



Vulnerability Assessment and adaptation strategies for the triangle-city region

Executive summary

Cities represent essential actors in the combat against climate change. It is expected that the majority of people in the planet will live in cities by mid-century. In the case of South America, the UN (2016) expects that around 80% of its population will live in urban centres by 2050. Concurrently, cities are expected to increasingly face climate effects in the form of more intense and frequent extreme weather events, putting millions of people at risk, especially those that are more vulnerable. Regarding South America, existing studies have shown that the region is particularly exposed to extreme climate-related events and displays numerous vulnerabilities (e.g. poverty, economic and political instability, lack of resources and infrastructure, etc.). In this sense, it is vital for cities to undertake actions to reduce their vulnerability to climate change and build climate-resilient development.

The aim of this study is to assess the climate vulnerability of the so-called triangle-city region, comprised of three neighbouring cities located in three South American countries. The cities are Foz do Iguazu (Brazil), Puerto Iguazu (Argentina) and Ciudad del Este (Paraguay), which share borders at the confluence of the Parana and Iguazu rivers.

Apart from sharing the same geographical area and a common historical background, these cities also face similar challenges and have shared climate vulnerabilities. Consequently, city-to-city cooperation plays a crucial role in order to successfully address these challenges.

This assessment represents the first attempt to examine the vulnerability of the triangle-city region to climate-related events. Furthermore, this study constitutes a novel effort to analyse the concept of vulnerability as a shared phenomenon, placing a particular emphasis on city-to-city cooperation as a paramount element to successfully

face the climate change challenge. This examination thus provides an initial understanding of the climate vulnerability of the region, offering valuable insights and highlighting gaps and areas of urgent attention. It also pretends to be a stepping stone for future research, as it reveals various issues that require a deeper exploration. The findings presented here are of interest to policy-makers, practitioners, academics, as well as individuals and organizations concerned about the climate resilience of the region and the well-being of its inhabitants.

This document reports the main findings derived from the study and its implications. It also provides a brief historical background of the region and describes the characteristics and socio-economic structure of the three cities. In addition, past climate trends are analysed, focusing on the main extreme weather events that have affected the region during the past decades. This examination is supplemented with a look at climate projections to determine the challenges that the region is likely to face in the future. Moreover, this document presents a scrutiny of the legal, policy and institutional settings in each city in relation to climate change adaptation. Regarding the vulnerability assessment, the report presents an Urban Vulnerability Index (UVI), which is a useful tool to compare the cities. Indices were constructed using different climate and socio-economic indicators to measure the various dimensions of vulnerability (sensitivity and coping/adaptive capacities). This

empirical analysis was complemented with a view on the strategies that the cities have adopted to react and respond to impacts caused by extreme weather events in the short-term, as well as the plans that are being undertaken to face future impacts. The report also presents an overview of the level of cooperation between the three cities and presents a set of preliminary solutions proposed by a group of stakeholders.

This study involved the participation of numerous actors from the three cities, who were instrumental in providing valuable advice and information. Our Steering Committee was key in granting us access to data and sharing their knowledge and experiences. Without their participation and support, this study would not have been possible.

Background

Since the 1960's, the triangle-city region has experienced rapid growth and continues to expand. Its population has increased more than 7 times, mainly attracted by the construction of the Binational Hydroelectric Plant of Itaipu (Brazil and Paraguay) and the touristic potential of the Iguassu Falls, considered as one of the natural wonders of the world. Furthermore, the development of Ciudad del Este as a low-tax commercial hub has attracted significant population flows into the region. This last city is expected to be among the ten fastest growing cities in Latin America by the year 2030,

according to UN urbanisation prospects. Moreover, the region receives millions of tourists each year, seeking the local attractions.

Urban planning and investment in infrastructure have not been on par with population growth. Adequate urban planning has been absent, resulting in an uncontrolled urban sprawl. Irregular land occupation has led to the creation of slums, mainly along rivers and risk areas, which is an issue of concern given their high exposure to floods. The speed of investment in public and private infrastructure has not been enough, and the pressure is increased by the intense flow of tourists. Some basic city services, like sanitation (sewer and refuse), are not available to all the population. Investment in tourism infrastructure is also required to capitalise on the large flux of tourists, especially in Ciudad del Este. Moreover, high deforestation rates represent a threat to the region's forests and biodiversity. Other problems related to the expansion of the cities include unemployment, illegal and clandestine practices, as well as issues involving traditional communities, such as violence and land appropriation.

Past climate trends

Historical trends suggest that climate patterns have changed in the triangle-city region during the last 5 decades. Results show that the annual amount of precipitation has increased over the years. Annual maximum daily precipitation and the number of

extreme precipitation events showed an increase, indicating that heavy precipitation events are becoming more intense and frequent. Moreover, daily maximum and minimum temperatures also presented a positive trend throughout the years, indicating a warmer climate. Furthermore, it is important to highlight that as the cities are located in an area prone to severe convective weather, it is likely that tornados can affect the cities in the future.

Extreme water-related weather events have caused the largest impacts in the triangle-city region. Heavy rainfall and flooding have been the most common events affecting the cities. Two types of floods were detected: river floods, caused by an increase in river levels, and urban floods, due to intense precipitation. Past episodes of droughts have affected the tourism sector, as well as the water drinking supply in Ciudad del Este. Moreover, we found that hailstorm events follow a pattern of low frequency and high impact. The most recent hailstorm event occurred in September 2015, generating severe material losses.

The meteorological monitoring system in the triangle-city region requires to be enhanced, while definitions of extreme weather events should be unified. These aspects are essential to enhance our understanding of weather and climate in the region. For instance, the different countries in the triangle-city area define heat-wave and cold-wave events in a different manner. This heterogeneity

complicates their analysis. Furthermore, it is necessary to increase the number of reliable weather stations. This study found inconsistencies in meteorological data collected in different weather stations, which complicated the analysis and limited the amount of reliable information.

Future climate projections

Mean temperature is expected to increase in the triangle-city region by the end of the 21st century. Studies conducted for South America and Paraguay, which use different global and regional climate models and scenarios, show an increase in temperature for all time-frames (near-to long-term) and seasons (spring, summer, autumn, winter). However, the magnitude of this increase depends mainly on the climate model used to produce those projections.

Changes in mean precipitation in the region are difficult to determine, given contradicting projections. Existing studies have produced conflicting evidence for this variable, resulting in a range of results that vary according to the scenario, term, and season that are selected in the modelling process. However, the analysis of past trends has revealed that extreme precipitation events have increased, and it is expected that these trends will continue.

Extreme weather events are expected to increase, especially those related to high temperatures. Heat waves could become more

common in the future across the triangle-city region. Positive trends were found in the number of summer days, tropical nights, and warm nights (see Chapter 4 for definitions of these terms). However, statistically significant trends were only obtained in relation to maximum and minimum temperatures. If this phenomena is combined with potential increases in precipitation, the triangle-city region could expect the occurrence of more severe extreme weather events.

Policy, legal and institutional settings for climate change adaptation

Climate change adaptation initiatives are still very incipient at the municipal level. The three countries have started to develop their plans for climate change adaptation. Brazil and Paraguay released their National Adaptation Plans (NAPs) in 2016, while Argentina has its plan currently under development. However, these efforts have not trickled down to local governments yet. Even when the NAPs mention the requirement for municipalities to develop their local plans, no specific planning instruments or strategies for climate change adaptation were identified in any of the cities. This constitutes an important gap that requires to be urgently addressed.

The cities possess emergency protocols and contingency plans, but prevention, preparedness and recovery measures are deficient. The cities have designed a course of action

to help them respond to an unforeseen event, although some of these plans were not available for consultation. Response mechanisms rely basically on the municipalities through different organisations, like the fire departments, with the support of other institutions. In Puerto Iguazú and Ciudad del Este the fire brigades are organized by volunteers, whereas in Foz do Iguacu they are formed by the military. In terms of preparedness measures, the existing early warning systems are not designed to provide timely and accessible information directly to citizens. Evidence on strategies for prevention were scarce. In relation to recovery and reconstruction actions, there seems to be no proper plans in place. These also represent important gaps that are waiting to be addressed.

Guidelines for local adaptation and the existing emergency settings in the three cities present similarities, providing an opportunity for joint planning and acting. The three countries have produced guidelines for local adaptation focusing on common aspects, such as territorial management, land use, sanitation and infrastructure, as well as the incorporation of climate change elements in all instances of urban management and development. Although formal climate change adaptation strategies are still inexistent, this represents a good opportunity for the three cities to develop joint initiatives and institutionalise city-to-city cooperation. There is evidence that willingness to cooperate already exists on this matter, as shown in this report,

although it happens on an informal basis.

There are established agreements and protocols that institutionalize cooperation among the three cities and countries, but these are not applied in practice. The Mercosur protocol for cooperation and assistance to environmental emergencies, as well as the complementary adjustment to the agreement between Brazil and Argentina for civil defence cooperation in boundary localities, provide guidelines for the exchange of information and assistance among parties in the face of emergency events. However, such protocols seem to be unknown or not used by local actors, while cooperation occurs on an informal basis, through the collaboration of individuals and organisations. Nonetheless, there are efforts to institutionalise cooperative actions, like a proposed agreement among the fire departments of the three cities.

Socio-economic vulnerabilities

Foz do Iguacu shows a lower level of vulnerability to extreme weather events compared to Ciudad del Este and Puerto Iguazú. Foz has relatively more green areas (45% of the municipal area), lower poverty indicators (less population living in poverty and in slums), better access to water, waste treatment, and education, a lower mortality rate, a larger public budget and a more dynamic and diversified economy. Foz also has

higher levels of preparedness and recovery. The results also indicate that its institutions, in general, enjoy good reputations, specifically for emergency management and for allowing citizen participation in government decisions. Foz has a better disposition to adopt good practices from other cities and cooperate with them, since it has adopted and applied similar policies from other cities.

Ciudad Del Este and Puerto Iguazú display larger vulnerabilities, compared to Foz do Iguacu. They have proportionally more population susceptible to impacts related to extreme events and a lower capacity to recover from them. These cities are highly-urbanised without sufficient green spaces. Their lack of urban planning has led to the occupation of risk areas. The level of public services is insufficient in the areas of health, water and sanitation. They also show low levels of preparedness and response, having limited resources for recovery. In addition, the results indicate lower reputational levels among their institutions for emergency response, as well as poor governance for the participation of the population in local government. This constitutes a barrier to build effective adaptation strategies in these cities.

Ciudad del Este is more sensitive to extreme events, like heavy rains and heat waves. This city is highly urbanised and has a lower proportion of green areas per person. This increases the heat island effect, which has consequences on human health. Given that the city has a larger

proportion of vulnerable population (below 14 years of age and above 65), the risk to be affected increases. Moreover, insufficient green spaces elevate the probability of flooding, since runoff increases and water infiltration is reduced.

The cities have different levels of development, reflected in the quality and coverage of basic public services. Ciudad del Este is the city that suffers the most from insufficient coverage of public services. A large part of its population does not have access to drinking water and sanitation. Energy supply problems were identified in Puerto Iguazú, while solid waste management was pinpointed as a serious issue in Ciudad del Este and Foz. Other problems that were detected are low levels of education and increasing levels of insecurity. In addition, it was found that road infrastructure requires urgent maintenance, along with an increase of transport services to communicate the three cities, especially between Puerto Iguazú and Ciudad del Este. For instance, a bridge and more ferries are required to connect these two cities.

The region offers a good business environment, but economic diversity in the region is low. The economy of Foz do Iguacu is more diversified, but still relies heavily on tourism, which is sensitive to climate impacts. The same is true for Puerto Iguazú, where tourism is one of the main activities. The agricultural sector in Ciudad del Este accounts for almost a third of its gross domestic product (GDP), being an activity that is also

sensitive to changes in climate. Regarding the business sector, the results show that Ciudad del Este possesses a large number of firms, but the majority are small and medium enterprises (SMEs), which are generally the most vulnerable in the private sector. Further diversifying the economies of the three cities would contribute to reduce their vulnerability.

Despite its lower levels of vulnerability, Foz do Iguacu still needs to improve its public policies for land use and spend more on infrastructure to address constant problems of flooding. Irregular occupation of areas along riverbanks puts deprived populations at serious risk. Furthermore, poor infrastructure in terms of water drainage systems leads to flooding of public roads, some of them on a constant basis. The municipality, however, has limited resources, which hampers its capacity to prepare, respond and recover from extreme weather events. So far, Civil Defence has identified 35 critical points across the city, and has acknowledged that in order to solve these problems a vast amount of investment will be needed.

Irregular settlements in high risk areas represents a serious governance challenge in the three cities. A key problem is the relocation of population living along riverbanks. However, this has proven to be a complicated issue, since people tend to return to the same areas after being relocated. This is due to various reasons, but mainly because the affected persons do not want to leave

the central region of the city, considering that new housing provided by the municipality is generally far from the city centre, away from their workplace, schools, and commercial areas. Despite most resettlement efforts have been ineffective, a successful case was registered in Foz do Iguacu, which deserves to be studied more attentively to identify any important lessons that can be applied to other cases.

Civil Defence is the first entity to respond to an emergency and disaster situation in the cities. Actors in the region, interviewed for this study, consider that this institution constitutes the foundation of the cities' capacity to respond to unforeseen events. It includes the fire brigades, which are the first to provide assistance to affected population. The Red Cross in Ciudad del Este equally plays a relevant role in aid delivery efforts. However, these institutions are often underfunded and lack training and special equipment for some types of emergencies and disasters.

Cooperation

City-to-city cooperation to respond against extreme weather impacts does exist, but mainly at an informal level. Customarily, extreme weather events are faced by each city independently. However, there are strong links and communication between certain institutions, like the fire brigades of the three cities. Although there are no formal protocols for cooperation, people show willingness

to cooperate and manifest solidarity mainly due to personal and professional affinities. There are several accounts of cases where the cities have helped each other to face threats, like fire and dengue outbreaks. Cooperation between the three cities still needs to be formalised, and this could help to reduce their vulnerabilities to extreme weather events.

Local development councils represent an excellent mechanism to build cooperation between the cities. CODESPI (Puerto Iguazú), CODEFOZ (Foz do Iguacu), and CODELESTE (Ciudad del Este) seek to promote long-term sustainable development in each city, while aligning and integrating the interests of society within government actions in a democratic manner. These entities have been successful in promoting policies and implementing improvements that have benefited the cities. They have also tried to strengthen the links between the three urban centres, opening new ways of cooperation and finding efficient communication channels in the region.

Cooperation among the cities is not balanced. Foz do Iguacu acts as a node, linking the three cities. On the one hand, the Friendship Bridge connects the city to Ciudad del Este, while the Fraternity Bridge (Tancredo Neves) links it with Puerto Iguazú. On the other hand, Ciudad del Este and Foz do Iguacu are strongly related through Itaipu Binacional, a joint partnership between Paraguay and Brazil, providing energy and a source of income to both countries. In turn, Foz do Iguacu and Puerto Iguazú are joined

by the Iguassu Falls, another source of income for these two cities. In this sense, Foz do Iguacu has strong links with both its neighbours. However, the relationship between Puerto Iguazú and Ciudad del Este is weaker. No bridge connects these cities and they are only communicated by ferries.

A certain level of coordination exists regarding the sharing of climate information. Civil Defence institutions play an important role in this regard. For instance, individuals interviewed for this study informed that climate information collected by the meteorological radar in the neighbouring town of Cascavel (Brazil) is used in Puerto Iguazú. There are other examples of information sharing between the other cities. Civil Defence in Foz do Iguacu also pretends to obtain better measuring instruments. The tasks undertaken by Civil Defence in these cities are thus valuable, since they generate co-benefits for the region and create a favourable terrain to foster stronger cooperation.

There are barriers to active cooperation between the three cities. Seeking to engage the three cities to undertake cooperative actions is not a simple task. There are numerous barriers, starting with language. Although a large proportion of the population understands and speaks Spanish and Portuguese, communication issues represent an issue. There are also cultural differences and divergent legal settings. Moreover, economic, political and security issues often hinder cooperation actions. The existence of

historical constraints between countries also plays an important role.

What can the cities do to reduce their vulnerabilities?

Stakeholders from different sectors of the three participating municipalities were brought together to discuss possible solutions to increase the climate resilience of cities, given the identified vulnerabilities. These solutions can be classified into four types.

Planning. Adequate urban and land-use planning are paramount for advancing on the development and resilience of the municipalities. An effective plan to organise the urban environment is essential to control the sprawl and correct any irregularities, like the inappropriate occupation of riverbanks and other risk areas. Effective city planning, however, is a process that involves technical and political elements. It also implicates the creation of policies and regulations which must be monitored and enforced.

Structural. As has been said, insufficient investment in infrastructure has led to various problems, such as a deficient level of public services. The need to invest in basic sanitation is essential. The cities do not provide full coverage of domestic sewage collection, especially in districts farthest from the central regions. Investment in efficient drainage systems is also urgent, contributing to reduce urban flooding. Other structural solutions are

related to the improvement of solid waste management systems, strengthening the resistance of housing in deprived areas, and the creation of more green spaces.

Non-structural. An important issue identified in this study is the lack of reliable data, from climatic to socio-economic. Building the capacity of the municipalities to collect, process and disseminate quality data is vital to foster climate resilient development, as it is necessary to better understand the situation and monitor progress. Other measures are aimed at providing training to municipal officials regarding climate change and adaptation actions. Improving environmental education and developing awareness among the population is also essential, in order to influence people's behaviour and make them aware of the risks faced by the region and the importance of keeping the cities and rivers free of pollution and waste.

Cooperation. The triangle-city region offers good opportunities to foster strong city-to-city cooperation. The creation of a Tri-National Civil Defence Council has been mentioned by various actors, which would allow a better coordination of preparedness and response actions, pooling financial and human resources from the three cities. Similarly, the establishment of a tri-national chamber formed by the three local development councils could help to address common problems and design a future vision for the region. Other solutions relate to the creation of joint early warning systems, as well as

setting more spaces for discussion and programmes for cooperative actions.

Conclusions

1. Given the expected population growth and climate projections that indicate the likelihood of more frequent and severe extreme weather events, the triangle-city region must urgently implement disaster risk reduction measures and increase its climate resilience. It is essential for the cities to revise and improve their contingency plans and make them publicly available. Efforts have to be made to develop strategies aimed at prevention, preparedness and recovery actions. Furthermore, municipalities require to start developing their local climate change adaptation plans in accordance with national-level guidelines, designing courses of action to deal with an uncertain climate in the future.

2. The three cities face the opportunity to develop joint local initiatives and plans to deal with future climate effects. Given that the cities have not yet incorporated climate change as an essential factor in their work programmes and are yet to start developing adaptation strategies, it is an appropriate moment to create these in a cooperative manner. It is important that the cities understand that their future is intertwined and that unilateral actions might not be as efficient and effective than when these are implemented in a cooperative manner.

3. The cities should adopt a medium and long-term vision to

successfully adapt to a changing climate. The existent early warning systems and the exchange of information between Civil Defence institutions are mainly oriented to deal with short-term issues. However, a longer term perspective is absent in the three cities. Future climate information is not used in the triangle-city region. It is required to investigate what type of information is required by different economic sectors (e.g. energy, tourism, agriculture, commerce) to undertake their adaptation actions.

4. The three cities share socio-economic vulnerabilities. Even though the analysis presented in this study treats the vulnerability of each city independently, this vulnerability is actually shared. In essence, the three cities form a single and cosmopolitan urban centre. People constantly crosses the borders in their daily lives to work, do shopping or for recreational issues. In this sense, any problem affecting one city would have immediate consequences on the rest. Addressing vulnerabilities or implementing solutions from an individual perspective thus makes little sense. In order to successfully build climate resilient development, cooperation must be an integral element in any climate change adaptation strategy.

5. Cooperation needs to be formalised and better balanced. The level of cooperation that exists today to face extreme events is to a large extent informal. Formalising and institutionalising city-to-city cooperation would strengthen links between the

municipalities and generate an atmosphere of certainty, security and trust. The proposed solutions to create a tri-national civil defence council and a tri-national chamber formed by the three local development councils is an important step toward this goal. However, the involvement of the municipalities is indispensable. Further efforts are required to engage them, as well as state and national authorities, in the process. Moreover, cooperation must be better balanced to ensure that links are strengthened between Ciudad del Este and Puerto Iguazú. Building a bridge between these two cities would contribute to boost their relationship.

6. The triangle-city region embodies an excellent opportunity for successful city-to-city cooperation. The region brings together more than 80 ethnic groups which, along with the presence of traditional peoples and an intense flow of visitors from all around the world, makes it a melting pot of cultures and ideas. Diversity and exchange are part of the local reality. This makes a favourable scenario for transboundary cooperation. The lessons learned from this region could be extremely helpful for other regions of the planet. The opportunity to build a more cooperative and resilient future is available today.