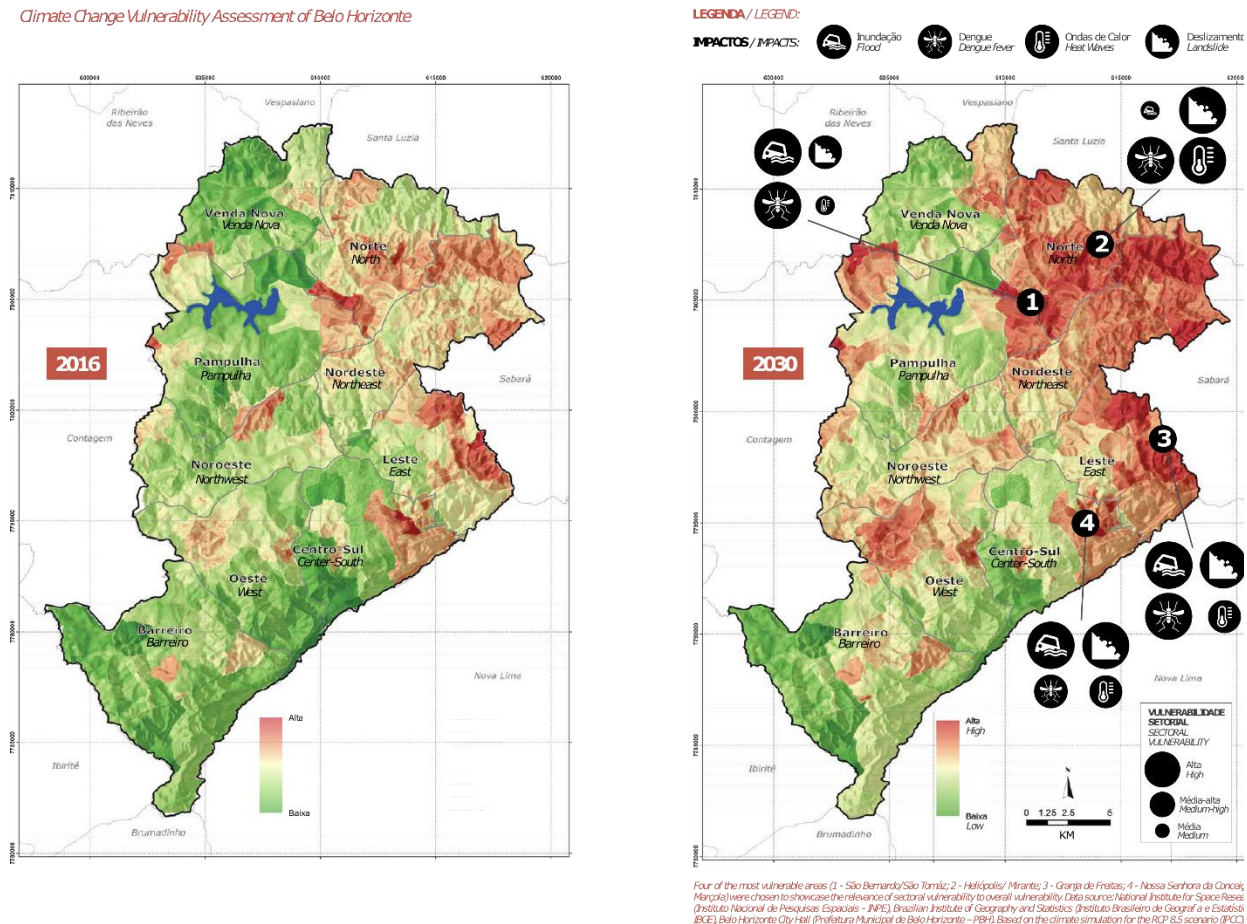


Figure 2. Climate change vulnerability assessment of Belo Horizonte.

Description of lessons learned and good practices identified:

Please consider the following points when describing lessons learned and good practices: (a) effectiveness/impacts of the activities/processes (including measurability of the impacts), (b) efficiency in the use of resources, (c) replicability (e.g. in different locations, at different scales), (d) sustainability (i.e. meeting the current economic, social and environmental needs without compromising the ability to address future needs).

In a scenario where there is restricted or no information about future climate impacts, spatially generated indicators for the city considering different sectors, and local environmental and socioeconomic

characteristics, are an effective tool to support public policies. Adaptive planning allows the adequate allocation of resources with low regret, bringing sustainable benefits in the present and at the same time increasing the resilience of the urban systems. Further, the analysis provide support to build momentum and foster a positive and proactive public policy agenda at local level, putting adaptation in the center of the debate. The methodology is based on the IPCC and is consolidated allowing replicability to other cities. The work was made possible by resources from the municipal environmental compensation fund, allowing the allocation of funds for a work that supports a more resilient and sustainable city.

Spatial assessment with maps contributes to the understanding of causes and effects that might be common to locations and brings the knowledge of similar characteristics that reinforce vulnerability. It is possible to find the same impact, caused by the same factors, in different locations. This allows the adoption of integrated and standardized action plans as a response to a particular diagnosis, as it is possible to identify and categorize regions that should be served by similar measures. The perception of spatially related vulnerabilities, marking pathways of impact, can be shown on the maps, highlighting the opportunity for regional action. The most common spaces for urban planning - neighborhoods and districts - are not the focus of action, which is now turned to river basins, watersheds and other spatial features that define areas of dispersion of a particular impact. In these cases, infrastructure and other adaptive measures must take into consideration the coverage of the impact, with a regionalized approach.

This study should be looked through the lens of prioritizing investments and building a Plan for Adaptation and Resilience. Choices in resource and effort allocation can be more assertive and well targeted if supported by a risk analysis. The risks of financial losses, such as assets, infrastructure and human life losses, can be indicators for guidelines for priority interventions and decision-making. The study leads to a line of actions that can positively impact the critical issues identified for the construction of resilient urban areas, and to support medium and long-term development plans of the city. However, for these actions to take place, they must encompass all relevant stakeholders and be continuously monitored by the government. It is necessary to develop efficient monitoring mechanisms for the future action plans, following performance and feeding back the decision-making process. Results shown here make it clear that the effort is not only for the municipal government. Synergies must be found through a collaboration of efforts from different levels of government, with companies and service providers that work in strategic areas like sewage and energy, the third sector and society. The vulnerability assessment of Belo Horizonte is a powerful tool for knowledge and reflection upon the future that can add to other planning tools already in place in the city. Turn it into an effective management tool, working for a resilient city, is the challenge shared by government and society alike.

The assessment pointed out well-defined areas where adaptation measures are needed. Proactive actions should be designed in line with the city mid and long-term planning in order to optimize the investment and decrease future losses and damages. The study pointed out that vulnerable areas often host low-income communities, characterized by low capacity of coping with climate change impacts. Usually, priority areas for adaptation measures are those inserted in shantytowns.

Description of key challenges identified:

Please describe the key challenges associated with those activities/processes or the use of those tools/methods, that policy-makers, practitioners and other relevant stakeholders interested in assessing sensitivity and vulnerability to climate change should know about.

Analyses of this kind are subjected to the participation and collaboration of stakeholders, and based on collaborative conversation with decision makers and technicians from the municipality, in order to deliver the best possible understanding of the scope of the study in the local context. One challenge faced by a study like this one is the availability and quality of input data. Frequently, the data exists but not in the ideal format for a spatial or time series analysis which would allow for better results. Some information might be in tables that do not allow the appropriate spatial allocation, or they might even present incomplete or inconsistent time series. Inefficiencies in collecting, storing and using data are one of the

limiting factors to vulnerability evaluations as a whole. To deal with this challenge, the Vulnerability study of the municipality of Belo Horizonte devoted great attention to the collection and treatment of data - a stage that lasted 6 (six) months. When data were not appropriate for the study, the second-best decision was to use less detailed but consistent and georeferenced data. The inclusion of a bottom up approach is necessary for a better understanding of society's needs, as well as access to relevant information of past impacts through a retrospective analysis.

Planned next steps (as appropriate):

Based on this experience or research, have next steps been planned to address/study some of the identified challenges, scale up or scale out such activities/processes?

- *Development of a Climate Change Adaptation Plan in a participatory manner, involving multiple sectors from society and taking into consideration the results from the vulnerability study;*
- *Alignment of the Climate Change Adaptation Plan with the Strategic Plan BH 2030, The New Master Plan and the Plan to Reduce Greenhouse Gases Emission (Plano de Redução das Emissões de Gases de Efeito Estufa - PREGEE);*
- *Quantification and publication of the financial benefits resulting from damages avoided through climate change mitigation and adaptation measures;*
- *Transparency on climate change mitigation and adaptation measures implemented on the city;*
- *Monitoring of climate vulnerability and its variations in the municipality;*
- *Combined analysis of climate change impact for all the municipalities in the Greater Belo Horizonte area (Região Metropolitana de Belo Horizonte) to look for integrated solutions;*
- *Climate risk study integrating the amount exposed to losses and damages to aid the understanding of a cost effectiveness analysis of the adaptation measures;*
- *Analysis of water availability on river basins supplying the city of Belo Horizonte, considering potential climate change impacts and future demands for water consumption.*

Relevant hyperlinks:

Please provide hyperlinks to sources of information

1. <http://www.moveonadaptation.com>
2. <http://conteudo.waycarbon.com/resumo-para-os-tomadores-de-decisao-estudo-de-vulnerabilidade-as-mudancas-climaticas-de-belo-horizonte>
3. <https://climatecolab.org/contests/2017/A2R-Anticipating-Climate-Hazards/c/proposal/1333845#>
4. <http://www.c40.org/events/c40-cities-awards-2016>