Economics of Climate Adaptation

*Report 02*

MAY 2020

# Base Data Report

## Honduras Urban Flood Risk

UNITED NATIONS UNIVERSITY

UNU-EHS

A project implemented on behalf of InsuResilience Solutions Fund

managed by Frankfurt School of Finance & Management

funded by KfW

on behalf of Federal Ministry for Economic Cooperation and Development

In cooperation ETH zürich

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# List of Acronyms

| | |
|---|---|
| BMZ | German Ministry for Economic Cooperation and Development |
| CCA | Climate Change Adaptation |
| COPECO | Permanent Contingency Commission of Honduras |
| CMIP5 | Coupled Model Intercomparison Project Phase 5 |
| DTM | Digital Terrain Model |
| EbA | Ecosystem-based Adaptation |
| ECA | Economics of Climate Adaptation |
| FAO | World Food and Agriculture Organization |
| GCMs | Global Climate Models (GCMs) |
| GDP | Gross Domestic Product |
| HadGEM2-ES | Hadley Global Environment Model 2 - Earth System |
| ISF | InsuResilience Solutions Fund |
| KfW | German Development Bank |
| LIDAR | Light Detection and Ranging |
| NAP | National Adaptation Plans |
| NBI | Unsatisfied basic needs index |
| NGO | Non-Governmental Organization |
| SPS | Municipality of San Pedro Sula |
| UNECLAC | United Nations Economic Commission for Latin America and the Caribbean |

# Context

Storms, floods, droughts and other extreme weather events can threaten urban and rural areas, from small regions to entire nations. Along with growing populations and economies, losses from natural hazards are rising in the world's most exposed regions as our climate continues to change. The Economics of Climate Adaptation (ECA) is a decision-making support framework that integrates climate vulnerability and risk assessments with economic and sustainability impact studies to determine the portfolio of optimal adaptation measures for diverse climate risks.

The United Nations University - Institute for Environment and Human Security (UNU-EHS) in cooperation with and funded by the InsuResilience Solutions Fund (ISF), is implementing the Economics of Climate Adaptation (ECA) framework in the Municipality of San Pedro Sula (SPS) in Honduras to identify the most cost-effective measures to address flood hazards. The ISF is funded by the German Development Bank (KfW) and commissioned by the German Ministry for Economic Cooperation and Development (BMZ). Currently, the Economics of Climate Adaptation (ECA) methodology is being implemented in three different countries (Vietnam, Honduras and Ethiopia).

The inception phase of the ECA study in SPS has concluded with the definition of the scope of the project, including the target hazard to be addressed, the key assets to be considered and the time horizon to be analyzed. The present phase and following phases will determine the distribution of risk levels within the municipality and evaluate different measures to mitigate such risk through a cost-benefit analysis. These phases will be supported by the modelling tool CLIMADA, which amongst others:

1) provides a comprehensive mapping of hazards, exposed assets and people and their specific vulnerability,
2) implements state-of-the-art probabilistic risk modelling techniques to integrate different economic development and climate impact scenarios, and
3) allows to assess a comprehensive portfolio of adaptation measures, quantifying the damage aversion potential and cost-benefit ratio for each measure.

This report will brief the reader on the state of data collection needed for running CLIMADA after thorough research with support from local authorities and other stakeholders.

The document is divided into five sections, the first two highlighting the most relevant factors regarding the selected hazard and assets in San Pedro Sula. The third section presents future climate and socio-economic scenarios for the time horizon defined during the inception workshop. The fourth section presents a general overview of the collected data, with a quality assessment regarding their usability for the ECA study, as well as the proposed proxies for those data sets that are insufficient for running CLIMADA or might lead to too high uncertainties in the final results. The last section concludes and details the next steps.

# 1 Hazard Selection

## 1.1 Flood Hazard Selection

During the Inception Workshop that took place in San Pedro Sula in November 2019, participants from public and private sectors, academia, community leaders, NGOs, and international organizations discussed at length the different hazards that continuously threaten the Municipality and all its inhabitants. The main concerns concentrated on floods and droughts in the Sula Valley and in particular their impacts on low-income populations. By the end of the session, all stakeholder groups agreed on flood being the most urgent and relevant climate hazard to be addressed. Consequently, the general agreement was to focus on the most vulnerable groups within the city boundary.

See **ANNEX 1** for further details on the criteria matrix used during the workshop to select the hazard.

Currently, flood modelling offers some challenges in terms of available data. As presented in Table 1, climate data are not of sufficient quality (or not available) for flood modelling. Consequently, alternative data sources have been identified and acquired. Stations with data available for short periods can be used for validation purposes. Beyond meteorological data, terrain and land use data are crucial for flood modelling, as well as hydrological modelling (boundary conditions). LIDAR data (1m resolution) for SPS have been obtained from COPECO and are complemented by a high-resolution DTM (5m) for the mountainous part of the watershed. Soil data have a poor level of detail and will be updated with existing alternatives from FAO whenever possible.

As part of the novel flood modelling exercise, a team of international consultants will work in close collaboration of the UNU-EHS team to i) provide better boundary conditions to the flood model using improved and high-resolution climate data, ii) model floods for the selected study areas using high-resolution topography data and updated boundary condition, and iii) validate the flood model outputs for large flood events in the SPS metropolitan area. Satellite data (e.g. MODIS) showing the extend of floods in the area will be used for the validation exercise. Three major events will be selected (one of them taking place during hurricane Mitch in 1999). The outcomes of the upgraded model will allow for a better assessment of the distribution of the hazard within San Pedro Sula, which will serve as input for CLIMADA to properly assess the risks of the different assets identified during the Inception Workshop and described in the following section.

## 1.2 Study Area Selection

As part of the inception workshop, participants were asked to identify key areas within the city that were - to their recollection - more affected by flood events and need special attention during the present study. Figure 1 presents the distribution of these areas within the urban ring of San Pedro Sula. The identified districts were 14, 15, 16 and 18, as well as the informal settlements located on the riverbanks (Los Bordos) in the districts 1, 2 and 3. See **ANNEX 2** for the photographic documentation of the area selection during the workshop.

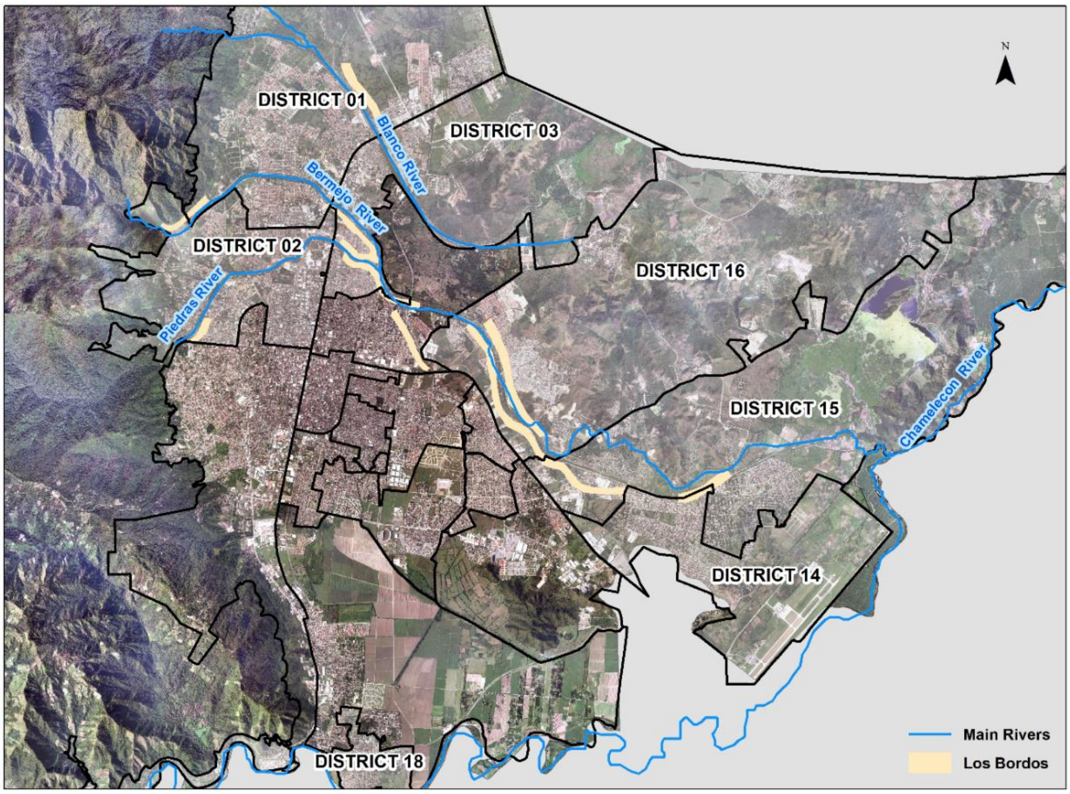


*Figure 1 Key areas for flood analysis in San Pedro Sula*[1]

[1] Own elaboration based on GIS files provided by the Municipality

# 2 Selection of Assets

The selection of key assets was undertaken by the stakeholder groups during the Inception Workshop. It responded to prioritization criteria based on perceived vulnerability. The participants shared their experiences facing floods in the Municipality and their concerns for future events. The concept of assets was explained as “any resource that represents value for the municipality”, the term ‘resource’ covers infrastructure, buildings, natural resources and social components including inhabitants. The selected assets are briefly described below, for photographic documentation of the results of the workshop see **ANNEX 3**.

## 2.1 Vulnerable Persons

The first asset identified by the participants was “vulnerable populations”. We suggest focusing on vulnerable populations as one asset as well as other population subject to exposure. Vulnerable populations are defined here using the IPCC definition[2] including the three main components of vulnerability:

- exposure,
- adaptive capacity,
- sensitivity,

**Exposure** is defined here by the expectation of the occurrence of a flood based on geographical location. Figure 2, presents the areas identified by COPECO as likely to be flooded for a 50 years return period, with an additional buffer (200m) to secure anhomogeneous delineation. Districts 14 and 15 are particularly exposed at the convergence point of the Bermejo and the Chamelecon rivers, and district 18 also faces flood hazards due to the Chamelecon River. Areas surrounding other water bodies like the Del Carmen and the Jucutuma lagoons are understandably also flooding prone within districts 3 and 15 respectively. Similarly, the neighbourhoods around the Blanco, Bermejo and Piedras rivers in districts 1, 2 and 3 are also considered highly exposed.

[2] IPCC (2014) Climate Change 2014. Impact, adaptation and vulnerability. Part A: Global and sectoral Apects Working Group (WG) II Report

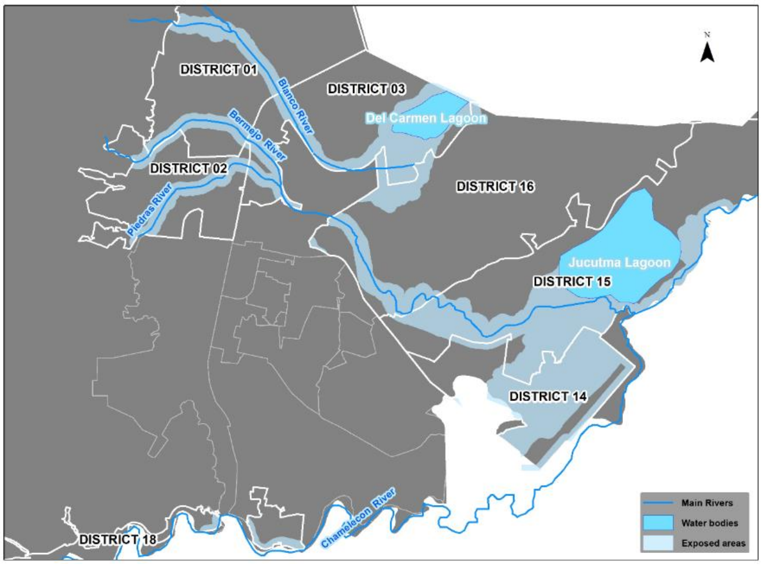


*Figure 2 Flood exposed areas in San Pedro Sula*

As explained in section 2.1, the flood model made available by COPECO will be updated in regards of hydrology using high-resolution data from satellite images, and in regards of the flood model itself through better resolution topography and updated boundary condition. This will influence the final exposure distribution of the municipality that will be ultimately used for the coming stages of the ECA study.

For the **adaptive capacity**, hence the ability of a system to cope, the available information provided for populations will be used, specifically through the percentages of unsatisfied basic needs (NBI). The NBI is an index that was developed in the 1960s and that was adopted by the UNECLAC (United Nations Economic Commission for Latin America and the Caribbean) for poverty monitoring and benchmarking within the region in the 1980s. The four basic needs categories considered by the NBI are: 1) Access to housing, which measures the quality of housing and level of overcrowding, 2) Access to sanitary services, defined as the availability of drinking water and the type of excreta disposal system in the household, 3) Access to education, in terms of attendance of children at school-age to an educational establishment, and 4) Economic capacity, which is measured as the probability of insufficient household income at any given time[3]. With one or more basic needs unsatisfied, we argue that a given population has a low coping capacity and therefore a low adaptive capacity.

Figure 3 presents the percentage of households that have no unsatisfied basic needs per neighbourhood, which for the study suggests a full adaptive capacity. Areas in the lowest 25% (red) indicate that only up to a quarter of the total population would have the ability to adapt if needed, while areas on the highest 25% (green) indicate that most households would be able to cope.

[3] Feres, Mancero, 2001: El método de las necesidades básicas insatisfechas (NBI) y sus aplicaciones en América Latina. Retrieved from: https://www.cepal.org/es/publicaciones/4784-metodo-necesidades-basicas-insatisfechas-nbi-sus-aplicaciones-america-latina

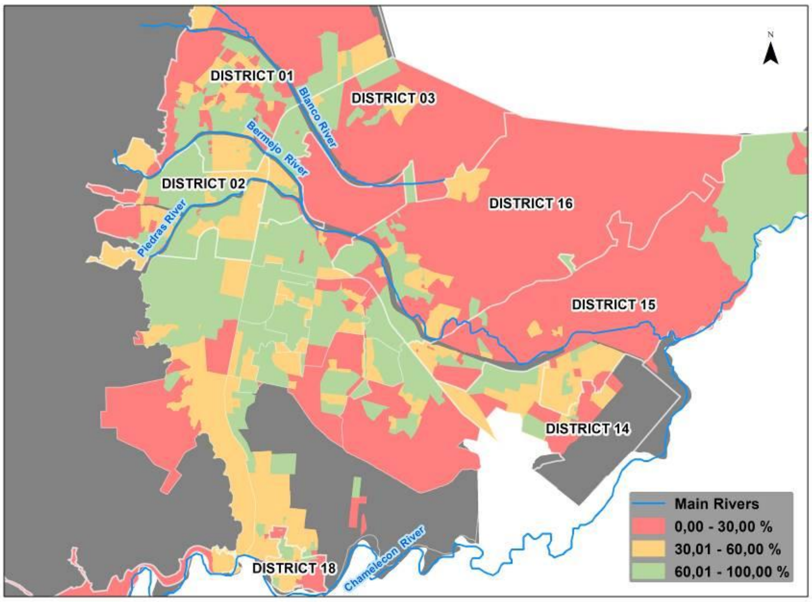


*Figure 3 Percentage of households with zero unsatisfied basic needs (NBI) in San Pedro Sula (PMDM 2017). The areas in the lowest 30% teer (red) indicate that up to a third of the total population have few of their basic needs covered and are consequently in a worst position to face a disastrous event than those that are lacking coverage before the event.*

Finally in regards to **sensitivity**, which describes the degree to which a system is affected is in this case by floods, will be defined by the modelling exercise in CLIMADA.

We suggest to break down this asset in two groups: vunerable population (NBI<=30% and 50yr footprint Buffer) and non vulnerable population (NBI>30%) as the latter migt also be affected by larger extreme events in the future. The NBI threshold of 30% is proposed based on the distribution of population with the area (see histogram in Fig 7). *Figure* 4 shows a draft map of the identification of "vulnerable population" and "population" considering the **exposure** distribution suggested by COPECO and the **adaptive capacity** distribution based on the NBI. The complete disaggregation of the different groups of inhabitants of these areas will be provided in the vulnerability report.  A complete update on the hazard footprints based on the flood model is being developed within the project. Figure 4 is therefore provided only as a baseline for the reader to better understand the study area.

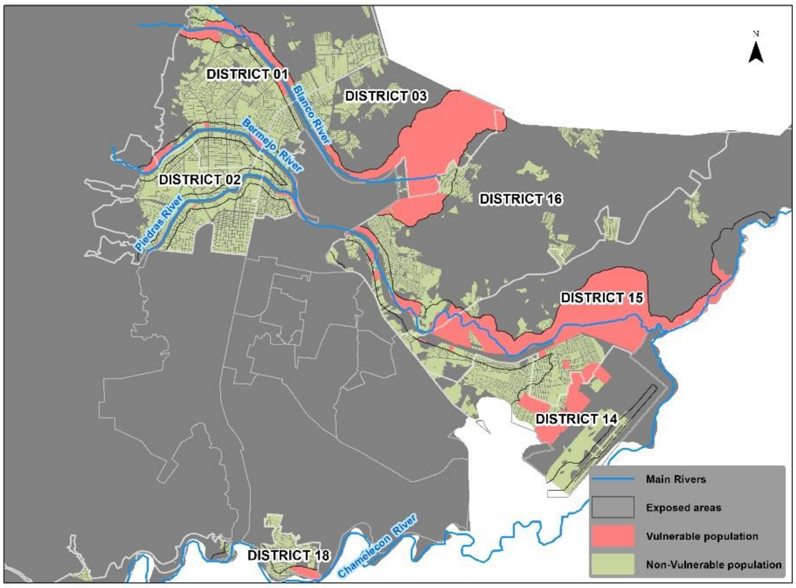


*Figure 4 Location of assets categories vulnerable population and non vulnerable population within the study area*

Unlike other assets analyzed by CLIMADA, a monetary value will not be assigned to people for further evaluation of flood impacts and the potential benefits of the suggested adaptation measures.

## 2.2 Informal Settlements (Los Bordos)

Large informal settlements in San Pedro Sula known as 'Los Bordos', are located within the riverbanks. The vulnerable communities inhabiting these neighbourhoods require special attention as their belongings and livelihoods are highly exposed and the territory where they lay on experiences little intervention for flood protection.

According to the "Plan Maestro de Desarrollo Municipal", around 6800 families live in Los Bordos neighbourhoods in SPS. Most of these settlements are located within districts 1, 2 and 3, including Guadalupe the most populated neighbourhood. The others are part of districts 4, 14, 15 and 16. Figure 5, shows the locations of Los Bordos along the Blanco, Bermejo and Piedras rivers and how they are located within the flood areas identified by COPECO.

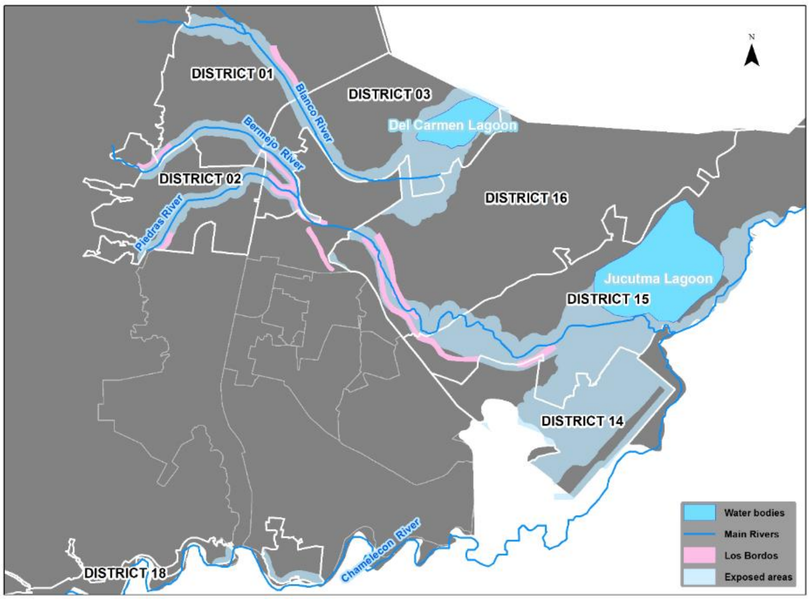


*Figure 5 Flood exposed areas in San Pedro Sula including Los Bordos*

## 2.3 Housing (3 categories)

Different criteria are suggested in the scientific literature for classifying levels of vulnerability of households to floods. Aside from the informal settlements, the participants of the study highlighted the importance of breaking down households into three different groups so that measures consider the gaps in response and resilience of different social groups.

We suggest defining categories based on the unsatisfied basic needs (NBI) index previously described in section 3.1, as it considers different dimensions of poverty including income, housing conditions, and access to sanitary services and school for children. The assumption here is that when a household cannot cover one or more of these needs it will be less capable to recover the occurrence of a disastrous event. The proposed categories are shown in Figure 6, being category 1 households in neighbourhoods where under 30% of the families have zero NBI, category 2 in neighbourhoods where between 30 and 60% of the population lives within a zero NBI household, and category 3 would cover the rest of the households. The breakdown for the categories was done based on the frequency of NBI conditions within the study area. Figure 7 presents the histogram for the households in the districts defined by the stakeholders during the workshop and the ranges selected for the categories.

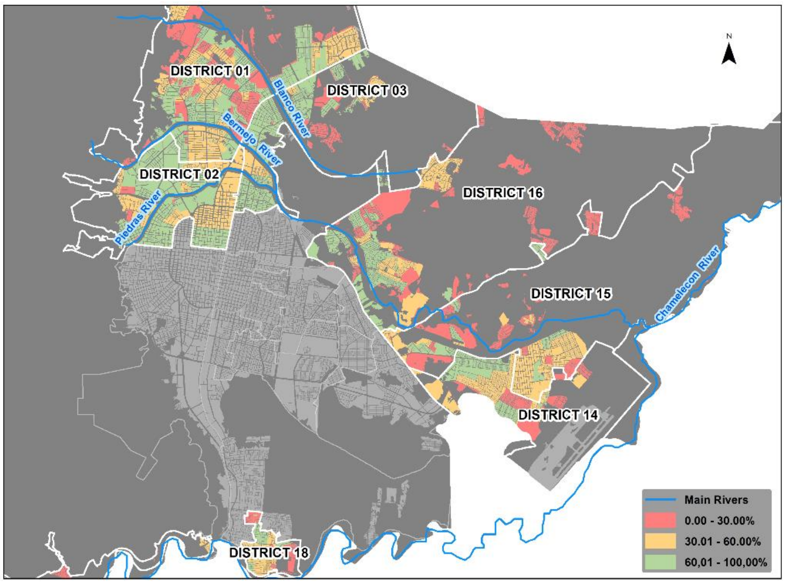


*Figure 6 Categories of households in study areas of SPS based on percentage of households with zero unsatisfied basic needs (NBI)*

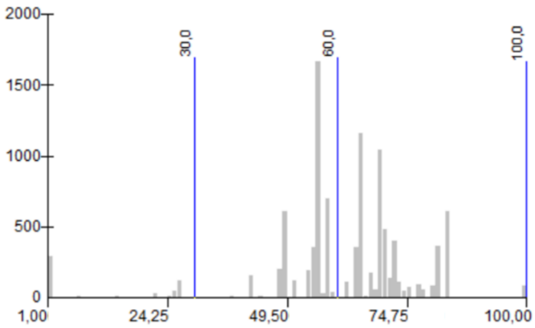


*Figure 7 Histogram NBI for key areas in SPS*

For the vulnerability report, further information will refine the category selection including the level of unemployment, construction material of the buildings and level of literacy per neighbourhood.

## 2.4 Public Assets

Another category highlighted by the participants in the workshop was public assets. No further disaggregation was given besides a few examples of hospitals and schools, but unlike households, there was not suggested a need to prioritize or discriminate amongst this type of assets. We, therefore, suggest, based on the available data to choose the following assets:

- The main and secondary road network
- Electric network
- Drainage system (water supply and sanitation)
- Education centres
- Health centres
- Fire brigades
- Airport

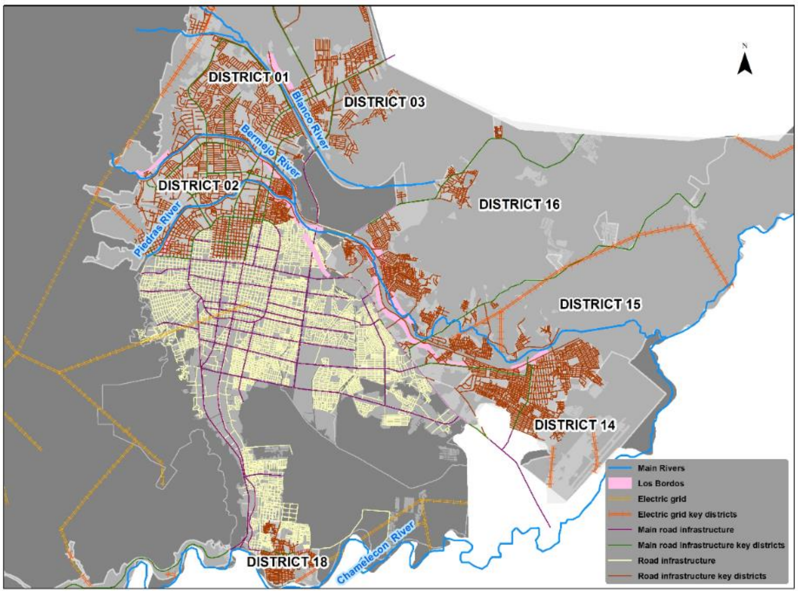


*Figure 8 Road network and the electric grid in San Pedro Sula*

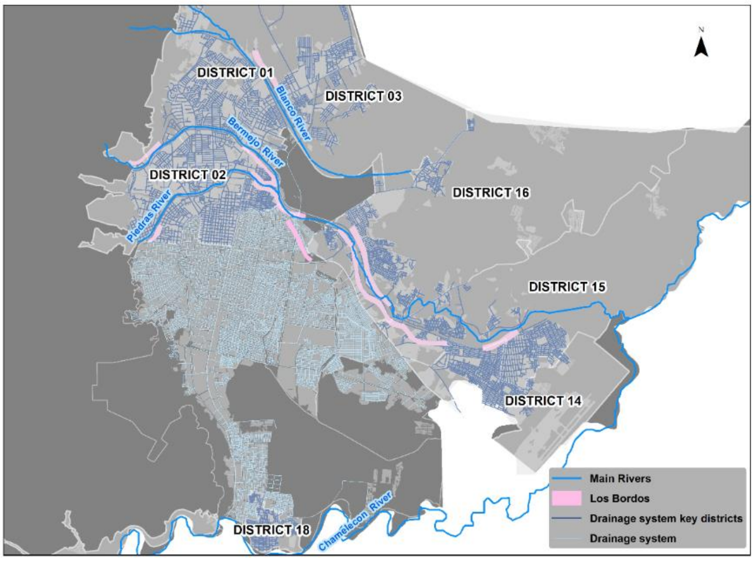


*Figure 9 Drainage network San Pedro Sula*

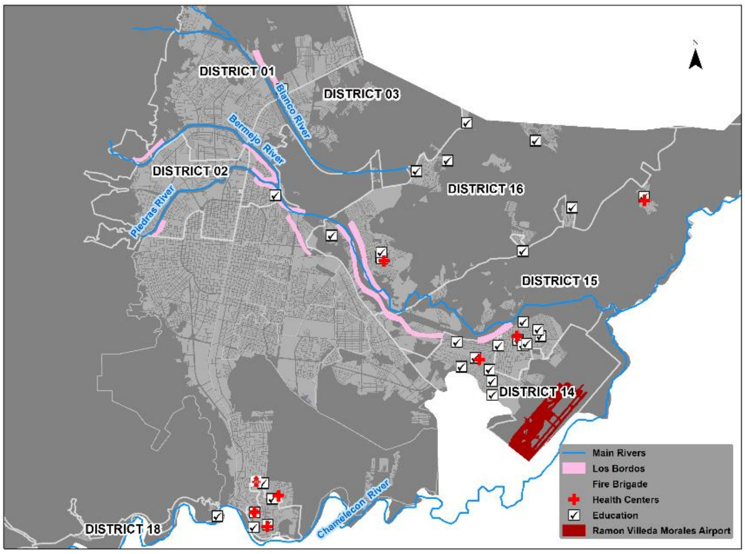


*Figure 10 Key public assets in key districts of SPS*

## 2.5 Environmental Assets

As discussed during the inception workshop, natural assets such as forest, open spaces, water bodies and green areas should be added whenever possible to the risk assessment.

Based on available data and for the districted selected, we suggest to include the following assets:

- Forest and green areas
- Water bodies

Figure 11 presents the different environmental classifications within the borders of San Pedro Sula according to local regulation. There are two major natural protected areas, El Merendón bordering the urban area of the Municipality to the west with 35000 hectares, and more to the west Cusuco with over 14000 hectares. Around 87% of the administrative area of the Municipality is under some kind of legal protection due to environmental reasons, including utilization areas which only allow restricted uses of land.

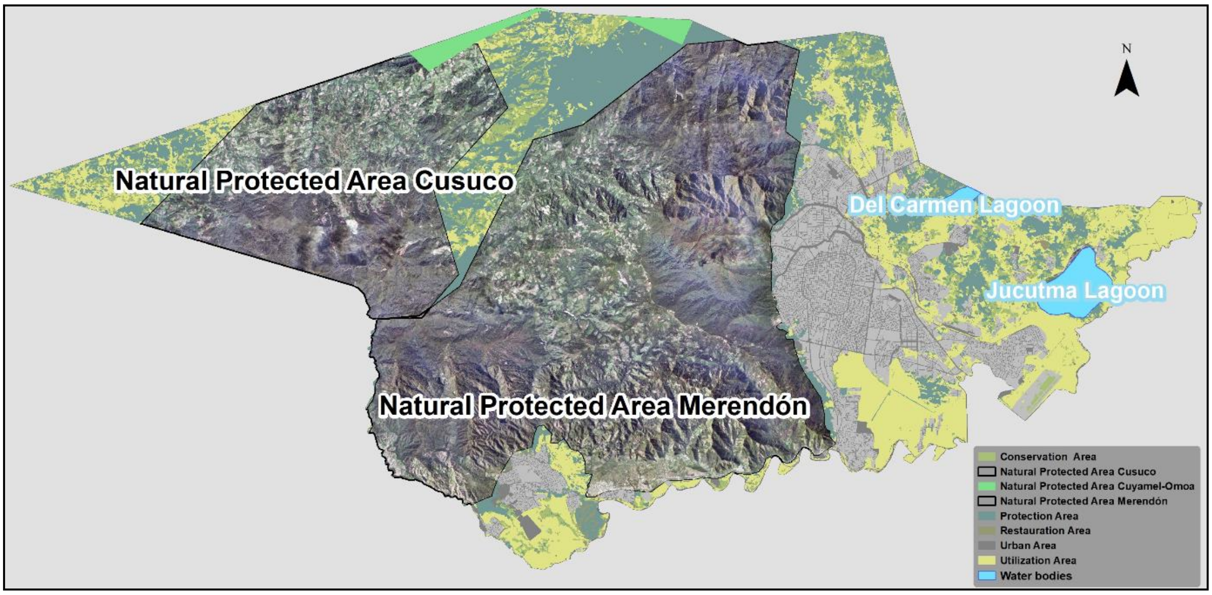


*Figure 11 Environmental assets regulated by law*

Similarly, Figure 12 highlights the different types of land use around the urban areas of the Municipality. Agricultural lands are located in the south of SPS over the Chamelecon River, and different types of forests are located in the periphery of the city. Considering the distribution of flood prone areas presented in Figure 5, the areas around the rivers and lakes have the highest exposure to flood risks.

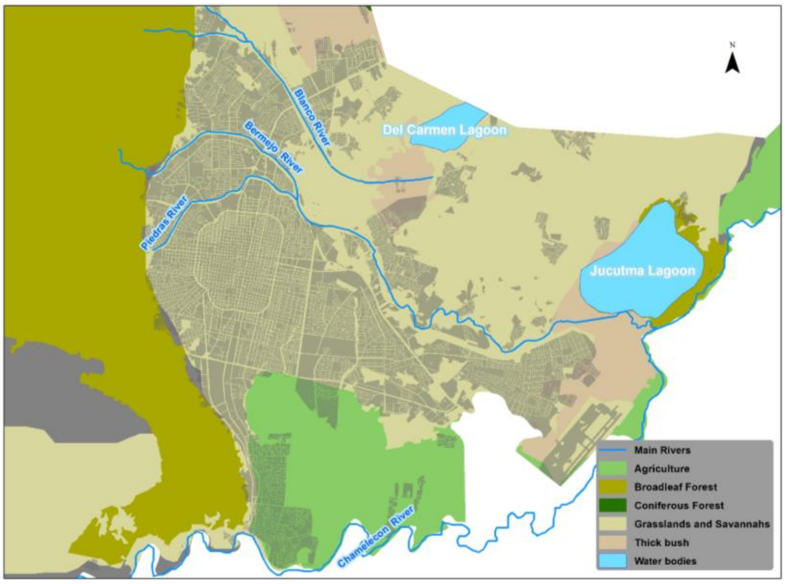


*Figure 12 Type of land use in San Pedro Sula*

# 3 Scenario Development

## 3.1 Climate Scenario

### 3.1.1 Overview

The objective of this section is to review different climate scenarios for Honduras. To date, only limited information covers Honduras and/or San Pedro Sula. The following section will, therefore, comment on projections of future climate in Central America and the Caribbean. This section will focus on several aspects of climate scenarios in the areas related to floods, precipitation, storms and tropical cyclones highlighting scientific consensus and actual debates.

### 3.1.2 Extreme Events in Central America

In Central America, the acceleration of hot extremes will likely occur[4]. Typical strong soil-moisture-temperature coupling, as well as projected increased dryness are not well represented in the current models, and therefore the results showing a reduction in evaporative cooling, have some discrepancies[5]. Besides, the relatively coarse resolution of global weather and climate observational datasets poorly capture the complexity of Central America topography[6].

As discussed above, in Central America, studies on trends in precipitation show discrepancies, whereas a general agreement exists on future warming trends[7]. Interestingly, Hidalgo et al. (2016) combined gridded datasets from satellites and temperature data from stations for almost 30 years (1970-1999), found two different trends in Central America, one warming trend like all other studies, and thus in most of that region, and another cooling trend in Central Honduras and western Panama[8].

Climate projections for the end of this century, given by an embedded model Eta-HadGEM2-ES, indicate warming over Central America of 3 to 3.5 °C (RCP4.5) to 6-7 °C (RCP8.5)[9]. It also indicates a decrease in precipitations for Honduras. In a recent publication, Lyra et al. (2017) used for the first

[4] Hoegh-Guldberg, O., D. Jacob, M. Taylor, M. Bindi, S. Brown, I. Camilloni, A. Diedhiou, R. Djalante, K.L. Ebi, F. Engelbrecht, J. Guiot, Y. Hijioka, S. Mehrotra, A. Payne, S.I. Seneviratne, A. Thomas, R. Warren, and G. Zhou, 2018: Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. MoufoumaX. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen,. Tignor, and T. Waterfield (eds.)].

[5] Vogel, M.M. et al., 2017: Regional amplification of projected changes in extreme temperatures strongly controlled by soil moisture-temperature feedbacks. Geophysical Research Letters, 44(3), 1511–1519, doi: 10.1002/2016gl071235.

[6] Imbach, P., Beardsley, M., Bouroncle, C. et al. Climate change, ecosystems and smallholder agriculture in Central America: an introduction to the special issue. Climatic Change 141, 1–12 (2017). https://doi.org/10.1007/s10584-017-1920-5

[7] Rios, R., Taddia, A. and Grunwaldt, A. (2016) Climate Change projections in Latin America and the Caribbean. Report. IDB, New York. 32pp

[8] Hidalgo HG, Alfaro EJ, Quesada-Montano B (2016) Observed (1970–1999) climate variability in Central America using a high-resolution meteorological dataset with implication to climate change studies. Clim Chang. doi:10.1007/s10584-016-1786-y

[9] Lyra, A. et al., 2017: Projections of climate change impacts on Central America tropical rainforest. Climatic Change, 141(1), 93–105, doi:10.1007/s10584-016-1790-2

time a dynamic vegetation model to assess long-term feedbacks between Central American biomass and Climate using two different emission scenarios (RCP4.5 and 8.5). The authors found that future distribution of predominant vegetation indicate that some tropical rainforest regions in Central America are replaced by savannah and grassland using the RCP4.5[10]. Such changes in ecosystems might have an impact on climate patterns in the region.

Other studies, concentrating on precipitation, show that GCM and ESM models do agree on future drier Central America. Although these models generally represent current ENSO precipitation anomalies well, future trends are less certain, except that ENSO events will be more frequent[11].

### 3.1.3 Global Climate Models

Global Climate Models (GCMs) are used to project changes in the Earth's climate. The prevailing generation of models associated with AR5 from the Coupled Model Intercomparison Project Phase 5 (CMIP5), includes more than 40 models from more than 20 modelling centres. Unsurprisingly, with such a disparate set of processes, locations, and variables, few models can stand out consistently, in either a positive or negative way, in such a variety of contexts[12]. Only a few models reproduced the standard deviation of observed temperature and precipitation with high accuracy. In an evaluation of precipitation and associated dynamics focused on the tropical part of South America, a superior dynamical simulation by HadGEM2-ES was identified[13].

### 3.1.4 Climate Scenarios Definition

In this study, it is important to decide what scenarios and what GCMS should be used for future simulation. However, there is no consensus on which of the four RCPs (RCP2.6, RCP4.5, RCP6, or RCP8.5) is most likely; the IPCC considers all RCPs to be within the likely range of actual radiative forcing. Although RCP4.5 is widely used, we believe it would be prudent to plan for additional less optimistic scenarios. Henceforth, for this analysis, RCP4.5 and RCP8.5 were selected simply because they are most consistent. As discussed above, we suggest using of HadGEM2-ES whenever available for future simulation of precipitation within the flood model.

## 3.2 Socio-economic Scenarios

### 3.2.1 Overview

As the second-largest city after Tegucigalpa, San Pedro Sula represents the economic capital of Honduras. Located in the North-West of the country in the department of Cortes, the city is home to the major international airport of Honduras and in the vicinity of Puerto Cortes, one of the nation's main port, as well as to the neighbouring country Guatemala. The economy of San Pedro Sula is largely based on the manufacturing, wholesale and retail trade with about 51% of the employed population

[10] idem

[11] Steinhoff D, Monaghan A, Clark M (2015) Projected impact of twenty-first century ENSO changes on rainfall over Central America and northwest South America from CMIP5 AOGCMs. Clim Dyn 44:1329–1349. doi:10.1007/s00382-014-2196-3

[12] Rios, R., Taddia, A. and Grunwaldt, A. (2016) Climate Change projections in Latin America and the Caribbean. Report. IDB, New York. 32pp

[13] Yin, L., R. Fu, E. Shevliakova, and R.E. Dickinson. 2013. How well can CMIP5 simulate precipitation and its controlling processes over tropical South America? *Climate Dynamics* 41(11–12):3127–3143.

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working in those branches of activities.[14] Primary sectors, such as agriculture, livestock, forestry, and fishing, are relatively underrepresented in SPS in comparison to the national average.[15] While the whole Sula Valley contributes roughly 63% to Honduras' GDP, the Master Plan for Municipal Development (PMDM) estimates the city's contribution at 40%, although this number would need further verification. The majority of economic establishments, roughly 94%, can be classified as medium and small enterprises, while 2% are micro-enterprises and the remaining 4% large enterprises.[16] According to the city's Master Plan, the total unemployment rate was 8% at the time of writing (2017). The problem of un- and underemployment has increased countrywide especially between 2012 and 2016. However, despite an increase of 5% during this period, San Pedro Sula performed much better than the country as a whole which experienced an increase of 20% in unemployment.[17]

Data collected during the 2013 Population Census indicate an illiteracy rate of 11% in the municipality among those of 15 years and older as reported in the city's PMDM.

In general, nearly 50% of the population have completed the compulsory elementary school (grades 1-9) while 26% have completed secondary school. Only about 4% of the municipality's population gain a university-level degree. 16.4% of the population receive no formal education. With those numbers, the municipality outperforms both, the Region Cortes as well as the Country slightly. On average 7.5 years of schooling are reported.[18]

### 3.2.2 Population Growth Scenario

As this analysis is meant to align with the city's PMDM it will focus on the same two scenarios regarding population development.

Scenario one provides a rather conservative population growth rate estimate of roughly 1.15% per year on average in the timespan from 2016-2042. Scenario two takes a different approach based on estimates of birth rates, death rates, as well as migration patterns resulting in an average of 2.46% per year over the same timespan if a floating population is not considered. For both scenarios, the city provides again two different base population estimates, one developed by the city's statistical unit (DIEM) while the other one was developed by the national statistical institute (INE).

In comparison, the second scenario seems to better match with the UN world population's projections of roughly 2.59% on average per year in the period 2015-2035.[19]

According to the PMDM, the differences in population result through DIEM considering larger areas around the city as well as floating and migrating population. For example, DIEM counted 874,561

[14] Municipality of San Pedro Sula. (2017). Municipal Development Master Plan of San Pedro Sula, Honduras - C1. Municipal Land-Use Plan. p. 65

[15] Municipality of San Pedro Sula. (2017). Municipal Development Master Plan of San Pedro Sula, Honduras - C5. Economic Development Plan. p. 48

[16] Municipality of San Pedro Sula. (2017). Municipal Development Master Plan of San Pedro Sula, Honduras - C1. Municipal Land-Use Plan. p. 52

[17] Municipality of San Pedro Sula. (2017). Municipal Development Master Plan of San Pedro Sula, Honduras - C5. Economic Development Plan. p. 93

[18] Municipality of San Pedro Sula. (2017). *Municipal Development Master Plan of San Pedro Sula, Honduras - C5. Economic Development Plan.* pp.23-24

[19] United Nations, Department of Economic and Social Affairs, Population Division. (2018). World Urbanization Prospects: The 2018 Revision, Online Edition. Retrieved from https://population.un.org/wup/Download/

people in 2013 while INE only considered 719,064 people in the same year. The UN world population estimate for population seems to lie between those of DIEM and INE with 767,271 for 2015.

For the purpose of the study the data provided by INE, starting with 754,061 in 2016 and resulting in roughly 1.419 million people in 2042 at an average annual growth rate of 2.46%, are preferred. Through excluding floating population the focus remains on the actual population of the city and their assets in the city rather, including floating population would be more appropriate when considering services provided in the city. As two growth scenarios (1.15% and 2.4%) are provided the second one was chosen as it is based on birth, death and migration rates as is also practice in the widely accepted cohort component method to estimate and project populations.

### 3.2.3 Discount Rate Scenario

Correlation tests show that annual average consumer price inflation (CPI), a proxy for the discount rate, produced by the Honduran National Bank for San Pedro Sula and the whole of Honduras are strongly correlated.[20] The same holds true when checking the correlation with the annual countrywide CPI provided by in the World Bank Database.[21] Correlation tests with the growth rates of national CPI data provided by World Bank, the Honduran National Bank as well as on CPI growth rate estimates provided by the Economist Intelligence Unit (EIU) confirm the results. Based on this it can be assumed that the city's CPI growth rate can be approximated using available national data.[22] Recognising this similarity and due to the sparse data environment, the more comprehensive data set from sourced from the World Bank Database of the countrywide CPI on an annual basis since 1960 is used[23].

For the estimation of future CPI values, and through that its growth rate, several autoregressive integrated moving average (ARIMA) models were examined to identify the best-fitting model. In such a parse data environment ARIMA models provide the important advantage of not needing exogenous variables and allowing us to estimate future values of using the dependents variable's own past values. The best-fitting model identified employs one lag (*AR=1*), two-stage differencing (*I=2*), and second-order moving averages (*MA=2*) resulting in an ARIMA (1,2,2) model.

Based on this model the CPI can be expected to continue its growth path, setting 2010 at 100, from 155.84 in 2020 to 310.94 in 2042 at an annual average growth rate of 3.30% over the 25-year leading to 2042. The projected growth rate continuously decreases from 3.84% in 2020 down to 2.68% in 2042. The median is 3.18%, the mean 3.22% the standard deviation of 0.37%. See Figure 13Figure 14 for a graphical illustration of the estimated CPI values and the corresponding growth rate.

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[20] Banco Central de Honduras. *Honduras en Cifras*. Editions 2002 to 2019. Retrieved from https://www.bch.hn/honduras_en_cifras.php

[21] World Bank (2020). "Consumer price index (2010 = 100)". World Development Indicators. The World Bank Group, https://data.worldbank.org/indicator/FP.CPI.TOTL?locations=HN. Accessed 31 March 2020

[22] Annual CPI values were compiled by the authors based on several country reports published by the Economist Intelligence Unit. The reports can be retrieved from http://www.eiu.com/index.asp?layout=displayIssue&publication_id=1200000920

[23] To check for stationarity in the data the Augmented Dickey-Fuller (ADF) unit-root test was applied. The null hypothesis of the data having a unit root cannot be rejected and it can be assumed that the data are non-stationary.

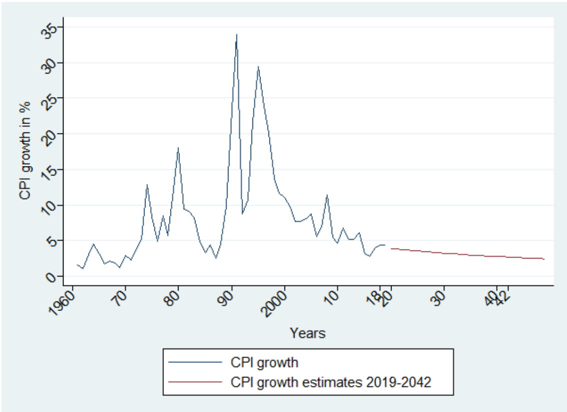



*Figure 13 Historical CPI growth in Honduras as proxy for SPS (blue) and estimated CPI growth 2019-2042 (red), Authors' own compilation based on World Bank data*

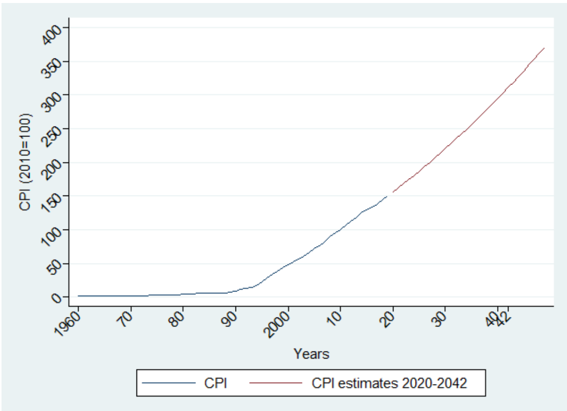



*Figure 14 Historical CPI in Honduras as proxy for SPS (blue) and estimated CPI 2019-2042 (red), Authors' own compilation based on World Bank data*

### 3.2.4 Economic Growth Scenarios

Based on the above assumption that the CPI of San Pedro Sula can be approximated using the national CPI, the same assumption is made about the respective GDP and its annual growth rate. This assumption is further underlined by the fact that San Pedro Sula presents the economic capital of the country.

As the World Bank provides GDP data annually since 1960, and thus more than the National Bank of Honduras, the GDP data in constant 2010 USD provided by the World Bank were chosen. After reviewing annual GDP growth[24] and GDP[25] data provided by the World Bank Database, the ADF unit-root test is applied to the GDP too to check for stationarity[26]. To estimate the country's GDP growth, and with that approximating the city's GDP growth rate, several autoregressive integrated moving average (ARIMA) models were examined to find the best fitting model. For the number of lags, the autoregressive parameter *AR*, 1 was chosen, the degree of differencing *I* proved to be most

[24] World Bank (2020). "GDP growth (annual %)". World Development Indicators. The World Bank Group, https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=HN. Accessed 31 March 2020
[25] World Bank (2020). "GDP (constant 2010 US$)". World Development Indicators. The World Bank Group, https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=HN. Accessed 31 March 2020
[26] Even with increasing lags the null hypotheses of the GDP series having a unit root cannot be rejected, hence the GDP is non- stationary.

appropriate at 1 as well, and the first order was chosen for the moving average *MA* component resulting in an ARIMA (1,1,1) model. The chosen model estimates positive growth rates with a decreasing trend from around 3.72% in 2019 toward 1.48% in 2042 resulting in an average annual growth rate of ca. 2.24% in the observed period. The median lies at 2.01%, the mean at 2.13% and the standard deviation at 0.55%. %. See Figure 15Figure 16 for a graphical illustration of the historical and estimated GDP growth rate and the corresponding nominal values.

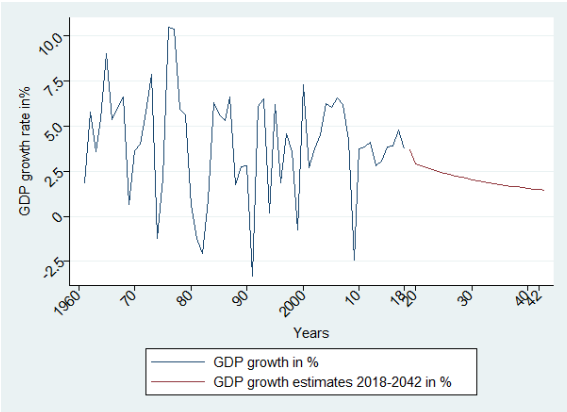



*Figure 15 Historical GDP growth in SPS (blue) and estimated GDP growth 2019-2042 (red), Authors' own compilation based on World Bank data*

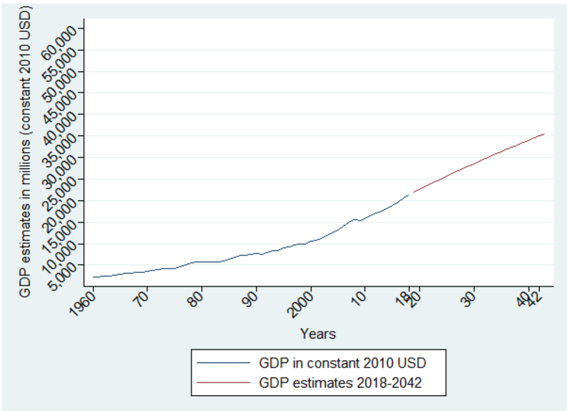



*Figure 16 Historical GDP of SPS (blue) and estimated GDP 2019-2042 (red), Authors' own compilation based on World Bank data*

### 3.2.5 Summary

Based on the above scenarios required by CLIMADA are chosen. For the population growth, an annual average of 2.46% was chosen. The PMDM provides average annual growth rates and absolute population in 5-year steps as shown in **ANNEX 4** which will be applied in CLIMADA accordingly. As for discount rate, the GDP deflator, an approximation through CPI growth rates, ranges from 3.84% in 2020 to 2.68% in 2042 are chosen. Regarding economic growth, ranges between 3.72% in 2019 and 1.48% in 2042 are chosen, both are being complemented by actual values since 2017. **ANNEX 4** provides a table with annual growth rates for both, the CPI and GDP, as applied in CLIMADA.

# 4 Data Collection and Evaluation

This section presents the availability of data necessary for this study. Different type of data is necessary and ranges from meteorological data, damage data, spatial data, socio-economic data to climate data. All data were subject to drastic quality control and stored in a dedicated database to avoid redundancy. Table 1 below presents the different data types along with their source, availability and an evaluation of their quality (green: good quality and suitable for the study; Yellow: Medium quality. Data needs to be updated; Red: Insufficient quality for the study). Where data is of insufficient quality or need additional work, we have indicated possible proxies and their sources. All proxies are acquired and are evaluated as of good quality for this study.

In addition to the databases provided after the inception workshop, the Municipality in collaboration with the local statistics office (División de Investigación y Estadística Municipal - DIEM), run a household survey within the key districts to collect firsthand information on the impacts of floods. The survey included a section on quality of the physical infrastructure of the housing, access to public services, appliances and other valuable devices, and one on the historical damages caused by the three major flood events that took place in recent years (Mitch in 1998, and the floods of 2014 and 2017). A total sample of 700 households was surveyed, evenly distributed within the districts 14, 15, 16 and 18, and Los Bordos in districts 1 and 3, the informal settlements in the district were inaccessible for surveyors due to security reasons. The questionnaire of the survey can be found in **ANNEX 5**.

*Table 1 Summary of data collected, quality assessment and supplementary sources when relevant*

| Data Type | Availability | Source | Quality Evaluation | Proxy | Proxy Source |
|---|---|---|---|---|---|
| **1. Impacts of past flood events** | | | | | |
| 1.1 Asset values | | | | | |
| 1.1.1 Public assets | No | | | • Values of similar assets in neighbouring countries or cities<br>• Use of monetary estimation methods | • Scientific literature<br>• Expert interviews |
| 1.1.2 Private assets | Yes | Survey Municipality (2020) | Existing housing values and information on household income | | |
| 1.2 Historical damages | | | | | |
| 1.2.1 Public assets | Incomplete | Municipality | Inventory of minor damages in 2-3 schools. Missing information on other assets (hospitals, roads, grids, police stations, fire brigades, etc.) | • Scientific literature<br>• Expert interview | • Scientific literature<br>• Expert interview |
| 1.2.2 Private assets | Yes | Survey Municipality | • No GIS data, but detailed maps about survey results<br>• Damage data provided but no direct recovery cost | Georeferenced data from surveys and complementary recovery costs | DIEM (SPS statistics department) |
| 1.3 Documentation of historical disasters (e.g. images) | No | - | - | - | - |
| 1.4 Flood maps | Yes | COPECO | • Flood model only based on topography<br>• Lack of monitoring values of historical flood events, precipitation and similar parameters for hydrological models.<br>• No validated discharge data | • Update of the current flood model, using satellite data for calibration (discharge)<br>• Improve the quality of the model from 1D to 2D where relevant<br>• Better hydrological modelling (boundary conditions)<br>• Use of gridded input precipitation | Consultants |

| | | | | | |
|---|---|---|---|---|---|
| | | | | • Simulation of future floods | |
| 1.5 Private Sector contingency plans | No | | | | |
| 1.6 Historical Damages (locations) | Yes | Municipality | Inventory of flood events between 1966-2015 available, but mainly with binary variables to describe impacts (i.e. fatalities (yes/no), affected households (yes/no)) | • Complemented with results of household survey (2020).<br>• Scope of new data to be identified. | DIEM |
| **2. Satellite imagery** | | | | | |
| 2.1 Satellite images | Yes | COPECO | Satellite images with high resolution (0.3m) | | |
| **3. Climate Data** | | | | | |
| 3.1 Precipitation | Yes | WWF weather stations | Insufficient data points with short time series (2012-2020), hence no statistical validation of results possible. | Satellite data from CHIRPS (daily, 5.4km resolution) | Data Library: UCSB CHIRPS v2p0 daily-improved global 0p05 |
| 3.2 Temperature | Yes | WWF weather stations | Insufficient data points with short time series (2012-2020), hence no statistical validation of results possible. | Satellite data from CHIRPS (daily, 5.4km resolution) | Data Library: FTP directory |
| 3.3 Relative humidity | Yes | WWF weather stations | Insufficient data points with short time series (2012-2020), hence no statistical validation of results possible. | • Satellite data from MODIS 7 (1km resolution)<br>• Satellite data from NCAR UCAR and AIRS2 (13km) | • NASA: MODIS Atmospheric Profiles<br>• Goddard Satellite-based Surface Turbulent Fluxes Version 3 |
| 3.4 Evapotranspiration | No | | | • Satellite data from AquaMODIS (500m resolution, 8days, 2000-present) | USGS: MYD16A2 Version 6 |
| 3.5 Water level | No | | No existing data. | Historical floods footprints (3 major events, will be used for calibration (250m to 1km) | MODIS |

| | | | | | |
|---|---|---|---|---|---|
| 3.5 Discharge | No | | No existing data. | Historical floods footprints (3 major events, will be used for calibration (250m to 1km) | MODIS |
| 3.6 Wind speed | Yes | WWF weather stations | Insufficient data points with short time series (2012-2020), hence no statistical validation of results possible. | Satellite data from CFSR NOAA (50km), TERRA CLIMATE (4km)and ADM AEOLUS ESA (0.5 to 1km) | The Climate Forecast System Reanalysis |
| **4. Topography/Water bodies/Soils** | | | | | |
| 4.1 Topography | Yes | COPECO | High resolution model (Lidar 1m, DTM 5m) | | |
| 4.2 Water bodies | Yes | Municipality | Appropriate data of water bodies (i.e. lakes, rivers, water-systems) | | |
| 4.3 Types of soils | Yes | Municipality | Fair to low level of detail, but in GIS format | Completed with other available sources | • FAO<br>• ISRIC |
| **5. Administrative areas** | | | | | |
| 5.1 Administrative areas | Yes | Municipality | GIS data classified in *neighbourhoods* and *districts.* | | |
| **6. Socio-economic data** | | | | | |
| 6.1 Socio-economic census | Yes | Municipality | • GIS data on neighbourhood level (2016, 2017)<br>• Complemented with household survey (2020) | | |
| 6.2 Employment | Yes | Municipality | Report on socio-economic conditions in SPS (2016) | | |
| 6.3 Development of income, consumption & wealth | No | | | Country`s CPI and GDP growth as proxy for SPS | National Bank of Honduras "Honduras en cifras" (documentation between 2000-2018) |
| **7. Households** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 7.1 Type of settlements (formal, illegal subdivisions) | Yes | Municipality | GIS data with location and number of families | • Complemented with results of household survey (2020)<br>• Scope of new data to be identified. | DIEM |
| 7.2 Household size and housing conditions | Yes | Municipality | GIS data with comprehensive information on household size and characteristics incl. housing conditions | • Complemented with results of household survey.<br>• Scope of new data to be identified. | DIEM |
| 7.3 Social studies in lower income settlements | Yes | Municipality | Report on population characteristics in Los Bordos, but limited to only a few areas. | Complemented with ad-hoc flood area survey. | Municipality |
| 8. Land Use & Population density (GIS) | | | | | |
| 8.1 Current land use | Yes | Municipality | A useful baseline of current land use. We could need further detail but that is will be defined in the near future. | | |
| 8.2 Planned land use | Partial | Municipality | Planned land use is expressed in road and sewage infrastructure plans, and a zonation for potential construction areas | | |
| 8.3 Population density | Yes | Municipality | GIS data on the neighbourhood level | • Complemented with household survey results.<br>• Scope of new data to be identified. | DIEM |
| 9. Cadastre and infrastructure (GIS) | | | | | |
| 9.1 Urban cadastre and land values | Yes | Municipality | GIS data with sufficient level of detail | | |
| 9.2 Asset values | No | Municipality | | • Values of similar assets in neighbouring countries or cities | • Scientific literature<br>• Expert interviews |

| | | | | | |
|---|---|---|---|---|---|
| | | | | • Use of monetary estimation methods | |
| 9.3 Road network | Yes | Municipality | High quality. GIS data. With network system and bridges | | |
| 9.4 Drinking water | Yes | Municipality | GIS data with a sufficient level of detail | | |
| 9.5 Sewage & drainage systems | Yes | Municipality | GIS data with a sufficient level of detail | | |
| 9.6 Electricity grid | Yes | Municipality | GIS data with a sufficient level of detail | | |
| 10. Service infrastructure (GIS) | | | | | |
| 10.1 Health, Education, Recreation, Administration and Government | Yes | Municipality | Location of facilities available, but no monetary values | • Values of similar assets in neighbouring countries or cities<br>• Use of monetary estimation methods | • Scientific literature<br>• Expert interviews |
| 10.2 Heritage sites | Yes | Municipality | GIS data with a sufficient level of detail | | |
| 11. Strategies and policies of the municipality | | | | | |
| 11.1 Zoning of protected areas (GIS) | Yes | Municipality | GIS data with a sufficient level of detail | | |
| 11.2 Rehabilitation of degraded ecosystems | Yes | Municipality | GIS data on the diverse ecosystems | | |
| 11.3 Inventory of implemented measures to prevent and prepare for extreme events | Yes | Municipality | Report on prevention and preparedness measures taken in SPS. Limited focus on floods. | Complementation of current and planned measures for flood events | • Expert interviews (DRM experts, COPECO)<br>• Literature review |
| 11.4 Contingency Plans of the municipality | Yes | Municipality | Report available | | |

# 5 Conclusions and Next Steps

The city of SPS is planning to implement grey and green adaptation measures to protect poor neighbourhoods in the Central District against landslides and flooding, early warning systems, and capacity development for communities and institutions. The ECA studies main objectives are to support decision-makers of SPS in further developing their adaptation strategy and to develop climate change adaptation (CCA) measures investment portfolios. The results shall help therefore to assess relevance and potential of possible risk transfer solutions and adaptation measures. Such solutions shall be embedded into existing policies and plans of the municipality and contribute to a more informed decision regarding adaptation options in SPS. Direct benefits for the municipality of SPS include but are not limited to i) a better risk analysis, ii) a detailed assessment of potential damages on selected assets, iii) a ranking of adaptation measures, including risk transfer, ecosystem-based adaptation, and already planned measures, iv) a detailed and spatial visualization of benefits (as compared to costs) for the municipality of SPS.

Moreover, the study results are immediately relevant for the project implementation of the KfW program "Urban climate change adaptation in Central America" which is expected to be extended to SPS, based on fund availability.

This report describes the state of data availability and data collection to run CLIMADA. It presents a general overview of the collected data, with a quality assessment regarding their usability for the ECA study, as well as the proposed proxies for those data sets that are insufficient for running CLIMADA or might lead to too high uncertainties in the final results. The inception phase of the ECA study in SPS defined the scope, including hazards, key assets, the time horizon and the most vulnerable areas in the city to be considered. This report documents and discusses data availability and quality for this purpose. Suggestions of possible proxies are made for unavailable data and data of insufficient quality. Collection of existing data and new data collection was made in close collaboration with the local authorities and other stakeholders. Besides, this document showcases hazard and assets selections in the study area along with final recommendations for climate and socio-economic scenarios to be included in CLIMADA. Considering the time horizon defined in the inception workshop.

The overall results of the database report are summarized below:

1) A systematic review of available data and collection of proxies whenever necessary for running CLIMADA
2) Visualization and final recommendations on hazards and assets selection
3) Development of climate and socio-economic scenarios based on the latest research and development available for Honduras

Specific results of the report include:

**Hazard**: Urban floods are selected and simulated for today and in the future for several areas selected by the stakeholders.

**Study Area**: The following areas are displayed together with their exposure to former flood events:

- Chamelecón (District 18)

- Rivera Hernández (D. 14 & 15)
- Los Carmenes (D. 16)
- Los Bordos (D. 1 ,2 & 3) - Informal Settlements

**Time Horizon**: The following time horizon (25 years) has been chosen based on the Municipality Master Plan (PNDM)

**Assets**: Based on the inception report, the following assets are supported by collected data and displayed in this report:

- Vulnerable Persons
- Informal Housing (Los Bordos)
- Housings (Three different categories)
- Public Assets
    - The main and secondary road network
    - Electric network
    - Drainage system (water supply and sanitation)
    - Education centres
    - Health centres
    - Fire brigades
    - Airport
- Environmental Assets

**Data availability**: We presented the availability of data necessary for this study. All data were subject to drastic quality control and stored in a dedicated database to avoid redundancy. We have selected alternatives for missing data. In addition to the databases provided after the inception workshop, the Municipality in collaboration with DIEM conducted a household survey on the historical impacts of floods. The survey included a section on quality of the physical infrastructure of the housing, access to public services, appliances and other valuable devices, and one on the historical damages caused by the three major flood events that took place in recent years (Mitch in 1998, and the floods of 2014 and 2017).

**Special note on COVID19 risk assessment**: In the actual pandemic context, the ECA Study team has conducted a thorough risk assessment for the project. According to our actual knowledge we estimate how the current situation might impact the timeline and deliverable of the ECA studies in Honduras. A separated detailed brief will be shared with stakeholders. The overall risk assessment level is estimated to be “medium” with an expected 1-2months delay compared to the initial schedule. Delays are mostly caused by travel restrictions. We offer several mitigation options including digital workshops and delayed final delivery workshops. An updated time ply is provided below.

Concrete next steps include:

**Base Data Workshop:** a short online workshop will take place in June 2020 to inform on the actual development of the ECA studies in Honduras. Invitation will follow

**Flood modelling**: (Deliverable July 2020, commissioned by UNU-EHS) Given the lack of an actual reliable flood model for the municipality of SPS and its surrounding, it has been decided that a flood model shall be commissioned within the frame of this study. A team of international and local consultants are currently working on the model set-up, including validation on historical events and simulation of future events. The flood model uses the best data available, making use of remote sensing technology, the latest LIDAR data and advanced GCMs simulations. The delivery of the flood model is expected for the beginning of July 2020. The results will be introduced directly into CLIMADA.

**A long list of adaptation measures**: A long list of possible adaptation measures will be prepared and discussed with stakeholder during a short online workshop in July 2020. After this workshop, a shortlist of measures will be selected for introduction into CLIMADA.

**Valuation of assets**: Selected assets will be given monetary values, using different methods. Values and methods will be documented in the vulnerability report.

**Damage functions**: Using available historical damages, desk research and expert interviews, the relationship between flood and the potential damage will be quantified by so-called damage function. Details about damages functions will be explained in the vulnerability report.

Simulation in CLIMADA: In this step, hazards risk maps, assets values and location as well as damage functions will be introduced in CLIMADA for simulation. Adaptation measures and climatic and socio-economic scenarios are also added to the model. Calibration and validation of the model are essential steps that will be performed, using historical events. Simulation of future flood events will document the effectiveness of the shortlist of adaptation measures.

**Vulnerability report**: (October 2020, UNU-EHS) The vulnerability report is expected to be circulated in October 2020. It will include the simulations and results by CLIMADA, the results of the flood model, and a ranking of recommended adaptation measures for SPS. It details decisions made for every step and makes recommendations on the best measures. Uncertainties linked to the modelling exercise are also discussed.

## Updated Timeplan

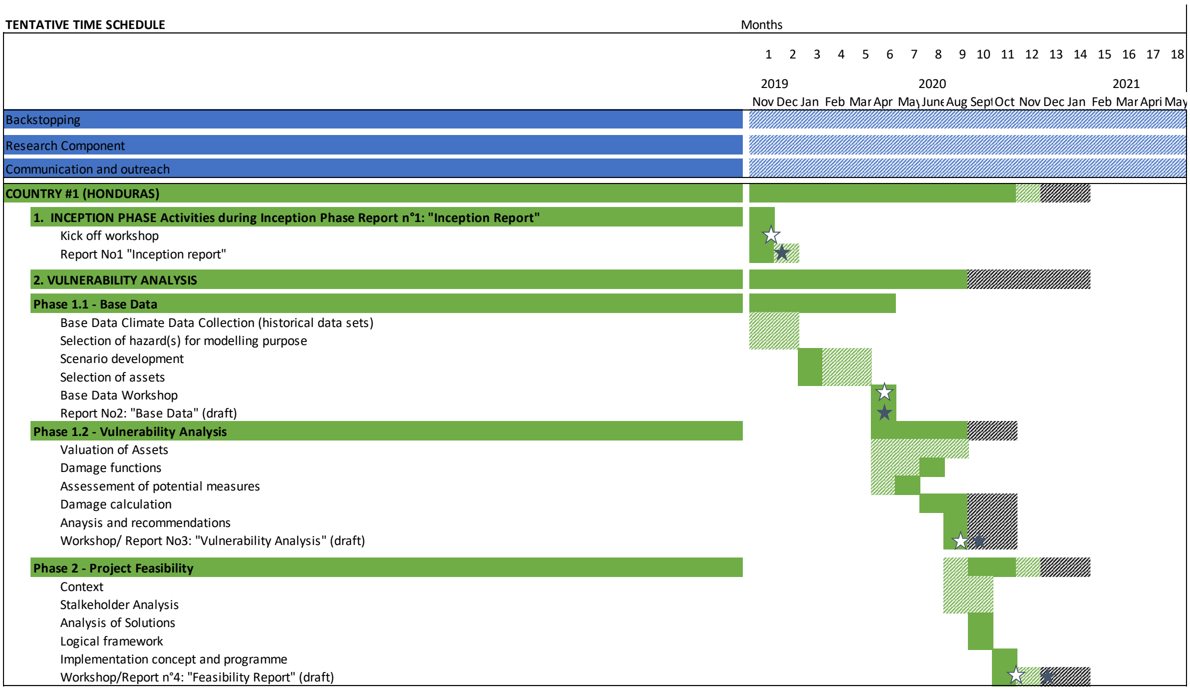



*Figure 18 Updated time plan of the ECA Study in SPS with the original main milestones and expected delays (hatched)*

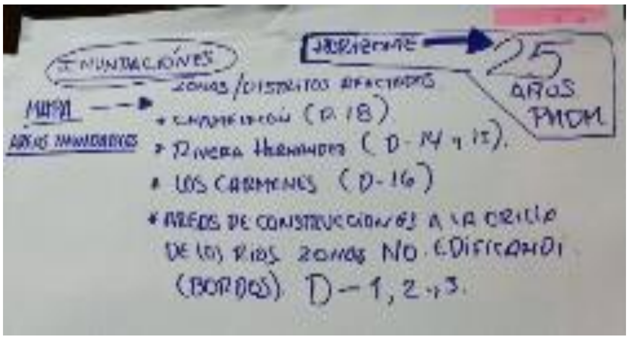
# ANNEXES

Economics of
Climate
Adaptation

**ANNEX 1**


MESA#1 AMENAZAS
NIVEL DEL IMPACTO
INTENSIDAD/ FRECUENCIA
IMPACTO ECONOMICO
IMPACTO SOCIAL
RESILIENCIA/ PERIODO DE RECUPER.
NIVEL DE CONOCIMIENTO
TOTAL
INUNDACION 3 3 3 3 3 1 16
SEQUIAS 2 2 2 2 2 1 11
VIENTOS 2 1 2 1 1 1 8
DESLIZAMIENTOS 1/2 1 1 1 1 1 6/7
ERRUMBES 1/2 1 1 1 1 1 6/7

**ANNEX 2**


INUNDACIONES
25 AÑOS
PMDM
ZONAS/DISTRITOS AFECTADOS
(D-18)
(D-14 y 15)
LOS CARMENES (D-16)
DE LOS RIOS ZONAS NO
(BORDES) D-1, 2 y 3

**ANNEX 3**


Inundación
Población
Vulnerable
Viviendas
Vial
Infraestructura
Eléctrica
Bordos
de
Ríos
Activos
Públicos
Sistema
Alcantarillado
Caudales repentinos
Casco urbano
Bosque
Ganado

**ANNEX 4**

| Year | INE population estimates in '000 (resulting annual estimates in *italic*) | Annual average growth rate | CPI growth rate (estimates from 2020 onward) | GDP growth rate (estimates from 2019 onward) |
|---|---|---|---|---|
| 2016 | 754 | | | |
| 2017 | *777* | | 3,93% | 4,79% |
| 2018 | *802* | | 4,35% | 3,75% |
| 2019 | *826* | | 4,37% | 3,72% |
| 2020 | 852 | 3,1% | 3,84% | 2,93% |
| 2021 | *880* | | 3,84% | 2,81% |
| 2022 | *908* | | 3,74% | 2,70% |
| 2023 | *937* | | 3,67% | 2,60% |
| 2024 | *968* | | 3,60% | 2,50% |
| 2025 | 999 | 3,2% | 3,53% | 2,41% |
| 2026 | *1025* | | 3,47% | 2,33% |
| 2027 | *1052* | | 3,41% | 2,25% |
| 2028 | *1080* | | 3,35% | 2,17% |
| 2029 | *1109* | | 3,29% | 2,10% |
| 2030 | 1138 | 2,6% | 3,23% | 2,04% |
| 2031 | *1162* | | 3,18% | 1,98% |
| 2032 | *1186* | | 3,13% | 1,92% |
| 2033 | *1211* | | 3,08% | 1,86% |
| 2034 | *1237* | | 3,03% | 1,81% |
| 2035 | 1263 | 2,1% | 2,98% | 1,76% |
| 2036 | *1285* | | 2,94% | 1,72% |
| 2037 | *1307* | | 2,89% | 1,67% |
| 2038 | *1329* | | 2,85% | 1,63% |
| 2039 | *1352* | | 2,81% | 1,59% |
| 2040 | 1375 | 1,7% | 2,77% | 1,55% |
| 2041 | *1397* | | 2,73% | 1,51% |
| 2042 | 1419 | 1,6% | 2,69% | 1,48% |
| | | | | |
| Annual average 25 years in 2042 | | 2,46% | 3,30% | 2,24% |
| Mean of projection | | | 3,22% | 2,13% |
| Median of projection | | | 3,18% | 2,01% |
| Standard deviation of projection | | | 0,37% | 0,55% |

**ANNEX 5**

**MUNICIPALITY OF SAN PEDRO SULA**
**DEPARTMENT OF INVESTIGATION AND MUNICIPAL STATISTICS (DIEM)**
***SURVEY ON THE IMPACT OF FLOODING ON COMMUNITIES IN VULNERABLE AREAS OF SAN PEDRO SULA***

**I. GEOGRAPHICAL IDENTIFICATION**

District: __
Neighborhood: _________________
Apple: ……………………………………………….
Edification:……………………………………………….
Unit: …………………………………………………..

**II. INTERVIEW CONTROL**

Date: _____/_____/ _______
Surveyor: _____________________________________
Supervisor: _____________________________________

**III. HOUSING DATA**

**1. Exact address**
____________________________________________________
____________________________________________________

**2. Material of the walls (**Quality assessment of surveyor: High, Medium, Low**)**
1. [ ] Brick, stone or block
2. [ ] Wood
3. [ ] Asbestos / panelit
4. [ ] Waste
5. [ ] Adobe
6. [ ] Plate
7. [ ] Other
8. [ ] Does not have

**3. Roof material (**Quality assessment of surveyor: High, Medium, Low**)**
1. [ ] Asbestos
2. [ ] Zinc
3. [ ] Tile
4. [ ] Straw / palm
5. [ ] Waste
6. [ ] Does not have

**4. Floor material (**Quality assessment of surveyor: High, Medium, Low**)**
1. [ ] Cement brick
2. [ ] Mud brick
3. [ ] Cement sheet
4. [ ] Wood
5. [ ] Earth
6. [ ] Other

**5. Tenure (**mark with X**)**

1. [ ] Own
2. [ ] Rented
3. [ ] Loan / borrowed

**6. Do you have any insurance that responds in case of damage?**
YES/ NO

**7. Does the house have access to the following basic services?**
1. Drinking water YES/ NO
2. Electricity YES/ NO

**8. The sewage system used in the house is (**mark with X**)**
1. [ ] Connected to sewer
2. [ ] Hydraulic latrine
3. [ ] Simple latrine
4. [ ] Does not have

**9. What is the *average* FAMILY income per month (Lps.) (**mark with X**)**
1. [ ] Up to 5000
2. [ ] From 5001— 10,000
3. [ ] From 10001 - 15000
4. [ ] From 15001 - 20000
5. [ ] More than 20000

**10. How long has the house been built (**mark with X**)**
1. [] Less than 1 year
2. [] From 1 to 5 years
3. [] From 5 to 10 years old
4. [] From 10 to 20 years old
5. [] More than 20 years
6. [] Don't know

**11. How many floors does the house have? _____**

**12. How many pieces does the house have (Do *not count the bathroom*)? ____**

**13. Do you have in this house any of the following devices or appliances? (**Quantity**)**
1. [ ] Refrigerator
2. [ ] Washing machine
3. [ ] Television
4. [ ] Fan
5. [ ] Air conditioning
6. [ ] Computer
7. [ ] Radio, sound system
8. [ ] Stove
9. [ ] Microwave
10. [ ] Electronic games: Wii, Nintendo, PlayStation
11. [ ] Beds
12. [ ] Furniture
13. [ ] Vehicle

**14. Have livestock or pets in this home? (**Quantity**)**
1. [ ] Cattle (Cows, Bulls)
2. [ ] Sheep
3. [ ] Pigs
4. [ ] Horses
5. [ ] Mares

6. [ ] Dogs
7. [ ] Cats
8. [ ] Birds
9. [ ] Fish

**IV. DAMAGE FROM ADVERSE EVENTS**

**15. Flood caused by Hurricane MITCH - October 1998 (**Cost from damage in Lps. due to:**)**

1. Water / mud cleaning __________
2. Affectation in potable water supply __________
3. Affectation in electricity supply __________
4. Damage to the structure of the building __________
5. Loss of livestock / pets __________
6. Damage in computers __________
7. Damage in beds __________
8. Damage in fans __________
9. Damage in air conditioning __________
10. Damage in home appliances __________
11. Damage in furniture __________
12. Damage in electronic games: Xbox, Nintendo, PlayStation __________
13. Damage in vehicle __________
14. Damage in TV / Sound equipment __________
15. Injured people __________
16. Dead people __________
17. Other: __________

**16. Flood caused by the Cold Front - January to March 2014**

1. Water / mud cleaning __________
2. Affectation in potable water supply __________
3. Affectation in electricity supply __________
4. Damage to the structure of the building __________
5. Loss of livestock / pets __________
6. Damage in computers __________
7. Damage in beds __________
8. Damage in fans __________
9. Damage in air conditioning __________
10. Damage in home appliances __________
11. Damage in furniture __________
12. Damage in electronic games: Xbox, Nintendo, PlayStation __________
13. Damage in vehicle __________
14. Damage in TV / Sound equipment __________
15. Injured people __________
16. Dead people __________
17. Other: __________

**17. Flood of January to March 2017**

1. Water / mud cleaning __________

2. Affectation in potable water supply _________
3. Affectation in electricity supply _________
4. Damage to the structure of the building _________
5. Loss of livestock / pets _________
6. Damage in computers _________
7. Damage in beds _________
8. Damage in fans _________
9. Damage in air conditioning _________
10. Damage in home appliances _________
11. Damage in furniture _________
12. Damage in electronic games: Xbox, Nintendo, PlayStation _________
13. Damage in vehicle _________
14. Damage in TV / Sound equipment _________
15. Injured people _________
16. Dead people _________
17. Other: _________

**18. Other flood event that your remember**

**Year ____________**

1. Water / mud cleaning _________
2. Affectation in potable water supply _________
3. Affectation in electricity supply _________
4. Damage to the structure of the building _________
5. Loss of livestock / pets _________
6. Damage in computers _________
7. Damage in beds _________
8. Damage in fans _________
9. Damage in air conditioning _________
10. Damage in home appliances _________
11. Damage in furniture _________
12. Damage in electronic games: Xbox, Nintendo, PlayStation _________
13. Damage in vehicle _________
14. Damage in TV / Sound equipment _________
15. Injured people _________
16. Dead people _________
17. Other: _________