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The Case of Lower Paraná Delta, Argentina

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The Case of Lower Paraná Delta, Argentina

Verónica M.E. Zagare

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TOC

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Towards a Method of Participatory Planning in an Emerging Metropolitan Delta in the Context of Climate Change

The Case of Lower Paraná Delta, Argentina

Dissertation

for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus Prof. dr.ir. T.H.J.J. van der Hagen
Chair of the Board for Doctorates
to be defended publicly on
Wednesday 17, October 2018 at 12.30 o'clock

by

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Summary

The Parana River is the third largest river in the American continent, after the Mississippi and the Amazon. Instead of flowing directly to the sea, it flows to the Rio de la Plata (located between Argentina and Uruguay) through a complex delta system. This delta is a large and heterogeneous territory that spreads over three provinces of Argentina and that is characterized by different dichotomies along its extension. On the one hand, the islands of the delta are young alluvial lands in constant transformation due to the processes of sedimentation, and are subjected to pulses of floods influenced by the Paraná River streamflow, droughts, precipitations and strong southeastern winds coming from the Atlantic Ocean. Although these alluvial territories seem to be pristine, they have been moderately altered as a result of the development of economic activities. On the other hand, along the edges of the delta, we find the older territories of the mainland, created in the Pleistocene and less dynamic. Here is a network of cities of dissimilar sizes, that establishes the wealthiest corridor of the country. Conurbations such as Rosario (located in the province of San ta Fe) and the Metropolitan Area of Buenos Aires (located in the homonym province), exert different pressures over the territory, generating an increasing impact on the delta system. In other words, this delta shows a contrast between the wild and dynamic condition of the islands and the more stable but strongly urbanized edges. Nevertheless, this dichotomy is not the only one that can be found in the delta. On the contrary, there are other oppositions regarding economic, policy and social realms, expressed through a polarized, unsustainable and unplanned land use, which turns the area into a vulnerable place, given the uncertain context of climate change.

Although this delta can be considered an extreme and particular case, many of the conflicts that can be found in this area replicate in other deltas around the world. Urbanizing deltas are subjected to pressures related to urban growth and climate change, within a context of uncertainty and unpredictability. Those pressures interact at multiple scales and temporalities, affecting the components of the systems, as well as the relations between them and with the environment. This complexity reveals the need for the society (including governments, institutions, civil organizations, academia, etc.) to enhance the adaptability of the system of the delta, in order to cope with changes without losing their substantial characteristics.

This research is focused on the study of the complexity of self-organizing processes that emerge in metropolitan areas located in (or near) delta territories, in order to link climate adaptation with urban development from an actor-oriented perspective. This aim is motivated by understanding urbanizing deltas as complex adaptive systems

formed by physical components, social actors and their mutual relations, which are in constant adjustment within the system and with the environment, in an atmosphere of uncertainty. In such a complex context, small changes can trigger qualitative impacts, that force the system to adapt in order to return to a new dynamic equilibrium. For example, in urbanizing deltas, extreme climatic events can cause tragic consequences when the context is not capable of adapting to that circumstances, generating effects at all scales. This vulnerability makes necessary to prepare to possible disruptive events though innovative planning methods towards increasing the system´s adaptive capacity. For that purpose, and adopting a bottom-up criterion, this research bases on the understanding of the self-organizing processes that emerge in urbanizing deltas to design and implement a methodology that can be applied at the local level, to generate an impact at other scales. The method designed in this thesis also includes the development of scenarios in order to think about possible future events and reflect on the necessary policy and actions to make the system respond to changes in a more adaptive way. The scenarios, as well as all the indicators analysed along the process, are developed through participatory workshops, after an analysis of the actor-network of the area, and also of the local, provincial and national regulations.

The method designed and implemented throughout this research is applied at the local level of the case study, and is flexible enough to be adapted for replicating it in other parts of the Argentinean Delta, in order to contribute to the increase of the systems´ adaptive capacity through the generation of initiatives at the local level that can generate an aggregate impact at higher levels.

Samenvatting

De Paraná is de op twee na langste rivier van het Amerikaanse continent, na de Mississippi en de Amazone. Deze rivier mondt niet rechtstreeks uit in zee maar vloeit samen met de Rio de la Plata (tussen Argentinië en Uruguay), tot een complex deltasysteem. Deze delta omvat een groot, heterogeen gebied dat zich uitstrekt over drie provincies van Argentinië. Dit gebied wordt gekarakteriseerd door een aantal tweedelingen van verschillende aard. Enerzijds zijn er de eilanden van de delta, die bestaan uit jong alluviaal land dat door sedimentatie voortdurend in beweging is. De eilanden staan bloot aan de afwisseling van overstromingen als gevolg van extreme waterafvoer van de Paraná, droogteperioden, , neerslag en de krachtige zuidoostelijke winden vanuit de Atlantische Oceaan. Deze alluviale gebieden ogen weliswaar ongerept, maar economische activiteiten hebben al voor enige verandering gezorgdAnderzijds vinden we oudere, minder dynamische gebieden van het vasteland langs de kustranden van de delta. Deze zijn in het Pleistoceen ontstaan. Hier is sprake van een netwerk van steden van uiteenlopende omvang, die samen de rijkste corridor van het land vormen. Conurbaties zoals Rosario (in de provincie Santa Fe) en het stedelijk gebied van Buenos Aires (in de gelijknamige provincie) zetten het gebied op verschillende manieren onder druk, en de gevolgen voor het deltasysteem worden steeds groter. De delta ligt dus ingeklemd tussen de wilde, dynamische eilanden en de meer stabiele randen van het gebied, waar sprake is van toenemende verstedelijking. Dit is echter niet de enige tweedeling die in de delta kan worden gesignaleerd. Er zijn namelijk nog andere tegenstellingen aan te wijzen op economisch, beleidsmatig en maatschappelijk gebied, die zich manifesteren in een gepolariseerd, weinig duurzaam en niet-planmatig landgebruik. De onzekerheden die gepaard gaan met de klimaatverandering maken deze dekta tot een kwetsbaar gebied.

Hoewel de situatie in deze delta als extreem en uniek kan worden aangemerkt, zien we veel conflicten in dit gebied ook terug in andere, over de hele wereld verspreide delta's. Verstedelijkende delta's staan onder druk als gevolg van stedelijke groei en klimaatverandering, met onzekerheid en onvoorspelbaarheid als bijkomende factoren. Daarbij is sprake van een wisselwerking op verschillende niveaus en met een verschillend tijdsverloop, die van invloed is op de componenten van het systeem maar ook op de relaties tussen deze componenten en de omgeving. De complexiteit van dit vraagstuk brengt de noodzaak met zich mee voor de maatschappij (met inbegrip van overheden, instituten, maatschappelijke organisaties, universiteiten, enzovoort) om het aanpassingsvermogen van het systeem van de delta te versterken, opdat kan worden ingespeeld op veranderingen zonder dat dit ten koste gaat van de wezenlijke kenmerken van het gebied.

Dit onderzoek richt zich op het in kaart brengen van de complexiteit van zelfregelende processen die ontstaan binnen grootstedelijke gebieden die in (of nabij) delta's zijn gelegen, om zo vanuit een handelingsperspectief een relatie te leggen tussen klimaataanpassing en stedelijke ontwikkeling. Dit onderzoeksdoel is ingegeven door het besef dat het bij verstedelijkende delta's gaat om complexe adaptieve systemen die zijn gevormd door fysieke componenten, maatschappelijke actoren en hun onderlinge relaties, en die in een sfeer van onzekerheid en in samenhang met hun omgeving voortdurend intern worden bijgesteld. In een dergelijke complexe context kunnen geringe veranderingen al leiden tot kwalitatieve gevolgen die het systeem dwingen tot aanpassing, om zo een nieuw, dynamisch evenwicht te laten ontstaan. Zo kunnen extreme klimaatgebeurtenissen in verstedelijkende gebieden dramatische gevolgen hebben als er geen flexibele context is die dergelijke omstandigheden kan opvangen. De gevolgen zijn dan op elk niveau merkbaar. Deze kwetsbaarheid brengt de noodzaak met zich om voorbereid te zijn op mogelijke ontregelende gebeurtenissen, door de ontwikkeling van innovatieve planningsmethoden gericht op vergroting van het aanpassingsvermogen van het systeem. Gebruikmakend van een bottom-up criterium richt dit onderzoek zich dan ook op het verkrijgen van inzicht in zelfregelende processen die ontstaan in verstedelijkende gebieden, om zo een methodiek te ontwerpen en implementeren die lokaal kan worden toegepast en die ook zijn invloed op andere niveaus laat gelden. De in dit proefschrift beschreven methode omvat tevens de ontwikkeling van scenario's die dwingen tot nadenken over mogelijke toekomstige gebeurtenissen en die stilstaan bij de noodzakelijke beleidsmaatregelen en handelingen die ervoor zorgen dat het systeem flexibeler op veranderingen reageert. De scenario's en de indicatoren die gaandeweg zijn geanalyseerd werden ontwikkeld in participatieworkshops, na analyse van het actornetwerk van het gebied, alsmede van lokale, provinciale en landelijke regelgeving.

De methode die in de loop van deze onderzoeksperiode is ontwikkeld en geïmplementeerd, wordt in deze casestudy lokaal toegepast en is flexibel genoeg om in aangepaste vorm te worden gebruikt in andere delen van de Argentijnse delta. Deze methode kan zo bijdragen aan vergroting van het adaptieve vermogen van de systemen, aangezien lokale initiatieven een cumulatief effect op hogere niveaus teweeg kunnen brengen.

1 Introduction

§ 1.1 Introduction

The Paraná Delta Basin is a large area of 22,587 km^2, with an extension of the Delta islands and the Pre-Delta of 17,400 km^2 (A. I. Malvarez, 1997; Secretaría de Ambiente y Desarrollo Sustentable de la Nación, 2008, p. 5). This Delta extends from the city of Diamante, located in the Province of Entre Ríos, in the Northeast, to the Rio de la Plata, in the Southwest, being a complex model of estuarine delta (Parker & Marcolini, 1992, p. 248). Unlike the adjacent mainland, the Paraná Delta is a young alluvial territory, created by sediments, transported and deposited by the Paraná River. This process of transporting and depositing sediments is highly dynamic, resulting in annual growth of the delta area of approximately 2.37 km^2/year (Codignotto & Medina, 2011, p. 72) towards the Rio de la Plata.

Until a century ago, the islands of the Delta were mainly used for fruit cultivation and forestry, and had some dispersed housing, and small-sized production units. From the last decades of the 20th century, a radical change is taking place, because of the dynamics coming from the Metropolitan Area of Buenos Aires and the cities along the coasts of the Delta. There, the metropolitan development expanded towards the Delta, in a context of lack of urban and environmental planning to counteract this process.

The result is an unsustainable use of the land, either in some sectors of the islands, where forestry and livestock activities have intensified, or in the continental areas, where gated communities (for high-income sectors) and informal settlements (for low-income sectors of the society) coexist, without planning and common infrastructure for transport, water management and flood defense.

At the same time, climate variability increases the vulnerability of the area, so clear strategies on the future of land use, water management and flood defense are needed. Due to the unsustainable and unplanned use of the land, the natural condition of the delta, which is characterized by pulses of floods and droughts, turned into a threat to urban settlements, which have been subjected to frequent floods during the last 40 years, such as the events of 1983, 1988 and 2003.

Summarizing, we can say that the Paraná Delta in Argentina is a region that exists within dichotomies. The concept of dichotomy is defined as "*a division or contrast between two things that are or are represented as being opposed or entirely different*" (Stevenson, 2010). The idea of dichotomy embraced in this research bases on the notion fenced by Jenks (1998, 8) in his book "Core Sociological Dichotomies", as "*pairs of ideas*" that usually stand in opposition to one another, and which are fundamental to the understanding of a phenomenon. Going back to the Paraná Delta, it is possible to address different dichotomies in terms of geographical, spatial, social, economic, environmental and political senses, which make it a challenging region to be studied within its particularities and in comparison, to other deltas in the world.

For example, a first dichotomy can be found regarding geographical, spatial and environmental aspects, since the Paraná Delta is a young wetland that is constantly growing between two shores. There is a sharp contrast between the islands of the delta (that seem pristine) and the continental surrounding areas (where cities and metropolitan areas are located). Furthermore, there are deep contrasts in social and economic senses, between rich and poor, expressed through dissimilar spatial development patterns that coexist without a clear territorial plan. These examples illustrate only some of the dichotomies that can be found in the Paraná Delta. Nevertheless, the major dichotomy of all is the coexistence of natural and human-made processes, related to climate change, and to urban and productive development. Both processes mutually enhance increasing the vulnerability of the entire system, even more considering the global context of uncertainty and climate change.

The recent developments and the increasing dichotomies in the Parana delta can be considered an extreme example of what is happening in many other deltas in the world, considering that they are highly complex territories which face strong pressures, mainly related to climate change, economic development and urban growth (Meyer, 2014c, p. 7; Pols, Edelenbos, Pel, & Dammers, 2015b, p. 156). In order to deal with the pressures of different temporalities of change and the multiplicity of scales and actors involved within an atmosphere of uncertainty, it is important that governments, institutions, companies and civil society organizations support and participate in increasing the adaptation capacity of the systems; this means the capacity to adjust to internal processes and external drivers of change (Folke et al., 2010).

This research studies metropolitan processes that emerge in deltaic areas, focusing on linking climate adaptation and urban development from an actor-oriented perspective in order to fill the existing methodological gap between practice and academia.

For that purpose, this research delves firstly into the concept of metropolitan deltas to address the level of complexity involved in these areas, as well as the different

processes that emerge from the coexistence of a natural system (deltas) and an urban systems (metropolis). Then, the research presents a theoretical analysis of planning, design and governance approaches to face complexity as well as to increase the adaptability of delta systems including social involvement. Nevertheless, in spite of its key role in the planning process, participation is not an easy task to achieve. Due to that, in the last part of this thesis, a method for that crucial part is developed, in order to link natural and urban dimensions through the participatory design of adaptive spatial plans, which applied at the local scale aims to generate impacts at higher scales.

The case of the Paraná Delta especially addresses the question how to link large scale and long-term spatial processes to societal support at the local scale through the design of a method that contributes to increase adaptability of the Delta as well as to generate an empowerment of different stakeholders within the context of social involvement. As a particular case, the Paraná Delta requires specific solutions, so foreign strategies cannot be directly applied but redesigned towards successful implementation. Unlike other examples, the Paraná case is characterized by a delta of extremely large dimensions, subjected to different pressures along its length, and governed by many jurisdictional authorities at different scales: local, provincial and national, which sometimes overlap in terms of legislation producing severe impacts on the area. This context is followed by the emergence of civil society organizations concerned with environmental issues and utilizing this promising moment to design new tools to act within existing legislation and instruments. At the same time, these civil society organizations aim to increase the level of community involvement as well as the level of adaptability of the delta.

In that sense, this research studies the high complexity of metropolitan delta systems, to understand the phenomenon and then analyze the Paraná Delta case study from different perspectives. Through the design of an innovative method to be applied at the local level, this research also aims to evaluate to what extent local initiatives can influence the increasing of the Delta´s adaptive capacity.

§ 1.2 Problem Statement

Historically, coastal areas (especially deltas) have attracted human settlements due to their natural wealth and their strategic location. These qualities have become conducive to the development of productive, industrial and commercial activities (Zagare, 2014b). It is estimated that near half of the world's population (around 3

billion people) is located within 200 kilometers of the coast, and it is expected to double by 2025 (Creel, 2003, p. 1; Reker et al., 2006, p. 21). The demand for land results in a change of functionality, which generates multiscale impacts on the natural territory. Therefore, these areas reach double complexity based on the dynamic coexistence of natural and human-made processes in a context of continuous change (Meyer, 2009, p. 432).

No single theory that can define or categorize urban deltas in all their complexity nor is there consensus on how to address this problem from the point of view of territorial planning or water management; two disciplines that are crucial for the regulation of processes in these territories However, visions such as the systemic approach, are valid for understanding the phenomenon addressing its dynamic condition From this perspective, urban deltas are understood as systems defined as "...a complex whole, a set of things or interconnected parts, an organized body of tangible or intangible things that interact to form a whole" (McLoughlin, 1985) Urban deltas are seen as complex and dynamic systems consisting of ecological, social and physical components that are influenced by certain trends in different ways (Dammers, Bregt, Edelenbos, Meyer, & Pel, 2014, p 157) In other words, urban deltas can be understood as "complex adaptive systems" (Dammers et al , 2014, p 157) in which continuous interactions take place in a nonlinear and unpredictable way, making it necessary for the system to adjust to those changes to reach a non-static equilibrium

In concordance with this approach, this research aims to analyze the processes that occur in metropolitan areas located in (or near) delta territories; to link climate adaptation with urban development through the design and development of an innovative participative method that contributes to the adaptation of systems to uncertainties that characterize the present context. The need for a balance between the natural and urban dimensions increases even more in deltas with political and institutional fragmentation, which means decentralization of governmental authorities, discontinuity of urban policies and overlapping in competences of political-administrative boundaries (Hardy, 2006; Judd & Swanstrom, 2015, p. 8).

The Paraná Delta is a clear example of such a case and is analyzed throughout this research. In this delta, complex interactions take place regarding the collision between metropolitan and natural forces, in a context of high vulnerability to the effects of climate change and uncertainty about future development and events. In such particular context, a method for participatory design of spatial plans is developed, locally implemented and tested in order to evaluate the effects that these methods generate in the system at higher scales.

§ 1.3 Towards a Theoretical Understanding and Methodological Approach to the Complexity of Metropolitan Deltas from the Perspective of Spatial Planning

The high level of complexity that characterizes emerging metropolitan systems located in highly dynamic delta areas requires a special phenomenological analysis. Starting with the ideas presented by Darwin (1861) on the origin of species, followed by theories from the world of physics as well as from the social sciences, the perception of the world shifted from a static top-down view to a dynamic bottom-up vision (Batty & Marshall, 2012, p. 22). According to Batty and Marshall (2012, p. 23), in the late 19th century the "theoretical concern for the structure of cities" emerged, forged within the idea that cities grow in a disordered way, which introduced the concept of complexity into the realm of planning. The city was seen as a complex system composed of subsystems (encouraged by general system theory) (McLoughlin, 1985) and was subjected to multiple analysis. From the point of view of complexity theory, cities can be understood as open (systems) because they exchange information with their environment (Portugali, 2006, pp. 651–652), and complex because they are formed by numerous components or agents with interdependent behavior, which gives rise to emergent effects (Durlauf, 2005, p. 226; Portugali, 2006, pp. 651–652). The interrelations between the system and the subsystems intersect within a non-static equilibrium (Durlauf, 2005, p. 226; Johnson, 2012), changing continuously and producing uncertain effects. Given that even a small change can trigger a qualitative impact in the entire system and require its adaptation to reach to a new balance (Durlauf, 2005, p. 227), deltas are consequentially vulnerable areas due to the increasing uncertainty of events and the associate impacts. As expressed by Meyer (2014, p. 154), the vulnerability of deltas results from the combination of climate change and human intervention. The consequences of those interactions cannot be precisely measured or predicted, and threaten the collapse of the entire system. Disasters like Hurricane Katrina (New Orleans, United States of America, 2005), and floods in the Netherlands (1953), Bangladesh and India (2017), are examples of sudden events that caused great impacts which produced changes not only in the physical realm but also produced changes in the perception of the problem and the design of solutions.

The effects can be catastrophic because deltas are highly populated areas and contribute with a great value to national economies. As a consequence, it remains necessary to understand the systems, its components and relations as well as to know the drivers of change that influence them at different scales throughout the history. This study must be accomplished through an evolutional analysis to understand path-dependencies and be able to reveal possible future developments and also to delineate possible key questions to be answered (van Bilsen, Bekebrede, & Mayer, n.d., p.4).

Considering Paraná Delta as a complex system, it is relevant to research about its characteristics, including the historical evolution of the main drivers of change, to approach the problematic that may arise in the future and build a robust structure to face uncertainty. To unravel the complexity of this delta, it is important to identify the subsystems that constitute it, their relationships, interactions and their mutual influence across the history.

§ 1.4 The Paraná Delta as a Complex System

The Paraná Delta, as other deltas in the world, presents a complex dynamic characterized by the confluence of two open subsystems: on the one hand, the natural processes that characterizes a deltaic environment and climate change; and on the other hand, the emerging metropolitan dynamics, both interacting under an atmosphere of uncertainty. In order to reach a sustainable and adaptive territorial management it is necessary to take into account these particularities within the planning process (Dammers et al. , 2014, p. 157).

The conceptualization of the emerging metropolitan dynamic that takes place on the Paraná Delta as a complex system, as a result of the interaction of subsystems from a bottom-up generative way, contributes to the understanding of the impossibility of tackling that complexity through traditional planning methods. On the contrary, it requires planning methods that focus not on the entire system in an attempt to control it, but on the components and their relations in an attempt to operate on that field, keeping in mind the inevitable context of irreducible unpredictability (Bertolini, 2010; Lempert, 2003, p. 19).

Following this perspective, planning emerging metropolitan deltas, and specially planning adaptation in Paraná Delta, regards the recognition of certain processes such as path-dependence relations and critical transitions, which encourage the need of enhancing the adaptive capacity of the systems (see Chapter 3). The concept of adaptive capacity is related to the potential of a social-ecological system to reduce its vulnerability (the level to which a system is unable to cope with adverse effects) and minimize the risks associated with a specific hazard (Adger, Huq, & Brown, 2003, p. 181; Adger, 2006, p. 269; Brooks, 2003; Smit & Wandel, 2006, p. 286; van Veelen, 2016). According to Folke et al. (2010), adaptability is a pre-requisite for system´s resilience, which can be defined as "the capacity of a system to absorb disturbance", reorganizing to maintain its identity (Folke et al., 2010), before changing to a radically

different state" (Adger, 2006, p. 268). Considering those assertions, this research will focus on planning as relevant for increasing adaptability in order to reach to a sustainable territorial management in a context of uncertainty and constant change.

For that purpose, this research first focuses on the assessment of the Paraná Delta system throughout the history, to understand evolutional relationships, and second, on the design of an innovative participative method for spatial planning. The idea that lies behind this method is to define a path-dependence sequence of actions able to adapt to the changing condition of the context, to enable policy makers to explore options using decision support tools. Furthermore, as the emerging processes within these complex systems are embedded in social processes, the method designed in this research confers collective action an important role for enhancing adaptation including participation, responding to the conditions of unbalanced development that persist in the selected case. Given the particular characteristics of the context and its actors, this research proposes an innovative adaptive methodology that considers exploring the existing interrelations as a part of the method itself. Furthermore, this method can be applied in other areas of the delta and other deltas, because it is a robust method where all the actors, variables and scenarios are designed according to each case study, after a deep diagnosis of the area. This characteristic turns this method an "empty boxes" methodology, in which each "empty box" (actors; variables; indicators; etc.) can be filled with the specific actors, variables and indicators of any context without interfering with the main structure of the design and contributing to specific values for each case.

§ 1.5 Research Question

How can a scenario-based method for participatory design of adaptive spatial plans be designed and implemented in the Lower Paraná Delta, and which effect can it have on higher scales of the system?

§ 1.6 Outline and Structure of the Thesis

This thesis is organized in six chapters. After the brief introduction carried on in **Chapter One**, where the subject of the research is presented together with the structure and outline of the dissertation, **Chapter Two** delves into the spatial implication of the confluence of highly dynamic natural processes that characterizes delta territories and the intense urbanization growth that typifies metropolitan areas. In **Chapter Three**, some concepts derived from Complexity Theory are tackled, being the Complex-Adaptive-System approach presented as one way to address the problematic of metropolitan deltas. Then, a definition of emerging metropolitan deltas is introduced taking into consideration the previously addressed theories and after that, a reflection on the role of design, planning and governance in these territories is presented, being that emerging metropolitan deltas are systems where the interaction among the components is in constant adjustment at multiple levels. This chapter also dives into methods to link climate adaptation with urban development from an actor-oriented perspective.

In **Chapter Four**, the Paraná Delta is presented as the case study of the thesis, describing its main characteristics across different scales: the delta-scale, the metropolitan scale and the local scale. Each of the levels implies different situations, drivers of change, pressures and vulnerabilities, which are studied addressing the natural substratum (including climate variables), the networks, the historic evolution of the urbanization, and the institutional context and governance. Finally, in this chapter, the local scale (delta front) is examined, including the Municipalities of Tigre and San Fernando. Both jurisdictions present different spatial development scenarios as a product of sectoral policies and actions of the public and private sectors, related to the environmental and socio-economic context. The similarities and particularities of both municipalities are studied and presented to set the context for the development of a method for the participatory design of adaptive spatial plans

Chapter Five introduces the design of a method for the participatory design of spatial plans applied at the local level, entitled "Scenario-based Method for Participatory Design of Adaptive Spatial Plans". This method consists on an adaptive and participatory process with the involvement of stakeholders, who build scenarios for the area and reflect on the most relevant challenges and consequent measures. After providing a detailed explanation of the theories and methodologies behind the design and development of the exercise, the results are examined.

Finally, conclusions are presented in **Chapter Six**, where the research questions are revisited and examined through an approach of the themes already discussed in the previous chapters. Thus, this chapter also set a basis for further research on the field.

Thesis structure and contents

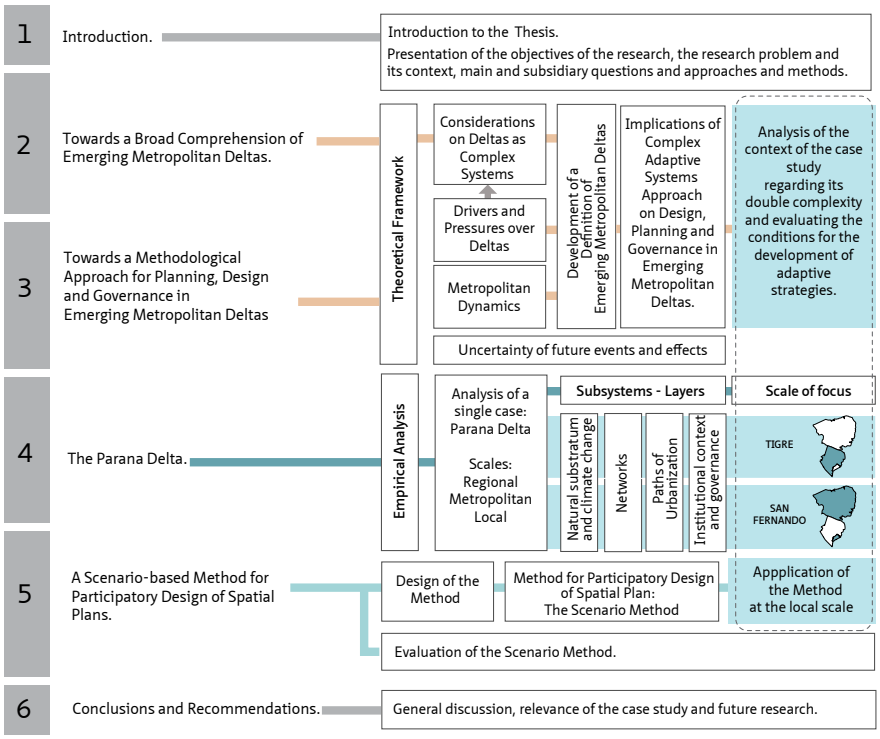

FIGURE 1.1 Thesis structure

TOC

2 Towards a Broad Comprehension of Emerging Metropolitan Deltas

§ 2.1 Introduction

Although the definition of metropolitan delta used by Smeets et al. (2004, 104) refers to a large river delta with a big conurbation, the discussion goes further than that. The definition of a metropolitan delta should entail the comprehension of the dynamic confluence of natural and urban systems which influence each other while maintaining their specificities (Meyer & Nijhuis, 2011, p. 1). On the one hand, coastal systems are extremely dynamic territories in constant change due to internal and external influences mainly related to climate change as well as natural and human-made processes. On the other hand, urban systems are also in continuous transformation resulting from global and local dynamics, which generate production, communication and lifestyle changes. This scenario requires urban planners to have a clear understanding of both systems components and their relatedness to design and implement strategies towards increasing the adaptive capacity of these areas to prepare for the uncertainty and unpredictability of the conflicts emerging from those interactions.

This chapter analyses the dichotomy between natural and human-driven aspects of metropolitan deltas, as a way to contribute to the understanding of these complex systems and to bring into light the necessity of developing approaches and methods for dealing with such complexity in times of climate change and urban development within an atmosphere of uncertainty.

§ 2.2 Definition and Classification of Deltas

Deltas are dynamic natural formations derived from the deposit of sediments that rivers carry when they flow into a water formation (Kandus & Malvarez, 2002).

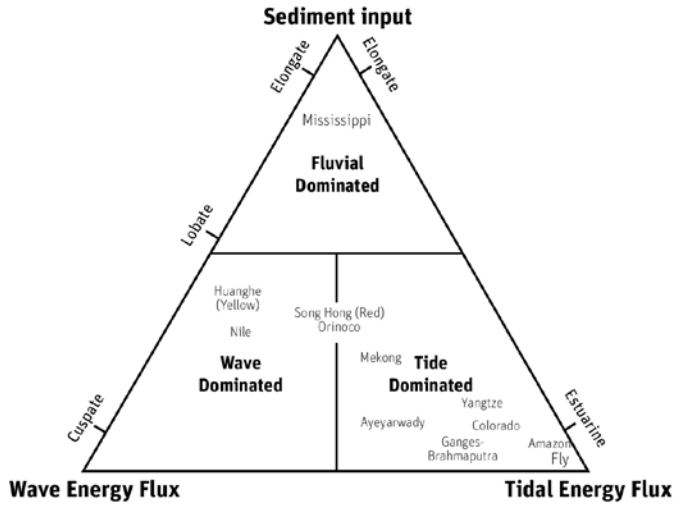

FIGURE 2.1 Ternary diagram of delta types according to fluvial, marine or tide dominance (Hori and Saito 2007, p.83).

FIGURE 2.2 Example of the fluvial dominated Mississippi river delta. (Landsat 5. Thematic Mapper data mosaic, 2001).

They are result of a interrelationships between coastal and fluvial processes, related to the regime of the river that transports its sediments, coastal processes that take place in the river mouth, tectonic and climate factors (Morgan, 1970; Zagare, 2016c).

According to Wright (1978), deltas can be defined as "(...) coastal accumulations, both subaqueous and sub-aerial, of river-derived sediments adjacent to, or in close proximity to, the source stream, including the deposits that have been secondarily molded by various marine agents, such as waves, currents or tides". Much of the current literature in the field pays particular attention to the study of the complex relationship between fluvial and tidal processes, as well as the relevance of sediment accumulation in shaping the shorelines (Elliot, 1986; Kandus & Malvarez, 2002; Marcolini & Parker, 1992; Walker, 1995).

Although deltas around the world may meet a general definition, they present different characteristics based on their location and morphology. Collison and Reading (2009, 166) argue that there is no single way to classify coasts due to the complex nature of the variables involved. Many classifications can contribute to a broad understanding of these natural landscapes. Hori and Saito (2007, 79) highlight that the best-known system for classifying deltas is the ternary diagram originally delineated by Galloway (1975), adapted from a concept built earlier by Fisher in 1969. This diagram distinguishes three types of deltas based on different influences of fluvial, tidal and marine processes (Figure 2.1).

Fluvial-dominated deltas are elongated and highly dependent on sediment input, the Mississippi Delta is a classic example of these coastal systems (Figure 2.2). On the contrary, wave-dominated deltas present cuspate shorelines, such as the Nile Delta (Figure 2.3), whereas tide-dominated deltas show an estuarine-related geometry, such as the Ganges-Brahmaputra Delta (Figure 2. 4). Boyd, Dalrymple, and Zaitlin (1992) later extended the ternary diagram to include other coastal systems such as lagoons, tidal flats, and strand plains, also focusing on the source of the sediments (Figure 2.5). The subsequent extension of the two-dimensional diagram developed by the authors includes a prism adding the action of prograding and transgressive processes (Figure 2.6). The result of this diagram leads to the conclusion that on the one hand, estuaries are transgressive systems where the rate of relative sea-level-rise exceeds the rate of sediment supply, while on the other hand, deltas are regressive/prograding systems when the rate of sediment supply exceeds the rate of sea-level-rise (Boyd et al. , 1992; Collison & Reading, 2009).

FIGURE 2.3 Wave-dominated delta, the Nile river delta in Egypt. (Jacques Descloitres, MODIS Land Science Team, 1999).

FIGURE 2.4 Ganges-Brahaputra delta, a tidal-dominated delta. (Jacques Descloitres, MODIS Land Team, 1999).

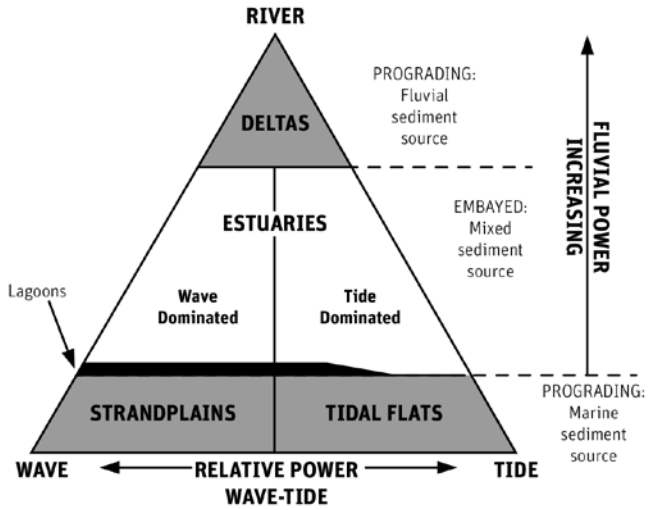

FIGURE 2.5 Ternary diagram extended by Boyd et al.(1992, p. 142) to include other coastal systems such as lagoons, tidal flats and estuaries.

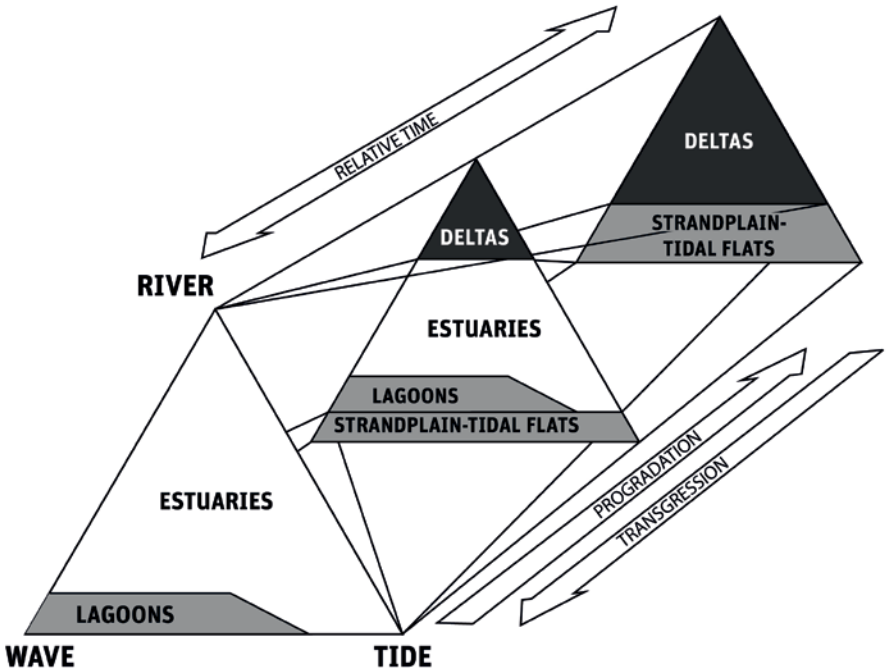

FIGURE 2.6 Evolution of the ternary diagram developed by Boyd et al. (1992, 144) according to the inclusion of prograding and transgressive processes.

FIGURE 2.7 Paraná River Delta and the estuary of Río de la Plata (Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GFSC).

Going back to Wright´s definition, the coastal accumulation of sediment also makes possible the distinction of two parts within the system, subaerial and subaqueous. The first one is the portion of the delta that is above the low tide level and can be divided into the "Lower Delta Plain" and "Upper Delta Plain" according to the tidal influence. The latter can also be split into a delta front and prodelta (Hori & Saito, 2007, p. 79; Marcolini & Parker, 1992) (Figure 2.7). Even though the presented definitions and classifications seem to locate estuaries and deltas as a result of different processes, there are always exceptional cases, such as the Paraná Delta. There, the Paraná River does not discharge its sediments directly to the sea but through the estuary of the Río de la Plata (Zagare et al., 2014a). Due to that unique characteristic, the Paraná Delta is considered a complex estuarine delta (Parker & Marcolini, 1992, p. 248). While from a geographic point of view the delta is restricted to the terrestrial part, from a geomorphologic perspective it can be analyzed together with the Río de la Plata estuary (Cavallotto, Violante, & Parker, 2004; Parker & Marcolini, 1992, p. 243). Furthermore, the subaqueous part of Paraná Delta approximately overlaps the entire Río de la Plata's river-bed connoting a relevant influence of the Delta over the estuary and vice versa (Figure 2.8).

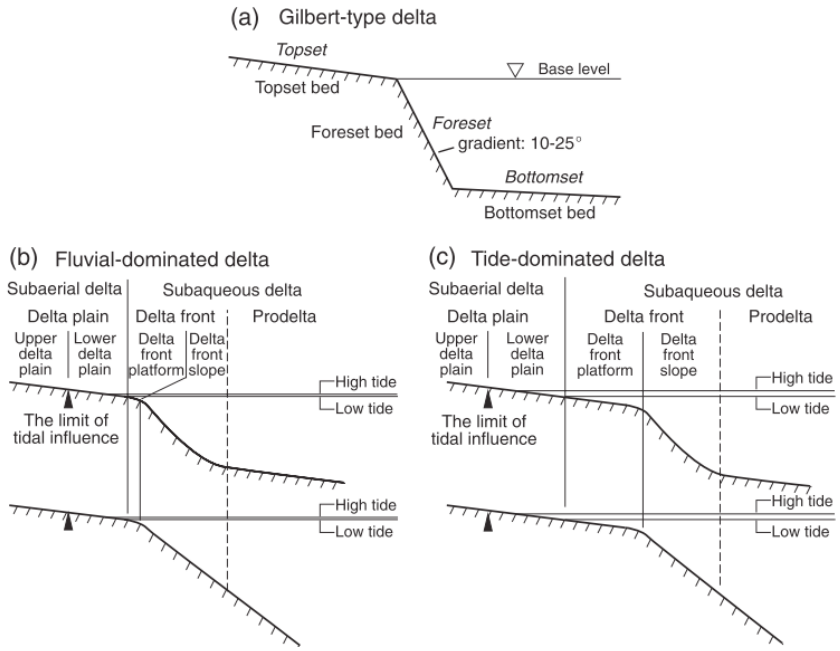

FIGURE 2.8 Components of deltas, extracted from Hori and Saito (2007, p. 78).

§ 2.2.1 Deltas as determinants for the development of cities

According to the Ramsar Convention Secretariat (2013, 7), deltas are one of the five different types of wetlands. They are "areas where water is the primary factor controlling the environment and the associated plant and animal life. Deltas occur where the water table is at or near the surface of the land, or where the land is covered by shallow water" (Ramsar Convention Secretariat, 2013, p. 7). Wetlands are among the world's most productive environments entailing a large biological diversity capable of providing *ecosystem services* and *economic value* (beneficial for the human population), representing an opportunity for the development of cities.

Following Finlayson, D`Cruz, and Davidson (2005, vi), *ecosystem services* are "the benefits people obtain from ecosystems". These include: (a) *provisioning services,* such as food, fresh water, fiber and fuel, biochemical and genetic material; (b) *regulating services,* such as the regulation of hydrological flows and floods, drought, land degradation, groundwater replenishment and discharge, shoreline stabilization, erosion control, stabilization of local climate conditions (rainfall and temperature) and

the regulation of atmospheric composition and disease among others; (c) *supporting services* such as soil formation, storage and purification of water and nutrient cycling; and (d) *cultural services,* such as recreational and religious activities, among other nonmaterial advantages (Costanza et al. , 1997, pp. 253–254; Finlayson et al. , 2005, p.vi, 2; Ramsar Convention Secretariat, 2013, pp. 8–9).

Regarding the *economic value* of ecosystem services, a study by Costanza et al. (1997) revealed that they contribute immensely to human welfare and if they become stressed and scarce, their value will proportionally increase. Thus, the more irreversible the damages are, the more valuable they become. Nevertheless, although the economic value of ecological services is understood as vital to human survival, wetlands are amongst the most threatened ecosystems of the world and only through the maintenance of their ecological processes can the provision of ecosystem services be guaranteed (Ramsar Convention Secretariat, 2013).

§ 2.2.2 Drivers and pressures over deltas

The main drivers of change that affect deltas are demographic growth, economic and technological development, climate change and subsidence (Bucx, Marchand, Makaske, van de Guchte, & van Driel, 2012, p. 14). Each driver generates different pressures over the territory, so governance plays a major role towards guaranteeing the provision of ecosystem services in a context of sustainable development. Increasing demographic trends translate into a spike in populations living on deltas and an exacerbation of migration processes, often lacking a planning framework and possessing high levels of self-organizing responses. Global economic and technological developments are related to changes in the local and regional economy and also to the world market making deltas -and their infrastructure- key actors for international trade. Technology accompanies economic development establishing a network of communication not only through transport infrastructures but also through information technologies. Hydraulic infrastructure modifies deltas by supporting energy generation, food and agriculture production and also by protecting cities. As it is a crucial factor for regional development, infrastructure usually follows design criterion that responds to logistics and other needs of the population, but they are consequently far removed from the natural recognition of the environment, jeopardizing the entire system.

Regarding climate change, the most important drivers are the variations in temperatures and evaporation rates, sea level rise, precipitation and river discharges, which together can cause extreme hydrological events. According to Syvitski et

al. (2009), 85% of the deltas are experiencing hard flooding with the result of the temporary submergence of around 260,000 km^2 and the surfaces vulnerable to flooding could increase by 50% under the projected values of sea-level rise for this century. These drivers generate pressures over the land and water in several ways, and the combination of changes could lead to hazardous situations. According to Marchand et al. (2012, 14), some of the pressures that the combination of drivers can cause are an increase in water demand and freshwater shortage, land use changes, salinity intrusion, coastal and fluvial erosion, and a loss of biodiversity and wetlands. In addition to the mobility of delta distributaries, flood hazard, changes in flood protection systems, irrigation and drainage, water supply and sanitation, and the development of roads, railways and ports. The interaction of the mentioned pressures across the different dimensions of deltas generates a scenario of constant and dynamic change. Although deltas may present different geomorphologic, economic and social characteristics, are subjected to similar driving forces, which require action on an institutional level in search for governance that encourages sustainability.

§ 2.3 Considerations Regarding the Concept of Metropolitan Delta

Taking the previous assertions into account, as there is not one single type of delta there cannot be a one-size-fits-all definition or set of policies to apply to all cases. On the contrary, each case should be analyzed according to the characteristics of each particular context and the different interactions that take place within each system. This research aims to broaden the concept of emerging metropolitan deltas, so after having analyzed deltas as the physical basis for urban development, the next step is to study the concept of metropolitan emergence in these particular territories.

Metropolitan regions are defined by the United Nations World Urbanization Prospects (United Nations, Department of Economic and Social Affairs, 2014, p. 5) as the "contiguous territory inhabited at urban levels of residential density and additional surrounding areas of lower settlement density that are under the direct influence of the city (for example, through established transport networks, road linkages or commuting patterns)". Throughout history, prominent cities around which metropolitan regions developed were fundamentally based on their role as centers of government, administration, and also their economic, industrial and socio-cultural potential all related to their political importance. Examples of this type of metropolis are Tokyo, Mexico City, New York, London or Delhi (Figure 2.9).

FIGURE 2.9 Tokyo by night 2008 (left) and London by night 2015 (right). (Earth Observatory, NASA).

However, also other large cities have expanded along large river deltas, and have gained importance due to their strategic location and ecological richness. High accessibility to the global economic system, good waterways and rail transportation make an efficient connection with the hinterland. Thus, the prominent biological potential for production, agricultural and industrial development, tourism and leisure are other benefits that turned these deltas into desirable areas for these cities to develop. According to Smeets et al. (2004, p. 104), "a metropolitan delta can be defined as the delta of a big river with a large conurbation, sometimes functioning as a port for its hinterland". However, this definition does not fully explain the complexity that lies behind the concept. As explained in the introduction of this chapter, metropolitan deltas entail a complexity based on the confluence of a natural system and an urban system. Both systems mutually influenced each other but also maintain their intrinsic dynamics. Much of the current literature on urban deltas from the perspective of complex systems pays particular attention to the dynamics of constant change that these specific areas are undergoing. According to Meyer and Nijhuis (2011, p. 1), these transformations result from (a) alterations of the delta's natural dynamics related to human interventions and climate change and (b) changes in land-use dynamics as products of urbanization, industrialization, agriculture, port-development and finally, leisure and tourism. In addition to the previous categories, another driver of those transformations should include the interaction between both types of changes.

Addressing the changes of deltas´ **natural dynamics** as a result of human intervention and natural phenomenon it is possible to observe that in many cases extensive unplanned urban growth takes place without considering the environment's unique characteristics. This occurrence exacerbates the vulnerability of coastal systems to

global climate change and worsens the effects of extreme events. A study of 14 deltas developed by Coleman, Huh, and Braud (2008) shows that the loss of wetland caused by land use changes (the conversion of land for agricultural and industrial purposes) is more significant than the loss of wetlands due to natural causes and both cause extensive damage. In fact, the study estimates that approximately 52.4% of delta plain areas were irreversibly lost in the period from 1986-2000 with average annual loss rates of between less than 1 km^2/y and 419 km^2/y. On the other hand, climate change that affects deltaic systems is related mainly to sea level rise, to increasing discharges from large rivers and the accretion and recurrence of extreme hydrological events such as storm surges, hurricanes and other natural phenomenon. The effects have a notable impact on coastal populations causing severe flooding as well as enhancing the degradation of ecosystem resources.

Regarding **land use** dynamics, the interplay between natural terrain, infrastructure and occupation patterns determines the development conditions of cities and regions together with their relation to the global market. According to Meyer (2014b, 8), settlements in deltas historically took place in safer higher areas, whether at the edges of the delta, on natural levees formed by sediment accumulation or on human-made dikes. Different types of settlements on deltas can be distinguished, such as the urbanization of the lowlands of the Delta (The Netherlands, Rhine-Meuse-Scheldt Delta), the settlement of a fortified city in the middle of the delta (New Orleans, located by Mississippi River´s meanders), or the settlement at the edge of the delta (Buenos Aires city, Paraná Delta).

Depending on the location and natural features, delta cities present different opportunities for productive development, mostly related to fishing, agriculture and port activities. It is a widely held view that the globalization process and technological progress turned port-related industries into key drivers for the spatial and economic development of several delta areas (Meyer, 2014a, p. 149). Shanghai, Guangzhou, Cairo, Buenos Aires, and Kolkata are some examples of metropolises located in deltas that despite having vastly different urbanization patterns, share similar forces that drive their development. As previously mentioned, near half of the world's population lives within 200 km of coasts, a figure that will double by 2025 (Creel, 2003, p. 1). This demographic growth (in many cases, unplanned) exerts high pressure over these spaces because it occurs in lowlands and presents an increasing vulnerability to extreme climatic factors. Due to that, the local level of governance (the municipal level) is challenged to provide the infrastructure that ensures inhabitants a high quality of life and a sustainable community while also preventing the degradation of ecosystem services and coping with economic and political pressures.

Metropolitan area at rivermouth	River Delta	Country	Population[3]			Rankings	
			1990	2014	2030	Urban agglomerations[4]	World´s container ports[5]
New Orleans	Mississippi	USA	1039*	977*	1037*	-	-
Cairo (Al-Qahirah)	Nile	Egypt	9892	18419	24.502	10	-
Buenos Aires	Parana	Argentina	10513	15024	16.956	13	-
Lagos	Niger	Nigeria	4764	12614	24.239	19	-
Shanghai	Yangtze	China	7823	22991	30.751	3	1
St. Petesburg	Volga	Russia	4989*	4479*	4476*	-	-
Kolkata	Ganges	India	10890	14766	19.092	14	-
Ho Chi Minh	Mekong	Vietnam	3038	7100	1.022	47	24
Karachi	Indus	Pakistan	7147	16126	24.838	12	-
Honk Kong[1]	Pearl	China	5766	7260	7.885	44	4
Dakha	Brahmaputra	Bangladesh	6621	16982	27.374	11	-
Randstad[2]	Rhine	the Netherlands	6700**	7900**	-	-	11
San Francisco	Sacrameto	United States	2691*	3684*	3898*	-	-
Guangzhou, Guangdong	Pearl	China	3072	11843	17.574	22	8
Shenzhen	Pearl	China	875	10680	12.673	26	3
Jakarta	Ciliwung	Indonesia	8175	10176	13.812	28	-
Dongguan	Pearl	China	1737*	5366*	6157*	42	-
Hamburg	Elbe	Germany	1639*	1791*	1792*	-	15

References and Sources

1 Although Hong Kong is not situated on the delta, it exerts pressure over it and has relation with the rest of the delta cities.
2 Randstad is the major conurbation of the Netherlands. It is formed by Amsterdam, Rotterdam, the Hague, Delft and Utrecht, among other cities.
3 Source: United Nations (2014, p. 26.)
4 Source: United Nations (2014, p. 26.)
5 Source: World Shipping Council (2005).
* Source: United Nations (2008)
** Source: http://www.randstadregion.eu/

TABLE 2.1 Metropolitan deltas. The relationship between the population and surface (Zagare, 2014b).

According to the World Urban Prospect 2014 (United Nations, 2014, p. 26–27), 23 of the 30 largest urban agglomerations with more than 5 million people are located along or near the coasts and have a port; Ten of those cities are located on river deltas (Table 2.1). For example, the city of Shanghai (China) (Figure 2.10), located in the Yangtze River Delta is the leader among the world's container ports according to the World Shiping Council (2015) and is considered the logistics and service center of China. Its population is around 22 million inhabitants and is considered the third largest urban agglomeration in the world, presenting a population growth rate of 3% per year (United Nations, 2014, p. 26). The population is mostly located in the inner area of the Shanghai municipality, reaching a density of 16,378 inhabitants/km^2 (Liu & Prieler, 2002, p. 15). A study carried out by Liu and Prieler (2002) showed that China's rapid population growth and the subsequent urbanization process was a result of China's economic reform during the 1980s and 1990s. It consequently led to a "great mass fervor on real estate development and the establishment of Development Zones" (Liu & Prieler, 2002, p. 34).

FIGURE 2.10 Shanghai (adpted from Zagare 2016).

The creation process of the so-called *Special Economic Zones (SEZs)* influenced the country's economy as well as the delta area encouraging rapid economic growth. The SEZs are understood as areas with flexible policies to attract foreign investment, where domestic and international trade is conducted without the need to obtain authorization from the Chinese central government. Shanghai is one of the SEZs and experienced a rapid demographic growth mainly after the 1990s. As a result, in Shanghai, changes in urbanization patterns were mainly related to a notable increase in residential use representing the loss of two-thirds of cultivated areas. The loss of the other remaining rural areas is attributed to industrial or commercial use. Residential land development was, in this case, the driving force of urban growth: the discontinuous settlements consumed cultivated areas, and then they increased in density becoming continuous and generating a solid pattern of urbanization. Another case is Pudong, a special zone within the Municipality of Shanghai, which had even more flexible policies than others, and presented a marked population growth, requiring the construction of transport infrastructure, such as bridges and tunnels, to accompany accelerated economic growth. The Chinese government also declared other coastal cities SEZs along the Yangtze River Delta as well as along the Pearl River Delta. Two of the most important ports along the Pearl River Delta are Shenzhen and Guangzhou, and outside of the delta plain but nearby, is the Special Administrative Region of Hong Kong. These three cities rank third, eighth and fourth among the world's top container ports respectively, concentrating almost 30 million inhabitants (United Nations, 2014, p. 26).

FIGURE 2.11 Randstad (adapted from Zagare 2016).

Port cities can also link local economies with regional supply chains and global trade (UN-Habitat, 2008a, p. 4). This condition, together with the development of transport, communication technology and expertise encourages the generation of regional corridors linking coastal cities with the hinterland and consolidating extensive networks around the port. This is the case of the Randstad (the Netherlands), the area that comprises the two western provinces (North and South Holland) and the province of Utrecht (Lambooy, 1998, p. 461) (Figure 2.11). This area is considered a "polynucleated metropolitan region" (Champion, 2001, p. 664; Lambooy, 1998, p. 457; Lambregts, 2006, p. 117) that Lambregts (2006, 118) defines as being a set of "more or less equally sized and historically distinct cities". The Dutch national government conceives the Randstad as a single urban network interacting as a whole.

At the same time, within this network, *economic core areas* are recognized with different potential for the creation of agglomeration economies and such variety positions the region in the international market. For example, the city of Amsterdam hosts the fourth largest airport in Europe and Rotterdam is the largest port and industrial complex of the continent. Together, both cities are part of a logistics network that links the Randstad with the global market, and they also link to cities within the region- transcending national borders. Following the Rotterdam Port Vision 2030 (Rotterdam Port Authority, 2016), the authorities of the industrial and energy complex of Rotterdam expressed their goal of intensifying collaboration with Antwerp (Belgium) to form a petrochemical and energy complex, which is expected to be the largest in Europe. This collaboration is an example of a regional connection that

FIGURE 2.12 Buenos Aires (adapted from Zagare 2016).

transcends jurisdictional boundaries and a paradigm shift as both ports have historically been competitors.

Occupation patterns also differ regarding communication infrastructure. In some cases, occupation takes place prior to the development of communication networks, while in others the infrastructure makes the occupation of a territory possible. On the one hand, Buenos Aires (Figure 2.12) has been important at the strategic level since the 16th century as an entrance to the La Plata Basin and grew as a port following a model of agricultural export development articulated with the British Empire. In the mid-nineteenth century, the advent of the railway in the city and its rapid expansion to the peripheries shaped urban sprawl and consolidated the connection to the rest of the provinces, located in the hinterland (Zagare, 2007, p. 34). A century later, in a context of a neoliberal model characterized by economic liberalization, decentralization and the affluence of Foreign Direct Investment, another type of occupation pattern took place around private transport. These new patterns mainly differed from the previous because they were closed neighborhoods, privately developed (without the participation of the State) and aimed at the upper-middle-income segment of the population to the exclusion of other sectors. On the contrary, in the surroundings, informal settlements expanded spurred by an economic crisis, resulting in a scenario of socio-spatial polarization and generating a need for infrastructure to reduce the vulnerability of the territories to flooding due to the unplanned occupation of the lands. On the other hand, unlike the case of Argentina, in the delta of the Rhine-Meuse-Scheldt (Netherlands), infrastructure, flood defense, and land reclamation

were the foundation that allowed the occupation of the territory. The central part of the Netherlands (now Randstad) "was transformed from a wet lagoon into a drained and rationalized landscape surrounded by a main dike ring" (Meyer, 2014b, p. 46), while the Southwest Delta turned into an archipelago of islands resulting from the fusing of natural sedimentary landscape and human-made dikes. There, urban planning was born from the hand of hydraulic engineering and water management through technology, a pattern that continues to dominate today.

As mentioned earlier, apart from the natural dynamics derived from human interventions and climate change and the land-use dynamics as a result of urbanization and development, it remains important to point out the dynamics arising from the interaction of both conditions. A notable example of this interrelation is flooding. Depending on the magnitude of the hydrological event, a sudden change (also called the "*tipping point*" Gladwell 2000, p. 12) can then trigger a critical transition forcing a search towards a new dynamic equilibrium within the delta. In the Netherlands, the floods of 1916 and 1953 gave rise to the *Zuiderzee Works* and the *Delta Works*, the two major hydraulic works conducted by the State (Meyer, 2014b, p. 46). The first case consisted of the closure of the Zuiderzee, which became the freshwater lake Ijsselmeer, and the construction of polders in which a system of *New Towns* was designed. The second case involved the construction of dikes, barriers and increasing the height of existing dams. Due to both programs, the extension of the Dutch coast was reduced from 1400 km in 1930 to 400 km in the year 2000 and resulted in severe damage to ecosystems (Meyer, 2014b, p. 49). After this rationalization and modernization of spaces, it is questionable whether the protection for such areas can be guaranteed in a context of increasing climate change, and whether it is possible to restore the delta back to its original state. After revising the Delta Works, an integrated water management and water systems approach were introduced concentrating on "working with and preserving the dynamics of the coastal areas as much as possible"(Vrijling & Stive, 2010, p. 37). In a certain way, the paradigm shifted from seeing water as an enemy to considering it an ally (Vrijling & Stive, 2010, p. 38). The creation of two programs (*Room for the River* and *Delta Program*) set out to generate new ways to restore the delta through more dynamic approaches that also consider the uncertainty of climate change and long-term social changes (Meyer, 2014b). According to Vrijling and Stive (2010,p. 41), although the combination of reversible and local measures related to natural processes (working with nature or "soft protection") combined with "hard protection strategies" is becoming more acceptable, it is still a challenge to reconcile both positions.

The Delta Program includes all levels and scales with the participation of many stakeholders, but the major innovation is the methodological approach to address spatial pressures on the territory: the Layer Approach (McHarg, 1969). This approach,

FIGURE 2.13 New Orleans (adapted from Zagare 2016).

already introduced in Dutch design and planning during the decade of 1980, analyzes the reality of the territory as an interaction of three layers: substratum (environment, or base layer), network (the physical infrastructure layer), and occupation layer (urban patterns). The principal aim of this approach is to analyze the pressures in each layer considering the different temporalities of change and the interaction with the other layers. This approach will be further described in the next chapter, as it is fundamental for the structuration of the analysis carried on in the thesis.

Another example is the case of New Orleans (Figure 2.13) that suffered the ravages of Hurricane Katrina in 2005, which flooded 80% of the city causing the evacuation of about 1.3 million people in the city and surrounding areas (Morris & Waggonner, 2008, p. 13). Currently, it is estimated that the city of New Orleans has 320,000 inhabitants. A study Wang and Wang (2013) carried out showed that the spatial distribution of the population in New Orleans changed after Katrina, presenting a decrease in the center of the city and an increase in its surroundings. This phenomenon was caused due to the combination of a demographic increase in the suburbs before Katrina and the uneven recovery of the affected areas which also led to changes in the mean centers inside of the city (Wang & Wang, 2013, p. 338; Wang, 2009, p. 33). This study also demonstrated that the Central Business District of New Orleans maintained its influence while the sub-centers influence declined, showing a change in the spatial distribution of the population. The population increase after Katrina was located in the highlands. Now the debate focuses on developing a new relationship between the

urban and water-management systems after having gone through such a devastating experience, which implied dramatic changes of its spatial dynamics.

All the presented cases show emerging characteristics derived from the interactions of the system's components that are caused by intrinsic dynamics and also by external drivers, which can cause sudden and extreme changes. These events can be changes in economic policies (like in China or Argentina), extreme climatic events such as the severe floods, which occurred in the Netherlands, or hurricane Katrina in the United States, among other factors. After having analyzed the concepts of deltas and metropolitan regions, the following section will delve into the field of complex adaptive systems to reach a comprehensive definition of *emerging metropolitan deltas*. Using this approach can help give urban planners a set of tools for analyzing the variables and interactions occurring within the systems and to also deal with the uncertainty related to these areas.

§ 2.4 Concluding Remarks

This chapter analyzed the concept of metropolitan deltas addressing the dynamics that take place in those territories; related to the contrast between natural processes and human-driven activities. These emergent dynamics confer the deltas different characteristics that turn each case a unique combination that must be addressed through concrete planning strategies. Nevertheless, there is a constant among all cases: in all deltas, there is a gap between the necessity of dealing with climate adaptation and urban development, as well as between the need of combining traditional planning frameworks with innovative strategies that include public participation. In this sense, it becomes necessary to develop methods to create these linkages recognizing the contrasts within the systems, their high level of complexity and the increasing uncertainty of the context. For that purpose, the ideas presented in this chapter settle a basis for the analysis of methodological approaches on planning, design, and governance towards a better understanding of the phenomenon of metropolitan deltas, and for the design of methods to link climate adaptation and urban development in a participative way.

In the next chapter, the concept of emerging metropolitan deltas will be defined. For that purpose, some theories and approaches will be analyzed to understand the complexity that characterizes the systems towards the design and implementation of a participatory approach to link climate adaptation with urban development.

3 Towards a Methodological Approach for Planning, Design and Governance in Emerging Metropolitan Deltas

§ 3.1 Introduction

At the present, no single theory can define or categorize the concept of metropolitan deltas in all their complexity or arrive at a unique consensus on how to approach the problem from the viewpoint of climate change, territorial planning and water management. In fact, the previous chapter showed that one of the main challenges in metropolitan deltas is dealing with the coexistence different drivers of change, in a context of uncertainty, which makes them highly dynamic and complex systems, vulnerable to extreme events.

For that reason, certain visions such as the complex adaptive systems approach are valid for understanding this phenomenon and also for planning and designing these areas addressing their dynamic condition. Through this approach, it is possible to understand metropolitan deltas as complex systems formed by ecological, social and physical components that interact with each other and with the environment and are influenced by certain trends in different and unpredictable ways (Bregt, Dammers, Edelenbos, Meyer, & Pel, 2014, p. 157). This concept focuses on the need of urban deltas to adapt to possible trends or disruptive events, through the synchronization of different sectors and on actors ability to mobilize and organize collective action (Dammers et al. , 2014, p. 157).

In other words, urban deltas are "complex adaptive systems" in which evolution is the result of the continuous interaction of different subsystems with external conditions in a non-linear path-dependent way. This feature challenges the traditional notion of planning and design, since such complexity must be addressed through flexible systems that can cope with the interaction of multiple governmental jurisdictions, combining urban and environmental agendas, actors, sectors, levels and time frames, within a physical framework able to be adapted according to the changing context. That means that the recognition of the complexity of these territories, the cohesion between

spatial planning and adaptive design, and the involvement of the actors involved is a key factor for metropolitan deltas to respond to external and internal changes, and to reduce its vulnerability.

This chapter analyzes the complexity of interactions within emerging metropolitan deltas from the perspective of planning, design, and governance in order to set the basis for the understanding of the phenomenon and for increasing their adaptive capacity through social involvement.

§ 3.2 Complex Adaptive Systems Approach to Metropolitan Delta Analysis

"The real world is (...) a complex system of both natural and human-made things" (Chadwick, 1971). The investigator Richard Peet says (1998, p. 2), "the relation between society and nature is thus an entire system, a complex of interrelations" in two senses: humanity is affected by natural evolution, and humanity equally affects the environment. As previously discussed a very complex interaction takes place in metropolitan deltas related to naturally occurring and human-induced dynamics. Both systems, the natural and the artificial, interact forming a greater system- the result of their interrelated components. After presenting concepts (and critiques) about systems approach and analyzing some aspects of the complex sciences applied to the case, an analysis of the complex adaptive system approach will be carried out to broaden the theoretical framework on metropolitan deltas, to reach a more comprehensive definition of the phenomenon.

§ 3.2.1 Systems and the "General System Theory"

Brian McLoughlin (1985, p. 2) defined a system as "(...) a complex whole, a set of things or interconnected parts, an organized body of tangible or intangible things that interact to form a whole". Although the author presents this definition, he assumes that it may result dangerously tempting to apply it to the real world, and referencing Beer (cited in McLoughlin 1985, p. 2), he makes clear that defining any particular system may result arbitrary. At any rate, a system implies the existence of a set of elements constituting it, a set of interactions between those components and a boundary between the "above" (inside the system) and the "rest-of-the-world" (outside the system). Systems are

categorized as "simple" or "complex" depending on the number of elements that form them and are considered to be "open" or "closed" according to whether or not they are analyzed in relation to their environment (McLoughlin, 1985, p. 2–3).

General System Theory was postulated between the 1950s and 1970s in the search for universal principles to apply to systems in general, irrespective of their kind, nature and number of components and the relations among them (von Bertalanffy, 1968, p. 32). In contrast to classical science, which explained phenomena as the result of an interplay of elements studied independently of each other, a general theory of systems focused not on parts and processes in isolation but on problems derived from the organization and dynamic interaction of parts as a whole in relation to the context. One of the developers of this theory, Ludwig von Bertalanffy (1968, pp. 33–37), saw it as a useful approach that could be applied to different fields because it was possible to find "principles that govern the behavior of entities that are, intrinsically, widely different" (von Bertalanffy, 1968, p. 33). This conception rapidly penetrated into very diverse areas, including urban planning, as cities are ideal entities to be explored through this approach. McLoughlin (1969), encouraged by the work of Perloff (1957), and later Chadwick (1977 and 1971) popularized this theory under the motto "the whole is greater than the sum of its parts".

Regarding planning, the systems paradigm implied a radical change in urban studies and was used in many countries, seen as a British Post-Second World War rational approach to planning (Keiner, Koll-Schretzenmayr & Nussbaumer, 2004; McLoughlin, 1985). Years later, this approach was challenged even by McLoughlin (1985, p. 15), who critiqued his former work regarding the theory, practice and ideology arguing that there is a disjunction between systems theory and the urban world and planning practice. He called it a "utopian optimism of system theory" versus a "stark pessimism in the face of the facts of urban life". Some points were also addressed by Batty (2007, pp. 6–9), who emphasizes that despite systems being understood as networks within themselves, they were also ordered according to a hierarchy with the need of a controller subsystem to keep the interactions in equilibrium, which according to the author is not possible. Following Batty, such equilibrium also implies a narrow idea of system interactions because it refers to a passive equilibrium while system's behavior regards an idea of turbulence and constant changes among different structures (Batty, 2007, p. 7). Many other critics have also challenged the general systems theory regarding other aspects, but they are not being presented here as these considerations surpass the scope of this research.

§ 3.2.2 Beyond System Theory, Complexity Theory

In his working paper "Complexity in City Systems, Understanding, Evolution and Design", Batty (2007) argues that the idea of planning (as a controller) aiming to restore the equilibrium of a city (as the system) conflicts with diversity and heterogeneity, among other aspects related to a "successful city life" (Batty, 2007, p. 8). This is the main conflict of general systems theory that led to a new paradigm addressed by complexity sciences because of the limitation of planning, design and engineering to exert control over the economic, social and spatial problems of a city. The increasing awareness of the uncertainty of future developments emerged as the fundamental problem for complex organizations (Thompson, 1967, p. 159), and the concept of resilience became a major issue that needed to be approached. As it was previously addressed, resilience can be defined by Adger (2006, p. 286), Folke et al. (2010) and Scheffer (2009) as "the capacity of a system to absorb disturbance", reorganizing to maintain its identity, before changing to a radically different state. Davoudi et al. (2012, 300) make the distinction between engineering and ecological resilience. The first concept refers to the ability of a system to absorb changes and return to equilibrium after a disturbance (Davoudi et al. , 2012, p. 300; Holling, 1973, p. 17), which could be a natural catastrophe, social or political upheavals among other causes. The second concept, ecological resilience, focuses on the ability of a system to persist and adapt to those changes, which means that it must be prepared for possible changing conditions in the future. The relation between resilience and -dynamic-stability defines the evolution of complex systems influencing planning strategies to deal with such inherent uncertainties, but these issues will be addressed later, focusing on adaptation, which is understood as a pre-requisite for resilience (Folke et al., 2010).

Complex systems are composed of complex subsystems and finding a precise definition regarding such complexity is impossible due to the number of components, the number of states that each component can take on and the infinite combination among them. Thus, the controller is no longer seen as a unique subsystem, due to the impossibility of controlling such a variety of combinations. Following the concept of *requisite variety,* any system can cope with turbulence and generate a wide repertory of responses to rapid changes in the environment (Haughton, Allmendinger, Counsell, & Vigar, 2010, p. 47; Heylighen, 2001, p. 15; Lissack, 1999, p. 44). As a result, systems need as many controllers as states can take on (Batty, 2007, p. 9). In other words, complex systems are a result of the interaction between their components in a bottom-up generative process and present so many variables that they are not able to be simplified using traditional methods.

Indeed, complexity sciences present opportunities for addressing the study of complex human and environmental systems from an interdisciplinary view. Thus, making them applicable for *space-and-place studies*, a broad group of disciplines within environment and planning, including geography, anthropology, urban planning, regional science, and architecture among others (Manson & O'Sullivan, 2006, p. 677). Nevertheless, it is not the intention of this research to delve into the concept of complexity theory or to investigate its "deeper messages" as defined by Portugali (2006, p. 651) when referring to the theoretical and philosophical ideas or the mathematical formalisms embedded into it. However, as the approaches embraced in this research on metropolitan deltas are based on complexity theory, it is necessary to remark on some specific issues that are relevant for this study.

Many authors argue that complexity theory is not a uniquely identifiable theory but an accretion of ideas applied to complex systems (Gregory, Johnston, Pratt, Watts, & Whatmore, 2009, pp. 105–106; S. Manson & O'Sullivan, 2006, p. 678; Thrift, 1999, p. 33). In this way, the underlying objective of complexity theory is to understand "the properties of interaction of the systems" in an anti-reductionist way (Thrift, 1999, pp. 3–4). This perspective of understanding the reality presents challenges the former ideas of a singular rationality, which claimed universality in social scientific explanation. Not fully against rational thinking, complexity theory rejects the notion of a singular mode of rational thought, and according to Little (2008), implies a different emerging rationality. Following this principle and from a post-structuralist perspective, it is impossible to "tell a single and exclusive story about something that is really complex" (Cilliers, 1998, p. 9).

From an ontological perspective, complexity focuses on the parts of a system and the relations among them and with the entire system (Manson & O'Sullivan, 2006, p. 681). This idea leads to a debate between holistic and reductionist perspectives because a system is not completely explained by the mere understanding of its parts and the rising concept of *emergence*. This concept results from the synergism that takes place between a system's components (Manson & O'Sullivan, 2006, p. 682) and will be described later. As Batty (2007, p. 31) highlights, complexity theory is a major paradigm for science and admits "unpredictability, uncertainty, ambiguity and pluralism".

According to Manson (2001, pp. 409–411), the key concepts of aggregate complexity (whose aim is analyzing the holism and synergy resulting from component's interactions) are *relationships, internal structure, environment, learning and memory, emergence* and *change and evolution*. *Relationships* are the central point in aggregate complexity because they refer to the interactions among system component's, they define an *internal structure* of relationships and also establish connections with

the *environment* (the "outside" of the system). Due to the existence of an internal structure, the components of a system can accommodate to changes through *learning and memory*, and the destruction of relations among them may turn into a loss of resilience capacity. The concept of *emergence*, which has already been described and will repeatedly be touched upon in this thesis, refers to the importance of the synergism within the components of a system. Finally, yet importantly, the idea of *change and evolution* regards the constant changes that the systems present, with the ability to balance between randomness and stasis through a process of self-organization. This process is defined as the creation of spontaneously occurring, globally coherent, non-linear patterns that go beyond local interactions (Batty 2007, 13; Heylighen 2001, 1–4 Manson 2001, 409–411).

§ 3.2.3 Complex systems

Durlauf´s definition of complex systems (2005, p. 226) refers to systems composed of "a set of heterogeneous agents whose behavior is interdependent and may be described as a stochastic process". Within the properties of complex systems, the author highlights four characteristics that are relevant for social science contexts: *nonergodicity, phase transition, emergent properties* and *universality*. First, a system is *nonergodic* when it lacks stable equilibrium and provable behavior over the long-term. In this context, exogenous and endogenous shocks can affect the long-run state of the entire system triggering path-dependent behavior (Batty, 2007, pp. 11–12; Durlauf, 2005, p. 226). A system exhibits *phase transition* when a small change in its parameters can generate a qualitative change in the aggregate properties of the entire system (Durlauf, 2005, p. 227). Third, *emergent properties* imply that there is a synergism between system's components at the lower stratum without any higher coordination (Durlauf, 2005, p. 227; Manson & O'Sullivan, 2006, p. 682), which connotes a relation with the idea of self-organization. Moreover, finally, the property of *universality* refers to the presence of invariant properties in time and space independent of the changes emerging from systems' components (Batty, 2007, p. 13; Durlauf, 2005, p. 227).

All changes imply a system's ability to adapt, find a new temporary dynamic equilibrium, and to reach a "balance between randomness and stasis", a concept proposed by Manson (2001, p. 410) which has been previously described. Concerning adaptation, it is interesting to refer to Gladwell´s (2000, p. 12) "tipping point" which is the "possibility of sudden change", sometimes referred to as a *critical transition*. In that state, sudden and extreme changes oblige systems to find a new dynamic equilibrium

according to the characteristics of their subsystems and the relations among them. This idea of a complex system facing a need to change and adapt leads us to the concept of *complex adaptive systems*. As defined by Mitchell (2009, p. 13), complex adaptive systems are composed of "large networks of components with no central control and simple rules of operation", giving rise to "complex collective behavior, sophisticated information processing and adaptation via learning or evolution". This behavior comes from self-organizing processes of emergence with a high level of unpredictability, and in the words of Giacomoni et al. (2013, p. 556) can be understood as a complex network of agents continually adapting to their environment.

§ 3.2.4 Emerging metropolitan deltas as complex adaptive systems

Going back to the universe of deltas, their previously explained metropolitan condition, and after having analyzed the main concepts regarding complex systems, it is possible to propose a comprehensive definition of emerging metropolitan deltas as "***complex adaptive systems where the dynamic confluence of deltaic and metropolitan subsystems takes place in constant transformation due to the emergence of self-organizing processes***". These processes affect subsystems, their relations and the system's wholeness. Additionally, the influence of external processes, also affects the system and its components requiring adaptation and reformulation of the intrinsic relationships towards a dynamic equilibrium.

Emerging metropolitan deltas are open systems in constant interaction with their environment. Inside the larger system, each subsystem (formed by physical components, social actors and the relations among them) has its proper environment and those relationships between each subsystem and the larger system repeat at different levels, which require constant adjustment. According to Pols et al. (2015, p. 53), boundaries between subsystems in deltas are difficult to define because of the high complexity of the constellation of spatial functions that take place within those territories (water management, urbanization, transport network, etc.) and also because boundaries change over time and are defined differently by a multiplicity of actors.

The variety of factors generate incremental changes influencing events in a path-dependent way (Pols et al., 2015b, p. 53), which means that previous events determine a particular event's direction; Those factors can mutually adjust or simply disrupt each other. When rapid economic and technological development accompanies strong demographic growth, it is possible to observe a reinforcement of both factors, which adapt in a co-evolutionary process. Nevertheless, those changes are also capable of

jeopardizing the delta's quality of water or exerting pressure over the territory through the rise of land demand. This situation can also lead to a rapid and unplanned land use change from rural to urban, followed by an unsatisfied demand for infrastructure which results in an increase of the population's vulnerability to extreme climatic events.

It is impossible to tackle such a network of interactions only through a traditional and regulatory view of planning. As pointed out before, complex systems are not compatible with a unique controller to *restore equilibrium* (Batty, 2007, p. 9), such as planning through a top-down driven approach. Returning to the concepts of *phase transition* and *emergence*, planning in emerging metropolitan deltas is about taking advantage of the synergism that lies in the generation of small changes of a system's components, which will impact the overall system structure in a path-dependent way. In other words, the formation of joint actions among different actors can undertake planning in emerging metropolitan deltas from a complex adaptive systems approach. This organization can address (and take advantage of) the complexity of planning practices that characterize those areas and the non-expedience of unilateral interventionist actions. In a certain way, given such self-organized networks with little hierarchy, intensive dialogue becomes a key action to consider in aligning subsystems with a "symbiotic evolution" (Pols et al. , 2015b, p. 55). In this synchronization, actors consider the effects of their activities on other subsystems from multiple points of view across (and even changing) established boundaries.

This vision implies a change in the traditional notion of planning and design, which needs to be revisited to understand the crucial role that adaptive plans and social participation plays to face uncertain future challenges in emerging metropolitan deltas.

§ 3.3 Planning and Design Approaches

Before any conception of a city as a complex adaptive system, it is considered a physical element, derived from a geographical and morphological view of space (Taylor, 2011, p. 391). Therefore, urban planning was perceived as an "exercise of physical design" of architecture on the scale of a town (Hall, 2011, p. 376; Taylor, 1998, p. 4, 2011, p. 390). Thus the planner's job was to make plans for a stable and static city (Hall, 2011, pp. 376–377). According to Taylor (2011, pp. 390–392), around the 1960s, the designed-based perspective of planning was left behind in favor of the *general system* and *rational process* views of planning. Although both approaches are conceptually different, together they represented a shift from post-war planning ideas. The general

system theory, whose principal features were explained previously, focused on the object of planning (the city).

On the contrary, the rational planning process delved into the method of planning as a "procedure for making instrumentally rational decisions" (Taylor, 2011, p. 391). The fundamental changes implied in both views consisted not only of replacing the old concept of cities as static physical phenomenon by understanding the city as a system of interrelated components (including social and economic interactions) but also consisted of the change in the techniques used to face such complexity. In other words, through the involvement of scientific methods to analyze the city and also through the inclusion of the view of planning as a rational process, the discipline changed from an art to a science (Taylor, 2011, p. 391). Although Hall (2011) and Taylor (2011) agreed on the existence of a radical rupture in the conception of planning during the 1960s, Hall believed that this change represented a shift of paradigm while Taylor disagreed, arguing that the design-based view persisted in some way during the following decades. Beyond this discussion, planning remained as a combination of skills (whether artistic or scientific) held only by specialists and not by average citizens. The emergence of the consideration of planning as a value-laden process (as called by Taylor, 2011, p. 392–393), also represented a change in the conception of the planner as a unique person capable of planning a city, challenging the expertise behind the discipline.

Contemporary to the rise of general system theory, Jane Jacobs (1961) was publishing her book "The death and life of great American cities" which deeply criticized post-war physical oriented planning which had been characterized by ordering the city through zoning and other mechanisms. She argued that cities consisted of a *mixture of uses* and that planning must comprehend urban interactions learning from the concept or organized complexity derived from life sciences (Jacobs, 1961, p. 433). To better understand cities, she proposes three actions: (a) to think *about processes*; (b) *to work inductively*; and (c) to seek "*unaverage clues*" (Jacobs, 1961, p. 440). Following Jacob's ideas, to *think about processes* means that that dynamics are the essence of cities, being understood and recognized by "almost anybody" and not being restricted to experts. To *work inductively* implies reasoning from particulars to the general, as city processes are too complex to be generalized and that generalizations may result in absurdities. Third, to look for *unaverage clues* refers to considering the facts that lay outside statistics, yet indicate the (economic, cultural, physical, etc.) aspects of a city. The author gives as an example that if a series of shops are open until midnight in a particular area of the city, it means that there is a public for them, entailing a local dynamic. In other words, this view opened the perspective of planning towards the apprehension of complexity and heterogeneity, later followed by McLoughlin (1969; 1985) and Chadwick (1971;1977), as was previously mentioned.

Beyond theory, Jacobs also includes the urban actors as connoisseurs of city dynamics, which leaves behind the concept of the urban planner as the unique expert (or controller) of development processes (1961, 441–443). Indeed, the role of planners seems to be related to articulating interests of individuals rather than representing the State through the design of plans from a desk. In the words of Davidoff (1965, p. 425) "where plural planning is practiced, advocacy becomes the means of professional support for competing claims about how the community should develop". Those ideas are aligned with the notion that planning and design as mere technical reasons are no longer viable given the complexity of issues involved. Indeed, years later, Friedmann (1987, p. 38) argued that planning "attempts to link scientific and technical knowledge to actions in the public domain", referring to "actions in the public domain" as both societal guidance and social transformation, which implies social mobilization.

Going back to the design realm, whether it is the design of a building or a city, worth mentioning are the concepts fenced by Christopher Alexander (1979). He also shared Jacob's view on processes towards a new synthesis of theory and practice of design within a more adaptive, open and reflective approach (Carmona & Tiesdell, 2007, p. 30; Lea, 1994, p. 44). Firstly, in his book "Notes on the Synthesis of Form", Alexander argues that "*No complex adaptive system will succeed in adapting in a reasonable amount of time unless the adaptation can proceed subsystem by subsystem, each subsystem relatively independent of the others*" (Alexander, 1964, p. 41). In this way, he agrees with a systemic approach to the design discipline and considers complexity, introducing the notion of *pattern* as a morphological law which establishes a set of relationships in space that are also related to other patterns of events associated with them (Alexander, 1979, p. 90). He also introduces the idea of systems that grow bottom-up, where order and structure emerge as a consequence of actions and interactions (Batty, 2007, pp. 7–10). Secondly, Alexander argues that the character of a building or a town is given by the events that happen in them, highlighting the importance of self-built places and participatory design that is directed by the intuitive needs and desires of everyday life (Alexander, Ishikawa, & Silverstein, 1977).

Worth mentioning is that his method was applied in a competition carried on by the United Nations together with the Banco de la Vivienda de Perú in 1969. It asked different teams for a design to build 1,500 houses on a site near Lima (Alexander, Hirshen, Ishikawa, Coffin, & Angel, 1969, p. 5). The team headed by Alexander developed a system that "would help the evolution of Peruvian Community and house design in the future" (Alexander et al. , 1969, p. 5). Their design was based on a series of patterns that could be combined by inhabitants to build their own houses according to their specific needs and the adaptability of the patterns was accompanied by an adaptive system of design for the creation of the homes.

A close vision of the process of creating or designing a city through collective action is seen in the work of Donald Appleyard and Allan Jacobs (1987), "The Urban Design Manifesto". It was developed years later as a plea for defining the physical characteristics of a good city and the process that lay beyond their generation. As expressed by (Bahrainy & Bakhtiar, 2016), although urban design's primary concern is about the urban form, its perceptual and visual attributes, urban form cannot be separated from its content. Therefore, Appleyard and Jacob's manifesto came about as a rejection of the Modernist Movement and the ideas of the CIAM (Congrès International d'Architecture Moderne), within the context of the emergence of pluralism in postmodern architecture and design (Bahrainy & Bakhtiar, 2016). In the decade of the 1980s, many design theories based on philosophical approaches ended up strengthening an integrative vision of the discipline.

§ 3.3.1 Theory of Communicative Action

The shift from considering cities as physical elements to recognizing them as social constructions changed the vision of design and planning as well as the perception of planners themselves. It is undeniable that the ideas behind that shift are related to the philosophical work of Jürgen Habermas and his Theory of Communicative Action (1984). Although the work of Habermas is not going to be further explained in this thesis as it exceeds the objectives of this research, it is important to comment on the "Theory of Communicative Action", which have been a relevant influence for planning theories up until the present, and also for this thesis.

Among other thinkers of the Frankfurt School such as Adorno and Horkheimer, Habermas argued that "reality is hidden under socially constructed understanding, theories assumptions and language" (Innes & Booher, 2010, p. 61), exposing power relations within a society. In this context, the "Theory of Communicative Action" represents a "theory of rationality and knowledge" (Bohman & Rehg, 2014), in which rationality is tied to discourse as it comprehends social and political-economic structures as operative communication structures (Bohman & Rehg, 2014; Forester, 1980, p. 276). In other words, communicative action helps actors coordinate their action plans and accomplish individual (or collective) goals through reaching an understanding (Habermas, 1984, p. 86). According to Bolton (2014, p. 9); and Flyvbjerg (1998, p. 215), this notion of the social construction of understanding is linked to an idealistic view of democratic society in which politics and planning require the consent that emerges from collective criticism (Forester, 1980, p. 277). According to Flyvbjerg (1998, p. 214), Habermas theory is "bottom-up situationalist" regarding

content and "universalistic top-down moralist" regarding processes. On the one hand, it refers to communicative action as determined by the participation of actors in the process of the construction of understanding based on their heterogeneity. On the other hand, it implies that the actors orient their action to common values complying with already established -and accepted- norms (Bent Flyvbjerg, 1998, p. 214; Habermas, 1984, p. 85).

Habermas' ideas were inspiring for many urban planning theorists such as John Forester, Patsy Healey, John Dryzek and Judith Innes. John Forester was the pioneer who translated Habermas' ideas into planning. In his article "Critical theory and planning practice" (Forester, 1980) he introduced the Theory of Communicative Action into planning; exposing planning practice as "attention-shaping" (Forester, 1980, p. 277) and part of a deliberative process rather than focused on a fixed goal (instrumental action). Meanwhile, in 1992 Patsy Healey wrote the article "Planning trough debate: The communicative turn in planning theory" and later forged the term "Collaborative Planning", which will be addressed later. Inspired by Habermas' theory "as a normative principle with which to evaluate and challenge the qualities of interactive practices" (Healey, 2003, p. 106). She also based her work on Giddens' structuration theory and believed that social order emerges as a product of dialectical forces of human agency. John Dryzek, a political theorist, also encouraged the application of Habermas' theories as a way to balance society's intrinsic power imbalance (Healey, 2007, p.VIII).

Going back to the concept of the planner's role, Forester (1987, p. 304; 1980, p. 280) presents them as orchestrators of political processes which imply multiple actors and viewpoints, as they are immersed in complex political fields acting as coalition builders (Murdoch, 2006, p. 143). In this context the recognition and understanding of social groups and behaviors played a key role for making the process of planning more "amenable" (Murdoch, 2006, p. 144), understanding the inherent social complexity and giving people the possibility to have a voice in the planning process. Besides, given the complexity that characterizes urban regions, they are not able to be managed through plans developed by governments and applied linearly (Healey, 2007, p. 23). On the contrary, going back to the idea developed in the previous section, complex systems are not compatible with a hierarchical conception of a unique controller (Batty, 2007, p. 9) but to the notion of self-organization. In this sense, the existence of a delineated governance process is crucial for understanding and acting according to the complex nature of these areas.

Along those lines, Innes and Booher (2010, p. 5) distinguish a new form of planning and policy led by the replacement of traditional linear methods that relies on formal expertise by nonlinear socially constructed processes that engage experts and stakeholders in the co-creation of different types of knowledge. According to the

authors, it shows the emergence of what they call *collaborative rationality*, which, although it may not be best for every political decision, when applicable in planning, it can contribute not only to reach consensus but also to build social and political capital. This could make the difference in long-term conflicts, which can transform "intractable problems to tractable ones" (Innes & Booher, 2010, p. 7).

§ 3.3.2 Collaborative approaches

Citing Grey (1985, p. 912), the term collaborative means "the pooling of appreciations and/or tangible resources, e. g. , information, money, labor, etc. , by two or more stakeholders to solve a set of problems which neither can solve individually". In this thesis, the concept of *stakeholder* is referring to citizens as individuals and to organized groups (either governmental agencies or civic organizations). In other terms, collaborative approaches regards consensus-oriented decision making through collective participation of engaged stakeholders (Ansell & Gash, 2007, p. 543), not only to find a consensus (or a mere collaboration) but also to generate individual and collective knowledge to develop new skills to make the community more adaptive and resilient (Connick & Innes, 2003).

Nevertheless, the collaborative approach has also had critics regarding power, social theory and applicability, among others. Susan Fainstein, (2003, p. 455) argues that even though the "communicative model should not be faulted for its ideas of openness and diversity", it presents vulnerabilities related to practice, and is difficult to implement, mainly in cases where multiple jurisdictions are involved. Other critics refer to the lack of understanding of power structures, arguing that collaborative processes reinforce power relations instead of changing them. Indeed, Flyvbjerg (2002, p. 353) argues that communicative approaches that focus on Habermas' ideas "*tend to remain strongly normative and procedural without the substantive understanding of Realpolitik and real rationality that characterizes studies of power*" (B. Flyvbjerg, 2002, p. 353). As in any other participatory method, power imbalance is an obstacle difficult to overcome. Important actors that do not have the organizational infrastructure to be represented in collaborative processes are often excluded, which requires a commitment of the public sector to empower their representation (Ansell & Gash, 2007, p. 551). Although Schuman (2006, p. xxviii) agrees that "all individuals and interest groups in all sectors of society have the right to meaningful participation, the truth is that it is difficult to achieve. Other problems related to the involvement of stakeholders, as Ansell & Gash (2008, p. 551) points out, are the difficulty for some stakeholders to understand the technical issues that may be discussed related

to territorial aspects, and the unwillingness of stakeholders to participate in such processes due to the lack of time and resources.

Moving beyond collaborative models, as remarked by Allmendinger and Haughton (2009, p. 621), in some way, planning is still part of the formal regulatory system of the hierarchical classical "government", where centralization and the dominance of experts and professionals in decision making remain present. Nevertheless, the presented historical evolution together with the perception of the object of planning as a complex system shows an encouragement of the inclusion of new associational networks in governance systems at all levels. Allmendinger and Haughton (2009, p. 621) call it an intriguing multi-scalar and multi-sectoral hybrid composed by "new style governance" and an "old style government" (Phil Allmendinger & Haughton, 2009, pp. 621, 631), which implications define the mentioned perception.

§ 3.4 Governance In Complex Adaptive Systems

Governance can be defined as the coordination of activities around collective problems by mutually dependent actors (Koppenjan & Klijn, 2004; van Buuren, Boons, & Teisman, 2012a, p. 118). In other words, it concerns how society or groups organize to make decisions, who makes the decisions, how the rest of the actors participate in those decisions and who is accountable for them. When analyzing governance in complex adaptive systems, three main features arise: (Teisman, van Buuren, & Gerrits, 2009, p. 21; van Buuren et al. , 2012a, p. 119; Young, 2017, p. 4, 17) *non-linear dynamics, self-organization* and *co-evolution*. *Non-linearity* regards that any particular incentive that can cause a specific result at one time, when applied in another timeframe may result in a very different response. In complex adaptive systems, all trajectories may lead to phase transitions, so any particular change can trigger a qualitative change at higher levels of the system (Bovaird, 2008, p. 322; Durlauf, 2005, p. 227). The second characteristic, *Self-organization*, has already been introduced in the sections and plays a vital role in adaptation related to the capacity of elements to adjust and develop emergent properties. It addresses how processes occur, develop and change, being characterized by the emergence of new structures based on the local interaction of agents without any external or internal imposition (Cilliers, 1998, p. 93). In the case of advanced organizations and networks, many agents participate at different levels, acting in parallel, with highly dispersed control, communicating and cooperating, revising their choices through their gained experience and their assumptions on the system and its environment (Bovaird, 2008, p. 322). Finally, the

third characteristic, *co-evolution* refers to the non-linear and erratic "ongoing process of mutual adjustment between interconnected elements" within or outside the system (Bertolini, 2010; Gerrits, Marks, & van Buuren, 2009, p. 226). As was already described, these characteristics are present in emerging metropolitan deltas and are potentiated due to the coexistence of the two systems: the metropolitan and the environmental.

§ 3.4.1 Stakeholder synchronization

According to (Teisman & Edelenbos, 2011, p. 102), fragmentation is an inevitable characteristic of governance structures, being integration often presented as a possible solution. Contrary to the thought of putting a controller in charge of "integrating" the system, the notion of integration, in this case, refers -both in practice and theory- to developing coordination mechanisms. There is no possibility of integration through the development of a unique integrated plan, the establishment of one organization in charge or applying a certain procedure. On the contrary, it would increase fragmentation even more, creating more boundaries (Teisman & Edelenbos, 2011, p. 102). Integration in complex governance systems regards synchronization, which is nothing more than mutual adjustment expanded to a wider scope of actors and dynamics (Teisman & Edelenbos, 2011, p. 106). Complex adaptive systems approach understands that systems are composed of parts which play a relevant role in the conformation of the system's structure. Those parts have the ability to self-organize creating spontaneous non-linear patterns beyond local interactions (Batty 2007, 13; Heylighen 2001, 1–4 Manson 2001, p. 409–411). Synchronization means alignment of the subsystems towards a symbiotic coevolution for reaching synergy instead of fragmentation (Pols et al. , 2015b, p. 55). As governance systems are composed of interacting actors, synchronization means that actors think and act "between self and the larger whole" (Teisman & Edelenbos, 2011, p. 101). Considering the effects of their actions on the system and subsystems while being aware of their characteristics and links (Pols et al. , 2015b, p. 55). To reach an alignment between subsystems, synchronization needs the mobilization of mutually accepted actors in common spaces to work in coalitions and to interact without being part of a hierarchical structure (Pols et al. , 2015b; Teisman & Edelenbos, 2011, p. 111; van Buuren, Boons, & Teisman, 2012b). Those common spaces, also named *soft-spaces* (Allmendinger & Haughton, 2009; Haughton et al., 2010; Pols, Edelenbos, Pel, & Dammers, 2015a, p. 159) take place outside of formal regulatory, governmental realms, or *hard-spaces*. Their aim is to encourage the emergence of creative thinking as well as opening new opportunities for consensus building that usually do not occur within a formal planning system. There, stakeholders

gather together to discuss design, government, and planning in a free environment. Once developed following a regular basis, *soft spaces* can generate results that can be anchored in hard-spaces (Dammers et al. , 2014, p. 57).

§ 3.5 Governance, Planning and Design Experiences in Emerging Metropolitan Deltas

Considering the double complexity that characterizes emerging metropolitan deltas regarding the coexistence of the metropolitan and natural systems, governance in these areas is indeed a challenge.

Regarding the metropolitan condition, governance must face functional areas of cities that often transcend physical boundaries conforming "cities of cities" spreading over several municipalities and comprising cities of different scales (Friedmann & Friedmann, 2007, p. 988; United Nations Human Settlements Programme, 2008, p. 226). One of the key challenges in these areas is reaching spatial, economic, social and environmental harmony between all the local governments involved, based on cooperation instead of competition (United Nations Human Settlements Programme, 2008, p. 226). This remains a difficult task given the absence of institutional agreement on the physical and functional delimitation of many metropolitan areas. The idea of a single city core as the center from where the expansion towards the hinterland takes place is no longer enough to describe the level of complexity of metropolitan interrelations. On the contrary, metropolitan regions are part of a dynamic of constant redefinition based on the emergence of different structures as a result of non-linear self-organizing processes.

As distinguished by Sabsay, García, Nápoli, & Ryan (2002, pp. 18–21), many authors have developed a series of typologies regarding the types of metropolitan organization. In general, these typologies take into account the existence (or not) of a metropolitan government, of agencies for specific purposes or services, and of inter-jurisdictional coordination. Sabsay, García, Nápoli, & Ryan (2002, pp. 19) highlight the distinction made by Martín Mateo & Allende Landa (1986), who establish three basic forms of government of metropolitan spaces: (a) central governments that assume metropolitan functions; (b) metropolitan entities that are created for specific purposes (such as waste management or other services); and (c) a metropolitan government that is structured to assume all metropolitan issues. Following that line and with regards to the municipal competence, Sabsay, García, Nápoli, & Ryan (2002, pp. 19) mention

another characterization Mouchet (1968) makes. He distinguishes four organizations: (a) the incorporation of the municipalities that form the metropolitan area into the central city; (b) the association of local units (which maintain their competences) and the subsequent creation of agencies to manage metropolitan issues; (c) the creation of agencies to manage metropolitan issues, but extract those competences previously held by municipalities; and (d) the creation of a metropolitan government which suppresses municipal jurisdictions.

In other words, these characterizations, among others many authors discuss (see Barrero Rodríguez, 1993; Barrero Rodríguez, 2004; Borja & Castells, 2000), address the importance of the recognition of issues that transcend jurisdictional borders and the coordination among the different scales of government. That always consider the legal and administrative contexts which set the rules for their organization.

In the case of metropolitan areas located in deltas or near their edges, the amount of issues that require an agreement increases even more: urban and port development; water management; scientific, technologic, industrial and socio-economic development; public services and housing; infrastructures for flood defense and transportation; public health and sustainable development, environmental conservation, water and food supply; energy generation; international trade; and climate change mitigation among others. All of those issues require consensus, which is difficult to achieve when the number of municipalities is high and also when agreement must be reached at all levels, from local to national governments and offices. Even more, being that functional limits of metropolitan areas do not often coincide with the limits of natural features, blurring jurisdictional competences. The spectrum of stakeholders goes from individuals, households, farmers, industries, developers, governmental and non-governmental institutions to large companies, among others. Thereby, the level of consensus needed is even greater being that they usually come from dissimilar realms.

The Cairo (Nile Delta), Kolkata (Ganges Delta), Karachi (Indus Delta), Jakarta (Ciliwung Delta) and the Randstad region (Rhine-Meuse-Scheldt Delta), have agencies dedicated to planning and administration at the metropolitan level (Picorelli, Barros, Tomas, & Molle, 2009). In all cases, national governments play a vital role in water management through their Ministries. The Ganges Delta, bases its National Water Policy upon the Integrated Water Resources Management system through the development of a National Water Management Plan, but decisions are still made at the national level even for local matters (Bucx, Marchand, Makaske, & Van de Guchte, 2010, p. 51).

In the Netherlands, the overall maintenance of the National infrastructure water system depends on the National Ministry of Infrastructure and the Environment. At the

present, this governing body is additionally responsible for the design, management and maintenance of the infrastructure and water systems, and the Delta's issues are included in the Delta Program, based on the recommendations of a Delta Commission. Unlike other cases, the Netherlands is a particular example since there, water management have been historically related to its urban development and during the last decades, the authorities revisited the paradigm of flood defense towards an adaptive integrated approach. The floods that took place in 1916 and 1953 gave rise to two of the largest hydraulic works initiated by the Dutch government: "Zuiderzee Works" and "Delta Works" (Meyer, 2014b, p. 47). The first case consisted basically of the construction of the Afsluitdijk, which turned the Zuiderzee into a freshwater lake (Ijsselmeer), and the generation of polders with a smart combination of a modern model of agriculture with a system of new towns and villages (Meyer, 2014b, p. 49). The second case consisted of the construction of dams, barriers and increasing the height of existing dams, as part of a top-down initiative (Meyer, 2014a, p. 181) in the struggle against flooding. As a consequence of both projects, the extension of the Dutch coast was reduced from 1,400 km in 1930 to 400 km in 2000 (Vrijling & Stive, 2010) resulting in a decaying ecosystem due to the disappearance of many fish, bird and plant species (Meyer, 2014b, p. 49).

§ 3.5.1 A change in paradigm of flood defense and planning

Decades after this rationalization and modernization of those spaces, which led to artificial flood defenses unable to cope with unforeseen events, the question was to what extent is flood protection guaranteed in a context of increasing climate change? In what way is it possible to achieve a restoration of the nature of the delta and how is it possible to combine economic development, environment and urban development considering flood defense? As a response to these questions, the programs "Room for the River" and the "Delta Program" emerged experimenting with new alternatives to restore delta condition more technically and dynamically while considering the uncertainty of climate change and long-term social changes (Meyer, 2014b, p. 49).

The "Room for the River" approach aims to restore river's natural floodplains in areas which are not vulnerable while protecting others which are more vulnerable to flooding events (Rijkwaterstraat, 2017). The program consists of a variety of solutions for different types of rivers, such as deepening summer beds, water storage, dike relocation, strengthening dikes, lowering floodplains, 'depoldering' (Rijkwaterstraat, 2017), and removing obstacles, among others. One remarkable example is the case of the town of Nijmegen, where an innovative solution was developed to protect the city

as well as generate a unique park for recreational activities. Nijmegen is located on the banks of the River Waal, the most extensive river in the Netherlands, in a floodplain. Along the other shore of the river, there is the city of Lent, which has a dike to protect it from flooding. Both cities are settled in the narrowest section of the watercourse, without room for the river to expand and that faces the threat of being flooded mostly during the winter season (European Climate Adaptation Platform, 2013). The challenge was to increase safety and also improve the environmental quality of the region. Therefore, the solution was to widen the floodplain to give more room for the river to decrease its water level, to construct a secondary meander with an island that would hold a recreational park, the relocation of the dike and the construction of three new bridges and a new quay. In this initiative, stakeholder participation was included as a key factor for the definition of plans and designs, following Strategic Environmental Assessment and Environmental Impact Assessment procedures[1] through the development of workshops, graphics, models for the actors to visualize the alternatives, and the consideration of their voice in the development of plans.

§ 3.5.2 The Layer Approach and the introduction of the use of scenarios in delta planning

Another Dutch example of these kinds of strategies is the workshop Delta Envisioning Support System (DENVIS), carried on within the scope of the Integrated Planning and Design in the Delta (IPDD) project, developed in the Netherlands. Specifically, the DENVIS has been applied to the area of Haringvliet (southwest of the Netherlands), located by the river mouth of the Rhine and Meuse, next to the port of Rotterdam (UNESCO-IHE, 2015, p. 2). This project was developed to strengthen the planning process through the building of relationships, the identification of challenges for the delta region and the subregion, the discussion of objectives and the exploration of options. In words of Pols et al. (2015a, p. 157), it was designed "to facilitate development of adaptive, synchronizing and mobilizing visions of the future" through planning support systems such as serious gaming and design studios. There, the effects of decisions taken were mapped and visualized using models, to make people

1 In order to ensure that environmental effects of decisions are considered before making them, the Environmental Assessment procedure must be undertaken. Environmental assessment can be undertaken for individual projects (Directive 2011/92/EU, also known as Environmental Impact Assessment - EIA Directive) and for public plans or programs (Directive 2001/42/EC, known as Strategic Environmental Assessment – SEA Directive) (European Union, 2017).

feel free to seek creative solutions to complex situations. These initiatives are clearly adaptive collaborative strategies for knowledge generation through soft spaces that are developed within hard spaces.

This program, which understands deltas as complex adaptive systems, addressed complexity through the implementation of the Layer Approach as a fundamental basis for the analysis of the dynamics and relations. As it was previously introduced in Chapter 2, the Layer Approach (*lagenbenadering*) was developed in the United States by Ian McHarg in 1969 and introduced in Dutch design and planning in the decade of 1980, for being later revisited by many authors (De Hoog, Sijmons, & Verschuren, 1998; van Schaick & Klaasen, 2009). The approach distinguishes three layers in the spatial organization of territory: the substratum layer (also called the environment or base layer), the network layer, and the occupation layer (De Hoog et al., 1998, p. 78; Pols et al., 2015b, p. 51). The main assumption is that each layer has a different transformation temporality and influences the other layers in a reciprocal process. The substratum layer has a temporality of change of around 50 to 500 years, while the temporality in network layer is 25 to 100 years and in occupation layer 10 to 40 years. That means that each layer has to be studied separately to understand its particularities, but then it needs to be analyzed in context with the other layers, to visualize the interactions of the different temporalities of change considering the complex network of interrelations of the system. The Layer Approach is an accurate tool for analyzing the contextual situation of a territory in constant change, considering all the drivers involved, and linking environmental issues and climatic change with urban development from an integrated perspective.

§ 3.6 Linking Climate Adaptation and Urban Development from an Actor-oriented Perspective

This thesis focuses on linking climate adaptation and urban development with participation processes. As it was previously addressed in this chapter, emerging metropolitan deltas are understood in this research as complex adaptive systems, which are composed by physical components, social actors and their mutual relationships. There, self-organizing processes emerge in a path-dependent way, within a context of uncertainty, also influenced by the unpredictable effects of climate change. In that context, planning, design and governance must adapt to this specific situation towards increasing the system´s adaptive capacity. To accomplish this objective, it remains crucial to include stakeholders into the processes of decision-

making over the territory through participative methods. Nevertheless, reaching social consensus is not an easy task. It requires flexible environments for public participation, where actors can interact in the creation of common knowledge that could trigger impacts at higher scales of the delta systems.

Furthermore, according to Haasnoot, Kwakkel, Walker, and ter Maat (2013) the high level of uncertainty requires a change of planning paradigm that should include the "strategic vision of the future" which should be combined with short-term measures through methods of public participation (Albrechts 2004, p. 743). In this sense, stakeholder participation is not only about finding consensus, but about constructing common desirable (or not) futures in order to explore the potentials of the different actions to take on the territory towards a more adaptive framework. Nevertheless, these "visions of the future" or scenarios must be delineated and constructed in certain way in order to include all the mentioned issues. In that sense, in terms of methodology, Prospective is the key discipline to guide this process.

Prospective is defined by Godet and Durance (2011, p. xvi) as a "multidisciplinary intellectual approach characterized by an all-encompassing and systemic vision in which various actors and variables may play a determining role in the outcome of any given future". Around the 1950s French philosopher, Gaston Berger gave the first outlines of what would later become *la prospective* claiming that the classical methods to justify political decisions based on analogies or extrapolations of past experiences were obsolete and that it was necessary to develop a new approach considering the future regarding decision-making processes (Berger, 1964). Although at the beginning, it was mainly focused on forecasting, since 1990, the concept of uncertainty addressed by Complexity Sciences led to a change of paradigm in the method. Without dismissing the classical vision of prospective as the anticipation and exploration of future events, the idea of future social construction was introduced, helping to develop a system that responds to changes in the instability of each context (Medina Vásquez & Ortegón, 2006, pp. 14, 94).

In this way, prospective broadened its scope becoming a suitable tool for knowledge generation and multidisciplinary social participation, considering the future world as a collective creation rather than something already established. According to De Jouvenel (2000, p. 37), prospective helps to build the future instead of predicting it. Within this construction of the future, prospective can also introduce the aim of elaborating and evaluating actions to prepare for it. In this case by adding a strategic dimension that makes a plan to achieve an overall aim (Crowther, 1995, p. 1179). In other words, prospective thinks about what will happen in the future, while the strategic dimension addresses what can be done and how to bring these desires into fruition (MIDEPLAN, 2005, p. 63). One of the methods to develop these simulations is the use of scenarios,

which can be defined as imagined hypothetical descriptions of possible futures constructed to reflect the impact of different casual events on the past, present and future (Godet & Durance, 2011, p. 25; Kok, Vervoort, van Lammeren, & Veldkamp, 2010, p. 605). According to Coates (2000, p. 116), the primary value of scenarios is to be able to gather complex elements and assemble them into "coherent, systematic, comprehensive and plausible" stories able to encourage stakeholders either to think about the future or to evaluate the future consequences of policy decisions. The advantage of scenarios versus econometrical models is that they can tackle complex sets of variables and simplify them into stories that are capable of being interpreted by different types of stakeholders, and that makes them a valuable tool for participatory planning strategies linking urban and environmental dynamics within the uncertain context of climate change.

§ 3.6.1 Characteristics and Types of Scenarios

According to Durance & Godet (2010, p. 1, 488), any scenario must respond to five characteristics: Pertinence, coherency, probability, importance, and transparency in order to be credible and useful within a prospective process. The principal element of a scenario is the description or "portrayal of step-wise changes in the society and the environment" (Alcamo, 2001, p. 7). Those descriptions can be expressed through diagrams, tables or a set of written sentences. Other elements that constitute a scenario are the recognition of driving forces, base year, time horizon and storylines (Alcamo, 2001, p. 12; De Jouvenel, 2000, p. 46). Driving forces are mainly the ones that influence society and the. The base year is the beginning of the scenario, while the time horizon defines when projected outcomes will occur. An appropriate time horizon is an essential factor for a successful scenario. Finally, the storylines or "scripts" are narrative descriptions of the scenarios that explain the most relevant features and their relationships to driving forces (Alcamo, 2001, p. 8). These narratives are not mere assertions about an issue, but require lengthy discussions, mostly when they are developed in a context of stakeholder cooperation.

There are two main types of scenarios: Exploratory, also known as descriptive scenarios, and normative, anticipatory scenarios (Alcamo, 2001, p. 11; Godet & Durance, 2011, p. 48; MIDEPLAN, 2005, p. 62). The main difference between the two groups is the direction they take. Exploratory scenarios begin in the present and end in the future, showing what could happen, whereas normative scenarios travel backwards from a future goal as a point of departure (Alcamo, 2001, p. 11; De Jouvenel, 2000, p. 46; Kosow & Gaßner, 2008a, p. 32). This desired (or undesired) vision of the future helps

to define the actions that need to be developed to reach those goals. The central question in the exploratory scenarios is "what if?" while in normative scenarios, it is "How do we get there?" (Kosow & Gaßner, 2008b). Besides, exploratory scenarios also reveal what different scenarios have in common, and which "no regret" interventions can be implemented in the short term triggering different adaptation measures in the long term.

Additionally, Alcamo (2001, p. 11) mentions two other possible distinctions of scenarios: Qualitative versus quantitative and baseline versus policy scenarios. The first distinction refers to the type of data and representation of the scenario. While qualitative scenarios describe the world through words, diagrams, or visual symbols, quantitative scenarios represent numerical information in the shape of tables and graphics (Alcamo, Kok, Busch, & Priess, 2006, p. 68). The advantage of qualitative scenarios is that they can represent the view of several actors at the same time and they have the potential to be understood by stakeholders from different backgrounds when accurately represented by clear storylines. On the contrary, the disadvantage of qualitative scenarios lies in the absence of numerical information about the system, which sometimes may lead to a lack of accuracy.

The second distinction addresses the difference between baseline scenarios (which exclude policy intervention) and policy scenarios (which consider policy framework and its impacts). Baseline scenarios also called "benchmark" or "non-intervention" scenarios, present a situation where the political context does not exist. They are often used in environmental studies to investigate the evolution of greenhouse emissions or to evaluate the possible impact of "no policy intervention". For instance, when analyzing what would happen with certain issues under current situations assuming that no new policy will be applied in the future (Alcamo, 2001, p. 11). On the contrary, policy scenarios, also called "reference scenarios" consider established policy. These scenarios can be part of any decision-making process because they stimulate and hypothetically test possible actions and their consequences (Kosow & Gaßner, 2008b).

Scenarios are useful for environmental and territorial assessments because they provide a picture of future alternatives thus raising awareness among different actors. They can also combine qualitative and quantitative information and translate hard theories into communicational stories that the community can then interpret. One example of participative scenario design is the Story And Simulation (SAS) approach for scenario development (Alcamo, 2001, p. 25). It is characterized by the development of qualitative storylines, the use of models to quantify them, and the application of an open and interactive process to define final scenarios. This approach involves ten steps; the definition of the actors that are going to conduct the process and develop the scenarios, the development of the storylines, the quantification and modeling of the

storylines and their subsequent revision, to their final development and publication. The advantages of this method are mainly that qualitative storylines can be quantified using quantitative information, which reduces the lack of accuracy regarding certain issues. Other benefits are the openness of the process to stakeholder participation at several stages and that it is finally possible to communicate results at each stage of the process through two publications. On the other hand, the disadvantages of the approach are related to the need to get accurate data to generate robust scenarios, and the need to hold several meetings to garner stakeholder's approval.

§ 3.7 Concluding remarks

In Chapter 2, the concept of metropolitan delta was presented, addressing all the dynamics that interact within these territories as well as the importance of considering climate change and urban development as key drivers of change that influence those areas in an unpredictable way. Subsequently, in this Chapter, System Theory and Complexity Theory were introduced as methodological approaches to understand the phenomenon not as a static object of analysis but as a complex system formed by components and their mutual interrelations. As a result, a definition of emerging metropolitan deltas was presented, as complex adaptive systems formed by physical components, social actors and the relations among them, which are in constant mutual adjustment within a context of high uncertainty.

After reaching to a definition, the dimensions of design, planning and governance were addressed to understand the implications that these disciplines have on emerging metropolitan deltas. In such changing and uncertain contexts, planning can no longer be a top-down exercise performed by "expert" planners that offer a unique solution for a static territory. On the contrary, design, planning and governance in emerging metropolitan deltas have to consider the complexity of the systems (contemplating all of their components and the emerging processes), the level of uncertainty, and the need for increasing adaptive capacity and social participation.

However, to accomplish a participative process towards linking climate adaptation and urban development is a difficult task. Power imbalance, insufficient representation, low interest on the part of the actors and lack of government support, are only some examples of some obstacles difficult to overcome. This thesis works within these difficulties, designing and implementing a method for this crucial part of the process of planning, design and governance in emerging metropolitan deltas.

The present chapter has delved into a methodological approach to design, planning and governance in emerging metropolitan deltas as a way to settle the theoretical basis for the analysis of the case study (the Lower Paraná Delta), which will be developed in the next Chapter, and also for the design of the method that is carried out in Chapter 5.

In the next chapter, the case study is analyzed, considering the complexity of the system and the processes that emerge as a result of the combination of natural and human driving forces, illustrating the concepts presented previously. The analysis is carried on structured around the Layer Approach, with the inclusion of a "new layer" regarding governance, since it plays a vital role for the implementation of any strategy or plan in the delta, not only in the creation of coalitions of actors but also in the development of any future scenario that must include policy as a crucial factor. The following chapter analyzes the Lower Paraná Delta in terms of: "natural delta" (base layer and climate change), "networks and regional development" (network layer), "historic evolution of urbanization" (occupation layer) and "institutional context and governance" (new "governance" layer).

As it was previously addressed, this structure of layers also guides the design and implementation of the scenario-based method for participatory design developed in Chapter 5 a way to link climate adaptation and urban development from an actor-oriented perspective.

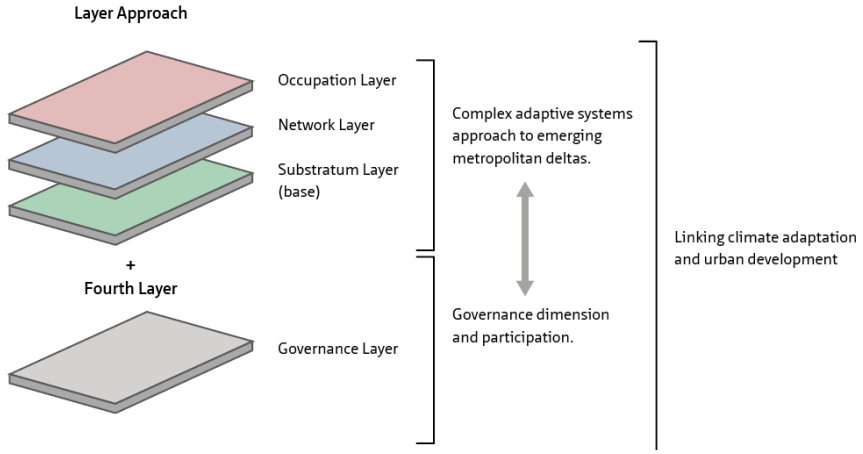

FIGURE 3.1 Layer Approach and the introduction of the fourth layer towards linking climate adaptation and urban development.

4 The Paraná Delta

§ 4.1 Introduction

The Paraná Delta is located along the wealthiest economic corridor of Argentina, which extends from the city of Diamante, situated in the Province of Entre Ríos, to the Río de la Plata. Along the edges of the Delta, there is a complex network of cities and metropolitan areas. On the one hand, in the North, the city of Rosario (located in the Province of Santa Fe) is relevant because it connects the Paraná Delta System with regional economies and it has a population of 1.2 million inhabitants. On the other hand, in the South, the Metropolitan Area of Buenos Aires is by far the most prominent urban agglomeration. Its population (around 12.8 million people) represents 32% of the national population, despite covering less than 0. 5% of the country's total territory (Gobierno de la Ciudad de Buenos Aires, 2010; INDEC, 2010). This delta is an area in constant transformation due to the confluence of metropolitan dynamics, natural processes, and climate variation.

This chapter analyses this area structured on the Layer Approach (De Hoog et al., 1998; McHarg, 1969; van Schaick & Klaasen, 2009) to tackle the complexity of the emerging metropolitan region related to the Delta. Firstly, the Lower Paraná Delta is analyzed regarding the area's natural characteristics (base layer or substratum layer), in order to understand the natural processes that take place in the region related to its landscape, geomorphology, ecological services, and climate change. Secondly, the networks and regional development (network layer) is described in relation to the metropolitan dynamics regarding the historical evolution of urbanization (occupation layer). These are examined within and outside the Delta at different scales, firstly those of regional economies, concentrating on the Metropolitan Area of Buenos Aires, followed by an analysis of the impact of these processes at the local scale. As the Paraná Delta's main characteristic is its heterogeneity, it is not possible to describe all the areas along its edges as *metropolitan*. On the contrary, this thesis identifies where the interactions between the metropolis and the Delta take place, and which are the cross-scale and cross-sectoral implications of these processes. Thirdly, an analysis of the "institutional context and governance" is carried on, introducing the fourth layer to the Layer Approach (new "governance" layer), which together with the three previous layers, make a complete description of the complexity of the Paraná Delta in all its dimensions.

FIGURE 4.1 Location of Paraná Delta.

This chapter first describes the Delta's specific case as a way to set the basis for the design of a planning method to link climate adaptation and urban development from an actor-oriented perspective to contribute to increasing the delta´s adaptability. For that purpose, as the method focuses on local areas, the municipalities of Tigre and San Fernando are mainly described.

§ 4.2 The Natural Delta (substratum or base layer)

§ 4.2.1 Landscape and geomorphology

The Paraná Delta is a key component of *La Plata Basin*, the second major catchment area of South America after the Amazon Basin, covering 3.1 million km^2 and spanning across Argentina, Brazil, Bolivia, Uruguay, and Paraguay (Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata, 2015). The basin drains to the Atlantic Ocean through the Paraná Delta and the Río de la Plata Estuary, a geological-hydrological sedimentary dynamic entity (Rinaldi, Abril, & Clariá, 2006, p. 134) located between the coasts of Argentina and Uruguay. It has a vital relevance for South America's hydrology and carries into the Atlantic Ocean more than 30% of the world's

FIGURE 4.2 Paraná Delta. Elaborated from Google Inc. (2018) Google Earth (Version 7.3.1.4507).

renewable fresh water, together with the Amazon and the Orinoco (Bates, Kundzewicz, Wu, & Palutikof, 2008) (Figure 4.1).

Within the system of La Plata Basin, the most important river is the Paraná, whose catchment area represents 50% of the entire basin, reaching around 1.51 million km^2 (Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata, 2015). The Paraná is a 2,570 km-long river which runs through Brazil, Paraguay, and Argentina (Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata, 2015). Its two initial tributaries are located in Brazil –Paranaíba and Grande Rivers-, but the most important ones are the Paraguay River, located in the homonymous country, and the Bermejo River, located in Argentina. Compared to other rivers, for example, the Paraná River has a similar flow than the Mississippi in spite of being half its length (Paraná´s medium discharge is approximately 18,000 m3/sec -Pittau, Sarubbi, & Menéndez, 2004- and Mississippi River's discharge is around 15,500 m3/sec -Campanella, 2014, p. 25-. Additionally, the Paraná is almost twice as long as the Rhine, but it has eight times its discharge and carries 16 times more sediment.[2]

2 The Rhine presents a length of 1,400 km and a discharge of 2,200 m^3/sec and carries 0. 07 Mt/year (Meyer et al., 2014, p. 43). The Paraná River carries 160 Mt/year (Sarubbi et al., 2006)

At the river mouth, the Paraná joins the Uruguay River forming the 250 km-long Río de la Plata, a wide estuary which presents a width from 50 up to 250 km (Barros, Camilloni, & Menendez, 2003b, p. 9) (Figure 4.2). The funnel-shaped transition between the Paraná River and the Río de la Plata is the Paraná Delta, one of the largest coastal wetland systems of Argentina. It is a plain spreading over three provinces -Buenos Aires, Santa Fe and Entre Ríos- (Secretaría de Ambiente y Desarrollo Sustentable de la Nación, 2008, p. 8). The area of the Delta Basin is approximately 22,587 km^2 while the extension of the Delta islands and the Pre-Delta is 17,400 km^2 (Malvarez, 1997; Secretaría de Ambiente y Desarrollo Sustentable de la Nación, 2008, p. 5). In contrast to other cases, the Paraná River is a complex model of estuarine delta (Parker & Marcolini, 1992, p. 248) as it does not discharge its sediments directly to the sea, but through the estuary of the Río de la Plata (Zagare et al., 2014b, p. 120). On the one hand, the classic definition of a delta is associated with the accumulation processes of sediments related in time and space to the river that transports them. On the other hand, the concept of an estuary regards freshwater-saltwater interface more than sedimentation processes. Within this complex estuarine delta system, a dynamic interaction takes place between both units, although they maintain their specific conditions.

Although from a geographic perspective the Delta was initially restricted to a terrestrial scope, from a geomorphologic point of view, it can be analyzed together with the estuary due to the interaction between the delta plain and its natural limit, the Río de la Plata (Cavallotto et al. , 2004; Parker & Marcolini, 1992, p. 243). Following the distinction of the components of deltas developed by Hori and Saito (2007) and according to the studies of Parker and Marcolini (1992), and Cavallotto and Violante (2005), it is possible to observe that the subaqueous part of the Paraná Delta overlaps with almost the entirety of Río de la Plata's river-bed. Thus implying n important influence of the sedimentary processes that form the Delta over the estuary and its coastline (Parker & Marcolini, 1992) (Figure 4.3). From a geological point of view, the edges of the Delta are ancient lands, while the Delta itself is a young territory, which has formed due to the accumulation of sediments coming from the Paraná's tributaries (mostly from the Bermejo River). These sediments are transported by the Paraná River and deposited on the coasts under the influence of the currents of the Uruguay River.

As the sediment transportation rate of the Paraná River is high, the area has been known for its rapid territorial growth over the years, especially on the Delta Front. The Paraná Delta carries around 160 Mt/year; 28% of this amount is composed of clay, 56% by mud and 16% by sand. These sediments shape the landscape and give the Delta a changing quality: The sand that is deposited on the river mouth increases the length of the Delta, while the mud contributes to its incrementing size through the emergence of banks that become islands (Pittau et al., 2004). In fact, during the period from 1900-2010, the delta has increased its area by around 260 km^2 at a rate of approximatelly 2.37 km^2/year

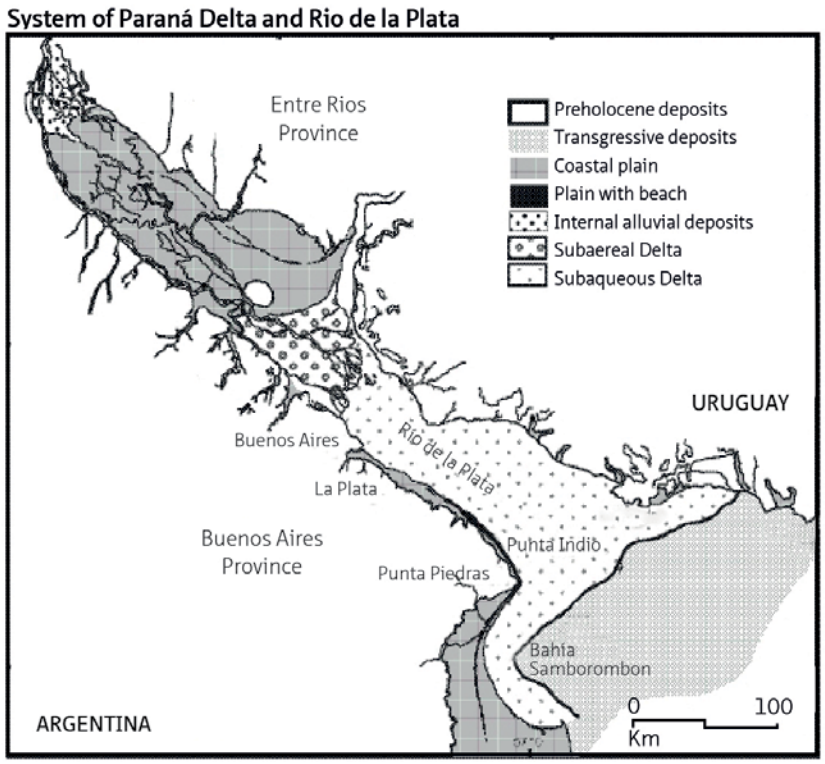

FIGURE 4.3 Subaerial and subaqueous delta. Reprinted from Cavallotto (2002, p. 377).

(Codignotto & Medina, 2011, p. 72). Despite the slight decrease in its growth rate during the latest decades, the Delta Front is expected to advance and reach Buenos Aires' coasts in about 110 years (Sarubbi, 2007) (Figure 4.4). This physical transformation will change the entire territory and alter relationships between the cities and their existing coasts with the river due to the potential generation of a new waterfront.

The subaerial delta starts in the Municipality of Diamante, located in Entre Ríos, and extends towards the South for 320 km. It presents a variable width from 18 km to 100 km (Pittau et al. , 2004; Secretaría de Ambiente y Desarrollo Sustentable de la Nación, 2008) and is divided into three main areas: The Upper Delta (from Diamante to Villa Constitución in Santa Fe), Middle Delta (From Villa Constitución to Ibicuy) and Lower Delta (from Ibicuy to the Río de la Plata). While in the Upper and Middle sections of the Delta the hydrology is based on the pulses of floods and droughts caused by the variability of the river and its tributaries' streamflow, on the Lower Delta it is also influenced by tides and the meteorological phenomenon known as *Sudestada*. This phenomenon consists of persistent south-eastern winds coming from the Atlantic Ocean (Barros et al. , 2003b). Consequently, the risk in this area is associated with the

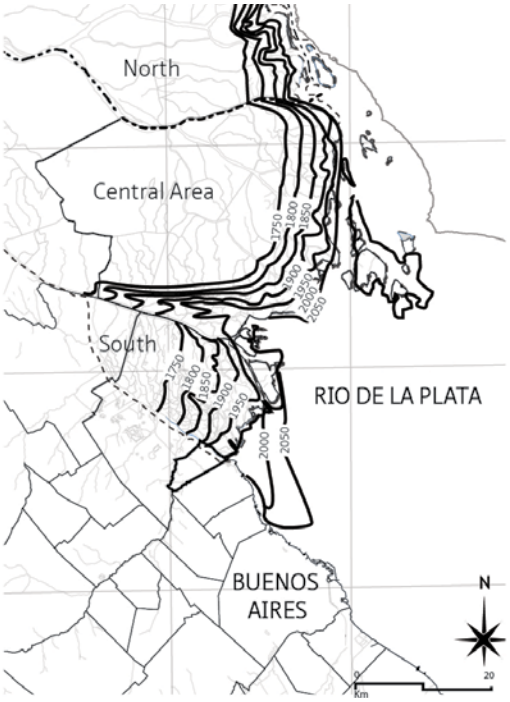

FIGURE 4.4 Advance of delta front. Reprinted from Zagare (2014, p. 215).

rise of the level of the Río de la Plata related in part to Sea Level Rise but mostly, by the action of the winds, which drag water into or out of the estuary altering the level of the river. These factors, combined with the increase in frequency and intensity of extreme hydrological events related to the *El Niño Southern Oscillation (ENSO*), block the natural and artificial drainage of the rivers and the cities respectively, generating important floods along the coasts and in the surrounding watercourses.

Regarding landscape units, the Paraná Delta is a kaleidoscope of patterns (Malvarez 2007). At least ten landscape units can be distinguished, according to studies by Malvarez (2007), Kandus et al. (2006), and Quintana & Bo (2011). From woods, prairies and lagoons in the Upper Delta, to savannahs and meanders in the Middle area and the scrublands and woods on the islands of the Lower Delta, all the environmental landscape units are related to the Delta's stage of evolution and to the hydrological regimes that influence them (Figure 4.5).

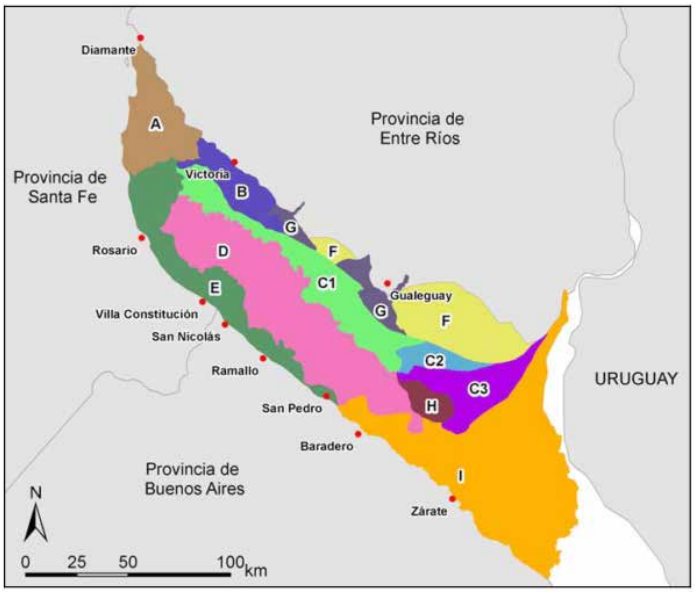

FIGURE 4.5 Landscape Units. Reprinted from Novillo (2011, p. 40).

§ 4.2.2 Ecosystem functions and services

The Paraná Delta, which is part of the wetlands system of the Paraná-Paraguay fluvial corridor, is the country's largest wetland making it vital to the area's hydrology, natural resources, and economic development. Just like other wetlands, it provides a number of ecosystem functions that ensure a high quality of life for local people and surrounding inhabitants (Kandus, Morandeira, & Schivo, 2010, pp. 7–8; Oddi & Kandus, 2011). Within the first group of functions, related to hydrologic regulation, worth mentioning are streamflow deceleration and regulation, reduction of water turbulence, sediment stabilization and retention, short and long-term water storage, groundwater replenishment[3] and the regulation of evapotranspiration processes. These functions lead to eco-systemic goods and services such as the control of sediments, erosion, and floods (Kandus et al. , 2010, p. 7; Oddi & Kandus, 2011, p. 138).

3 Under La Plata basin there are important underground reserves of fresh water for agricultural, industrial and domestic uses, such as the Puelches, Pampeano, Paraná, or the Guarani aquifers. The last one, spreads over 1. 2 million km2 through Brazil, Uruguay, Paraguay and Argentina storing approximately 40,000 km^3 of water (Programa de las Naciones Unidas para el Medio Ambiente (PNUMA), 2003, p. 88).

EFECTOS SECUNDARIOS DEL CAMBIO CLIMÁTICO		EFECTOS TERCIARIOS DEL CAMBIO CLIMÁTICO
Aumento de temperatura.	Cambio en las tasas de evaporación. Sequías.	Combinación de altas temperaturas con períodos de sequías, posibilidad de incendios. Incremento del efecto UHI (Urban Heat Islands). Colapso de infraestructura. Problemas de suministro de energía
Aumento de precipitaciones. Aumento de variabilidad climática.	Variabilidad de descarga de los ríos. Descargas extraordinarias. Mayor recurrencia de eventos hidrológicos extremos.	Pulsos de inundaciones y sequías. Impactos sobre las actividades económicas y la sociedad.
Aumento del nivel e Río de la Plata. Aumento del nivel del mar.	Inundaciones de las áreas costeras. Erosión costera.	Bloqueo de los drenajes naturales y artificiales (de los cursos naturales y del desague urbano). Colapso de infraestructura de protección y drenaje. Inundaciones de las zonas costeras urbanizadas y aumento de la vulnerabilidad de los terrenos ocupados. Impacto sobre las actividades económicas.
Aumento de recurrencia de Sudestadas.	Salinización. Aumento del nivel de las aguas.	Sobreprotección. Construcción de diques privados, incremento de la vulnerabilidad de las áreas intersticiales. Incremento de la vulnerabilidad social. Reducción de la calidad del agua subterránea.

FIGURE 4.6 Effects of climate change. Elaborated from Zagare & Sepulveda Carmona (2016) and Harkin (2008).

Within the second group of functions, related to biogeochemical regulation processes, it is possible to highlight retention and nutrient storage and transportation and exportation of carbon dioxide and methane. The consequent goods and services are, among others, the increase of water quality and freshwater availability and the maintenance of system productivity. The third group of eco-systemic functions is related to Ecology and Biodiversity, such as primary, secondary and tertiary production, habitat provision and support of biological interactions. This group leads to the production of food, fuel, construction materials, and energy (among other elements). It provides habitat for different uses such as forestry, livestock, apiculture, fishing, etc. , maintenance of biological corridors and support for artistic, cultural, and social activities (Galafassi, 2011; Kandus et al. , 2010, p. 7; Oddi & Kandus, 2011, p. 138).

§ 4.2.3 Climate Change

As Harkin (2008, p. 4) points out, changes in atmospheric composition caused by increased greenhouse gas emissions are one of the primary impacts of climate change; secondary impacts are alterations in temperature, evaporation rates, precipitation, and changes in other climate variables. The third group of effects, known as tertiary or flow-on impacts, are a direct result of primary and secondary impacts and are related to the vulnerability that societies, the natural landscape, and the built environment have to droughts, floods, fires, and other adverse effects. This thesis addresses the secondary and tertiary impacts of climate change on the Paraná Delta based on regional and local

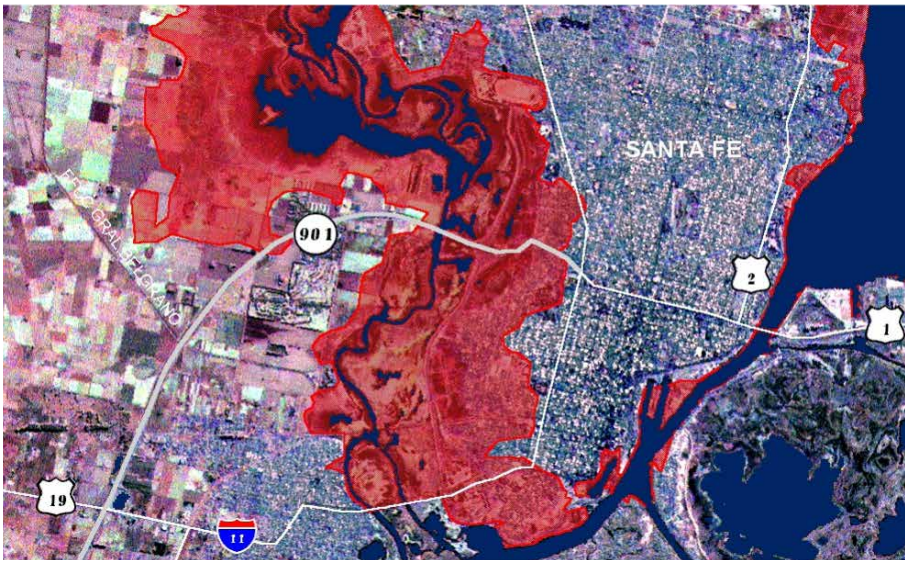

FIGURE 4.7 Floods in Santa Fe. (Comisión Nacional de Actividades Espaciales, 2006).

climate projections developed by international and national research institutions for the area (Figure 4.6).

Some of the impacts of climate change observed in the area are; (a) variations in the Paraná River discharge and sediment load caused by fluctuations in the upper Paraná Basin, which will affect the advancement rate of the Delta Front; (b) changes in the Paraná River hydrological regime (also linked to the upper basin) that might alter the frequency of extraordinary floods having strong implications for the evolution of the Delta morphology and its surrounding cities; and (c) temperature increases that may lead to variations in local water balances, affecting different land uses (Zagare et al. , 2014a, p. 111). As an example, changes in precipitation and the displacement of isohyets are a cause of the expansion of agriculture and livestock production into increasingly marginal lands, accelerating land use changes with high biodiversity alteration (Barros & Bejarán, 2005, p. 11).

According to the Intergovernmental Panel on Climate Change, temperatures are expected to increase from 0. 4°C to 1.8°C in the next five years and up to 7.5°C in the next 80 years (Magrin et al. , 2007, p. 593). For the last 40 years together with global warming, there has been an increase in precipitation, which has given place to simultaneous trends in river streamflow. It is estimated that for every percentage point of change in precipitation there is a 2% change in river streamflow (Berbery, Doyle, & Barros, 2006). In the middle and upper sections of the Paraná Delta, the effects of streamflow variability are associated with more extended periods of droughts and

FIGURE 4.8 Floods in Tigre. (Diario El Día, 11/04/2014).

FIGURE 4.9 Floods in Tigre. (Diario El Día, 11/04/2014 and Clarín Digital, 25/03/2016).

floods, (Zagare et al. , 2014a). These prolonged episodes significantly affect cities causing ignificant catastrophes such as the 2003 flood in Santa Fe (Figure 4.7).

On the contrary, the main influences on the Lower Delta are the Río de la Plata and the discharge of the Paraná and Uruguay rivers in addition to the climatic events that take place in this estuary, such as the already mentioned South-Eastern winds or *Sudestadas*. Regional trends show an increase in precipitation levels for the Upper and Middle Delta, increasing river streamflow and extreme hydrological events, which affect the watercourses of the surrounding areas. However, these increases do not affect the level of the Río de la Plata in a significant way (Barros et al. , 2006, 2003b). It is instead influenced by Sea Level Rise and is mostly affected by the winds that take water in and out of the estuary. In fact, according to Barros et al. (2006, p. 7) the hydrodynamic model simulations developed by the National Center for Environmental Prediction/ National Center for Atmospheric Research (NCEP/ NCAR) show that 5 of the 13 cm in the rise of water levels occurred in the Port of Buenos Aires during the 20th century due to changes in the direction and intensity of winds. Consequently, the increase of the average water level at the Río de la Plata is expected to affect the low lands of the coast of Buenos Aires province (Re & Menendez, 2006) by increasing the vulnerability to floods when combined with *Sudestadas*. Such increase in water level jeopardizes the buffer condition of the Paraná Delta and the coastal cities draining capacity, in a context of low state presence in regional planning and poor adaptive capacity (Figures 4.8 and 4.9).

In other words, the increase in temperatures and precipitation and the recurrent extreme hydrological events caused by Sudestadas are related to the combination of three processes; (a) The El Niño Southern Oscillation (ENSO) cycle[4]; (b) the increase in temperature of the Antarctica; and (c) the displacement of the South Atlantic anticyclone, caused by the increase in greenhouse gas emissions concentrations which is linked to global climate change (Barros & Bejarán, 2005, p. 11).

Furthermore, numerous studies have demonstrated that strong anthropogenic interventions have accelerated the natural dynamic of the Delta generating severe environmental impacts that are exacerbated by the adverse effects of climate change, for example, the lethal combination of drought and high temperatures with farmer's traditional practice of biomass burning to increase their production. Although this practice may present advantages related to the stimulation of new vegetation species, nutrient recycling and the liberation of seeds for new germination, it also presents negative externalities such as soil degradation and erosion, changes in vegetation structure, loss

4 The ENSO is a phenomenon that takes place in the Tropical Eastern Pacific Ocean and is characterised by a change in temperature and pressure of surface water.

FIGURE 4.10 Fires in the Paraná Delta affecting its surroundings. Source: Aqua/MODIS 2008/109 17:50 UTC Fires and smoke in Argentina.

of animal biodiversity, etc. (Kandus et al. , 2009). Thus, they are able to start disasters like in 2008, when uncontrollable fires became responsible for burning 12% of the wetland and for spreading ashes up to 250 km away also causing troubles in the urban cores of the cities along the Delta even reaching Buenos Aires (Zagare, 2016c) (Figure 4.10).

§ 4.3 Networks and Regional Development (network layer)

"The political-institutional framework in Argentina has varied over time. It is good to remember that Argentina is not born with the May Revolution, nor with the Declaration of Independence, but responds to a slow process of formation and consolidation of the human with its geographical environment, and with its circumstances".

(Colomé & Gumierato 2009, p. 53)

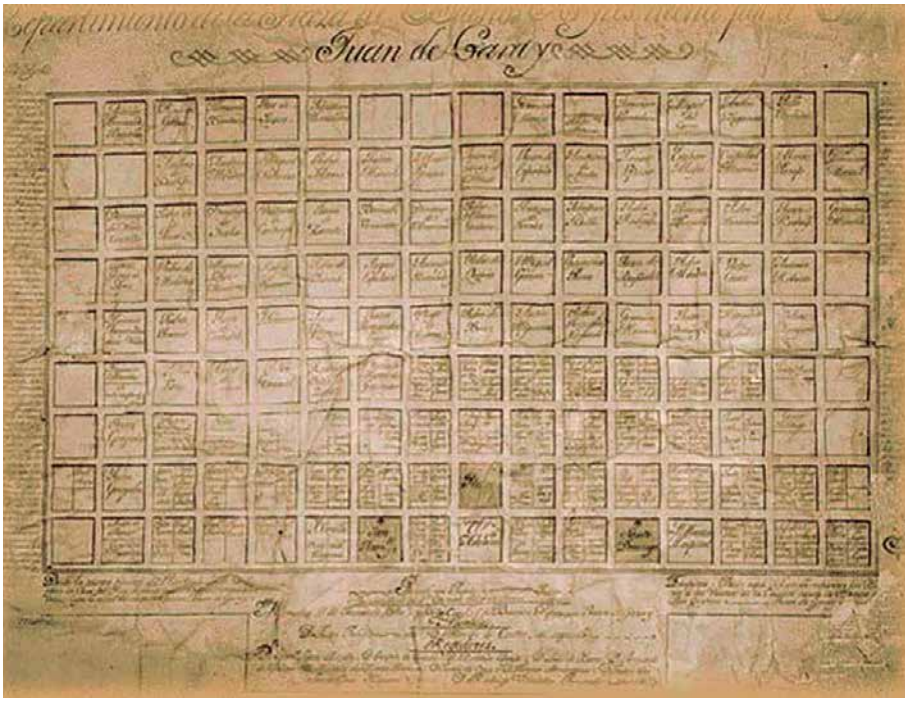

FIGURE 4.11 Foundational map of the city of Buenos Aires, 1583. Digital Archive, Universidad Nacional de Rosario, Facultad de Arquitectura, Planeamiento y Diseño

The region of the Paraná Delta has been the scene of many political and institutional transformations that marked the history of the country. Since the 16th century, the Spanish crown started a process of founding cities along the territory consolidating the Provinces that later formed the "Viceroyalty of Río de la Plata". The most prominent city by that time was Buenos Aires, which had been settled twice, first in 1536 and then re-founded in 1580 by the banks of Río de la Plata (Figure 4.11). During the Hispanic period, the most developed areas regarding agriculture were the North-Eastern and Cuyo regions, followed by the cities of Buenos Aires and Santa Fe that run along the corridor of the Río de la Plata-Paraná River. The North-Eastern and Cuyo regions were much more profitable than the areas of Buenos Aires and Santa Fe regarding agricultural development due to the possibility of watering the plots through canals and of having a workforce constituted by aborigines. Their proximity to Potosí also helped as it was one of the most populated cities of that time, located in Bolivia (Colomé & Gumierato, 2009, p. 55). While Buenos Aires and Santa Fe experienced other advantages related to their location near the fluvial corridors. By the year 1797, Buenos Aires and its surroundings had a population of approximately 72,168 inhabitants, while Santa Fe and Entre Ríos had around 11,292 and 11,600 inhabitants respectively (Comisión Directiva, 1895, p. xv).

After the "May Revolution" (1810) the provinces started an independence process from Spanish domination, which was formally declared in 1816, leading to new rules and conflicts in a context of free trade. In fact, during the 1820s, relevant changes took place in Argentina's social and political structure and its primary economic resources originated from the ports. With the port of Buenos Aires being the largest in Argentina, receiving ships coming from Denmark, England, Spain, and the United States among other countries (Hardoy & Gutman, 2007, p. 61). After the Battle of Caseros (1852), a new National Organization process began, and the Constitution of the Argentine Confederation was signed in 1853. At first, all of the provinces agreed to that Constitution, except for Buenos Aires, which joined the Confederation in 1862, after several years of conflict (Colomé & Gumierato, 2009).

Free trade, together with the condition of fertile soil, led to the establishment of agricultural colonies in the areas of Santa Fe, Entre Ríos and Córdoba, and to a consequent immigration process of people mainly coming from the countries of Switzerland, Germany, Italy, England and Spain (Colomé & Gumierato, 2009, p. 54). It is important to highlight that the first agricultural and livestock colony, San Pedro, was settled on the banks of the Paraná River in 1825. By 1860, the estimated population of Buenos Aires reached 330,000 inhabitants. Santa Fe, Entre Ríos and Corrientes had 43,000; 82,000 and 86,000 inhabitants respectively and Córdoba had 140,000 inhabitants (Comisión Directiva, 1895, p. xvi).

During the period from 1880-1914 after the consolidation of Buenos Aires as the capital of the Nation, and until the beginning of World War I, the country's GDP (Gross Domestic Product) grew at a rate of 5% per year. A subsequent expansion of areas planted with wheat, maize, and flax took place, going from around 100,000 hectares in 1872 to over 12 million hectares in 1920 and with production reaching approximately 13.5 million tons (Colomé & Gumierato, 2009). Together with the increase in agricultural lands, the percentage of the urban population also increased from 34.6% in 1869 to 42.8% by 1895 (Comision Directiva, 1895, p.xxiv).

The chain of commerce derived from grain production evolved into an agro-export model articulated with the British Empire. David Ricardo (1817) an economist and founder of the theory of comparative advantage encouraged the international division of labor which suggests that through rationally founded specialization, international trade would provide an equal supply for all nations. In concordance with these theories, England focused on industrial activity and Argentina was in the international market as an exporter of raw materials after 20 years of supplying domestic consumption (De Marco, 2008; Zagare, 2007, p. 33). The wholesaler firms, dedicated to exportation, settled mainly in Rosario (Located in the Upper Paraná Delta.), and also in Buenos Aires, Santa Fe, and Bahía Blanca. Consequently, the Argentinean transportation

FIGURE 4.12 Buenos Aires in 1903 (Archivo General de la Nación).

system concentrated in port areas, helping to establish them as the country's principal engine of economic development until the first half of the 20th Century (Basadonna 2002, p. 256). The railway system was established towards the port of Buenos Aires and Rosario, which was the first transport mode in the interior of the country (Hardoy & Gutman 2007, p. 114) integrating Argentinean provinces within the network and connecting their capitals with the fluvial system. It extended from 9 km in 1857 up to 43,000 km in 1943 and the system was electrified in 1916 (Colomé & Gumierato, 2009; Salvatori, Salvatori, & Schmidt, 2002). This network contributed to the development of settlements across the country, constituting regional economies that could access both internal markets and international trade through connections with the ports.

Buenos Aires transformed from a village to the "Paris of South America" (Hardoy & Gutman, 2007, pp. 120–136) incorporating new buildings and other public works in the city core (Figure 4.12). Nevertheless, the international crisis of 1929 suddenly affected this growth, together with the beginning of a period of several coups d'état alternating with constitutional governments. Following a nationalist tide, most of the service companies were taken into public ownership, and the State assumed several functions such as security, health, social and cultural assistance, among others; While public, social and administrative power concentrated even more in Buenos Aires (Basadonna,

FIGURE 4.13 Emergency villas in Buenos Aires, 1930 (Pascual, 2013).

2002, pp. 261–262). By then, the protectionist economic model of Industrialization by Import Substitution (ISI) was applied in Argentina (as in many other Latin American countries), encouraged by the economist Raul Prebisch, who was head of the United Nations (UN) Economic Commission for Latin America (ECLAC). This model consisted of the development of national industry to fulfill internal demand. It increased the demand for a greater workforce, spurring migration towards urban centers, especially to Rosario and Buenos Aires, which reached a population of 529,801 and 2,982,580 inhabitants by 1947, having increased their population by around 20% in 30 years. The migration from the provinces towards the city cores led to the rise, in the case of Buenos Aires, of "emergency villas", which are basically the non-organized and informal occupation of private or public empty plots in urban areas (Cravino, del Rio, & Duarte, 2009, p. 2; Grahl, 2009, p. 4) (Figure 4.13). The first emergency villa created in Buenos Aires was in 1932, and this typology grew over time forming an irregular pattern of occupation in intermittent areas of the city, first near the port and then in other areas. The suburbanization process started in the 1940s (Hardoy & Gutman, 2007, p. 220; Zagare, 2007, 2014a) and had different characteristics according to political and socio-economic contexts that will be discussed later when describing the historical occupation of the metropolitan area in relation to the Lower Delta.

Until the 1970s, development focused on strengthening mainly chemistry, steel and automotive industries, the latter to the detriment of the railway and fluvial transport systems. While the State's inefficient management of transport companies contributed

to the decline of both railway and fluvial systems (Basadonna, 2002). By this time, a specialization process had begun: Rosario, Santa Fe, Diamante, and San Lorenzo specialized in grains. Villa Constitución and San Nicolás specialized in minerals and industrial products, while other ports completely stopped operating commercial loads[5], prompting the depression of some productive sectors (Basadonna, 2002, pp. 262–263). The massive production of oleaginous, competitive prices and the increasing demand of international markets led to a process of industrialization mainly of soy, which produced an increase of cultivable areas. These areas were mainly located in the center and south of the Santa Fe province, north of Buenos Aires province, east of Córdoba and the area now called Rosafé; The influential area of the cities of Rosario and Santa Fe). This cultivable area then extended the frontiers along the north-west and south-west areas of the country. In the face of an ineffective state-managed port system, the private companies started operating through their own terminals, mainly placed along the Paraná River.

In 1983, the rebuilding of the political structure with the arrival of democratic government produced transformations in the agricultural and livestock, industrial and services sectors. The number of exports from the areas of Rosario, San Lorenzo, San Martín, Arroyo Seco, and Alvear also reached new heights. From 25 million/ton/year exported in the 1970s, the country exported 39 million/ton/year in the 1980s, with Rosario contributing 30% to this amount in the latter decade (Basadonna, 2002, p. 264). Nevertheless, during the rest of the 1980s, the decline in manufacturing products together with industrial investment led to the formation of strong economic groups, weakening small and medium-sized companies (Hardoy & Gutman, 2007, p. 221). The economic recession and the increase of the external debt brought the country to a crisis, as well as many other Latin American countries, which were going through similar political and economic contexts.

In 1989, the reform package known as the Washington Consensus which consisted of a set of 10 recommendations for developing countries to face the crisis (Williamson, 1990) marked the transition of the Argentinean economy towards a Neoliberal model. Open markets, privatization, deregulation, globalization, and free trade and services were, among others, the main characteristics of the 1990s. Despite apparent rapid economic growth encouraged by robust Foreign Direct Investment directed to public and private urban development, the social inequities within cities and their surroundings increased, because of the different effects of this economic system on the different sectors of the population. In 2001, a significant economic and political

5 That is the case of the ports of Ibicuy, Gualeguay, Paraná, La Paz, Goya, Corrientes, Formosa, Reconquista, Barranqueras, among others (Basadonna, 2002).

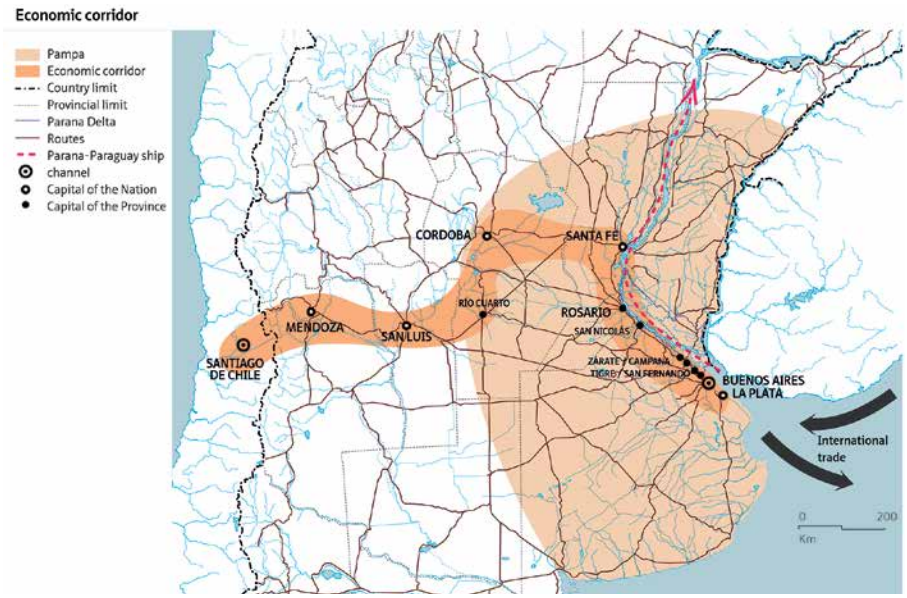

FIGURE 4.14 Economic corridor. Adapted from (Zuidwijk, 2016).

crisis took place and was stabilized in 2003, when the economy started to grow again regarding the increase of international prices for agricultural products and the growth of services and construction sectors (Hardoy & Gutman, 2007, pp. 270–271).

Up until the present, within an atmosphere of profound economic fluctuation, one of the most relevant challenges for cities are to decrease growing poverty, reduce social inequities, and generate a profitable system in which each city and port can grow in terms of social, urban and economic development maintaining their specificities but integrating a regional network of interactions.

The fluvial system of Río de la Plata and Paraná River

At present, the Río de la Plata-Paraná River port system is still the most significant fluvial network of the country. As the Río de la Plata is shallow, it needs the development of significant infrastructure to be navigable, such as a system of canals that reach up to 30 feet (9.1 meters) (Subsecretaría de Puertos y Vías Navegables. Dirección Nacional de Vías Navegables. , 2016). The canals that go through the Paraná Delta present a reasonable depth of 32 feet (9.75 meters) from the river mouth up to San Lorenzo/San Martin ports, and 22 feet (6.7 meters) from there to Santa Fe (Basadonna, 2002, p. 265), meaning that they are prepared to receive large ships. The ports of the Paraná's coasts also have several advantages such as their large extension

which allows them to be expanded in the future and the strategic location that makes them useful for the activities developed in each area of the Delta (production, industry, etc.), linking them nationally and internationally.

Moreover, the navigable system of La Plata Basin and especially the Río de la Plata-Paraná corridor are considered highly relevant to the economic development of the South American Continent (Figure 4.14). Within this system, the Paraná-Paraguay waterway constitutes a 3,302 km-navigable corridor which connects Argentina, Bolivia, Brazil, Paraguay and Uruguay, providing the major artery of communication and efficient fluvial transport for these countries (Moiraghi de Perez, 2010). This initiative was held by the Intergovernmental Committee for the Coordination of the La Plata Basin (CIC), to contribute to the physical and economic development of the countries in the region through the improvement of a transport system according to the present commercial requirements.

Although the consolidation of this waterway consists mainly of the development of a continuous channel along the rivers from the Nueva Palmira port in Uruguay to Caceres Port in Brazil (Salvatori et al. , 2002, p. 407), high sedimentation rates, exorbitant costs of dredging and the lack of maintenance and upgrading of the ports makes it a not so easily achievable feat. Furthermore, a consolidated waterway plays a vital role within the regional economy of the Common Market of the South (Mercosur[6]), initially established in 1991 between the countries of Argentina, Brazil, Paraguay and Uruguay and was then broaden with the inclusion of Venezuela in 2012[7]. Within this system, the metropolises of São Paulo and Buenos Aires play a significant role, establishing a commercial network along with Santiago de Chile, which is part of The Pacific Alliance, an integration initiative formed by Chile, Mexico, Peru and Colombia.

§ 4.4 The historical evolution of urbanization in the Lower Paraná Delta and its surroundings (occupation layer)

There is a network of cities with different scales of importance as well as diverse specializations along the waterfront of the Paraná Delta, recognized within the

6 Mercado Comun del Sur.

7 At present, Bolivia is also in the process of inclusion.

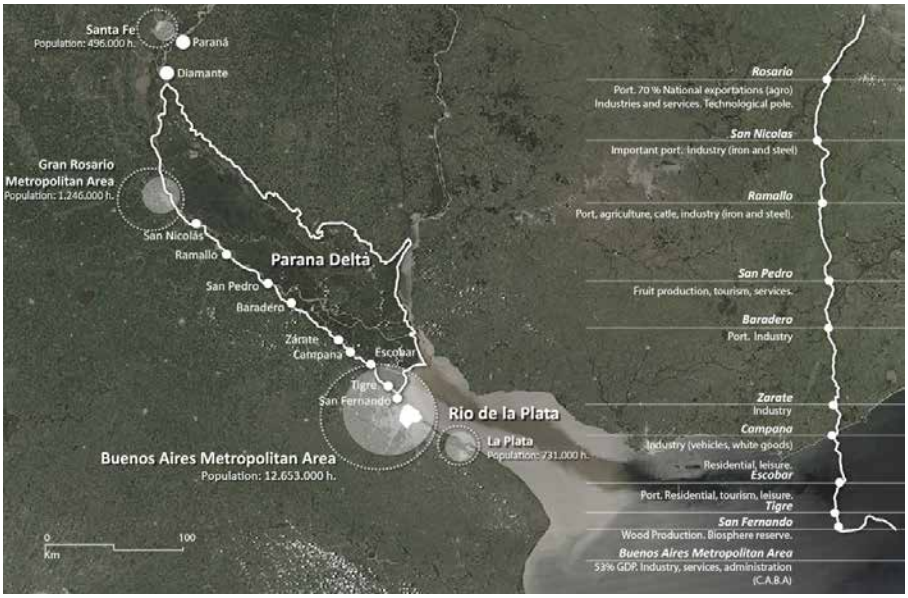

FIGURE 4.15 Paraná Delta's economic corridor. Cities and their economic specializations.

emerging metropolitan system (Figures 4.15 and 4.16). From ports to industrial nodes or recreation and cultural centers, all these cities impact the Delta in different ways even those that are not situated strictly on it, but near its coasts. At a metropolitan level, four urban agglomerations can be distinguished: Buenos Aires Metropolitan Area – the largest conurbation of the country, with a population of around 13 million inhabitants; Gran Rosario Metropolitan Area – the third largest urbanized area in the country, with more than 1.2 million inhabitants; La Plata city – capital of the Province of Buenos Aires, with a population of 700 thousand inhabitants; and Santa Fe – capital of the homonymous Province, with almost 500 thousand inhabitants. Although La Plata and some areas of the Metropolitan Area of Buenos Aires are not located on the Delta but on the coasts of the Río de la Plata, they represent a significant impact on the area at a regional scale, also impacting smaller cities.

The Lower Paraná Delta is influenced by the urban development of the Metropolitan Area of Buenos Aires, which exerts political pressure because of its size, its level of productivity and its elevated growing rate. The Metropolitan Area of Buenos Aires is home to 31% of the Argentine population and provides 53% of its GDP, but covers less the 0. 15% of the country's total area (Gobierno de la Ciudad de Buenos Aires, 2010). It is formed by the City of Buenos Aires, (which covers an area of approximately 200 km^2 and has around 3,000,000 inhabitants -INDEC, 2010-) and 24 Municipalities of the

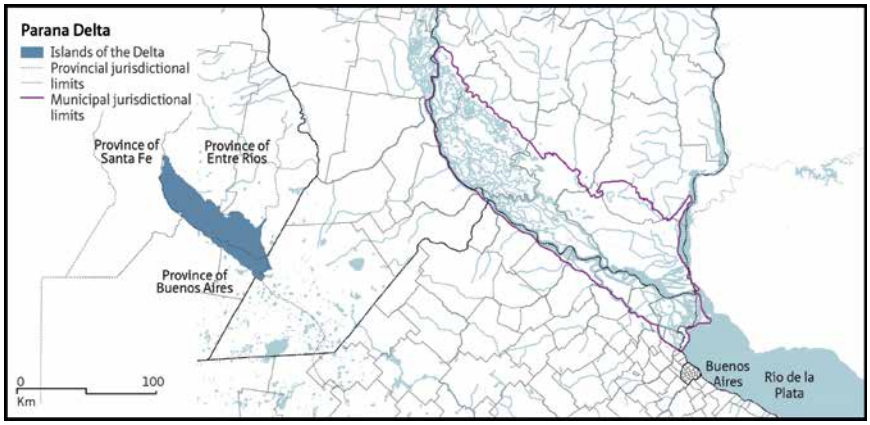

FIGURE 4.16 Municipalities of the Paraná Delta.

first and second crown around the city of Buenos Aires[8]. The Metropolitan Area covers an area of approximately 2,900 km^2 and has 9,100,000 inhabitants (Ciccolella, 2002, p. 5). The Municipalities of Tigre and San Fernando are situated on the Delta Front and have the domain of the islands while San Isidro and Vicente Lopez are located between the Delta and the city of Buenos Aires and do not have islands.

Currently, in a context of the continuous expansion of metropolitan dynamics, the Metropolitan Region of Buenos Aires is also distinguished, including the third crown of 15 municipalities, which covers 11,000 km^2 and has approximately 1,600,000 inhabitants[9]. Within these districts, Escobar, Zárate, and Campana are part of the Delta; the last two are a node for industrial activities that have a terrestrial connection with the province of Entre Ríos in Argentina, and to Uruguay, through a route that transversally crosses the islands of the Delta.

The paths of urbanization

The process of social construction in the Delta and its surroundings regarded the relation among certain variables such as the interactions between the terrestrial and aquatic

8 Almirante Brown, Avellaneda, Berazategui, Esteban Echeverría, Ezeiza, Florencio Varela, General San Martín, Hurlingham, Ituzaingó, José C. Paz, La Matanza, Lanús, Lomas de Zamora, Malvinas Argentinas, Merlo, Moreno, Morón, Quilmes, San Isidro, San Fernando, Tigre, San Miguel, 3 de Febrero and Vicente Lopez (Figure 4.17).

9 It includes the municipalities of Beriso, Brandsen, Campana, Cañuelas, Ensenada, Escobar, Exaltación de la Cruz, Gral. Las Heras, Gral. Rodriguez, La Plata, Luján, Marcos Paz, Pilar, San Vicente and Zárate -Figure 4. 16- (INDEC, 2010).

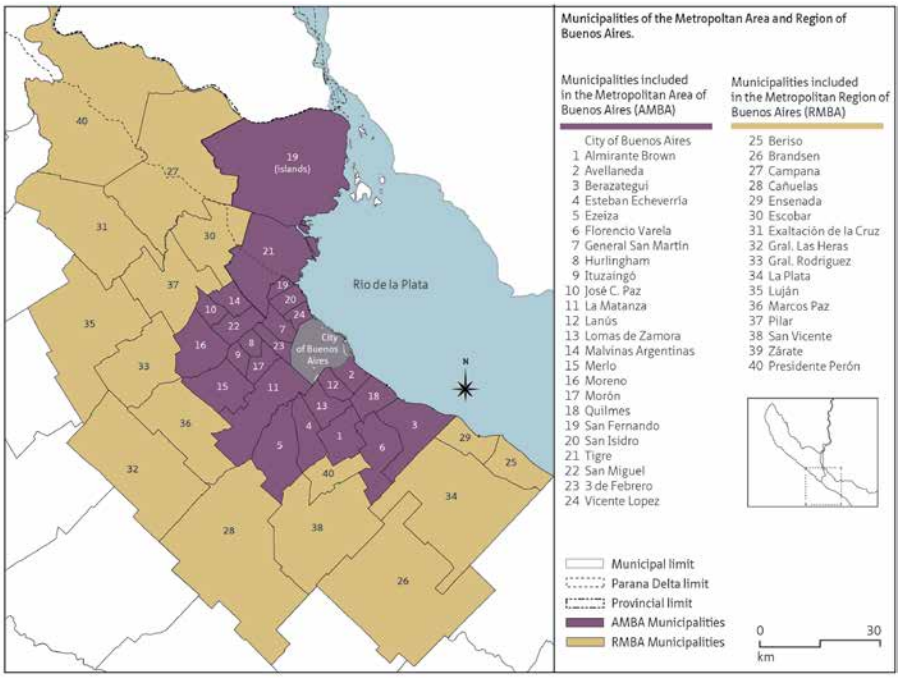

FIGURE 4.17 Metropolitan Area and Region of Buenos Aires.

environments, the proximity to the Metropolitan Area of Buenos Aires, the strong processes of migration both from the provinces and Europe, the marginal price of the lands despite their high productivity and the production related to the exploitation of natural resources of the area (Galafassi, 2011). Some of the issues regarding the historical development of the Delta in terms of a regional perspective have been previously addressed, so now it is time to focus on the historical process of the occupation of the Lower Delta regarding metropolitan dynamics related to the Metropolitan Area of Buenos Aires.

Before Spanish colonization, an aboriginal community called the *Guaranies* inhabited the Lower Delta. Then, the lands were occupied by foreign travelers, Spanish and *criollos*, a term used to name the people born in America of European descent, to perform a direct extraction of natural resources mainly focused on cultivating fruits and logging (Galafassi, 1996, 2011; Sierra, 1967). The settlements were unplanned, disperse and precarious, and access to the lands was difficult because of the lack of infrastructure. The State did not regulate the possession and distribution of the plots of the Delta, and at first, the lands were considered to be a *non-productive natural beauty* (Zagare, 2014a, p. 219, 2016c, p. 5). It was not until the end of the 19th century that the lands of the Lower Delta could be measured and distributed. In 1856, a decree granted land to the Municipalities of Tigre (called initially 'Las Conchas'), San Fernando and others to exploit and cultivate

it. Then in 1888, Provincial Law No. 2072 was enacted to achieve the measurement and distribution of the plots (Gobierno de la Provincia de Buenos Aires, 1888).

This law gave priority of sale to the occupants who had already established their houses on the islands and had cultivated them. According to Galafassi (1996, p. 6), during the 45 years while this law was valid, 55% of the islands were transferred to the private domain. In 1937, another law also encouraged the sale of plots with access to navigable waterways in an attempt to increase the area's production (Gobierno de la Provincia de Buenos Aires, 1934).

The political context and the legal tools encouraged the population of the islands and the development of plantations, mainly destined for the internal market within the area of Buenos Aires. Even though some of the crops were foreign and altered the autochthonous species, the cultivation processes carried out by the farmers were concordant to the floods and droughts cycles that characterize the delta and also took into account the water and the sediment accumulation levels (Galafassi, 1996, p. 7). By that time the productive system of the islands was based on small-scale units of production (Family Economy) focused on fruits, vegetables,. and forestry. The population, especially the first and second sections of the islands in the Delta of the province of Buenos Aires (Tigre and San Fernando) continued growing until the 1930s, reaching 25,000 inhabitants (Galafassi, 1996, p. 8). During the following decade, the highest fruit production in the country took place in this area. However, after that, the country implemented the Industrialization by Import Substitution (ISI) economic model and the area started losing its competitiveness due to the development of other regions in the interior of the country; the productivity loss was then followed by a changing demographic composition. This industrialization produced a radical impact on the productive system of the Lower Delta, which consisted of an increase in the size of production units, and on a shift in production towards forestry. This transition implied new actors, new technologies and different working processes. Among the new stakeholders involved in the Delta were large companies or wealthy entrepreneurs that bought plots from past owners, who migrated to the continent to find new opportunities (Galafassi, 1996).

Meanwhile, Buenos Aires, which had started a rapid expansion as a metropolis in the mid-19th century, was facing a crisis of its agro-export economy in the 1930s, yet managed to maintain and even increase its primary role in the countries' economy (Torres, 1993, p. 5). The vigorous industrialization process that followed the fall of the agro-export model that took place in the 1940s encouraged suburbanization through the development of new centralities relatively close to the city center, which continued growing for the next thirty years. Those areas, usually located 5 to 20 kilometers away from the city of Buenos Aires, offered commercial spaces, banks, medical, and educational services among others (Ciccolella, 2002, p. 9). The first and second crown of the Metropolitan Area of Buenos

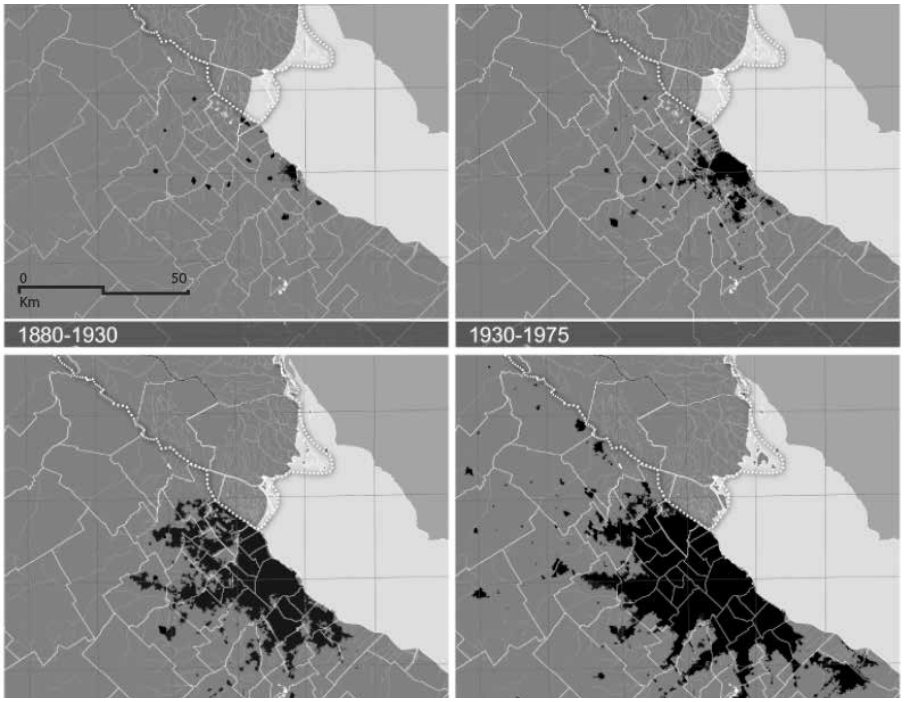

FIGURE 4.18 Expansion of the Metropolitan Area of Buenos Aires.

Aires was beginning to take shape due to the nearby location of its industrial facilities[10]. The contemporary construction of the *Acceso Norte* highway led to the consolidation of an industrial corridor along it. This corridor integrated with the Industrial and Fluvial Axis that runs along the Paraná River and Río de la Plata from the Metropolitan Area of Rosario going through Buenos Aires and reached the city of La Plata (Ciccolella, 2002, p. 9; Galafassi, 1996, p. 9; Hardoy & Gutman, 2007, p. 226). Unfortunately, with the notable increase of population along the Industrial and Fluvial Axis, the islands of the Delta experienced a significant population loss being so close to and linked with the fluctuant processes of wealth and economic crisis in Buenos Aires (Figure 4.18).

In the last quarter of the 20th century, the metropolitan expansion of Buenos Aires was characterized by an urban growth model of *spatial dispersion and global integration* (Ciccolella, Mignaqui, & Szajnberg, 2006, p. 2) which led to social, economic and urban restructuring. That process exacerbated during the 1990s, when the implementation of

10 By 1963, 85% of the industrial developments of more than 25 workers were located within a radius of 20 km from the city of Buenos Aires, and only five industries were located 30 km away from it (Hardoy & Gutman 2007, p. 226).

the liberal economic model led to the expansion of new centralities along the third crown of the Metropolitan Area of Buenos Aires establishing a more complex network and creating new spatial relations along highways, instead of along the old railway system.

As was previously described, the political and economic context of those years was characterized by structural changes such as a state reform, economic deregulation, monetary stabilization (convertibility), construction of mobility infrastructure, privatization of public services and new urban laws (Ciccolella, 2002; Ciccolella et al. , 2006; Gobierno de la Ciudad de Buenos Aires, 2010; Williamson, 1990; Zagare, 2014a). In light of this scenario, the withdrawal of the State as a territorial planning regulator encouraged foreign investors to finance urban (private) growth and change occupation patterns, leading to a new configuration of the space and the development of large urban projects. Foreign Direct Investments increased, and large plots were appropriated by private brokers near the river, especially on the continental lands of the North-Axis of the province, near the Lower Delta, encouraging the development of ***gated communities*** (neighborhoods with a closed perimeter, isolated from the rest of the urban fabric). Directed towards higher and upper-middle income groups, the success of these developments was certain.

Something worth mentioning is that initially, gated communities did not have the same characteristics as they presently do. During the 1930s, the first "country clubs" (as they were called at the time) were not gated. The first generation of this typology consisted mainly of recreational complexes built on private land owned by clubs, mainly dedicated to golf and polo, which also had accommodations for visitors (Liernur & Aliata, 2004, p. 181). Some examples are the Tortugas Country Club (1930), Hindú Country Club (1944), and the Highland Park and Olivos Golf Club which were both founded in the 1950s (Liernur & Aliata, 2004, p. 181). They were exclusive to the traditional elite of Buenos Aires, but they did not consolidate as a provincial urban landscape form until the 1970s (Randado, 2010, p. 111). By that time, the second generation of country clubs emerged, encouraged by the construction of the Acceso Norte highway, and also by the sanction of the Decree-Law 8912/1977 of Territorial Ordering (1977), which included "country clubs" as legal and regulated entities. That Decree-Law was sanctioned in a way to regulate the popular division of rural land without infrastructure (and sometimes in areas sensitive to flooding) into lots, which were in many cases irregular. This second generation of country clubs was constructed up until the mid-1980s, presenting some differences from the original ones; they were not as exclusive as the first, extending to other sectors of the society and were embedded into a more robust regulatory framework (Kozak, 2008, p. 206; Randado, 2010, p. 113).

However, the real inflection points for the development of this typology took place during the 1990s, as a consequence of the liberal economic model previously described. Then, country clubs were not only for weekend houses but also for

permanent residences (Liernur & Aliata, 2004, p. 182). That qualitative change, together with the advance of Foreign Direct Investments, led to a radical change in the urbanization of the Metropolitan Area of Buenos Aires.

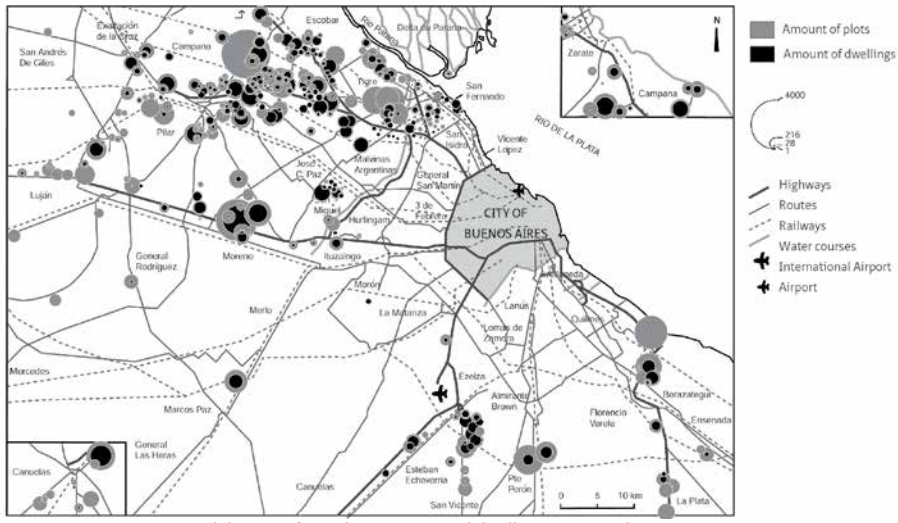

FIGURE 4.19 Location and density of gated communities (Thuiller, 2005, p. 8).

Historically, and according to legislation, the municipalities had carried on urban development. Nevertheless, in this decade, the combination of the absence of the State as a regulator of development and the increase of Foreign Direct Investments brought about the shift of the private sector in occupying the role of territorial developer (Cohen 2007, p. 278; Zagare & Manotas Romero 2014, p. 30; Zagare 2014, p. 218). Strong economic groups planned great areas of gated communities, including internal norms such as the planning of the roads, common spaces, and even the architectural language of the constructions. Located in floodplains lacking of services, these neighborhoods required the construction of infrastructure, and also encouraged the development of service areas for those from high-income sectors, such as commercial centers. Which developed mainly in the Northern area of the province, in the municipalities that are part of the Delta area (Ciccolella, 2000; Cohen, 2007, p. 279) (Figure 4.19).

The number of private urbanizations increased from 100 to 350 from 1995-2000 and today they reach more than 400. According to Ciccolella (2002, p. 5) and Cohen (2007, p. 277), the area of gated communities is near 500 km^2 (2.5 times the area of Buenos Aires city). One of the extreme cases of private developments is the former neighborhood and now considered locality called Nordelta (Figures 4.20 and 4.21).

FIGURE 4.20 Nordelta area. Google Inc. (2018) Google Earth (Version 7.3.1.4507).

FIGURE 4.21 Detail of Nordelta´s Neighborhoods. Google Inc. (2018) Google Earth (Version 7.3.1.4507).

Nordelta is a group of 23 neighborhoods which covers around 13,000 hectares of the continental area of the Municipality of Tigre, with an average density of 30 inhabitants/ hectare (Municipio de Tigre, 1996). This locality has become a satellite city of Buenos Aires, having hospitals, schools, universities, heliport, cinemas, commercial centers, and offices.

Together with the boom of private urbanizations, there was also an increase in poverty and the unemployment rate, along with a consequent rise in the number of informal settlements, usually called *villas* and *asentamientos* according to their internal conformation and origin. The villas, which as previously addressed, were born in another political period and were initially thought of as temporary settlements built in response to the impossibility of having access to the housing within the formal market. Asentamientos are another type of irregular occupation of private and public plots but differ from the villas in several respects. First, they appeared during the decade of 1980, not as a result of individual action but as a consequence of collective organization of social movements. Second, they settled in peripheral lands, in most of the cases, without infrastructures and under adverse environmental conditions. Third, they were planned, in an attempt to establish a continuity with the regular urban grid, following parameters such as minimum dimensions, relation between the areas, regularity of patterns, etc., without the intention of becoming a villa and attempting to become a part of a city acquiring formal tenure (Cravino et al., 2009, p. 3; Cuenya, 1985; Gonzalez, 2010; Grahl, 2009, p. 5). Following the scheme of urban sprawl of the Metropolitan Area of Buenos Aires, the villas (which are older than the asentamientos) can be found mainly in the first crown of the Metropolitan Area, while the asentamientos can be found in the second crown. The population of these vulnerable areas has increased from around 37,000 inhabitants in 1981 to 107,800 inhabitants in 2001 and reached almost 130,000 inhabitants in 2006 (Cravino et al. , 2009, p. 6). It is estimated that from the period of 2001-2005, 6 of every 10 new inhabitants of the Metropolitan Area established in informal settlements, which represented the principal form of demographic growth in the area (Cravino et al. , 2009, p. 13).

FIGURE 4.22 Gated communities, shopping centers and emergency villas (Thuiller, 2005, p. 7).

FIGURE 4.23 Gated community and its surroundings (adapted from Zagare & Manotas Romero 2014).

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FIGURE 4.24 Gated community and its surroundings (Zagare 2014).

The result of the Metropolitan Area's historical occupation process is a polarized scenario full of spatial segregation and social inequities, as a consequence of the struggle for land between two opposite sectors of society. Exclusive gated communities, traditional urban patterns and informal settlements (villas and asentamientos) are located next to each other, on lands sensitive to flooding (Figure 4.22). This scenario is exacerbated in the northern areas of the Province, as Tigre, San Fernando, and Escobar are three of the municipalities that illustrate this situation, and are also located in the Delta plain. The coastal areas of the main watercourses have been mostly privatized, so the traditional urban fabric does not have much relation with the water except for a few public areas in certain places. Furthermore, due to the lack of an integral public flooding defense policy, private developers protect their gated communities by building their own dikes or embankments, which depending on their size, affect surrounding environmental and construction areas, which remain below the Flood Hazard Level (FHL) (Figures 4.23, 4.24). On the islands, the result of the metropolitan expansion pattern is expressed in the intrusion of typologies related to the gated communities that modify the land's natural topography and its watercourses, affecting biodiversity and introducing foreign species to the environment. Another result is the contrasting situation between the first and second sections of islands. While the first section (in the Municipality of Tigre) has gained popularity due to short-term tourism and recreation activities, the second section (in the Municipality of San Fernando) has lost population due to the lack of accessibility and decreased productivity.

As described above, the historical evolution of the occupation and the socio-economic situation in the Lower Delta was not far from the extreme situations that the country has experienced. On the contrary, being so close to the Metropolitan Area of Buenos Aires has made the area susceptible to changes at different scales, regional, metropolitan and local. The imbalance between the issues previously described at the metropolitan level gives rise to certain types of dichotomies, which make this delta a particular case and act as a framework for the dynamics of the local analysis that will be presented later.

§ 4.5 Institutional Context and Governance in the Paraná Delta (governance layer)

§ 4.5.1 Federal organization of the country

Argentina is a federal country organized in three levels of hierarchy: The State, the provinces, the municipalities (local level), and the Autonomous City of Buenos Aires[11]. Each level has specific functions that must be accomplished within their territory. After the reform of 1994, Article No. 123 of the National Constitution guarantees that the provinces must have their own Provincial Constitution, which ensures the autonomy of the municipalities located in their territory. This autonomy allows the faculty of any municipality to define its norms, to elect its authorities and to administrate itself.

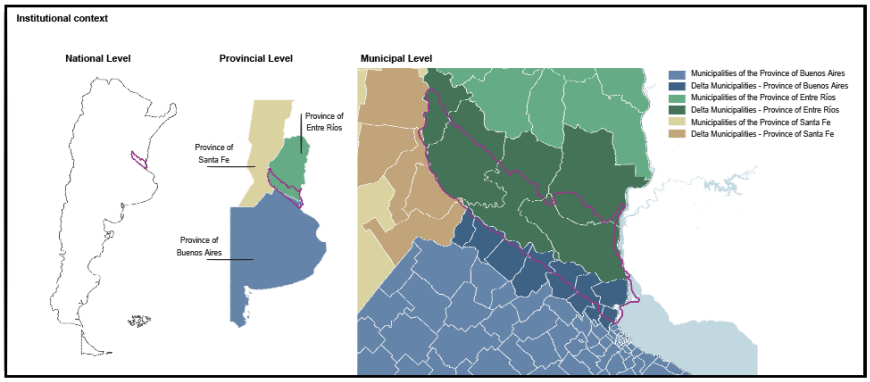

FIGURE 4.25 Scales of jurisdictional organization.

The autonomy (or semi-autonomy in some cases) is established according to each Provincial Constitution, so it may present different criteria according to the level of importance that each province gives to their municipalities or departments (Di Paola, García, & Alonso, 2001, pp. 69–70). Although the autonomy referred to in the National Constitution must be reached at the institutional, political, administrative

11 Since the reform of the National Constitution in 1994, the City of Buenos Aires has an "autonomous" legal status, which means that is has its own governmental authority, such as the provinces.

and economic levels, some provinces do not guaranty it and to do so, they would need to reform their Provincial Constitutions. Such as in the case of the Province of Buenos Aries, whose Constitution dates from 1933 and does not guarantee municipal autonomy. Notwithstanding, national, local and provincial regulations must respect International Treaties, among other superior orders.

Considering this scenario, the Paraná Delta falls under **one** State jurisdiction, **three** provincial governments and **nineteen** municipalities. It is clear that in such a complex network, the lack of intergovernmental coordination between the governments is an obstacle for reaching integrated strategies. The larger part of the Delta area is in the province of Entre Ríos (82.2%), while the rest lies in the provinces of Buenos Aires (16.3%) and Santa Fe (1.5%) (Zagare et al., 2014a, p. 110). In the province of Entre Ríos, the delta occupies part of the departments of Paraná, Diamante, Victoria, Gualeguay, Gualeguaychú and Ibicuy Islands. In the Province of Santa Fe, the delta occupies a portion of the departments of La Capital, San Gerónimo, San Lorenzo and Rosario. In the province of Buenos Aires, it comprises part of the departments of San Nicolás, Ramallo, San Pedro, Baradero, Zárate, Campana, Escobar, Tigre and San Fernando (Figure 4.25).

Environmental policy at the national level

After the modification of the National Constitution carried out in 1994, the issue of sustainable development as a necessary variable in decision-making processes was considered. Article No. 41 says that the national State sanctions the laws to ensure a healthy environment, and the provinces (which have the *original domain*[12] of the natural resources according to Article No. 124) must abide by those laws. Environmental policy is treated at the national level by Law No. 25675/2002, which establishes minimum environmental standards for the sustainable management of the environment. Among other aspects, it refers to the preservation, conservation and improvement of environmental resources, including mechanisms for social participation in the decision-making processes, together with the necessary measurement of environmental damages and the design of processes for its recovery. It also establishes a federal system of inter-jurisdictional coordination regarding the implementation of environmental policy.

12 The term domain refers to the "real right that grants all the faculties to use, enjoy and dispose material and juridically of a thing, within the limits foreseen by the law" (Congreso de la Nación Argentina, 2015; Machain, 2010, p. 85). The term original regards the pre-existence of the provinces over the Nation (Machain, 2010, p. 85).

This system aims to find an agreement between the National government, the 24 provincial governments and the Government of the City of Buenos Aires. The Federal Council of Environment (Consejo Federal de Medio Ambiente, COFEMA) coordinates these entities, with each province having representatives, dividing the country into six regions: Nuevo Cuyo, North-West, North-East, Northern Patagonia, Patagonia and Center (COFEMA, 2016). Other initiatives to mention are the Environmental Federal Agreement (Pacto Federal Ambiental), signed in 1993 between the provinces and the Nation and the Federal System of Protected Areas (SIFAP, Sistema Federal de Áreas Protegidas), which was created in 2003 also through an agreement between the provinces and the Nation (Figure 4.26). Among other regulations regarding minimum environmental standards, there are three notable ones: National Law N° 25 831/2004 of "Free Access to Public Environmental Information", National Law N° 26 331/2007 of "Minimum Standards for Environmental Protection of Native Woods", and National Law N°26 562/2009 of "Minimum Standards for Environmental Protection to control Burning Activities" (Machain, 2010, p. 88).

Concerning water management, extreme complexity exists due to both the variety of sources (seas, rivers, underground watercourses, wetlands, lagoons and rainwater, among others) and the large number of jurisdictions involved. Water is considered a resource that falls under the domain of the jurisdiction where it is located. Nevertheless, National Codes (Civil and Penal) indicate that this resource is federal, and the Civil Code establishes some considerations regarding its use and domain (Machain, 2010). The provinces have sanctioned specific legislation such as the Water or Rural Codes to regulate provision, permissions, restrictions, and other aspects. According to Machain (2010, p. 88), in the delta area, there are no unique laws that apply to the entire zone only some that apply to specific territories. The author argues that one of the main challenges is the future development of a federal tool for water management in the Delta, such as the Plan for the Sustainable Management and Conservation of the Paraná Delta Region, (Plan Integral Estratégico para la Conservación y Aprovechamiento Sostenible del Delta del Paraná, PIECAS-DP). This topic will be expanded upon later.

It is important to mention that a project for a National Law on Wetlands (Ley de Humedales) has been approved in 2016 by the chamber of senators, but it has still not been introduced in the chamber of deputies and is about to lose parliamentary status. A law establishing minimum budgets for the protection and rational and sustainable use of Argentinean wetlands is needed as these ecosystems occupy 23% of the country's area (Kandus, Minotti, & Malvarez, 2008), within which is the territory of the Paraná Delta.

NATIONAL LEVEL

International Agreements

- Ramsar Convention on Wetlands (1971) approved by National Law No. 23 919/1991
- United Nations Convention on Biological Diversity approved by National Law No. 24
- 375/1994
  United Nations Framework Convention on Climate Change approved through National Law No. 24 295/1993

National Constitution (reformed in 1994)

- Art. No. 41: the Estate must ensure a healthy environment.
- Ar. No. 124: the provinces have the domain of the natural resources.
- Art. No. 123: the provinces are guaranteed to have their own Provincial Constitution, and are required to ensure the autonomy of the municipalities located under their territory.

National Laws

- Law No. 25 675/2002: establishes the environmental minimum standards for the sustainable management of the environment.
- Law No. 25 831: Free Access to Public Environmental Information.
- Law No. 26 331: Minimum Standards for Environmental Protection of Native Woods.
- Law No. 26 562: Minimum Standards for Environmental Protection to control of Burning Activities.

Some federal agreements and plans...

- Environmental Federal Agreement (Pacto Federal Ambiental), signed in 1993 between the provinces and the Nation.
- Federal System of Protected Areas (SIFAP), which was created in 2003 also through an agreement between the provinces and the Nation.
- Plan for the Sustainable Management and Conservation of the Parana Delta Region (PIECAS-DP), (agreement between the provinces of Entre Ríos, Santa Fe and Buenos Aires).

Other federal agencies, services and programs within the Delta Area...

- National Parks Administration (APN)
  National Institute of Agricultural Technology (INTA)
  Ministry of Agriculture, Livestock and Fisheries
  Programs to promote production activities (PROSAP)...

Authority of application

Federal Council of Environment (COFEMA): Representatives of each province, dividing the country in six regions: Nuevo Cuyo, North West, North East, North Patagonia, Patagonia and Center.

FIGURE 4.26 Legislation framework: National level.

Nevertheless, in 2016 the Ministry of Environment and Sustainable Development of the Nation announced the beginning of the development of an inventory of wetlands, which would serve as a relevant tool that can be used to support the future law. Civil organizations and the academic sector, within the scope of The United Nations Development Program (UNDP) and the national government (Benzaquen et al. , 2013) have begun taking part in this inventory.

Specific environmental and urban policies regarding the Paraná delta area across the scales

International agreements

As was previously addressed, international legislation (agreements and treaties), when recognized by the National State is essential for the management and conservation of the area as they are superior to national laws and other regulations and must be respected. In the case of the Paraná Delta, three international agreements must be taken into account: The first one is the Convention on Wetlands, also called The Ramsar Convention because it was first signed in Ramsar, Iran, in 1971 (Ramsar Convention Secretariat 2013). This intergovernmental treaty is highly significant because it was approved in Argentina through National Law N° 23 919/1991. The primary objective of the Convention is the conservation of wetlands around the world, and for that purpose, it establishes a list of Ramsar sites with a series of actions for the countries to complete. Among its principal obligations are; the elaboration of a planning method towards the conservation of these areas, the rational use of wetlands, a constant assessment of ecological conditions, the encouragement of research and data exchange, the support of legislation and initiatives towards the conservation of wetlands, among others (Machain, 2010, p. 86). In the Delta area, there are currently two Ramsar sites: "Delta del Paraná", an area located in the Upper Delta, covering a 243,126-hectare territory in the provinces of Santa Fe and Entre Ríos, and "Reserva Otamendi", a 3,000-hectare territory located in the Lower Delta, province of Buenos Aires (Ramsar Convention on Wetlands, 2017). Apart from those sites, there is another one concerning the city of Buenos Aires, called "Reserva Ecológica Costanera Sur", a small site, which covers 353 hectares.

The second international agreement is the Convention on Biological Diversity (United Nations, 1992). Approved under National Law N°24 375/1994, its objective is also the conservation and sustainable development of the different components of biological diversity. This agreement includes the design of specific protocols regarding research, education, public awareness, impact assessment, reduction of adverse impacts, access to technology, information exchange, scientific and technical cooperation and biotechnology management and equal distribution of benefits.

Finally, it is also important to mention the United Nations Framework Convention on Climate Change (UNFCCC), approved in Argentina though National Law N°24 295. The UNFCCC exhorts nations to orientate their policies towards climate change mitigation, encouraging the development of specific measures focused on the stabilization of greenhouse gas emissions in the atmosphere (United Nations Framework Convention on Climate Change, 2017). Gas emissions is a particular issue for this delta as biomass burning is a regular practice carried out in the area (Kandus et al., 2009;

Machain, 2010). As a result of the combustion, carbon dioxide (CO_2) is released into the atmosphere, which means that this activity must be regulated not only for the sustainability of the area but also regulated for global interests and compromise. Also, it is relevant to mention the recognition of the Paris Agreement (UNFCCC), which was signed in 2016 and approved in Argentina through the National Law N° 27 270/2017.

National Policy

The Federal government has competence in the Paraná Delta area through the Plan for the Sustainable Management and Conservation of the Paraná Delta Region (Plan Integral Estratégico para la Conservación y Aprovechamiento Sostenible del Delta del Paraná, PIECAS-DP), developed in 2008 through the cooperation of the national State and the provinces of Entre Ríos, Santa Fe and Buenos Aires. The federal government also acts through conservation agencies such as the National Parks Administration (Administración de Parques Nacionales APN), extension services like the National Institute of Agricultural Technology (Instituto Nacional de Tecnología Agropecuaria INTA), and the Ministry of Agriculture, Livestock and Fisheries (Ministerio de Agricultura, Ganaderia y Pesca). It also acts through national policies and programs to promote production activities (PROSAP - Programa de Servicios Agricolas Provinciales-, etc.) (Zagare et al., 2014a, p. 124).

Although the National government and the three provinces committed to working together to achieve sustainable development in the region, sustainable practices are not always easy to implement given the existence of conflicts between jurisdictions. There is a complex network of institutions that have competence over the Paraná Delta region, and in many cases, they have different perspectives and positions concerning the role of the islands and the coastlines. It is evident that sometimes there are contradictions between policies at different levels. Although provinces hold the domain over natural resources, national policies influenced by international demand encourage the production of certain species that may negatively alter the region. Soybean monoculture is an excellent example of this instance. Contradictions also happen within the same level of government, for example, environmental agencies work to mitigate and minimize impacts on natural systems while other agencies aim to regulate production activities simultaneously promoting an increase of development activities in the same areas. Furthermore, an additional conflict exists among provinces and municipalities as there are often distinctions in policy implementation according to the capacities of each municipality. Moreover, also due to the political position and parties of their governmental authorities which generates disagreements across levels, often obstructing policy implementation (Zagare et al. , 2014a, p. 124).

Provincial Policy

As previously mentioned, three provinces share the territory of the Paraná Delta: Entre Ríos, Santa Fe and Buenos Aires. The three provinces have their own Constitution and have different positions regarding environmental and land use planning (Figures 4.27, 4.28). The Constitution of the Province of **Entre Ríos**, reformed in 2008, recognizes the domain of natural resources according to the National Law of the Environment No. 25675/2002 which gives the municipalities the autonomy required by the National Constitution and also confers their right to territorial planning within the limits of their province. In Article No. 84, the provincial Constitution declares that a provincial office has the faculty of territorial and environmental planning among other functions.

At present, the degree to which each province has competence on environmental issues depends heavily on the power the Secretary of the Government grants to the Secretary of the Environment while the Ministry of Planning and Infrastructure addresses planning matters. There are not many examples regarding environmental legislation in the province. The province's Law of Water (Law N°49 172/1998) regulates the use and management of the resource, while other specific laws address waste management, industries, protected areas, flora, fauna, etc. Provincial Law N°8 534/1991 regulates the construction of water management works, and Decree No. 1329/2015, Law No. 10284 regulates the planning of native woods, including the zoning of the Paraná Delta, which has received both praise and criticism.

The Province of **Santa Fe**, ratified its constitution in 1962, recognizing municipalities' autonomy not specifying anything, however, concerning urban or environmental issues. Thirty years later, the legislature promulgated the Law of Environment, No. 11717/99 and Decree No. 827/2000, which established the Provincial Secretary of Environment and Sustainable Development (Secretaría de Medio Ambiente y Desarrollo Sustentable) as the authority responsible for applying the Law. Additionally, it implemented mechanisms for citizen participation, and created the Provincial Council of Environment (COPROMA, Consejo Provincial de Medio Ambiente) as an advisory body. The provincial law, Article No. 2, describes territorial planning as one of the components of successful conservation, improvement and recovery of the environment, but without delving into its characteristics or detailing the mechanisms needed to achieve its goals successfully.

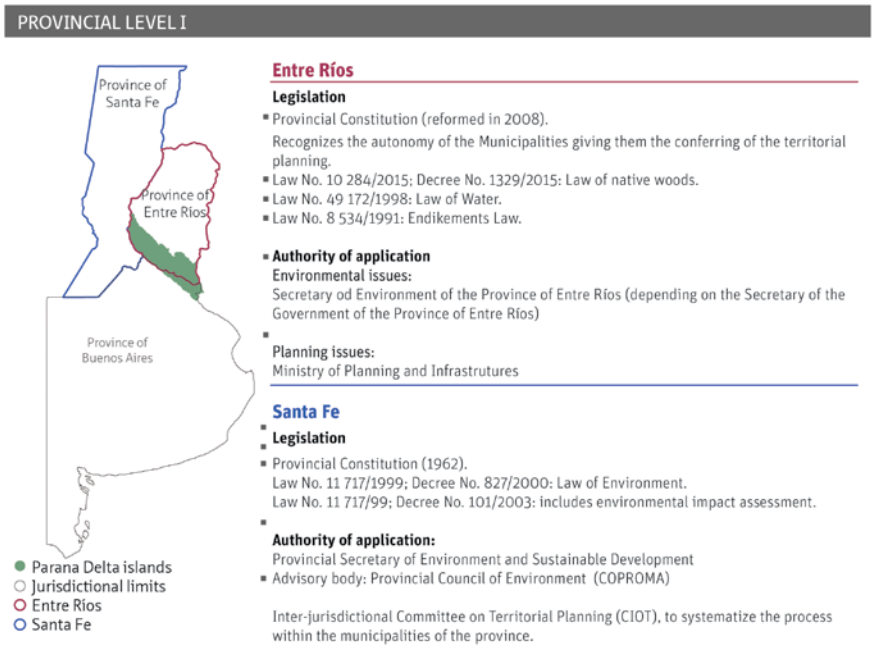

FIGURE 4.27 Legislation framework: Provincial level.

Four years later, in 2003, through Decree No. 101/2003, Law No. 11717/99 was modified and regulated, addressing environmental impact assessment. It mentions that environmental assessments are an instrument for territorial planning, and defines the latter as a "tool for decision making regarding the location of activities within a geographical space or physical area of a territory". Through Decree No. 638/2014, the Inter-Jurisdictional Committee on Territorial Planning (CIOT, Comité Interjurisdiccional de Ordenamiento Territorial) was created to systematize the impact assessment process within the municipalities of the province.

In the Province of **Buenos Aires**, the Constitution does not entirely recognize municipalities' autonomy. Regarding environmental legislation, provincial Law No. 11723/1995 the Law of Environment was sanctioned according to Article No. 28 of the Constitution of the Province (1994), which recognizes that the domain of

PROVINCIAL LEVEL

Buenos Aires

Legislation:

- Provincial Constitution (1994), which does not recognize entirely the autonomy of the municipalities.

Environment:

- Law No. 11 723/1995: Law of Environment.

Urban Planning and Land Uses:

- Decree No. 3487/1913: establishesd parameters for the creation of new centres.
- Decree No. 2189/1949: regulates the indicators for the settlement of urban nucleous and weekend houses, prohibiting their location on floodplains. (This decree was derogated in 1953 due to the pressure to build on those areas).
- Law No. 6053/1954 allowed the construction of houses on stilts in areas susceptible of flooding.
- Law No. 6254/1960 prohibited the fractioning of plots located under the flooding level, exempting the islands of the Parana Delta and the territories in which infrastructure works are developed either by public or private sectors.
- Decree-Law No. 8912/1977, also called Law of Land Uses: establishes minimum standards for new settlements, division of habitable plots, uses and infrastructure, and gives to each municipality the responsibility for local land use planning. Introduce the term of Club de Campo (country club).
- Decree No. 1.549/1983 establishes that a floodplain does not guarantee the basic conditions for settlements.
- Decree No. 9404/1986 complements the chapter about country clubs of the Decree-Law No. 8912/1977.
- Decree No. 27/1998 establishes norms over country clubs
- Decree No. 1727/2002 gives the municipalities the faculty to approve private developments but it was derogated through the Decree No.1069/2013.
- Decree No. 947/2004 adopted the proceeding established in the National Law No. 13512 of Horizontal Property, and included country clubs and private neighbourhoods under this legislation.
- Decree No. 188/2011: creates the Program of Social Housing.
- Decree No. 14 449/2013: creates a program for socio-urban integration of villas and settlements.

Authority of application:

- Law 11 469/1993: creation of the Provincial Institute of Environment.
- Law No.13 757/2007: creates the Provincial Organism for Sustainable Development (OPDS), (Environmental enforcement authority, depending on the Ministry of Chief of Cabinet and Government)
- Decree No. 1496/2008: creates the Inter-ministerial Commission of Urban and Territorial Planning (CIOUT)

FIGURE 4.28 Legislation framework: Provincial level.

natural resources is held by the province and committees to guarantee the right of its inhabitants to enjoy a healthy environment. It understands territorial planning as an environmental policy tool, related to the localization study of different land uses according to the characteristics of each area, environmental impact assessment, and other aspects. This law also has a chapter dedicated to water, establishing parameters for the development and implementation of policies regarding the issue.

Since 2007, the Provincial Organism for Sustainable Development (OPDS, Organismo Provincial para el Desarrollo Sostenible) was created through Law No. 13757/2007 toserve as the environmental enforcement authority in the province of Buenos Aires. It is an autarchic entity of public law in the orbit of the Chief of the Cabinet of Ministers that replaced the former Secretary of Environmental Policy of the Province of Buenos Aires (Secretaría de Política Ambiental de la Provincia de Buenos Aires). On the other hand, Provincial Decree-Law No. 8912/1977, also called Law of Land Uses (Ley de Ordenamiento Territorial y Usos del Suelo) regulates urban planning legislation in the Province of Buenos Aires, which derogated the preceding Law 3487/1913 responsible for the creation of new centers and urban areas. The Decree-Law No. 8912/1977 establishes minimum standards for new settlements, the division of habitable plots, uses and infrastructure, and gives each municipality the responsibility for local land use planning. It has been modified several times mainly addressing issues such as urban indicators, private domain regulation, the nature and use of the land before and after urbanization and the authorities that can approve certain developments.

The Decree-Law No. 8912/1977 was also the first piece of legislation that introduced the term of *Club de Campo* (country club, a form of gated community), although in 1949, Decree No. 2189/1949 had already recognized *núcleos urbanos* (urban nucleoli), *barrios-parque* (neighborhoods-parks) and *casas de fin de semana* (weekend houses), regulating the indicators for their settlement and prohibiting their location on floodplains. This decree was derogated in 1953 due to the pressure to build on those areas, so recently Law No. 6053/1954 has allowed the construction of houses on stilts in areas susceptible to flooding (Lombardo, 1999, p. 45; Ríos & Pírez, 2008, p. 101). In 1960, provincial Law No. 6254/1960 prohibited the fractioning of plots located under the flood water level, but exempting the islands of the Paraná Delta and the territories in which infrastructure works are developed either by public or private sectors. Although the original text of Decree-Law No. 8912/1977 did not include this prohibition it was later added by Decree No. 1549/1983, which establishes that a floodplain does not meet the necessary conditions for settlements. In 2008 the Inter-Ministerial Commission of Urban and Territorial Planning (CIOUT, Comisión Interministerial de Orenamiento Urbano y Territorial) was created through Decree No. 1496/2008. The Unique Urban Register for the Province of Buenos Aires (Decree No. 1636/2008) was created later as well.

According to what has been explained thus far, the two contrasting expressions of urban development that have characterized the Metropolitan Area of Buenos Aires during the last 40 years were the country clubs (also called private urbanizations, gated communities or closed neighborhoods) and informal settlements, whether in the form of *villas de emergencia* (emergency villas) or *asentamientos* (settlements). These two expressions coexist with the existing industrial-residential pattern that

characterizes the traditional urban settlements of the area, formed by the repetition of mixed-use blocks following a regular pattern (Ciccolella, 2000, p. 487; Kozak & Vecslir, 2013). On the one hand, the normative framework that regulates the country clubs is based on the already described Decree-Law No. 8912/1977, with the complementary regulations included in Decree No. 9404/1986. Years later, Decree No. 27/1998 established more norms over these areas and Decree No. 1727/2002 gave municipalities the faculty to approve these developments, but Decree No. 1069/2013 struck down the former law. This Decree establishes that the approval procedure for settling new gated communities would be carried out by the Provincial Registry of Gated Communities (Registro Provincial de Urbanzaciones Cerradas) under the scope of the Under-Secretariat of Government of the province of Buenos Aires, previous validation of feasibility. In the agreement, Resolution No. 29/2009 of the Provincial Organism for Sustainable Development (Organismo Provincial para el Desarrollo Sostenible, OPDS), established that an Environmental Impact Assessment must be approved by the Provincial Environmental Authority, as established in the provincial Law No. 11723/1995 Law of the Environment. This resolution focused on the recognition of the technical limitations of the local governments (municipalities) to carry on with the approval of such complex assessments. Nevertheless, this resolution was modified through Resolution No. 567/2017, which establishes that municipalities must again carry out the Environmental Impact Assessment approval process, but with a previous opinion from the Provincial Environmental Authority.

It is important to note that the difficulty of measuring the value of the lands previous to the development of these gated communities was evaluated through the mechanisms established in Decrees No. 996/2001 and the Ministerial Resolution of the Tax collection Agency of the Province (Agencia de Recaudación de la Provincia de Buenos Aires, ARBA) No. 62/2012. Furthermore, in 2004, Decree No. 947/2004 adopted the proceeding established in the National Law No. 13512 of Horizontal Property and included country clubs and private neighborhoods under this legislation.

On the other hand, regarding informal settlements, one of the key issues is domain regularization. The occupation of these plots (whether public or private) is informal and generates several conflicts because it represents a fight for the rights of two groups; the legal owners of the lands and the illegal inhabitants. In most cases, the informal occupation of the plots generates a parallel land market outside of the formal one, where people sell lands that they do not legally own and other people buy them to fulfill their right to a dignified house. Several policies have been developed to solve those conflicts, such as Decree No. 188/2011, which created the Program of Social Housing and Decree No. 14449/2013 that created a program for socio-urban integration of villas and settlements. The *sustainable and inclusive* vision of the government, beyond its different parties, has always been to integrate these areas into existing urban

patterns to recover the dignity of the inhabitants and reduce the spatial and social segregation that they suffer because they live there. To accomplish this, it is necessary to cover all aspects: A census, domain regularization, provision of infrastructure, modification of the occupation pattern to better integrate these settlements into the city, the construction of commercial centers, schools, hospitals, and other services.

Although there are a few points of contact between existing environmental and urban legislation at the provincial level, generally speaking, in the three provinces, both issues run parallel to each other. In the Santa Fe Province, planning and environmental issues do not have recognition in the Constitution, perhaps because it was last modified in the 1960s. However, there is a set of provincial laws that aim to fill that void and there is also an intention to find agreements through the Inter-Jurisdictional Committee on Territorial Planning (Comité Interjurisdiccional de Ordenamiento Territorial, CIOT) and the Provincial Council of the Environment (Consejo Provincial de Medio Ambiente, COPROMA). Nevertheless, despite the intentions of improving vertical coordination among scales of government and horizontal dialogue between governmental offices, environmental issues require long-term and robust base policies because they go through all governmental levels of the territory without distinguishing jurisdictional limits.

The difficulty of updating and streamlining environmental policies among various jurisdictions is seen mainly in the province of Buenos Aires, where the numerous changes applied to the norms and the changing authorities that regulate land use have generated a context of instability. As explained in the previous sections, the Paraná Delta is subjected to pulses of floods and droughts, apart from being influenced by different hydrologic regimes along its extension. Hydrologic regimes together with the increasing effects of Climate Change have caused severe floods in the cities along the coasts with catastrophic results. The south of the Santa Fe province and the north of the province of Buenos Aires are usually the most affected areas due to this phenomenon. Consequently, in times of disaster, a real coordination and contingency program is needed to face the problem and to plan coherent and integral initiatives to mitigate damage and reduce the adverse effects of natural catastrophes. These efforts should also go towards building increasing adaptive capacity of the area as a whole and overcoming jurisdictional limits or party disagreements. It is essential to make clear that policies should declare that municipalities or specific government departments have the power over planning decisions regarding the territory and that urban and territorial planning is under their scope as this is an area where policies at intersecting government levels often collide.

Local Policy

According to the National Constitution, municipalities must have autonomy regarding institutional, political, administrative and economic orders. When local authorities are responsible for their urban development and planning policies, they can act according to people's needs because they are aware of local problems. Nevertheless, they do not have enough power to counteract the pressures of different stakeholders, such as large economic groups and at the same time, to respond to societal demands, such as the needs of the poorest sectors of society. That is why in some cases, it is said that urban planning is being carried out in the interest of particulars instead of the national State. A clear example has already been presented when referring to the decade of the 1990s when the expansion of the Metropolitan Area of Buenos Aires was characterized by the development of gated communities and informal settlements as a result of the socio-economic and political contexts at the time. Thus, legislation that limits jurisdictions prevents the recognition of regional dynamics, environmental and socio-economic processes and makes it necessary to broaden the scope of policies. In other words, **local authorities are crucial for the integration of policies among the scales of government and their offices, both being able to join efforts to transcend jurisdictional limitations.**

It is important to mention that Article No. 124 of the National Constitution allows the creation of regions and the celebration of treaties among its provinces, which encourages cooperation. Nevertheless, the legislation and instruments that are applied within the Metropolitan Area of Buenos Aires are national, provincial or local because a regional management institution for this area does not yet exist (Clichevsky, 2002, p. 33). Since the 1960s there have been many initiatives implemented in an attempt to organize the region through the creation of offices, programs, agreements and even councils, which previous chapter has presented in greater detail regarding governance issues in the area. The latest initiative that took place was the creation of the Consultative Commission of the Metropolitan Area of Buenos Aires (COCAMBA, Comisión Consultiva del Area Metropolitana de Buenos Aires). It was created through National Decree 1126/2016 to coordinate public policy among national, provincial and municipal levels, and will be dissolved once its mission of preparing a final report of projects on a fixed timeframe is accomplished.

Regarding the Delta area, the Province of Buenos Aires created the "Consejo Intermunicipal del Delta" CONINDELTA (Intermunicipal Council of the Delta) through Provincial Decree No. 2064/1970 (modified by Decrees No. 7881/1972 and 10003/1983) (Gobierno de la Provincia de Buenos Aires, 1970, 1972, 1983). The mayors of the municipalities in the province of Buenos Aires who have jurisdiction over the Delta's territory[13] are responsible for implementing the Decree. Although

13 San Nicolás, Ramallo, San Pedro, Baradero, Zárate, Campana, Escobar, Tigre and San Fernando

its functions are, among others, the study, planning and management related to the Delta, the council has had no significant role in addressing other governance issues regarding the Delta apart from the Decree.

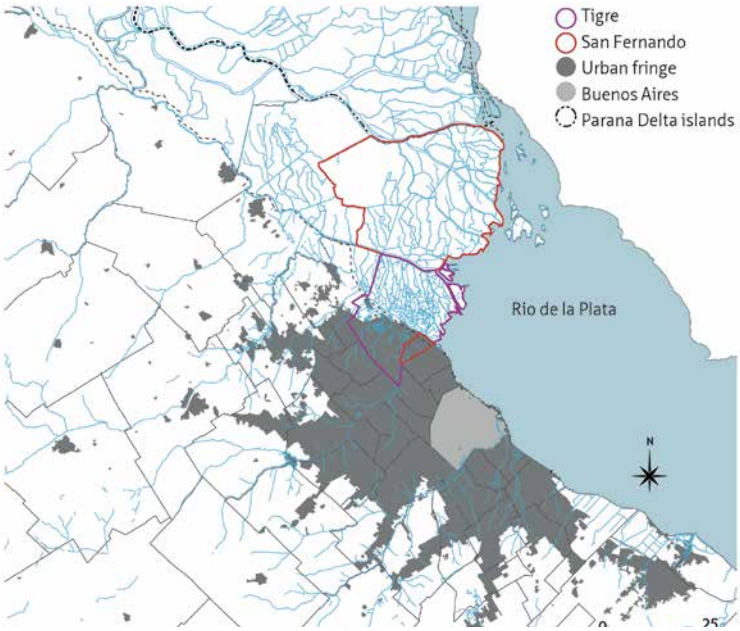

FIGURE 4.29 Location of the Municipalities of Tigre and San Fernando.

§ 4.6 The Municipalities of Tigre and San Fernando

The continental and insular areas of the municipalities of Tigre and San Fernando, are located in the Delta Front, 20 km away from the city of Buenos Aires and the surrounding Metropolitan Area (Figure 4.29). As part of the Metropolitan Area, they play a vital role for the Delta, as the islands that belong to the municipalities concentrate 20% of the Delta's entire population (Municipio de Tigre, 2013c) despite of occupying less than 1.5% of the Delta's territory. Despite being located adjacently, both municipalities have different goals regarding land use planning, which has impacted the territory generating different results regarding socio-spatial

conformation. Especially Tigre, have experienced the transformation of the occupation patterns in concordance with metropolitan growth trends.

FIGURE 4.30 Location of the Municipality of Tigre.

§ 4.6.1 The Municipality of Tigre

The Municipality of Tigre has an area of around 360 km^2, 60% of it is islands, and 40% is continental land (Municipio de Tigre, 2013c, p. 6) (Figure 4.30). It has a population of 376,381 inhabitants presenting an increase of 25% in the period from 2001-2010 (INDEC, 2010). According to the 2001 National Census (INDEC, 2010), 18% of Tigre's population at the time was under the poverty line. Aboriginal groups first populated the area followed later by foreign inhabitants and *criollos*. It was initially called *Las Conchas*, taking the name of the river that runs through the territory, which was later called Reconquista. It was one of the few settlements located around the city of Buenos Aires in the 17th Century, harboring a major port that some years later was surrounded by 19 sawmills and a shipyard.

By 1805, a *Sudestada* originated a severe flood that produced important changes in its topography, the loss of the original colonies and around 100 deaths. Due to that, the settlement moved to the present location, by the mouth of Lujan River, establishing

a new port (Del Mastro, 2008). By 1854, the department had approximately 960 inhabitants, and changing the name to Tigre inspired one of the largest bifurcations of the Reconquista River (Figures. 4.31, 4.32, 4.33).

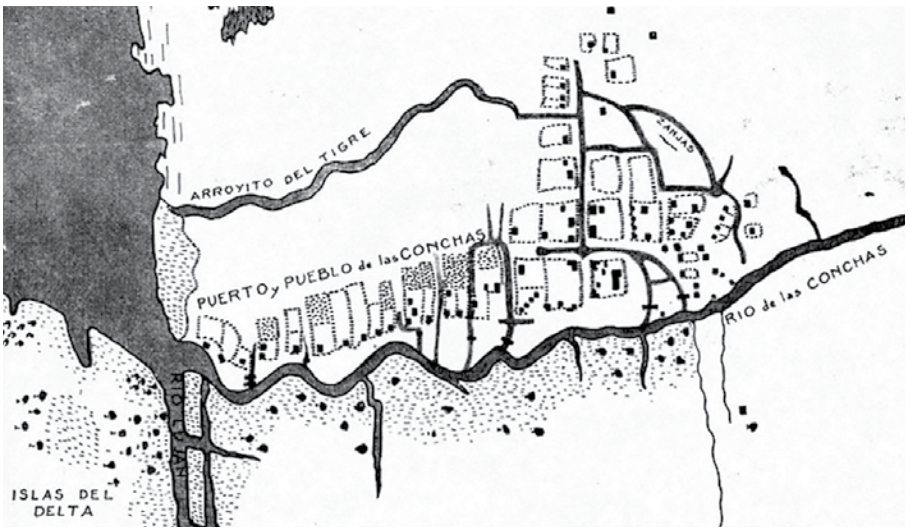

FIGURE 4.31 Historical map of Tigre created by José María Manso between 1806-1807 or 1817 (Histarmar, 2016).

During the 20th Century, Tigre was a relevant department, being subjected to constant densification as a consequence of suburbanization processes. During the 1990s, the political changes that took place in the country impacted the municipality generating socio-spatial transformations. The Municipality of Tigre was one of the most transformed departments due to the combination of several factors: (a) its proximity to the city of Buenos Aires, (b) the natural beauty of the territory which is an attraction for tourism and housing, and (c) the goal of local authorities to encourage the municipality's growth by attracting external investments in the development of housing and infrastructure (transportation and tourism). The ability of public authorities to generate interest in private investments to the area is critical as municipalities in the province of Buenos Aires do not have full autonomy and do not have the resources for urban development and infrastructure. This phenomenon repeats in other municipalities throughout the Metropolitan Area of Buenos Aires. In fact, it is especially true in the case of Tigre, where the support given by the local government to private investments has given rise to coalitions between public and private actors, resulting in the improvement of highways, commercial centers, and other facilities that attracted an increase in private investments to this municipality.

FIGURE 4.32 Dike construction in the port of Tigre in 1934 (Histarmar, 2016).

FIGURE 4.33 Port of Tigre in 1922 (Histarmar, 2016).

As already described, the provincial policy limitations for urbanizing floodplains (established with Decree No. 1549/1983) were counteracted with more legislation which allowed the location of new gated communities close to the existing floodplains through the development of infrastructure to reach secure levels (Decree No. 9404/1986). Within this context the Municipality of Tigre sanctioned Ordinance No. 1846/1996 regarding Urban Planning and Land Uses, changing some uses to encourage the development of private developments located in areas susceptible to flooding (Ríos & Pírez, 2008, p. 109). The elaboration of discourse on environmental recovery and sustainable development followed these actions ending in large dikes and modifications over the topography carried out by private companies.

Regarding infrastructure, to establish new urbanizations that reach safe levels, it is necessary to implement large-scale projects that remove substantial amounts of land from its original place following a privately-made design. This generates voids, which are filled with water to make artificial lagoons that give neighborhoods "natural" features. According to Ríos (2014, p. 73), some of the negative externalities generated by these actions are: (a) modification of water runoff in the area, which enhances flooding upstream and downstream, (b) changes in the functionality of the wetland system in terms of retention of water surpluses, (c) conflicts resulting from negative micro-impacts during and after the construction of the private development, d) enhancement of the social micro-fragmentation[14] processes among the inhabitants of private urbanizations and their surrounding areas. This is due to both socio-economic differences and the environmental benefits of living on polders, which avoids much of the damage caused by floods compared to the rest of the inhabitants that are outside of the protected area.

14 This social fragmentation refers to the social processes that occur as a product of dissimilar occupation of the land by rich and poor sectors of the society.

FIGURE 4.34 Instruction of gated communities Google Inc. (2018). Google Earth (Version 7.3.1.4507).

From 1991-2001, the area occupied by private developments over artificial land in the floodplains of Tigre grew over 20 times reaching 3,300 hectares (Ríos & Pírez, 2008, p. 102) (Figure 4.34). The interventions over the territory had adverse effects on the ecosystem, despite the environmental discourse behind building them, and an increase in the levels of water and land pollution apart from increasing the vulnerability of the interstitial areas between the dikes (Ríos & Pírez, 2008, p. 109). The Municipality of Tigre also holds the already described *private city Nordelt*a, with an expected capacity of 140,000 inhabitants (Fernández, Kochanowsky, & Sgroi, 2010, p. 177; Municipio de Tigre, 1996; Ríos & Pírez, 2008, p. 111). Despite Nordelta's initial master plan that proposed an open city integrated into the existing urban fabric, the final results were far from that. On the contrary, it is a closed city with hospitals, universities, schools, commercial centers and other facilities that have no interaction with the surrounding urban areas. Although Decree-Law No. 8912/1977 establishes that access to new urbanizations should be public, the local government granted its use to Nordelta until the project's completion (more than 20 years.) through Decree No. 714/2001(Ríos & Pírez, 2008, p. 113).

Within this context of large-scale housing and infrastructure developments for the high-income sectors of society, informal settlements also grew considerably. They began occupying the interstices between gated communities and the open-grid formal city (Figure 4.35) that are located along fiscal (and private) lands, along the coasts of the canals and beside railways and highways. According to Cravino et al. (2009, pp. 5–6), the number of inhabitants living in villas and informal settlements in Tigre increased from 9,131 inhabitants in 1991 to 51,641 inhabitants in 2006, representing respectively around 4% and 15% of the municipality's total population. In 1991, there were approximately 34 villas and informal settlements in Tigre. Although the amount of these settlements decreased to 23 in 2001, the figure increased again to 39 in 2006, representing a rise of 170% in the 5-year period from 2001 to 2006 (Cravino et al. , 2009, p. 6). These settlements lack necessary infrastructure and municipal support. They are frequently located on polluted land and in areas without services like clean running water or electricity, representing a high sanitary risk for both the inhabitants of the settlements and a risk for the surrounding urban community.

FIGURE 4.35 One of the informal settlements located in Tigre (Villa El Garrote). Google Inc. (2018) Google Earth (Version 7.3.1.4507)

Land use policy

Land Use Planning in the Municipality of Tigre is strictly based on the *Zoning Code for the Municipality of Tigre* (Ordinance No. 1894/1996), which establishes occupation criteria for the entire municipal territory (continent and islands). With the approval of the *Comprehensive Management Plan for the Delta of Tigre* (Ordinance No. 3343/2013, promulgated by Decree No. 176/2013) this code has undergone some changes. This amendment consists of the incorporation of Annex 1 into the Zoning Code, the *Territorial Ordinance Particularized for the Locality of the Delta of Tigre,* through Ordinance 3344/13, promulgated by Decree No. 177/13 (Municipality of Tigre, 2013c). Conceptually, the incorporation of Annex I represents in principle the recognition of the particularities that distinguish the different sectors of the islands of the First Section (the Delta of Tigre) from continental lands. Before that, the Zoning Code, which was approved in 1996, recognized the islands as "Rural Area A2" (Municipio de Tigre 1996, Art. 9 "Classification of the Territory") without addressing any categorization according to its environmental characteristics, occupancy or level of fragility. Likewise, and also linked to the criteria used in the Management Plan, the *Construction Code for the Delta of Tigre* (Tigre Municipality, 2013b) has been incorporated into the existing *Construction Code of the Municipality of Tigre*, tending to regulate spaces built from the island area (Zagare, 2016a).

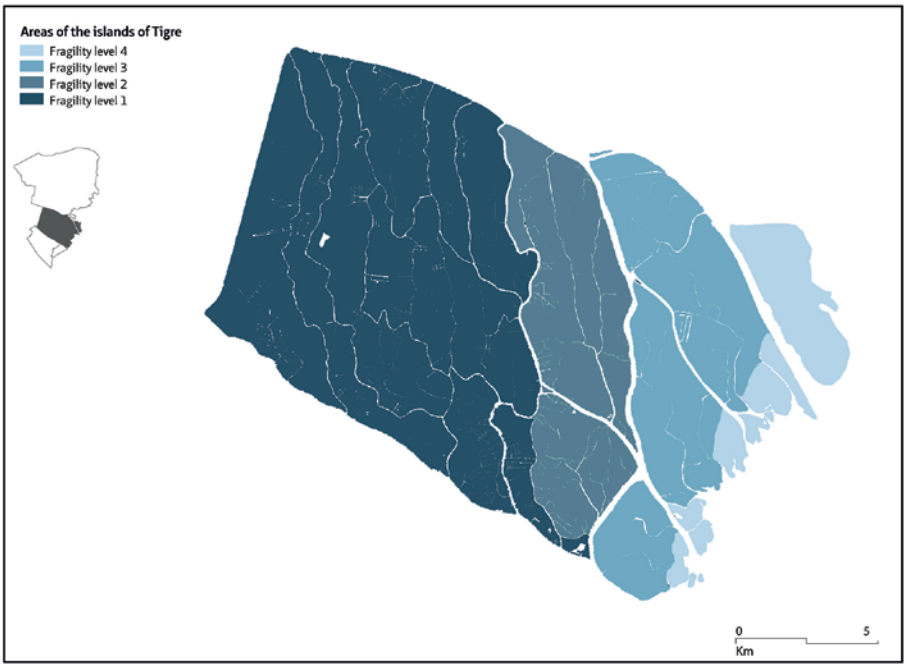

FIGURE 4.36 Areas of the islands of Tigre, according to the Management Plan. Design based on the Municipality of Tigre (2013).

The Comprehensive Management Plan for the Delta of Tigre establishes criteria and strategies in order to "balance the process of territorial occupation of the Delta with the preservation of the natural processes that take place in that territory highlighting the strategic value that the islands represent for the municipality and the whole ecoregion" (Municipio de Tigre, 2013c, p. 8). The Plan is based on three main parameters for the establishment of occupancy densities: (a) the current territorial structure, considering the different hierarchies of watercourses, the presence of an infrastructure of services and community facilities, the main activities and occupation patterns; (b) the fragility levels and the consequent carrying capacity determined for the section, assigning the highest density values for the areas with the lowest environmental fragility; and (c) the territorial design model, establishing that the growth and expansion of the residential area should be adapted to the characteristics of the wetland so that it continues to fulfill its ecological functions (Zagare, 2016a). The Management Plan proposes the concentration of indicators that define centralities in the most consolidated and less fragile areas, while setting different parameters for the most environmentally vulnerable areas (Figure 4.36). Between the areas with the highest level of human intervention and the most fragile ones, the Plan proposes zones that may serve as buffers between or a transition from these areas and that also create "natural reserve areas to promote the conditions of the Delta" (Municipio de Tigre, 2013c, p. 42).

Following these indicators, there is a established growth pattern towards the Northwest that is limited to the Southeast where the islands that are part of the Delta Front are located (Zagare, 2016a).

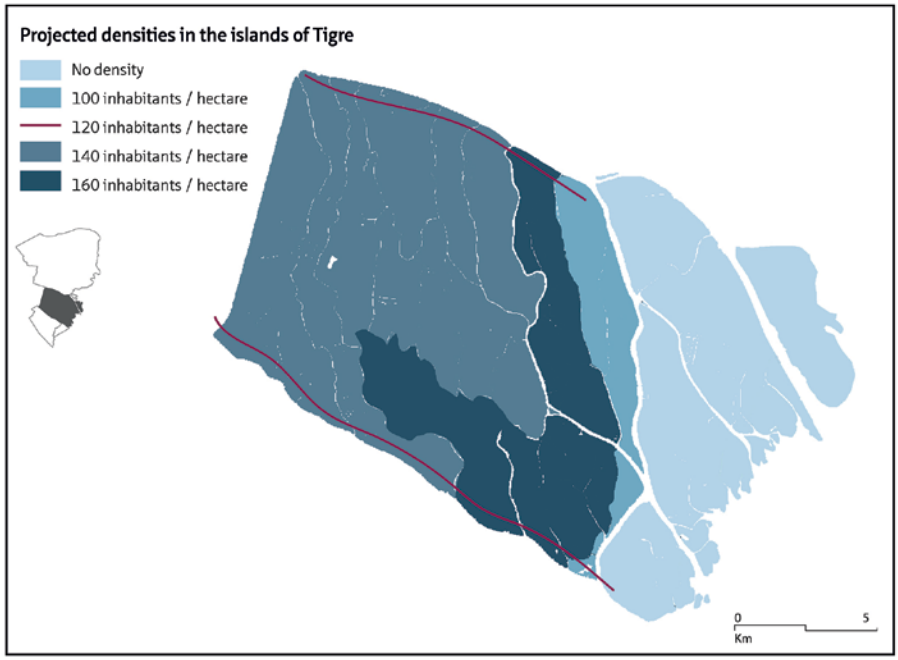

FIGURE 4.37 Projected densities for the islands of Tigre, according to the Management Plan. Design based on the Municipality of Tigre (2013).

Current population densities and future scenarios

In the Management Plan, the demographic development is considered fundamental in determining the wetland's carrying capacity, which is established by the use limit that supports the wetland without altering its functions. To evaluate the carrying capacity factors taken into account are environmental aspects, the type of occupation, and the potential of its use (Municipio de Tigre, 2013c, p. 18). The Plan clarifies that the land use patterns of the continent cannot be applied to the islands because they are incompatible, and this argument is one of the pillars of the normative change in the area. Two trend scenarios are established to estimate the carrying capacity according

to the demographic variable. A **first scenario** maintains a constant trend of land occupation; based on an area of 20 m^2 per person (Municipio de Tigre, 2013c, p. 17), it estimates a maximum population of 229,491 inhabitants, distributed at present as 21% permanent residents and 79% temporary inhabitants. It also adds the visitor population (without accommodation) to this figure, which represents 50% of the temporary inhabitants and amounts to 90,000 people.

By adding these values, in this first scenario, a population of approximately 319,491 inhabitants is added to the Delta of Tigre. A **second scenario** increases the percentage of the population derived from any tourist activity and reduces the residential population, reaching a population total of 382,161 inhabitants for the Delta. For the calculation of the carrying capacity derived from these scenarios, the consumption of water, food, and gas by the population was considered, as well as the generation of urban waste and household wastewater to estimate the cumulative impact. It is important to clarify that in the Management Plan the current population of the Tigre Delta (including permanent residents and visitors) is estimated to be 25,000 inhabitants (Municipality of Tigre, 2013d, p. 18). Consequently, both scenarios project significant population growth although the Management Plan does not specify the time horizon in which these estimated increases will take place, and as of now no monitoring systems have been designed or implemented to assess these changes as they occur.

The use of scenarios in the generation of the design model

Although two scenarios were established to estimate the cumulative impact of people inhabiting the territory, the use of scenario development methodology was not restricted to that single aspect in the Management Plan but was used as a tool for the discussion of the territorial occupation model for the area. Through a participatory process that included workshops with the presence of varied actors, a trend scenario and the desired scenario were generated around the discussion that took place regarding territorial conformation, in addition to physical-environmental and socio-economic development. The difference between the two scenarios is fundamentally based on the fact that the first scenario is the result of an analysis of current trends, while the second scenario is organized towards the sustainable development of the area and the protection of natural resources (Zagare, 2016a). According to the Plan, the desired scenario is: "flooded, insular, conserving island centers, respecting the wetland as a functional unit, ensuring environmental and landscape quality and protecting water resources, the coasts and biodiversity, the habitat and the dynamic interactions that give the wetland entity" (Municipio de Tigre, 2013c, p. 21) (Figure 4.37).

Rules regarding the zoning of the area

Regarding land use, the incorporation of the Tigre Municipality Zoning Code in Annex I "Territorial Ordinance Particularized for the locality of the Tigre Delta" establishes new areas as all the islands were previously classified as "Rural: Zone A2". These zones are: (a) *Extra-urban Residential Zone* (**Zona Residencial Extraurbana**), composed by the

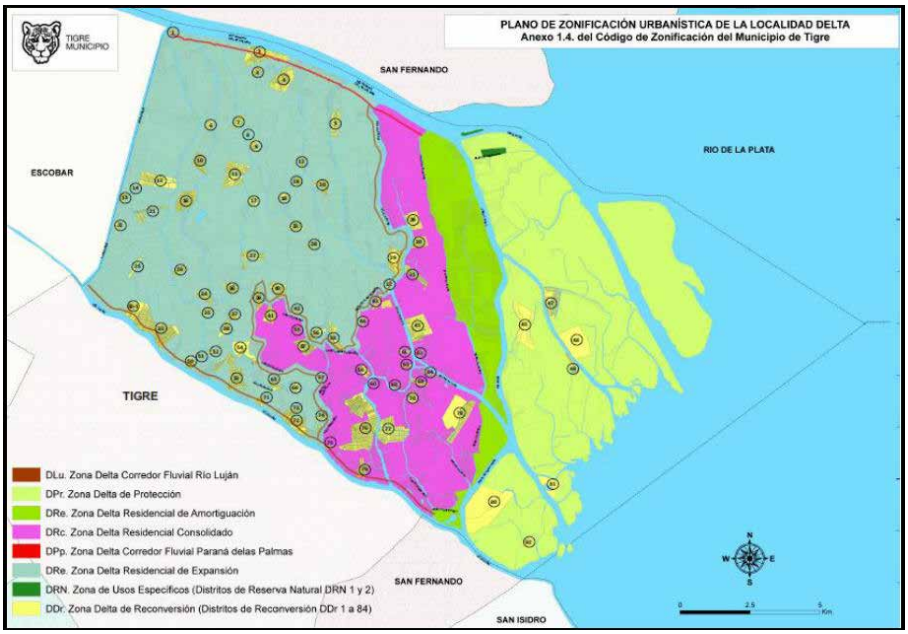

FIGURE 4.38 Zoning of the islands of Tigre. Source: Municipio de Tigre (2013, 46).

Delta Consolidated Residential Area (DRc), the Delta Residential Expansion Zone (DRe) and the Delta Residential Buffer Zone (DRa); (b) *Delta Area of the Fluvial Corridor* (**Zona Delta de Corredor Fluvial**), composed by the Fluvial Corridor of Paraná de las Palmas Zone (DCFp) and the Fluvial Corridor of the Lujan River Zone (DCFLu); (c) *Delta Reconversion Zone* (**Zona Delta de Reconversión**) (DDr); (d) the *Zone of Specific Uses* (**Zona Usos Específicos**), or Natural Reserve Districts (DRN); and finally (e) *Reserve Zone* (**Zona de Reserva**), which is the Protected Delta Zone (DPr) (Figure 4.38).

The zoning reflects the area's future growth intentions and, in turn, establishes the necessary restrictions to achieve the protection of the wetland's most vulnerable sectors. Comparing the urban indicators that governed the Zoning Code of the Municipality of Tigre with the indicators of the new zones, shows that the maximum

density (previously set at 40 inhabitants/hectare) is considerably increased in the *Extra-Urban Residential Zone* and in the *Delta Area of the Fluvial Corridor* (where they have 160 inhabitants/hectare and 120 inhabitants/hectare respectively). Likewise, density is restricted in the *Delta Reconversion Zone* to one single-family dwelling per lot and in the *Zone of Specific Uses* and *Reserve Zone* where settlements are not allowed.

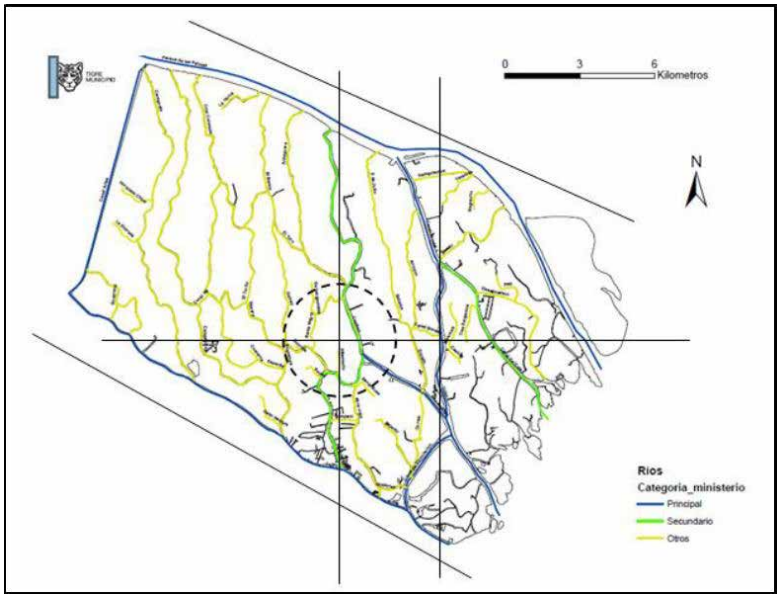

FIGURE 4.39 Territorial structure and hierarchies of water courses. Location of the projected Civic Center area, design based upon the Municipality of Tigre.

Change of structure and dynamics on the islands: The project to create the civic center

As indicated above, the Management Plan proposes growth in the most consolidated areas of the islands, sectors that were chosen for their environmental characteristics, their infrastructure and socio-economic development. Following these criteria, the Plan proposes the creation of a Civic Center on the islands, as well as sub-centers of services in the surrounding areas, which will generate a significant impact in the zone. This Civic Center would be located in the most consolidated area of the Delta, between the Rama Negra, Sarmiento and Capitán River channels (Figure 4.39). The foremost objective of the Center is to consolidate existing sub-centers that are currently spatially fragmented. Through a series of connections (trails, elevated walkways, green corridors and service corridors), a cultural corridor will be developed connecting elements with heritage value that would end up consolidating the future location of the municipal

delegation. The Civic Center implies the construction of buildings to allocate both municipal space and other functions such as shops, cultural facilities and urban infrastructure, as well as all appropriate means of interconnecting transportation. Likewise, the impact of the transfer of a municipal delegation to the area and the incorporation of an increased supply of activities should be considered according to the proposed densities, as well as the area's carrying capacity to avoid negative consequences (Zagare, 2016a).

Specific conflicts within the area

It is clear that the primary conflicts that arise in Tigre are related to socio-spatial polarization and segregation, as a product of the territory's planning being driven by private interests (Figure 4.40). The continental area has presented an increase of low-density private developments as well as new high-density areas on the urban fringe and also in some neighborhoods of the Nordelta. The spatial conformation of the new developments together with the introduction of privately-built flood protections generate changes in the topography and produce alterations of hydrologic regimes and water runoff, resulting in severe floods and the heightened flood risk of surrounding areas (Figures 4.41, 4.42). This phenomenon increases the demand for local governments to develop infrastructure to mitigate negative externalities and to integrate the different sectors of society, which are separated by long walls. The increase of informal settlements also contributes to socio-spatial segregation causing insecurity problems, pollution, and poor sanitary conditions.

On the islands, although there has been a sustained reduction of inhabitants for the last 70 years, a densification process is taking place as a consequence of touristic activities. During the weekends, the population of the islands (estimated at 5,668 inhabitants) duplicates due to the arrival of temporary visitors (Municipio de Tigre, 2012, p. 50). This increase encourages the development of touristic facilities and also the development of private neighborhoods emulating the pattern implemented in the continental zone (Figure 5 43).

FIGURE 4.40 Spatial fragmentation: view of the limits of gated community in the Municipality of Tigre (Zagare 2014).

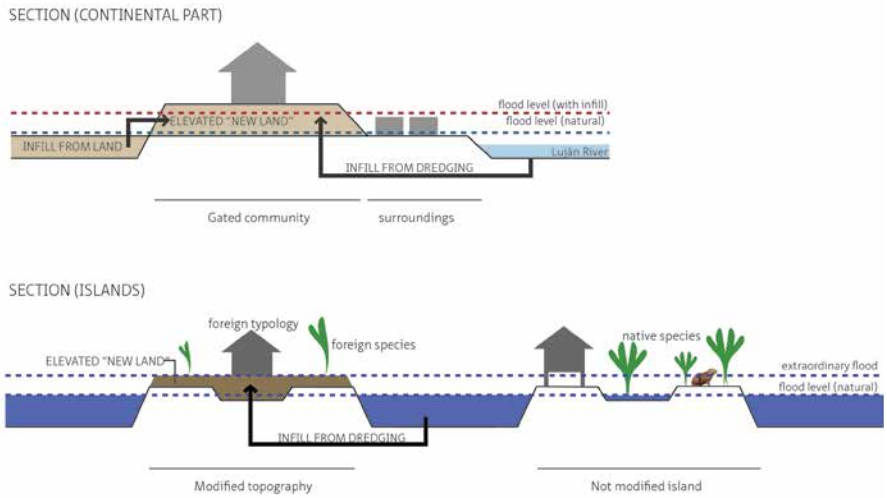

FIGURE 4.41 Section of a typical area of the continental part and islands of Tigre where gated communities are located above the level of the surroundings.

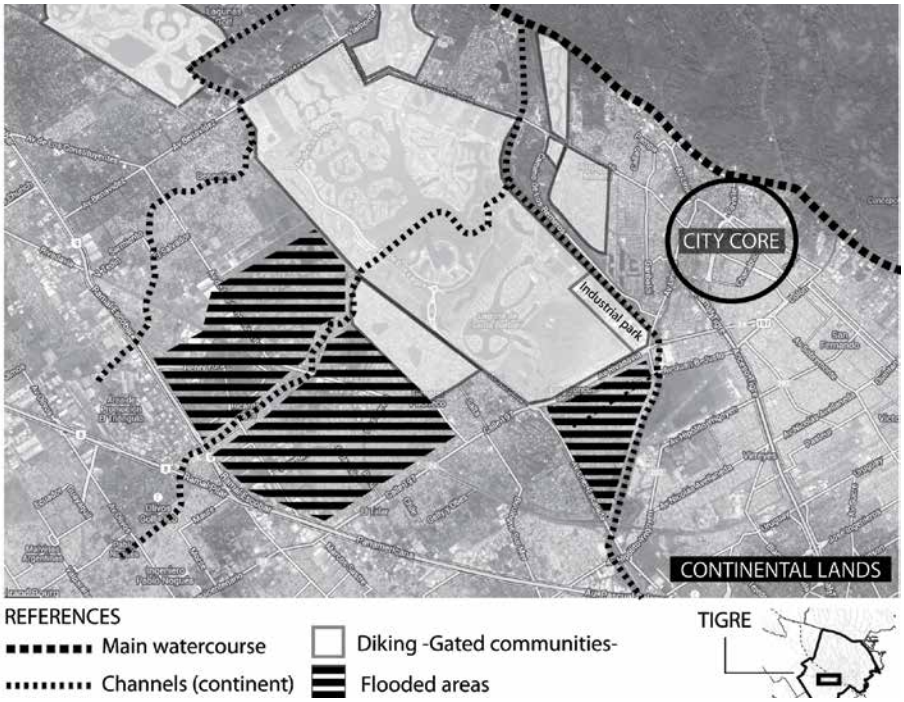

FIGURE 4.42 Floods in the continental area of Tigre due to the changes in topography and the blocking of water courses (Zagare, 2014a).

FIGURE 4.43 Private development on the islands of Tigre "Isla del Este" Google Inc. (2018) Google Earth (Version 7.3.1.4507) and Panoramio.

TOC

§ 4.6.2 The Municipality of San Fernando

The Municipality of San Fernando has particular geography. It presents a consolidated continental area of 23 km^2 along the coastline of the Lujan River and 924 km^2 of lands located in the second and third sections of the islands of the Lower Delta (Municipalidad de San Fernando, 2007, p. 6) (Figure 4.44). The population of the continental part of this area was 145,111 inhabitants in 2005 (Municipalidad de San Fernando, 2007) while on the islands it only reached up to 3,700 inhabitants (Municipalidad de San Fernando, 2000). It is relevant to point out that 98% of the population concentrates on the continental section of San Fernando, which represents around 2.45% of the municipality's area, when only 2% of the total population is on the island, representing 97.5% of the territory.

The first settlement named San Fernando dates back to 1802 when it was part of the Municipality of Las Conchas. In 1821 the area separated from it becoming part of a new region, called *San Fernando de la Buena Vista*. By the year 1822, the population of the area reached 1,276 inhabitants and was mainly located in the city on the continental part (Municipalidad de San Fernando, 2007, p. 9). The municipality grew and developed following the dynamics of the Metropolitan Area of Buenos Aires while the islands suffered an opposite process of depopulation due to the loss of productivity.

FIGURE 4.44 Location of the Municipality of San Fernando.

Located 16 km away from the continental core, the islands of San Fernando, as well as the islands of Tigre, were populated by aborigines and later received several colonies of immigrants mainly coming from Italy, Poland, Spain, Ukraine and Portugal. In the beginning, economic activities were related to the cultivation of fruits and vegetables, which were developed along the *albardones* (the highest perimeter areas of the islands) and later they also included livestock and forestry (Municipalidad de San Fernando, 2000, p. 94). At the end of the 19th Century, the first period of depopulation took place, spurred by economic difficulties, when the most severely hit region was the third section of the islands (the most remote areas of the Lower Delta).

Later, forestry became an activity to face the loss of competitiveness, mostly related to the extraction of cellulose for the paper industry. However, a subsequent crisis caused the second wave of emigration to the continental areas after 1950, when the population decreased from 30,000 inhabitants to around 3,058 (INDEC, 2001; Municipalidad de San Fernando, 2000, p. 71). To increase the island's population attempts were made to recover its competitiveness. The local government carried out initiatives such as the settlement of the town *Nueva Esperanza*, located on a strategic area of the islands, accessible by land and water, as a new center for productive developments (Figure 4.45). This town consisted of 1,122 dwellings and was created between 1992 and 1994 (Municipalidad de San Fernando, 2000, p. 99). Thus, as a way of recognizing, preserving and sustainably developing the islands, the local government approved the creation of the "Municipal Biosphere Reserve of the Paraná Delta" in 2000, through Ordinance No. 7470/2000. It was modeled after the Zoning

FIGURE 4.45 Sawmill in the town of Nueva Esperanza (Panoramio 2017).

Code and Land Use Regulation of San Fernando (Ordinance No. 589/1983, approved by Decree No. 1303/2000). In 2004, the area was included in the World Network of Biosphere Reserves of UNESCO's Man and the Biosphere Program (MAB), as a way to institutionalize the protection of the area and increase its potential. According to the Sevilla Strategy (UNESCO, 1996, p. 5), there existed a necessity to develop a new concept of the ecological reserve as a place for people to live and grow economically towards a more sustainable future, including areas of conservation and production.

As was previously addressed, the continental area developed according to the dynamics of the Metropolitan Area of Buenos Aires but was completely different from the adjacent department of Tigre. The topography has not been so altered by the construction of gated communities; on the contrary, the urban pattern follows the traditional Spanish grid but adapting to its coastal condition. The continental part of the department is clearly divided transversally by a railway and a highway into three areas that are not connected: one zone located in the East (between the coast of the Lujan River and the railway), another zone located in the center, between the railway and the highway, and a zone located in the West, between the highway and the Reconquista River (Figure 4.46). The most densely populated area is the center, concentrating 44.3% of the population, while the remainder, 55.7% is equally spread throughout the other two areas (Municipalidad de San Fernando, 2007, p. 11). The access to water and sewage is more than 90% in the three areas, as well as the percentage of houses with electricity. Nevertheless, the level of poverty reaches 15.3% yet the number of families living in informal settlements is 3,702, less than 3% of the department's total population (Municipalidad de San Fernando, 2007; Subsecretaría Social de Tierras, 2017).

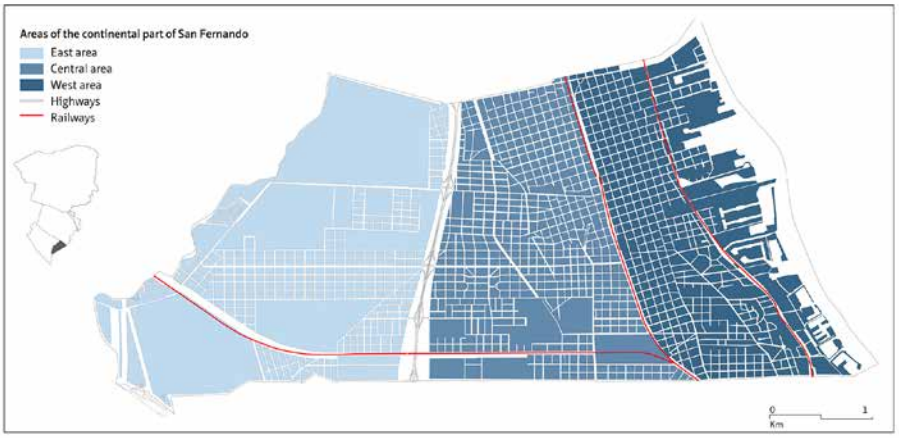

FIGURE 4.46 Areas of the continental part of San Fernando. Design based on information from the Municipality of San Fernando.

Land use policy

Ordinance No. 589/1983 establishes land uses in San Fernando (regulated by Decree No. 1303/2000). It establishes the instruments used to apply the ordinance following the principles of UNESCO's Sevilla Strategy formulated in 1995 for the conservation and sustainable use of Biosphere Reserves (UNESCO, 1996). It was also in 2000 when the *Municipal Biosphere Reserve of the Paraná Delta* was created through Ordinance No. 7470/2000. Land uses are also established through Ordinance No. 10049/2009, or the "Urban Development Plan of the Municipality of San Fernando", which identifies three categories of land uses: urban, rural and complementary. Urban land use applies to the continental area of the municipality, while rural and complementary uses occur on the second and third sections of the islands and are regulated by previously mentioned Ordinance No. 589/1983 and Decree No. 1303/2000.

The allowed densities of the continental area oscillate between 130 up to 1,400 inhabitants/ha, while on the Complementary sector of the islands population densities vary from 100 up to 150 inhabitants/ha. According to Ordinance No. 589/1983 and Decree No. 1303/2000, the second and third sections of the islands are separated into three zones: Core Zone (A); Buffer Zone (B); and Transition Zone (C) (Figure 4.47). The Core Zone is the most fragile area and includes the young lands of the Delta Front. The legislation does not allow any productive or residential activity in this area. In the Buffer Zone, the legislation allows uses such as forestry, agriculture and artisan activities compatible with a sustainable model, and also allows ecological tourism and recreation. At present, 1,500 hectares of this area are destined for production;

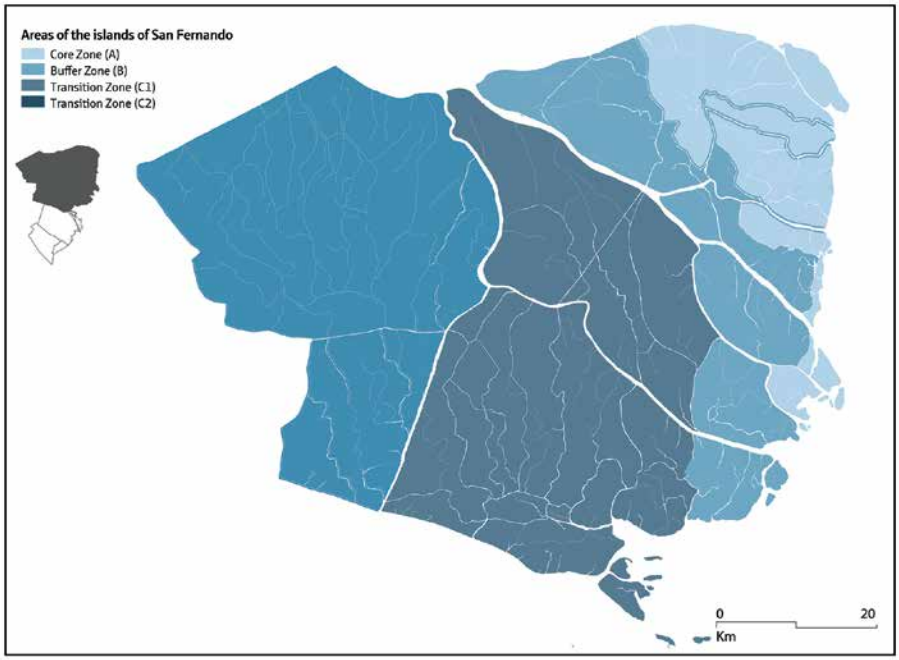

FIGURE 4.47 Areas of the islands of San Fernando. Design based upon information given from the Municipalidad de San Fernando (2000, 2004).

the average productive unit is 50 ha, and the number of producers reaches 30 (Municipalidad de San Fernando, 2000, p. 96). The Transition Zone is divided into two parts: in the first part, next to Buffer Zone (C1), the dominant commercial use is forestry and fruit cultivation, with complementary uses of rural micro-developments and artisan activities. The number of hectares destined for production is approximately 5,000; the productive unit on average is 20 ha and the number of producers reaches 250 (family businesses). Transition Zone (C2) includes cattle farming, forestry, and intensive and extensive agriculture as well as industrial developments for the processing of primary materials. The amount of land exploited reaches 8,800 ha and the average productive unit has an area between 70 and 200 ha; the amount of producers is 99 (Municipalidad de San Fernando, 2000, pp. 80, 96). The Transition Zone is the most populated area, with 3,451 inhabitants, while the Buffer Zone has 249 and the Core Zone does not contain permanent inhabitants (Municipalidad de San Fernando, 2000, p. 95).

Apart from the three mentioned zones, as it is established in Ordinance No. 10049/2009 the "Urban Development Plan of the Municipality of San Fernando",

there is also a distinction between Complementary and Rural areas[15]. These areas admit uses such as nautical urbanizations, permanent residential settlements, and eco-tourism developments and urbanizations, which have a maximum allowed density of 100, 150 and 100 inhabitants/hectare respectively (Kalesnik & Candel, 2004, pp. 185–196). The rest of the islands are considered Rural and do not permit any of those uses. It is relevant to note that the required level for settlements such as the ones previously mentioned is minimum 3.75 meters above sea level when the island levels go from 0. 5 and 3 meters (Kalesnik & Candel, 2004, p. 97).

Specific conflicts within the area

Despite its adjacency to Tigre, San Fernando has different conflicts. Although the urban fringe of San Fernando presents a compact grid with almost no presence of gated communities, it shows spatial discontinuities due to the presence of the railway and the highway, which separate the territory into three zones. The area located in the East (along with the coast of Lujan River) suffers from floods caused by Sudestadas, while the West area, located along the Reconquista River, gets flooded due to fluctuations in the river's streamflow. The middle area suffers both from Sudestadas and an increase in river streamflow, and an increasing level of precipitation that also causes floods in the three areas. Through an Urban Development Plan, local government have identified various challenges: (a) the lack of spatial connection between the three areas; (b) the need for increasing green spaces; (c) the need for coastline improvement; (d) the necessity of integrating informal settlements; (e) the recovery of the Reconquista River; and (f) flood mitigation.

On the other hand, the islands have lost their competitiveness due to the long distances they are located from the ports and the high costs of transportation, which makes it difficult for small developments to be profitable. Also, the increase of intensive agriculture and the change from small productive units into large ones has encouraged the arrival of new actors to the territory in detriment to the establishment of traditional family farms. The depopulation process and productivity loss can be counteracted through the implementation of strong measures, accompanying the initiative of the introduction of the islands to UNESCO's Reserve World Network. This is a serious initiative that is expected to play a significant role as an instrument for the area's development.

15 Complementary areas are the 100 meter-fringe located along the main rivers and canals (Carabelas River, Canal Alem, Arroyo Toledo, Canal N° 5, Canal Seoane, Paraná Guazú River, Paraná de las Palmas River, Paraná Miní River, Canal N° 4, Barca Grande River, Barquita River, Correntoso River, Canal Arana, Arroyo Chaná, Arroyo Caracoles, Arroyo Estudiantes, Arroyo Felicaria, Arroyo Fredes, Canal de la Serna, Canal Luciano and Arroyo Grande).

§ 4.7 Metropolitan Governance in Buenos Aires

Article No. 124 of the National Constitution empowers Provinces to create regions for economic and social development and establish agencies for those purposes (Congreso de la Nación, 1994). That article does not mean the creation of a new institutional scale of government but reinforces the power of the Provinces focusing on regions concerning social and economic aspects (Sabsay et al. , 2002, p. 41). The Regional Commission of Bermejo River[16] is one example of a regional agreement devoted to conducting an integral and sustainable development of the basin's water resources. Other examples are the Regional Environmental Accord for the North-West area, which was signed in 2000 with the aim of developing an environmental plan for the area[17] and the Patagonia Region Treaty[18], signed in 1996. Nevertheless, even though the Metropolitan Area of Buenos Aires is the larger conurbation of the country, it does not have any metropolitan entity or organization in charge of the management of the area (Clichevsky, 2002, p. 31).

As it was already mentioned, the Metropolitan Area of Buenos Aires is constituted of 24 municipalities in the Province of Buenos Aires and the city of Buenos Aires (which has the political and administrative entity of a province), converging within a functional area in constant expansion. Furthermore, beyond the Metropolitan Area of Buenos Aires, the Metropolitan Region of Buenos Aires can also be distinguished. As it includes 16 additional municipalities and adds around an additional 11,000 km^2 (Subsecretarias de Planeamiento y Urbanismo y Vivienda del Gobierno de la Ciudad Autónoma de Buenos, Aires, & Gobierno de la Provincia de Buenos Aires, 2008, pp. 1–2). Therefore, the conflicts that emerge within the area fall under national, provincial and municipal concerns, which gives rise to a complex governance scenario. According to Sabsay et al. (2002, p. 14), this institutional overlapping not only reduces the possibilities of integration but also affects local capacities.

Even though an institutional entity to conduct metropolitan affairs is lacking, a recognition of metropolitan dynamics emerged in the 1940s, when, through Decree No. 70/1948, the provincial government distinguished the area of "Great Buenos Aires",

16 The Bermejo River Basin covers areas in the provinces of Chaco, Formosa, Jujuy, Salta, Santa Fe and Santiago del Estero, which signed this agreement with the Nation to establish the Regional Commission in 1981.

17 The area included in the accord is formed by the provinces of Salta, Tucumán, Jujuy, Santiago del Estero and Catamarca.

18 The provinces included are Tierra del Fuego, Chubut, Río Negro, Neuquén and La Pampa.

consisting of 14 municipalities[19] (Gobierno de la Provincia de Buenos Aires, 1948). During that year, a Study for the Plan of Buenos Aires (Estudio del Plan de Buenos Aires –EPBA-) was developed, which despite its short duration (it was dissolved one year later), laid out the foundation for the initiatives that were carried on during the following years (Liernur & Aliata, 2004, p. 204). In 1962, a Director Plan was carried on by the Organization of the Buenos Aires Regulatory Plan (Organización del Plan Regulador de Buenos Aires –OPRBA), which was approved by Ordinance N°9064/1962. Although this plan was developed within the Municipality of the City of Buenos Aires, it included structural guidelines on the metropolitan and regional scales and addressed measures regarding transportation, environment and Urban Renewal (Gonzalez & Charriere, 2013, p. 14; Liernur & Aliata, 2004, p. 204; Sarrailh et al. , 1968). The institutional organization efforts carried on in that decade were also materialized with the creation of the Regional Office of the Metropolitan Area (Oficina Regional del Área Metropolitana -ORDAM-), by an initiative of the National Council of Development (Consejo Nacional de Desarrollo -CONADE-). Another initiative was the development of the Habitat Coordination Program (Programa de Concertación del Hábitat - CONHABIT-), which developed the Study on the Metropolitan System of Buenos Aires (Estudio del Sistema Metropolitano Bonaerense -SIMEB-) (Clichevsky, 2002).

Concerning institutional organization, in 1979, the Under-Secretariat of Great Buenos Aires was created through Decree No. 760/1979 to provide the area with a functional organic structure, but two years later, Decree 753/1981 dissolved it (Gobierno de la Provincia de Buenos Aires, 1979). Undoubtedly, a relevant antecedent is the creation of the Metropolitan Area of Buenos Aires Agreement (Acuerdo del Área Metropolitana de Buenos Aires), signed by the National government, the Province of Buenos Aires and the City of Buenos Aires in 1984, to develop studies of the area, develop plans and programs and the elaboration of legislation regarding land uses, among other activities. Later in 1987, the Ministry of Interior (Ministerio del Interior) was convened to conduct those actions, subsequently constituting the Political Committee of the Metropolitan Area of Buenos Aires (Comité Político del Área Metropolitana de Buenos Aires -CONAMBA-). One of the actions of this Committee was the proposal of the "Law for the Metropolitan Area of Buenos Aires", an instrument that was never introduced in Congress but that signifies an effort to organize the area (Clichevsky, 2002, p. 31; Sabsay et al. , 2002, p. 32).

19 Avellaneda, 4 de Junio (today called Lanús), Lomas de Zamora, Matanza, San Martín, Vicente López, Quilmes, Esteban Echeverría. , Florencio Varela, San Isidro, San Fernando, Morón, Las Conchas (later called Tigre) and General Sarmiento (which was dissolved in 1994 by provincial Law No. 11551/1994 -Gobierno de la Provincia de Buenos Aires, 1994-, splitting it into three municipalities: José C. Paz, Malvinas Argentinas and San Miguel).

Going back to the distinction made by Martín Mateo & Allende Landa (1986) of the three primary governance types of metropolitan spaces, it is possible to see an example of the second kind, where metropolitan agencies are created for specific purposes. This is the case of the Central Market Corporation (Corporación del Mercado Central), constituted in 1967; the Ecologic Coordination of the Metropolitan Area Public Society (Coordinación Ecológica del Area Metropolitana Sociedad del Estado –CEAMSE-), created in 1977: the Tripartite Entity of Sanitary Works and Services (Ente Tripartito de Obras y Servicios Sanitarios –ETOSS), established within the framework of the State Reform Law 23696/1989: the Executing Committee of the Environmental Plan and Management of the Matanza-Riachuelo River Basin (Comité Ejecutor del Plan Ambiental y del Manejo de la Cuenca Hídrica Matanza-Riachuelo) constituted in 1993; the Entity for the Regulation of Transportation in the Metropolitan Area (Ente para la Regulación del Transporte en el Area Metropolitana -ECOTAM-) created in 1998; and the Agreement of Air Monitoring Plan for the Petrochemical Complex Dock Sud (Convenio Plan de Monitoreo Conjunto del Aire para el Area del Polo Petroquimico Dock Sud), created in 2000 (Clichevsky, 2002, p. 31; Pirez, 2002, p. 152; Pedro Pírez, 2000; Sabsay et al., 2002, pp. 24–31; Subsecretarias de Planeamiento y Urbanismo y Vivienda del Gobierno de la Ciudad Autónoma de Buenos et al., 2008).

§ 4.7.1 Legal considerations regarding provincial capacities and limitations

Sabsay, García, Nápoli, & Ryan (2002, pp. 67) recognize three systems of territorial conformation in Argentina regarding municipal competency related to the government. In the first system, called "urban center", the municipal territory covers only the urban area while the other areas (mainly suburban and rural) fall under the province's jurisdiction. In the second system, called "partido or municipality", several urban areas, including their surroundings (suburban and rural lands) are under the municipality's jurisdiction. The result is that the entire territory is under both provincial and municipal jurisdiction, which is conducive to the emergence of conflicts. In the third system, the municipality's territory concerns the urban center, planning an expansion around it as a reserve, to adapt to future growth. The provinces of Santa Fe and Entre Rios are organized using the first system with an "urban center" while the province of Buenos Aires embraces the second system of "partido or municipality".

The province of Buenos Aires, the autonomy of its municipalities is not recognized. The reform of the National Constitution (1994) establishes this autonomy in other areas of the country, but because Buenos Aires' provincial constitution dates back to 1933 and has not been modified since, this requisite was not initially taken into

consideration (see the Decree-Law No. 6769/1958). Contrary to Buenos Aires province, the provinces of Santa Fe and Entre Rios do recognize municipal autonomy in their Municipal Organic Laws (Ley Orgánica de Municipalidades, No. 2756/1986 and No. 10027/2011 respectively). Regarding environmental protection, a study by Sabsay, García, Nápoli, & Ryan (2002, pp. 65–67) shows that although there are a large number of faculties delegated from the province to the municipal government because there is no recognition of municipal autonomy that only increases their scarcity regarding legal concerns.

In terms of regional accords, the Province of Buenos Aires' Constitution does not set considerations on the capacity of its municipalities to establish formal agreements with other jurisdictions within the country but declares that local authorities can constitute inter-municipal consortiums. For example, the municipalities of San Fernando, San Isidro, Vicente Lopez, and Tigre created the Consortium of the "Northern Metropolitan Region" (Region Metropolitana Norte) with the aim of resolving common issues (Sabsay et al. , 2002, p. 70). Regarding Delta issues within the limits of the Province of Buenos Aires, the "Consejo Intermunicipal del Delta" CONINDELTA (Inter-Municipal Council of the Delta) can also be mentioned, this institutional agreement, however, has not played a relevant role within the area's governance.

§ 4.7.2 Governance structure in the Paraná Delta

Regarding the different levels of governance, the entire Delta area is situated under the jurisdiction of the national State and the three provinces of Buenos Aires, Santa Fe and Entre Ríos. Within the Province of Buenos Aires' jurisdiction, lay nine municipalities along the edges of the Paraná Delta. Two of those municipalities belong to the Metropolitan Area of Buenos Aires (Tigre and San Fernando), and another two municipalities belong to the Metropolitan Region of Buenos Aires (Escobar and Campana). The remaining municipalities, although not officially part of the Metropolitan Area or Region, are part of the emerging dynamics of the regional connections along the Delta's axis (San Nicolas, Ramallo, San Pedro, Baradero and Zárate). In the Province of Entre Rios, the delta extends along six municipalities (Paraná, Diamante, Victoria, Gualeguay, Gualeguaychú and Ibicuy Islands) and in the Province of Santa Fe spans across four municipalities (La Capital, San Geronimo, San Lorenzo and Rosario). The Delta's management is undoubtedly complex as it crosses territories that fall under national laws and regulations, **three** different provincial governments as well as **nineteen** cities.

There is no institution in charge of the Delta's integral management at the national nor the provincial level. According to Article No. 124 of the National Constitution, provinces have the original domain of natural resources, but the State has competence in the area through different agencies and programs. At the national level, the Plan for the Sustainable Management and Conservation of the Paraná Delta Region, PIECAS-DP (Plan Integral Estratégico para la Conservación y Aprovechamiento Sostenible del Delta del Paraná) is the only existing environmental legislation for the complete Delta area. It was developed as a joint action between the national State and the provinces of Entre Ríos, Santa Fe and Buenos Aires. There, the coordination among all scales of government is established, although this level of interaction is difficult to implement in practice (Secretaría de Ambiente y Desarrollo Sustentable de la Nación, 2008, p. 124; Zagare et al. , 2014a). At the National scale, other agencies intervene in the area, such as the National Parks Administration (Administración de Parques Nacionales APN), the National Institute of Agricultural Technology (Instituto Nacional de Tecnología Agropecuaria INTA), and the Ministry of Agriculture, Livestock and Fisheries (Ministerio de Agricultura, Ganadería y Pesca). These agencies can be distinguished as well as some national policies and programs for promoting production activities (PROSAP - Programa de Servicios Agricolas Provinciales) (Zagare et al. , 2014a, p. 124).

At the provincial level, the government of the Province of Buenos Aires created the "Consejo Intermunicipal del Delta" CONINDELTA (Inter-Municipal Council of the Delta) through Provincial Decree No. 2064/1970 (and the modifications of Decrees No. 7881/1972 and 10003/1983). It comprises the mayors of the nine municipalities of the province of Buenos Aires that have territory in the Delta (San Nicolas, Ramallo, San Pedro, Baradero, Zárate, Campana, Escobar, Tigre and San Fernando). It would be "*in charge of the study, planning and all management related to the problems that affect the region of the Buenos Aires Delta and its inhabitants*" (Gobierno de la Provincia de Buenos Aires, 1970). The Decrees established that CONINDELTA must be directed by one of the mayors, elected by a majority, whose position lasts one year. They could have their own budget, administrated by the Municipality whose major directs CONINDELTA. At present, the council has had the same president since 2012 and has played no significant role in the development or conservation of the area. Worth mentioning is that in 1993, the "Coorporación de Fomento del Delta Bonaerense" was created to stimulate private participation and generate -private associations that worked towards the "integral development of the Delta" (Decree 3803/1993). That Decree together with the Fund "Fondo del Delta Bonaerense", both dissolved through provincial Law 12355/1999 and were liquidated through Decree No. 248/1999.

The different levels of decision making that converge within the area of the Paraná Delta makes implementing legislation a challenging task due to differing viewpoints and the aims of national, provincial and municipal authorities (Zagare et al., 2014a, p.

124). That overlapping generates in some cases, legal voids and at times contradictory actions. For example, at the same level, some agencies devoted to the promotion of productive activities may develop programs to increase the exploitation of some areas, while other agencies associated with environmental conservation generate programs towards the preservation of those same areas. Also, at the local level, municipalities scarce economic resources present an obstacle for decision-making and implementing actions. Nevertheless, some efforts can be distinguished, such as the Comprehensive *Management Plan for the Delta of Tigre* developed in 2013 by the Municipality of Tigre. It was created to find equilibrium between territorial occupation of the Delta and preservation of its natural resources, recognizing the value that the islands have for the municipality and the region (Municipio de Tigre, 2013d).

Public-private cooperation

Despite the enhancement of power at the local municipal level, there are still discrepancies regarding the vision behind urban development and environmental policies. There are also gaps in the relationships between governments and stakeholders along political and territorial lines. Nevertheless, there is an emerging trend of development-oriented private-public partnerships though the process is presenting some accountability gaps, based on the power imbalance among actors. Thus, these programs do not work well in practice given the context of segmented views and an unresponsive planning framework.

The private sector that characterizes the Paraná Delta is very diverse, including from small cooperatives (such as the fisher's) and small producers (family economies) to institutions that gather large producers such as the Argentine Forestry Association (AFoA, Asociación Forestal Argentina) and the Rural Society of the Ibicuy Islands, among others (Machain, 2010; Zagare et al. , 2014a). In general, the production sectors differ in their knowledge and position regarding the environmental value of the Delta, the impact of their activities on nature and the internalization of the associated costs, depending on the activities they carry out, their level of information, their role within the market and the local and regional economy.

Different types of public-private participation can be distinguished in the Delta. On the one hand, national institutions such as the National Institute of Agricultural Technology (Instituto Nacional de Tecnología Agropecuaria INTA) and National Institute of Industrial Technology (Instituto Nacional de Tecnología Industrial INTI) promote programs to strengthen those who produce in the Delta (Zagare et al. , 2014a). On the other hand, provincial and local governments have the power to authorize infrastructure and developments, which generate additional types of public-private cooperation mainly related to large urban developments.

Stakeholder involvement

The severe effects that the advance of large-scale gated developments have produced in the continental area and the imminent negative externalities that some new developments will produce over the island's natural processes has encouraged the interest and active participation of civil society, resulting in the creation of different groups that hold political influence. These associations are mainly concerned about the environmental and social impacts that some activities and developments have, and also about lax environmental regulations asking authorities to assume a more proactive response concerning these issues. Among the activities performed within these environmental groups is the generation of further knowledge, working with producers to develop and implement sustainable production practices, spreading communication through social networks and the monitoring of the advance of harmful activities. At present, there are more than 35 civil society organizations working on the Paraná Delta and its surrounding areas.

The regime on Free Access to Public Environmental Information aims to guarantee the right of access to government information, either under the national, provincial or municipal spheres. Furthermore, there are several instruments of participation at local, provincial and national levels; Such as the Environmental Public Hearing process, which provides the community with the opportunity to be aware of the works, activities and projects that are currently being (or will be) developed, and to reflect on the positive or negative externalities of the implementation of those projects over the Delta (Tom Bucx et al., 2014a, p. 125). Nevertheless, the process of citizen participation in the decision-making process is still emergent, and new tools should be designed to act within the existent legislation as a way of increasing the level of community involvement while simultaneously legitimizing governmental actions.

§ 4.8 Dichotomies within the System

The combination of the ecological, infrastructural and occupational aspects previously described turn the Lower Paraná Delta into a complex system of interconnections that require an integral perspective in finding a way towards adaptation. Although the central dichotomy of this system relies on the coexistence of a rich environment with rapid on-going metropolitan processes, the contrasts go further than that. Some of the existing dichotomies are described below.

FIGURE 4.48 Dichotomy between the continent-island (Zagare, 2013)

§ 4.8.1 Continent vs. islands; environment vs. urban

A notorious contrast exists between the continental area and the islands of the Lower Delta (Figure 4.48). The population density of the continental part of the municipalities of Tigre and San Fernando is approximately 2,144 inhabitants/km^2 while the density of the islands only reaches 11 inhabitants/km^2 (INDEC, 2010; Municipalidad de San Fernando, 2000; Municipio de Tigre, 2013c). The differences between an almost pristine territory and a profound transformed one (either through patterns of compact urbanization or low density planned communities) are noticeable at first glance. This dichotomy makes this case a singular scenario requiring the development of strategies according to its characteristics. This means considering both the differences between the continent and the islands, the interactions that take place between them and the effects that activities have on other areas.

The Plan for the Sustainable Management and Conservation of the Paraná Delta Region, (Plan Integral Estratégico para la Conservación y Aprovechamiento Sostenible del Delta del Paraná, PIECAS-DP) is the principal legislation regarding the Delta at a national level, which establishes the guiding principles for the protection and sustainable development of the entire Delta zone. However, this plan does not consider the activities that are being carried out in the coastal territories, particularly in cities. The plan comprises the Delta basin establishing no connection between this legislation and the local norms regarding land uses. In the PIECAS-DP, the cited legislation addresses environmental aspects but not land uses and other issues. It is worth mentioning that the *Comprehensive Management Plan for the Delta of Tigre* (Ordinance No. 3343/2013, promulgated by Decree No. 176/2013) does establish the need to connect with the Integral Plan, but does not go further than that (Municipio de Tigre, 2013c, p.28).

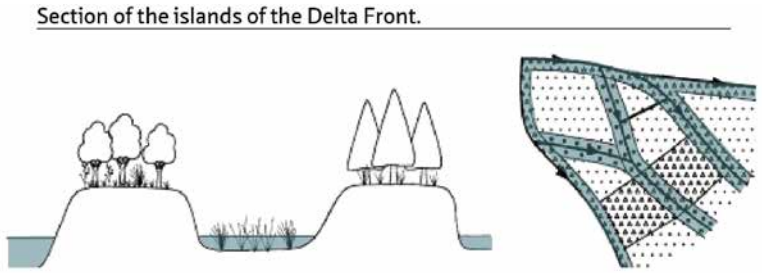

FIGURE 4.49 A section of an island on the Delta Front (I. Malvarez, 2007, p. 46).

§ 4.8.2 Floods as natural characteristics vs. floods as a threat

The main cause of floods, as was previously described, in the Lower Paraná Delta is related with the discharges of the Paraná and Uruguay rivers, which are affected by precipitation, and by Río de la Plata's currents and Sudestadas (Barros, Camilloni, & Menendez, 2003a; Zagare et al. , 2014a). The effects of these factors are also intensified by unsustainable land practices for residential and productive purposes. It is possible to distinguish two different realities regarding floods on the islands and the continental area.

On the islands, the natural cycles of floods and droughts determine the species that inhabit the area and also the kind of occupation and production practices suitable to them. Settling on the islands implies being aware of flood risks, so native constructions are specially designed on stilts to deal with rising water levels, and the inhabitants of the region are also used to these conditions and know how to best respond to them. Flood-proof infrastructure and water management on the islands is not implemented or regulated by the government; on the contrary, all the actions are carried on by individuals and are mostly focused on protecting small-scale production from water level variability and guaranteeing ancient production schemes. The islands of the Lower Delta are characterized by a depressed center surrounded by an *albardón*, an elevated natural dike that presents an approximated height of two meters above sea level (Alvarez, 2011, p. 7) (Figure 4.49). Residential settlements, as well as production plots, are located along the albardón. Regarding productive practices, according to the National Institute of Agricultural Technologies (INTA), there are two productive zones: The *Delta Front* (islands of Tigre and the Southern islands of San Fernando) and the *Forestry Nucleolus* (which covers the Northern islands of San Fernando).

In the Delta Front sector, the traditional production method is *zanja abierta* (open trench), which consists of regulating water levels through the use of trenches to water

and drain plots of land, complementing the system with pumps and gates or pipes. Each production unit generates its own scheme according to the types of crops being grown and to the development's economic equation. Due to the small dimensions of the plots, the many individual producers and the challenging economic situation, it is difficult to implement collective solutions (Alvarez, 2011). In the Forestry Nucleolus, the productive units require the development of infrastructure in conjunction with pumps, water and drainage, to counteract the periods of extreme floods and droughts (in which the water level has reached a maximum height of 5 meters above sea level in 1983 and 1998). Here, the main infrastructures developed to prevent floods are two types of embankments: *atajarrepuntes* and *dikes*. Both forms are usually constituted by natural sediments of the river (principally sand and mud), differentiating them by their size. While the atajarrepuntes can reach a height of 3.5 to 3.8 meters, the level of the dikes varies from 4.8 to 5 meters. The selection of each option as well as the design of the section is a decision made according to the cost-benefit analysis of the productive activity of each plot (Zagare, 2014a, p. 221).

Apart from the production initiatives, the islands are also being modified by the construction of residential developments. The level and sections of the islands are modified to create marinas, rowing clubs and large-scale residential areas, even reaching a level of 5 meters above sea level, to be even safer than required by legislation. These works are a consequence of the insertion of the typology of *gated communities* and Complementary Areas on the islands both of which are a result of the model of metropolitan expansion and the encouragement of local authorities to carry out these types of construction. In other words, traditional residential and production typologies coexist with flooding as a natural phenomenon. Therefore, flood-proof infrastructure falls under the scope of the private sector, which, in a context of lacking guidelines and low governmental control this implies harmful consequences for the wetland and the surrounding territories. Especially, considering that new actors are arriving at the Delta to carry out touristic or residential developments. Notably, the danger lies in developments employing practices that are typical in terrestrial environments yet are unsustainable for the wetland (Zagare, 2012).

Conversely, on the continental area, urban cores are subjected to regular floods as a product of the area's lack of adaptive planning and as a consequence of allowing the private sector to make urban planning decisions concerning the territory with little government oversight and without having an integral view of the entire area's needs. The urban fringes of Tigre and San Fernando are located between the original ravine and the right bank of the Paraná River in a Halo-Hydromorphic terrain (Bonfills 1962); A plain territory highly susceptible to flooding (Kandus et al. , 2009). The most densely populated areas are located there, requiring local governments to maintain an active presence and to provide the infrastructure that helps mitigate this dangerous situation.

The eastern part of the continental land (the waterfront along the Luján River) usually gets flooded as a result of the effect of the Sudestadas, while the western part is regularly affected from precipitation and the increase of another rivers' streamflow, such as the *Reconquista*. When both events coincide in time and place (A Sudestada increases the level of the Río de la Plata, blocking the city's drainage, while precipitation increases other river's streamflow) the situation is disastrous due to the collapse of the cities' drainage systems. At present, the main infrastructure the government has developed to address this problem is the construction of drainage channels and river tubing (Zagare, 2014a).

Nevertheless, the situation becomes even more problematic considering the existing spatial fragmentation (mainly in Tigre), unplanned urban growth and the prevalence of private interests concerning urban decision-making. In other words, gated communities are constructed by dyking areas to reach the safe levels required by existing legislation (Daniele, Rios, De Paula, & Frassetto, n. d. , p. 457) resulting in a mosaic of elevated private (protected) areas and depressed public (vulnerable) zones. The closed dikes block the land's natural drainage increasing the vulnerability of the surroundings affecting not only middle and high-income inhabitants but also affecting those from the most impoverished sectors who are the least prepared to counteract climate and sanitary contingencies.

§ 4.8.3 The formal vs. the informal

It is somewhat logical to think of illegal settlements as being "*informal*" and to think of gated communities as "*formal*", regarding legal frameworks and land markets. However, that distinction has intermediate connotations. Informal settlements usually take place when a group (organized or not) occupy public or private lands without accessing them through the formal land market. Often, those areas that lack formal infrastructure are environmentally and sanitary vulnerable. Inside these developments, an informal market is generated, with its own rules and without any government regulation or development.

Nevertheless, during the last decades, there has been a political intention to urbanize these neighborhoods to *turn informal into formal* to mitigate socio-spatial segregation, improve life quality, regularize tax collection and reduce crime rates. The National Law N° 24374/1994 established the Regime of Domain Regularization, which was later followed by Provincial Decree N° 2815/1996; this decree created the Secretary of Lands and Urbanism to apply that Law. Later, Provincial Decree N° 188/2011 created

the Social Urbanism Program, and Law N° 14449/2013 instituted the Access to Land Program, both aiming to integrate informal settlements into the formal scheme.

Gated communities, on the other hand, are "*inside the formal market*", being oriented towards accommodating the residential demand from the richest sectors of society. Notwithstanding, there are records of private developers engaging in informal practices during the installation of these neighborhoods, and of some difficulties regularizing the land's domain. Those practices are carried on thanks to the gaps, overlap, and contradiction of laws at the National, Provincial and Local levels. Some of the naturalized actions are the closure and privatization of public roads, the deviation of water courses (in spite of being public domain) and the illegal use of public infrastructure such as electricity or water supplies (Tella, 2011). Meanwhile, inside these developments, a new *formality* is created, through the development of internal rules, such as construction codes, housing rules, and statues that ignore their necessity to be part of the greater city (Zagare, 2014a, p. 222). Two contrasting processes shape a polarized metropolitan space full of inequities, and in the middle, there is a city which is clearly "*inside the formal scheme*" yet suffers from both of these conflicting processes.

§ 4.8.4 Navigation vs. environment

It is known that port activities generate positive and negative externalities within delta systems. They are a crucial factor for regional economic development, so they need to be linked with a robust multimodal transport system to establish connections between areas of production, industries and services, among others. The ports of the Río de la Plata and the Paraná River are vital to the area as they are part of the economic activities within the Mercosur network. They are expected to play an even more prominent role due to the development of the Paraná-Paraguay waterway. Still, that ship- channel project has generated praises and critiques. On the one hand, proponents for the waterway say that it positively affects economic development at the local and regional levels, and improves their connection with the Mercosur market, arguing that the port system has not reached its potential capacity (Zuidwijk, Ocampo, & Savarese, 2015). On the other hand, the critics of the waterway argue that the presence of these ships along the Paraná river produces negative externalities such as coastal erosion, need for constant dredging, loss of vegetation and water pollution, among other consequences (Moiraghi de Perez, 2010).

Concerning the harmful impacts on the river, there is not a unique perspective on the subject. Some studies reveal that the damage caused by dredging is not significant

and that erosion is related to natural river processes (Facultad de Ingeniería y Ciencias Hídricas, 2006). While other analyses argue that the works could cause problems and that more specific impact studies should be carried out to measure any real damage that has occurred because dredging could also cause a severe alteration in the streamflow of the internal channels (Moiraghi de Perez, 2010; Stancich, 2007). Apart from the practice of dredging itself, the waves that the ships generate as they navigate along the river can also cause the erosion of the river way. Water oscillation affects the shores thus affecting the ecosystem and causing the disappearance of coastal vegetation and animal species (Moiraghi de Perez, 2010). It also represents a danger regarding pollution and dissemination of diseases along the river.

§ 4.8.5 Fifth dichotomy: *Lots* of nature vs. *lack* of green spaces

Even though the Delta is an enormous green area with a privileged waterfront, the coastal cities do not have a fluid relationship with the water, and the public green areas have no spatial continuity towards the rivers. The privatization of the coasts, as well as the dominance of infrastructure development along the coastline over the last thirty years, hindered society's use of the space, which is only able to *reach* the water in specific places (Zagare, 2014a, p. 224). Marinas, gated communities, commercial facilities, amusement parks and rowing clubs occupy a large extent of the waterfront. Other land uses such as port activities and industrial poles also block access to the coast isolating the city from the river and vice versa. All the processes that take place on the continent such as the prevalence of private interests over land use planning, socio-spatial polarization, spatial fragmentation and vulnerability to flooding, have exacerbated due to the lack of spatial connections between the city and the river and also between the areas of the city itself. Public domain is an issue that needs to be addressed as water is considered a public good and access to it should be guaranteed at least in some areas of the departments. Spatial connections and the lack of green public spaces could be counteracted with strategies at the regional and local levels focused on connecting the fragmented territory through green areas and sustainable infrastructure that includes green methods of transportation and recreational areas, which could also contribute to the resolution of problems in the area regarding vulnerability and sanitation.

§ 4.9 Concluding Remarks

This chapter has exposed the principal characteristics of the Lower Paraná Delta as well as the main conflicts that arise as a consequence of the interrelation of different factors at the regional, metropolitan and local scales within territorial decision-making processes. It is true that every delta has its own specificities and that there is no one-fits-all solution. This case is an example of that concept for different reasons.

- It is a growing delta in a world of shrinking deltas, expanding towards the most important urban conurbation of the country and with the potential of generating a new waterfront in about a century.
- It presents a contrasting territory of almost pristine islands in front of densely populated cities characterized by dissimilar occupation patterns and high levels of socio-spatial polarization.
- It is a hard to manage territory as it falls under one national government, three provincial jurisdictions and nineteen local authorities that have to oversee large territories with limited economic resources. This level of complexity requires a robust cross-scale cooperation and cross-sectoral coordination that is not so easy to achieve.
- The participation of civil society in the decision-making process is not enough and has not been exploited to its full potential.
- Urban and environmental aspects are not integrated regarding legislation and also in reference to the cumulative impacts that derive from the interrelations among natural, infrastructural and occupational issues. This is a crucial factor regarding the impact that the advance of a metropolitan area could generate on a wetland in detriment to the environmental services that it provides.
- The increase of extreme hydrological events related to global warming and climate change in the area produces severe consequences not only for the natural landscape but also for urban areas, most of them located in lands susceptible to flooding and social vulnerability. The complete spectrum of the issues described above turns this particular case into a complex system in constant transformation due to the collision of natural and metropolitan dynamics at all levels, in a context of climate change. In consequence, it is necessary for the system to adapt to those transformations to become more resilient and to face a future full of uncertainties. The emerging metropolitan processes must be addressed in conjunction with the natural dynamics of

a changing delta through planning strategies that comprise all levels and include a wide range of actors, designed for this specific case but that are also able to be applied in other cases. To increase the adaptive capacity of these areas in these complex contexts, the inclusion of future scenarios in planning processes seems to be a useful method to prepare decision-makers and the community, in addition to making legislation more robust and adaptable. This thesis aims to develop and test that planning method. However, to do so, it is necessary to first delve into the natural and urban processes that occur in metropolitan deltas in addition to understanding the theories behind their complexity and the ideas that support planning strategies to deal with that complexity in the face of a changing and uncertain future.

The analysis of the Paraná Delta that has been presented in this chapter was structured in way to serve as input for the development of the scenario-based method that is designed in the next chapter, considering: the natural condition and drivers related to climate change; the networks and regional development, the process of urbanization, and the institutional context including governance issues. Thes four aspects of the delta analysed in this chapter, including the layer "governance", consider the methodological approaches addressed in Chapter 3 not only regarding concepts but also in terms of actor involvement and recognition of the relevance that social processes have on the area.

5 A Scenario-based Method for Participatory Design of Adaptive Spatial Plans

§ 5.1 Introduction

Previous chapters have discussed how emerging metropolitan deltas are complex adaptive systems that require the development of specific planning strategies to deal with and to adapt to constant and partly unpredictable changes. Davoudi et al. (2012) recognized that the high levels of environmental uncertainty and social change need a context of adaptation cycles where both dimensions (the ecological and social) intersect in a nuanced approach that addresses each dynamic. According to Boelens (2010), to reach a more active development-oriented approach, it is necessary to reconstruct territorial planning processes in an actor-oriented manner focusing on the reorientation of strategies, instruments and institutional settings. Nowadays, existing planning conditions in Tigre and San Fernando, characterized by a development-oriented approach with an emphasis on the activation of actors and relations, are conducive to the development of strategies into one single direction. This thesis proposes a method of participative, dynamic and immersive spatial planning based on the development of several co-created scenarios.

These scenarios aim to position the issues resulting from the interaction between actors and government agencies on the government agenda, providing both parties with the tools to deal with uncertainty through the early discussion of problems that can help generate possible solutions. To successfully achieve this outcome a key objective is to identify the shared values between different actors as a way to create a standard *knowledge and practice-based common narrative* regarding the territory. The design of this scenario method, therefore, focuses on the continued production of images to help construct a collective narrative as the basis for building a new one that can be widely accepted. It then becomes easier to find agreements and to discuss interventions, regulations and other actions as a way to legitimize adaptation measures over the territory. This chapter describes and analyses the method designed to accomplish that goal in order to study its advantages and limitations for future replication.

The method designed in this thesis was designed and implemented during a period of two years, from 2013 up to 2015, and included different stages of assessment, development of maps, and the convening of two workshops with the participation of key stakeholders of the area. The method consists of three stages: (a) a preliminary stage of diagnosis, (b) a second stage of development and implementation in which a series of participatory workshops took place, and, (c) a final evaluation stage. The design of this structure relies on the approach of, which is mainly focused on the generation of environmental scenarios, which has been interpreted, reinvented and expanded for subsequent implementation consistent with the particular context of the Lower Paraná Delta. The developed scenarios are a combination of exploratory and normative types. At the first stage, they are mainly qualitative but then they are quantified and translated into indicators and interactive maps.

Regarding policy, the scenarios addressed in this research are reference scenarios. The method presented in this thesis was designed considering planning, design and governance approaches addressed in Chapter 3. In the case study's context, (described in Chapter 4), there is a profound lack of resources and insufficient availability of official data. These issues may generate some difficulties when quantifying storylines and modelling the combined scenarios. The Lower Paraná Delta is also a vast territory that is increasingly becoming heterogenic, which makes it challenging to prepare complex models and to hold several meetings with the participation of stakeholders. There is also a lack of awareness concerning environmental hazards and the consequences of human activities, not only by citizens but also by governmental authorities. The planning context includes political decentralization and overlapping in competences of political-administrative boundaries, policy discontinuity, and emerging participation of civil society in the decision-making process. This complex governance structure must be faced through a method specifically designed to address environmental and urban dimensions of growth in the context of the uncertainty of climate changes.

Following Chapters 3, the method designed in this thesis aims to reach an integrated vision through collaborative planning exercises performed at the local level that do not change the existing governance structure but intervene in the relationships between actor-networks. Chapter 3 invokes the idea of phase transition where emerging metropolitan deltas as self-organized complex adaptive systems where a small change in the parameters can generate a qualitative change in the aggregate properties of the entire system (phase transition) (Durlauf, 2005, p. 227). In this sense, this thesis seeks to measure how far it is possible to develop these experiences and what effect they have on the area's planning context. It also generates a method that although originally designed for the Lower Paraná Delta, has enough flexibility to be replicated in other areas of the delta, or even in other contexts, having to be revised and adapted.

The method was structured following the Layer Approach, which was previously described, and led the assessment of the delta carried on in Chapter 4.

§ 5.2 A Scenario-based method for Participative Design of Spatial Plans in the Lower Parana Delta

§ 5.2.1 Preliminary diagnosis stage

In the initial diagnosis stage, an analysis of the two municipalities of the Lower Paraná Delta was developed, focusing on the environmental, socioeconomic and urban aspects of the area. This assessment also included a survey of national, provincial and municipal level environmental and urban regulations, an evaluation of secondary and tertiary impacts of climate change and how they affect the dynamics of the system, and a study of the network of actors and their interrelationships.

At this stage, the scenario team and scenario panel were defined. The scenario team consisted of three members responsible for coordinating the scenario's construction and who were expected to participate until the end of the exercise. An additional member in charge of modeling the scenarios who would join the team at the time the storylines would be quantified, and three other members who would be in charge of the facilitation of the workshops. Regarding the scenario panel, the selection was based on analysis done by the actor-network, to achieve the highest possible representation and inclusion of groups that are usually not considered in decision-making processes. Due to the extensive network of actors, the selection of such a small team was difficult to achieve but had to be done in an effort to help guaranty the possible realization of the upcoming scenarios that will be discussed and modeled through a participatory method. At first, the scenario panel consisted of 20 members predominantly selected due to their role within the area's actor-network in addition to their knowledge of the system. They were expected to participate in a first and second workshop; in the second one, this scenario panel was expected to reach 50 participants in order to broaden representation.

Apart from defining the scenario team and scenario panel, this stage also established the base year, timeline, area of study and the project's goals. For this case, 2015 was declared the base year for the scenarios, and the time horizon was 20 years (until

2035). The areas studied were the municipalities of Tigre and San Fernando both are located in the Paraná Delta Front and have continental lands and islands. The goals set for the scenarios were: (a) to generate a space of reflection and the construction of joint knowledge through the participation of governmental and non-governmental actors, academia, and other interested parties; (b) to define and align positions thinking spatially about the possible future agents of change influencing the territory of the Lower Paraná Delta; (c) to discuss the availability of data and the reliability of such information; (d) to analyze land use policy and its implications for environmental conservation and urban development; (e) to think about possible policies that may be developed in the near future addressing the changes in the territory.

§ 5.3 Stage I of Development and Implementation

After completing the preparation stage, the scenario team convened the first meeting of the scenario panel to build qualitative scenarios and construct the "zero order draft" of the storylines. That meeting consisted of a full-day workshop[20], which would be the basis for the generation of inputs for the next steps of the processes. During the morning, experts on environmental, urban and policy issues gave presentations regarding the area's problems to prepare members of the scenario panel for a three-stage open dialogue, which took place during the afternoon. First, the scenario panel with the help of the scenario team discussed the case study's main problems at the time of the base year and agreed on the identification of the key indicators that influence the area's future development. The issues were divided for discussion following the Layer Approach, with the introduction of the fourth layer of governance (see Appendix 1). The discussion then focused on the definition of causal connections that may lead the area to an undesirable scenario, and finally, the connections were analyzed to help create a desirable future scenario. The results included the joint construction of the future vision of the Lower Paraná Delta including uncertainties, trends and expectations. Also, the basis of a "zero order draft" of the storylines was generated then shaped by the scenario team into real storylines (narrations) that organized the previously delineated concepts. These qualitative storylines reflected path-dependent effects regarding an undesirable scenario, a desirable

20 The "Seminar- Workshop of Urban and Environmental Scenarios for the Lower Parana Delta" (May 10th, 2013) was organized by Lincoln Institute of Land Policies (USA), Fundación Humedales / Wetlands International Argentina, Delft University of Technology (the Netherlands), Universidad de Buenos Aires, Instituto Superior de Urbanismo, Territorio y el Ambiente (ISU), and Fundación Cambio Democrático.

scenario and identified the necessary actions to reach a desirable state. After developing the stakeholder workshop, the scenario team sent members of the scenario panel a copy of the storylines and their conclusions to revise them and consider any comments.

§ 5.3.1 Results of development and implementation of stage I

After the workshop, the scenario team incorporated the information generated at the meeting and finished shaping the storylines. The storylines were then analyzed, and a set of actions and recommendations to accomplish the desirable scenario were completed, addressing the strategic dimensions of the prospective method. A set of maps and diagrams were also designed to give a spatial perspective of the problem area according to each layer. Included in Appendix 1 is the diagnosis of the present situation and the "zero order draft" of storylines and final storylines.

§ 5.4 Stage II of Development and Implementation

This second stage of development and implementation was focused on developing the final scenarios through a collaborative process. To accomplish that objective, it was necessary to quantify the storylines produced in the first workshop to build indicators that are the basis for constructing scenarios in a Geographic Information System (GIS) platform. These GIS-based scenarios were not the final scenarios; on the contrary, they were just the starting point of an interactive process with the participation of the scenario team and the scenario panel during the second workshop.

The storylines were analyzed and conceptualized, revisiting the drivers of change identified in the area (Bucx, Makaske, Marchand, van de Guchte, & van Driel, 2012; Zagare et al. , 2014) and the indicators built from the storylines developed at the first stage. Subsequently categorizing them into the three original layers of the Layer Approach (substratum, networks and occupation) (Figure 5.1), and then incorporating a fourth layer (governance), which is considered when designing the indicators of all layers. The incorporation of this Layer is a crucial action to implement in this case, since legislation, political relations and governance are also part of the context of the case study influencing many of the interrelations within the system and also its evolution towards the future.

Main indicators analyzed by layer to be included in the GIS-generated maps
Substratum Layer a) Extent of the floodplains (the surface which is endangered and is flooded occasionally). b) Loss of wetlands (the surface of wetland that is lost due to the advance of embankments, dikes for production and housing purposes). **Networks Layer** a) Dikes and embankments (the area of new dikes for both forestry or private uranization and land embankments). b) Fluvial transportation (the degree of public transportation lines along the rivers and channels within the study area). **Occupation Layer** a) Production (the land used for forestry). b) Provate urbanization (the area occupied by private residential developments). c) Informal settlements (the area occupied by informal housing). d) [Enhanced] Consolidation of the islands (the area which could be further exploited fir turistic activities).

FIGURE 5.1 Main indicators by layer.

For each Layer, the two most representative indicators were mapped. First, a map of the current situation was created, as a starting point for a future discussion (Figures 5.2, 5.3 and 5.4). Second, three scenarios were developed for each indicator considering their possible future evolution within the time horizon set in the preliminary stage. The three maps showed possible future evolutions of low, medium and high impact for the relation matrix among the layers. Official data, together with an analysis of legislation, planning intentions derived from law projects and trend estimations helped to develop the indicator's projections.

Due to the high level of political decentralization, overlapping of competences and discontinuity of urban and environmental legislation, it was crucial to include policy into the scenario projections. Thus, it was possible to understand the connections and contradictions that take place in the area, the overlapping and the legal vacuums. The analysis of land use policy is essential at this stage because it regulates the limits for specific productions, occupations, density and level of protection of the natural landscape. The simulations were made on the basis of the maximum levels of production, occupation, and density levels allowed by law among others in addition to the trends reflecting these maximum amounts implemented. Consequently, the result was a combination of qualitative, quantitative and policy scenarios intending to cover all the complexity of the system and the different future combinations of the indicators' evolution within a real and possible scope.

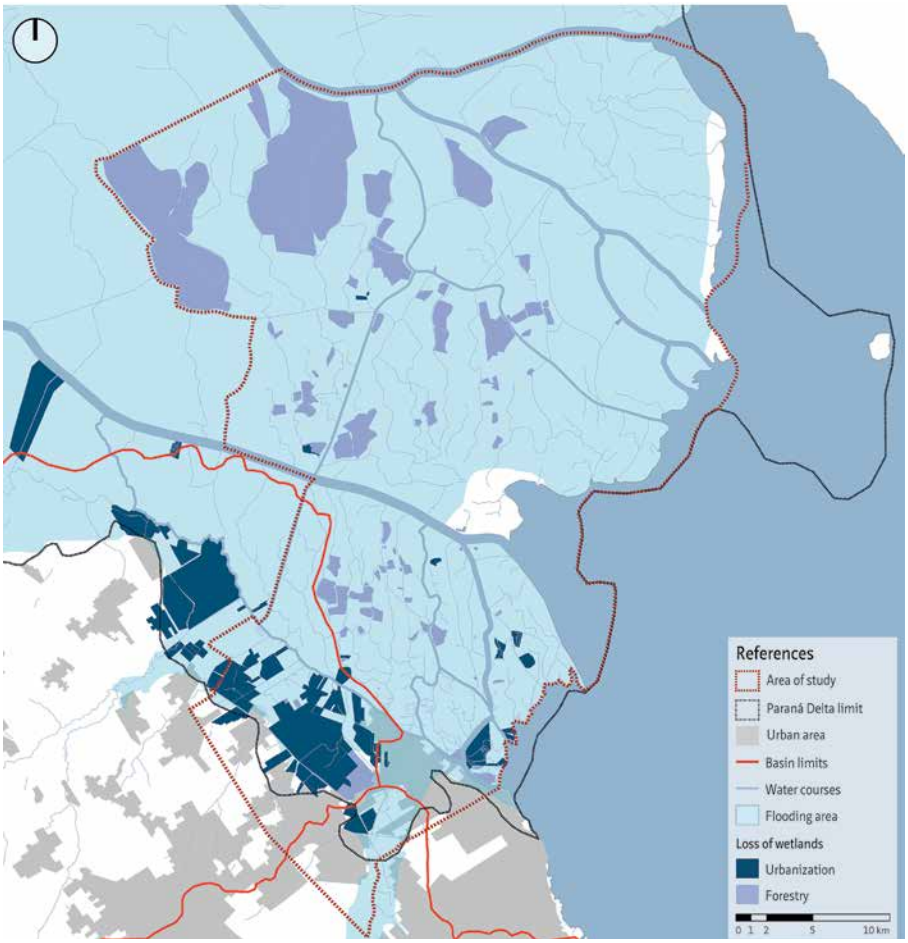

FIGURE 5.2 Map of the current situation. Substratum layer (Zagare, V. & Kesarovski T., 2015).

§ 5.4.1 Maps of the current situation

Substratum layer

The map shown in Figure 5.2 illustrates the situation regarding the indicators selected for the substratum layer, at the base year point. The pressures identified in this layer are related to the Delta's dynamic condition. On the one hand, high sedimentation rates are

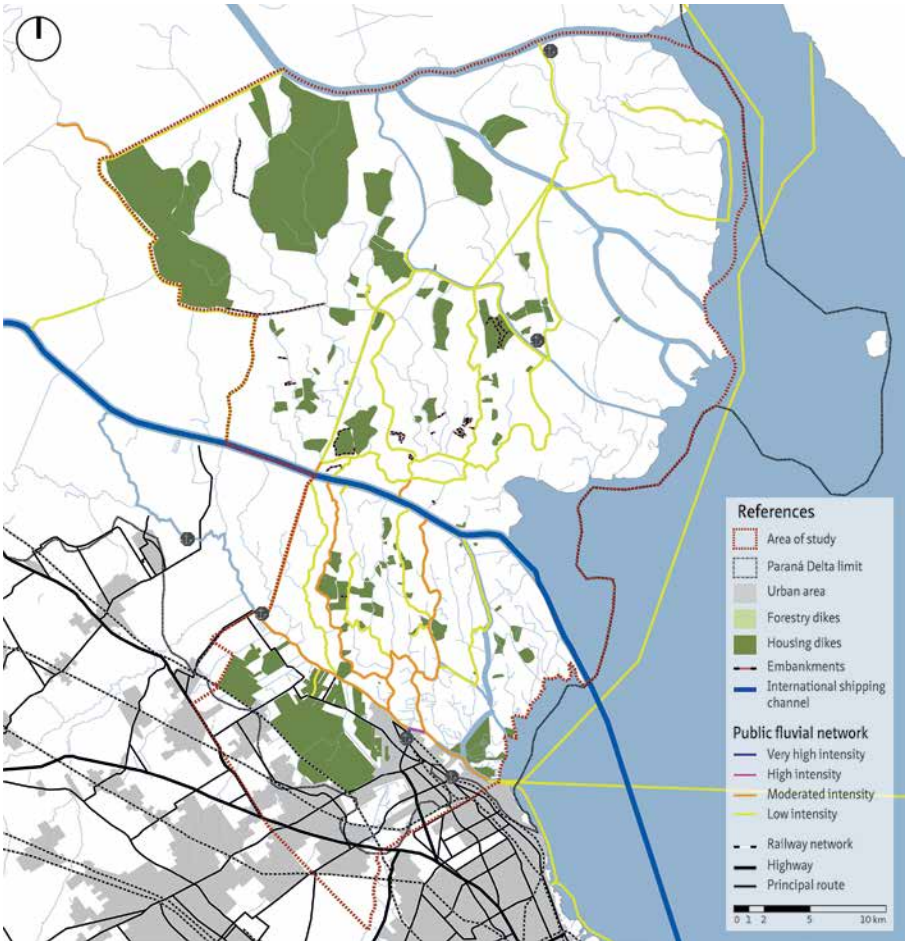

FIGURE 5.3 Map of the current situation. Network layer (Zagare, V. & Kesarovski T., 2015).

the main cause of an increase of the Delta area advancing the Delta Front towards the city of Buenos Aires coast's (Pittau et al. , 2004; Sarubbi, Pittau, & Menendez, 2006). On the other hand, the lack of control of land use changes and the increase of economic activities may cause a severe loss of wetland mainly related to endikements, which results in a consequent rise of water and soil pollution. Climate change expressed by extreme flood events results in the changes of hydrological cycles which also alters the topography of the Delta and jeopardizes the occupation of the lands.

The two main indicators (a) loss of wetlands and (b) the extent of the floodplains were mapped with certain difficulties due to the lack of official information, mainly related to the latter indicator. In that case, complicated estimations needed to be made respecting the extensions and levels of the floodplains, so the indicator could not be

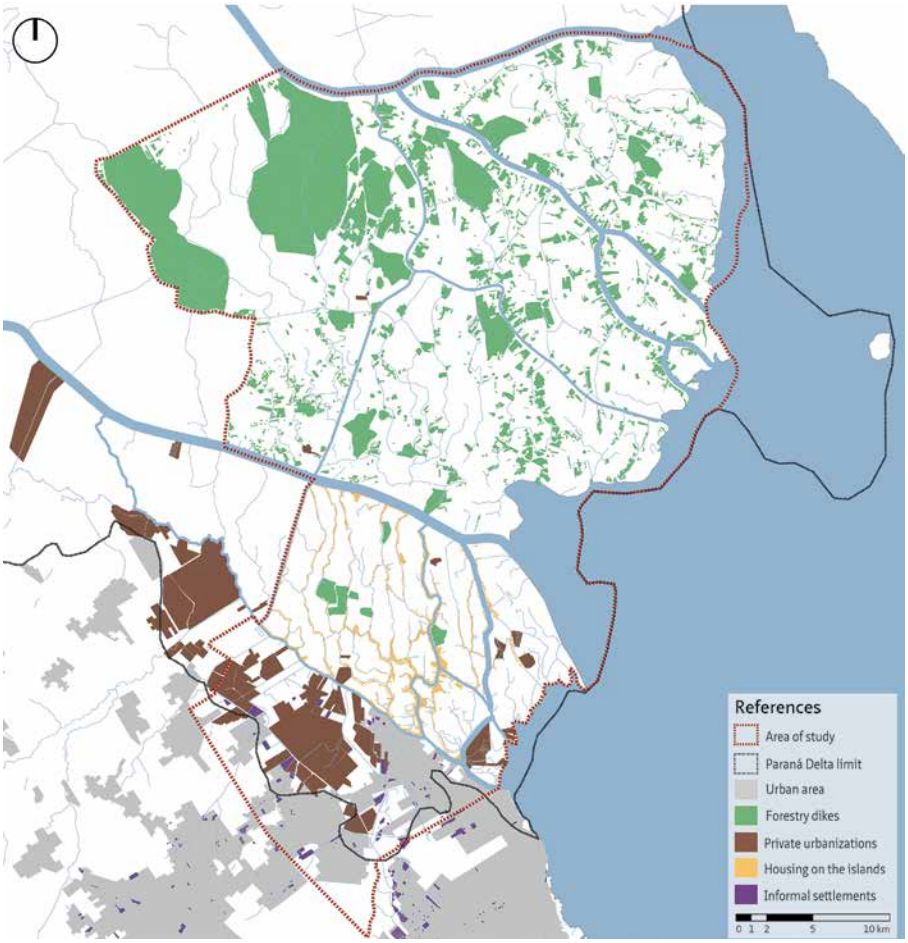

FIGURE 5.4 Map of the current situation. Occupation layer (Zagare, V. & Kesarovski T., 2015).

mapped with significant variations from low to high impact scenarios. On the contrary, the available information for estimating wetland loss was more accurate, making it possible to be mapped at around 22,500 ha. The mapping of the indicators is based on the assessments of the dikes for private urbanizations (Fabricante, Minotti, & Kandus, 2012; Minotti & Kandus, 2013), and the Strategic Outlines for the Metropolitan Area of Buenos Aires (Subsecretarías de Planeamiento y Urbanismo y Vivienda del Gobierno de la Ciudad Autónoma de Buenos Aires, & Gobierno de la Provincia de Buenos Aires, 2008). Additionally, it is based upon the project for diking and road construction developed within the Program for Sustainable Development of the Delta prepared by the National Ministry of Agriculture (Ministerio de Agricultura Ganadería y Pesca, 2011). The map also took into account the assessments presented in the Plan for the Development of The Islands of Tigre (Municipio de Tigre, 2012, 2013d), the document

for the incorporation of the San Fernando islands as a Biosphere Reserve within the MAB-UNESCO (Municipalidad de San Fernando, 2000) and the Zoning Code and the Urban Development Plan of San Fernando (Municipalidad de San Fernando, n. d. , 2009).

Network layer

The main pressures that influence the indicators chosen in the network layer were the unplanned and privately oriented construction of flood protections (a feature that characterizes the case study), which produces significant changes in the topography (Figure 5.3). A second pressure is derived from the growth of the Metropolitan Area of Buenos Aires and its regional network, which demand a robust transportation system (fluvial, terrestrial and aerial) within and outside the Delta area to guarantee effective communication. Finally, and related to the latter, the critical impact that the Paraná -Paraguay International shipping channel has on the entire Paraná Delta and its surroundings.

The mapping of the indicators for this layer showed (a) the dikes (22,500 ha) and embankments (42 km) within the area and (b) the fluvial transport system. Which also includes the Paraná -Paraguay international shipping channel and local transport defining the number of services as low (1-5 lines); medium (6-15); high (16-25) and very high (>25).

Occupation layer

The map of the current situation shown in Figure 5.4 focuses on occupation pressures related to the land use changes for production and residential purposes as well as the further consolidation of the tourism and services on the Islands of Tigre. The two significant indicators in this layer are: (a) a change in land use for forestation purposes (23,000 ha) and (b) a change in land use for residential purposes, divided into gated communities (4,750 ha) and informal settlements (365 ha). The two chosen typologies of residential use are relevant to study because of the reasons presented in Chapter 4 regarding the spatial polarization that characterizes the area. Besides, both types of residences (in both the high and low-income sectors) showed a remarkable increase during the last decades, and the trends are important to analyze in future scenarios. The urban pattern of the Metropolitan Area of Buenos Aires is also mapped together with the occupation patterns of the Islands.

§ 5.4.2 Map of scenarios for low, medium and high impact

Scenarios for the indicators of the substratum layer

The projections regarding the environmental layer specifically the loss of wetlands were estimated from studies and trends published in the assessments on the dikes for private urbanizations (Fabricante et al. , 2012; Fabricante, Minotti, & Kandus, 2015; Minotti & Kandus, 2013). The projections also considered trends regarding the

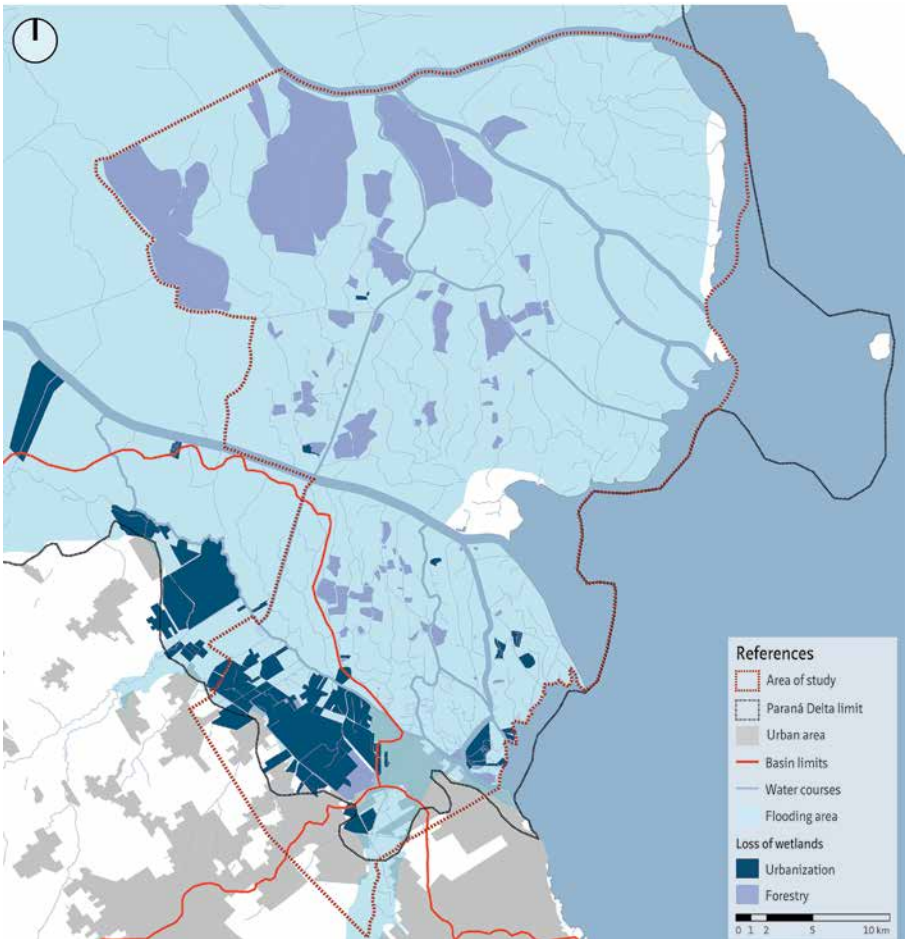

FIGURE 5.5 Map of the low impact scenario of the substratum layer (Zagare, V. & Kesarovski T., 2015).

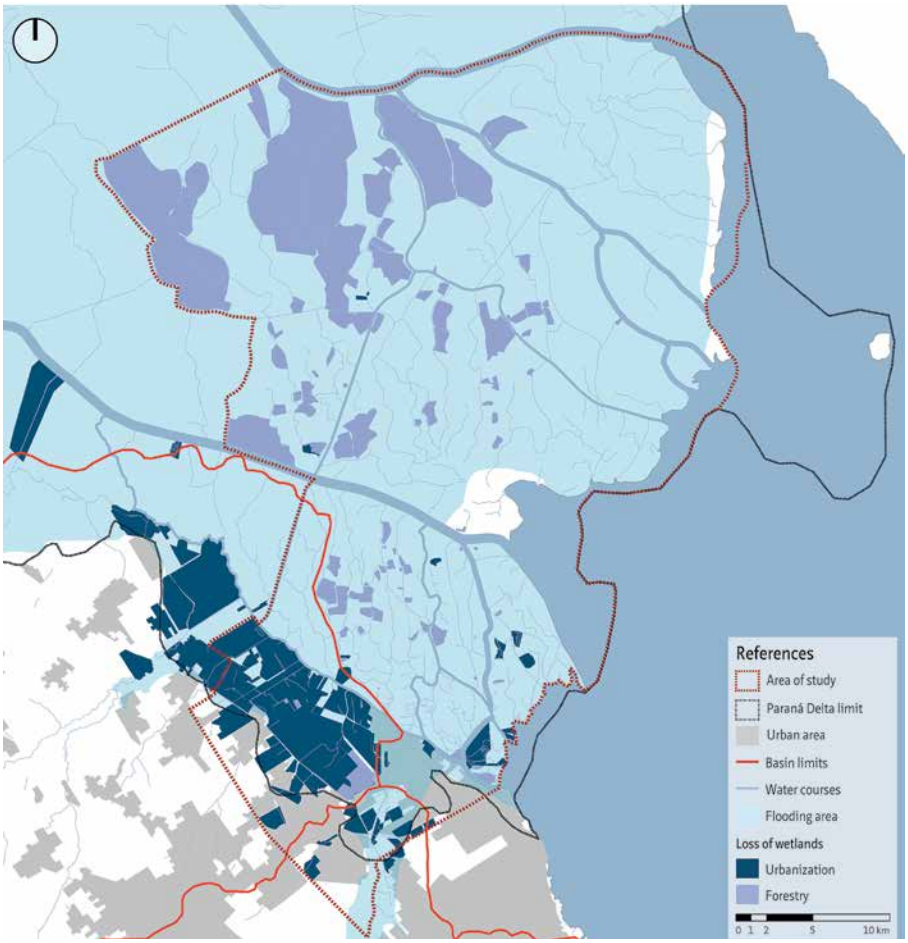

FIGURE 5.6 Map of the medium impact scenario of the substratum layer (Zagare, V. & Kesarovski T., 2015).

advancement of urbanizations described in the Strategic Outlines for the Metropolitan Area of Buenos Aires (Subsecretarías de Planeamiento y Urbanismo y Vivienda del Gobierno de la Ciudad Autónoma de Buenos Aires et al. , 2008) and from the project for dyking and road construction developed within the Program for Sustainable Development of the Delta prepared by the National Ministry of Agriculture (Ministerio de Agricultura Ganadería y Pesca, 2011). This data was also combined with the Land Use Legislation of Tigre and San Fernando, specifically the Plan for the Development of The Islands of Tigre (Municipio de Tigre, 2012, 2013d), the Normative on Land Uses and the Construction of Tigre (Municipio de Tigre, 2013b, 2013a) the document for the incorporation of San Fernando islands as a Biosphere Reserve within the MAB-UNESCO (Municipalidad de San Fernando, 2000) and the Zoning Code and the Urban Development Plan of San Fernando (Municipalidad de San Fernando, 2009).

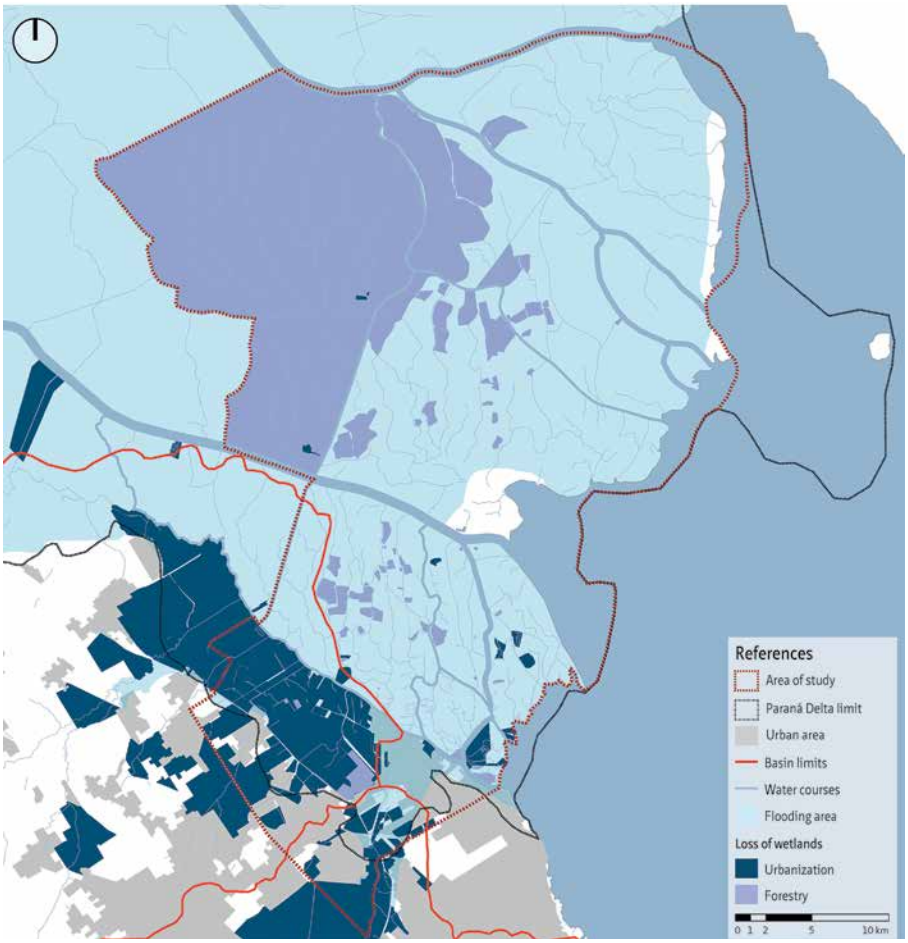

FIGURE 5.7 Map of the high impact scenario of the substratum layer (Zagare, V. & Kesarovski T., 2015).

Based on the described sources, the estimated changes regarding the loss of wetlands range from a 2,500-ha increase (slightly more than 10% of the current area) extending up to a total of 25,000 ha of lost wetlands for a low impact scenario. For a medium impact scenario, estimates range from a 7,500-ha increase (around 33% of the current area) reaching a total amount of 30,000 ha and for a high impact scenario range from a 25,000-ha increase (around 110% of the existing area) to a total amount of 50,000 ha.

Concerning the second indicator (the extent of the floodplains) it was difficult to generate a different simulation of each scenario due to the lack of information available. For that reason, the scenarios considered a flooded area, considering extreme situations when there is a combination of southeastern winds (Sudestadas) and heavy rainfall. The result was an almost entirely flooded floodplain.

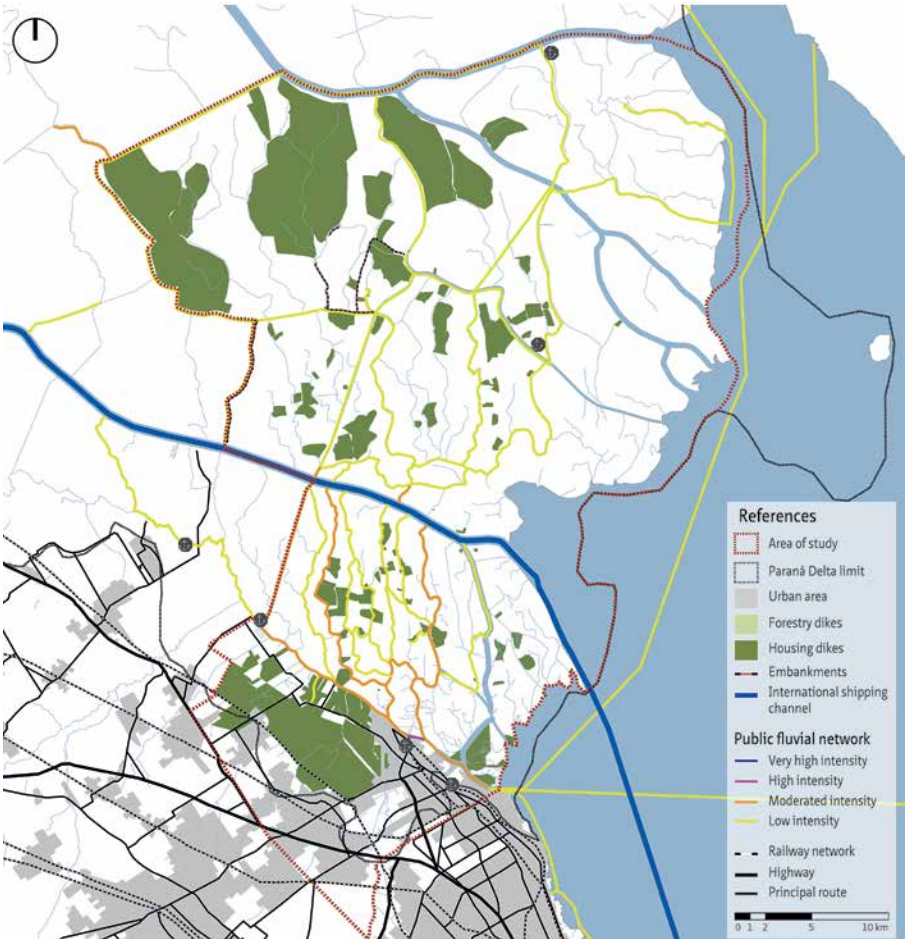

FIGURE 5.8 Map of the low impact scenario of the network layer (Zagare, V. & Kesarovski T., 2015).

The estimations were based on the Strategic Outlines for the Metropolitan Area of Buenos Aires (Subsecretarías de Planeamiento y Urbanismo y Vivienda del Gobierno de la Ciudad Autónoma de Buenos Aires et al. , 2008), on the study of Vulnerability to Floods in the Metropolitan Region of Buenos Aires under future climate change (Barros et al. , 2006), and on an assessment of news reports during the floods of 2014 and 2015 in the Metropolitan Area of Buenos Aires (Figures 5.5, 5.6 and 5.7).

Scenarios for the indicators of the network layer

The analysis used for developing the estimations of this layer was focused on the type of impact that each kind of dike produces on the area related to their purpose, and

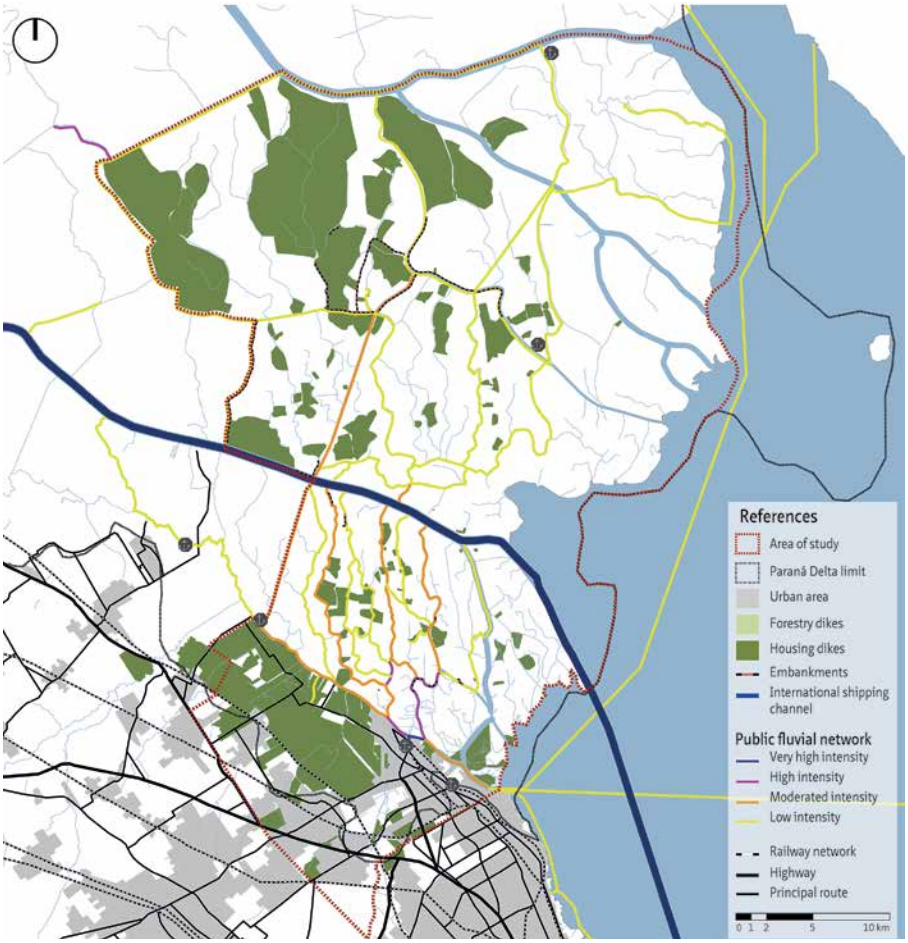

FIGURE 5.9 Map of the medium impact scenario of the network layer (Zagare, V. & Kesarovski T. , 2015).

also to what extent the use of that dike impacts the area generating the need for the development of more. This indicator also included the construction of embankments within the area for transport purposes (roads) and protection against floods. Regarding the transport system (terrestrial, aerial and fluvial), the team concluded that for future scenarios the transport system that would be most affected by changes in the area is the fluvial network. This is because of the development of the Paraná-Paraguay international shipping channel and also due to the increase of productive and touristic activities in the first and second sections of the islands.

The development of estimations was mainly based on the Strategic Outlines for the Metropolitan Area of Buenos Aires (Subsecretarías de Planeamiento y Urbanismo y Vivienda del Gobierno de la Ciudad Autónoma de Buenos Aires et al. , 2008) and the

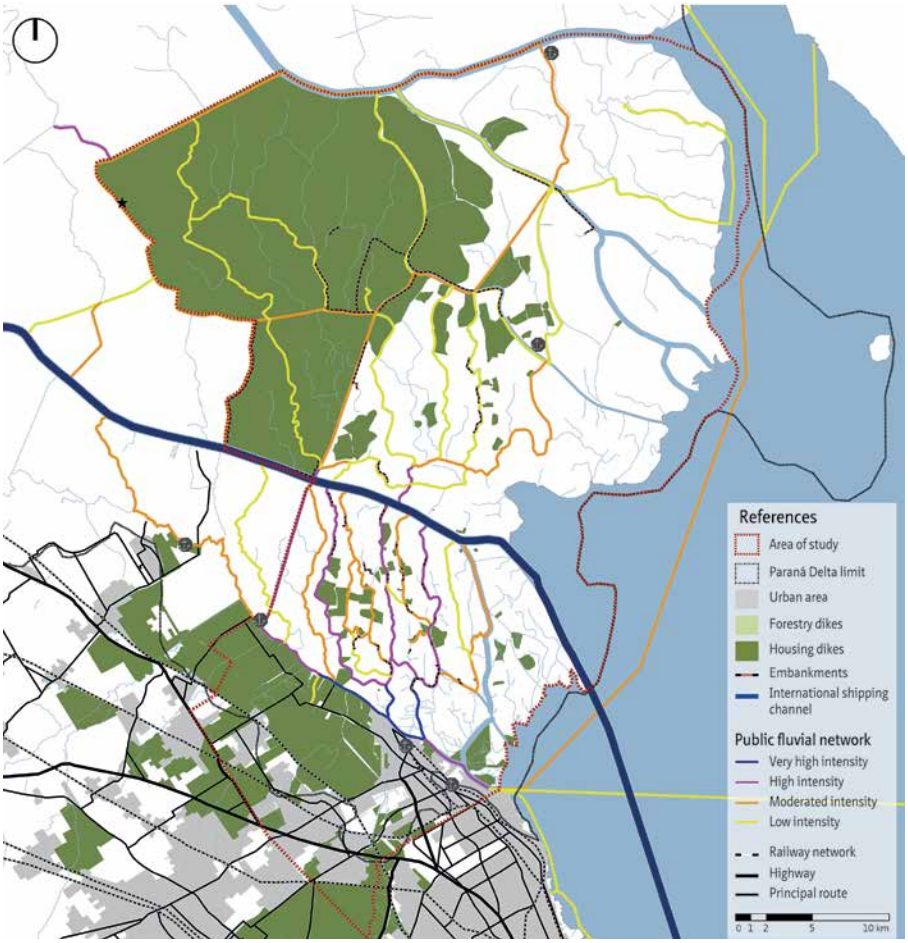

FIGURE 5.10 Map of the high impact scenario of the network Layer (Zagare, V. & Kesarovski T. , 2015).

project for dyking and road construction developed within the Program for Sustainable Development of the Delta prepared by the National Ministry of Agriculture (Ministerio de Agricultura Ganadería y Pesca, 2011). Regarding the changes to the fluvial transportation system, the consulted sources were the Plan for the Development of The Islands of Tigre (Municipio de Tigre, 2012, 2013d) combined with an assessment of information obtained from the National Secretariat of Transport and the National Port Council.

The estimation of dike construction was taken from the scenarios of low, medium and high impacts on the Substratum Layer, with the addition of embankments. Regarding the increase of embankments, there is an estimated rise of 23 km for a low impact scenario, an 88 km rise for a medium impact scenario and a 111 km rise for a high impact scenario. Regarding the number of services impacting the fluvial

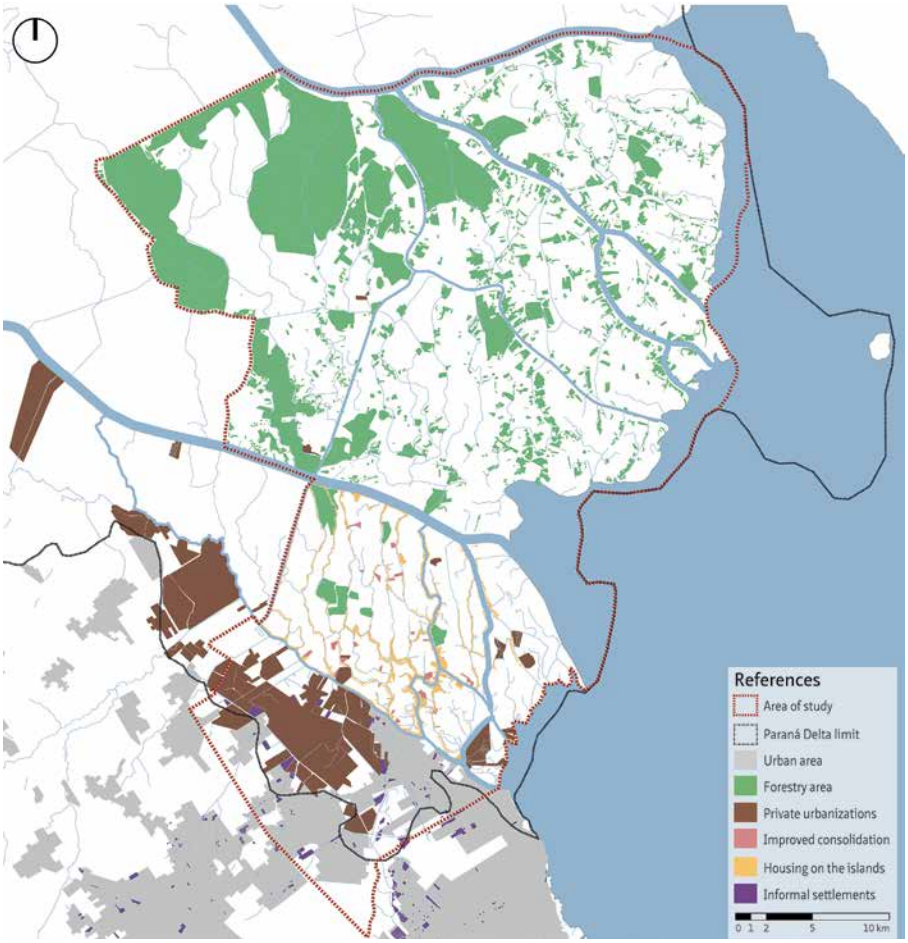

FIGURE 5.11 Map of the low impact scenario of the occupation layer (Zagare, V. & Kesarovski T., 2015).

transportation indicator, estimations were increased related to dike construction for production and housing, and information in the Plan for the Development of The Islands of Tigre (Municipio de Tigre, 2012, 2013d) regarding the touristic growth of the area (Figures 5.8, 5.9 and 5.10).

Scenarios for the indicators of the occupation layer

The indicators analyzed in this layer were: (a) land use change for forestation purposes and (b) land use change for residential purposes, divided into gated communities and informal settlements. The increase of the urban fringe of the Metropolitan Area of Buenos Aires as well as densification of the occupation within the first section of

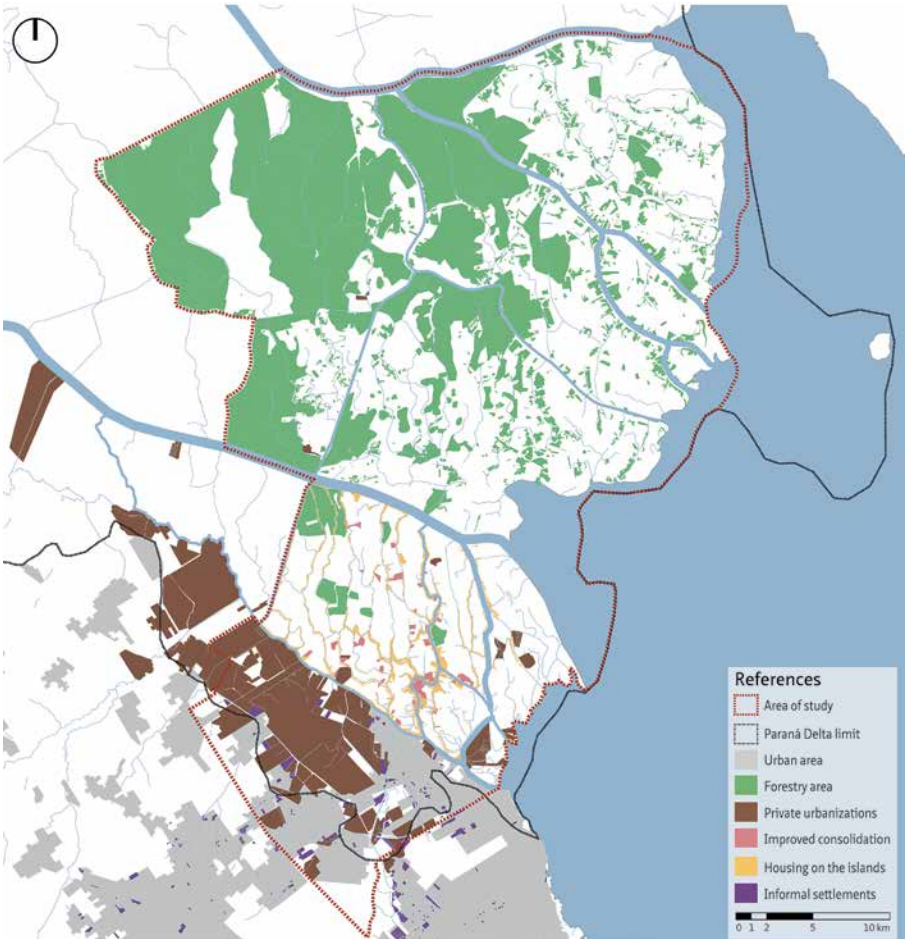

FIGURE 5.12 Map of the medium impact scenario of the occupation layer (Zagare, V. & Kesarovski T., 2015).

islands (Tigre) were also mapped to interact with the studied indicators and broaden the discussion. To develop the estimations the sources analyzed were the Strategic Outlines for the Metropolitan Area of Buenos Aires (Subsecretarías de Planeamiento y Urbanismo y Vivienda del Gobierno de la Ciudad Autónoma de Buenos et al. , 2008), the Plan for the Development of The Islands of Tigre (Municipio de Tigre, 2012, 2013d), the Normative on Land Uses and Construction of Tigre (Municipio de Tigre, 2013b, 2013a). Also analyzed were the documents for the incorporation of the San Fernando islands as a Biosphere Reserve within the MAB-UNESCO (Municipalidad de San Fernando, 2000) and the Zoning Code and the Urban Development Plan of San Fernando (Municipalidad de San Fernando, n. d., 2009).

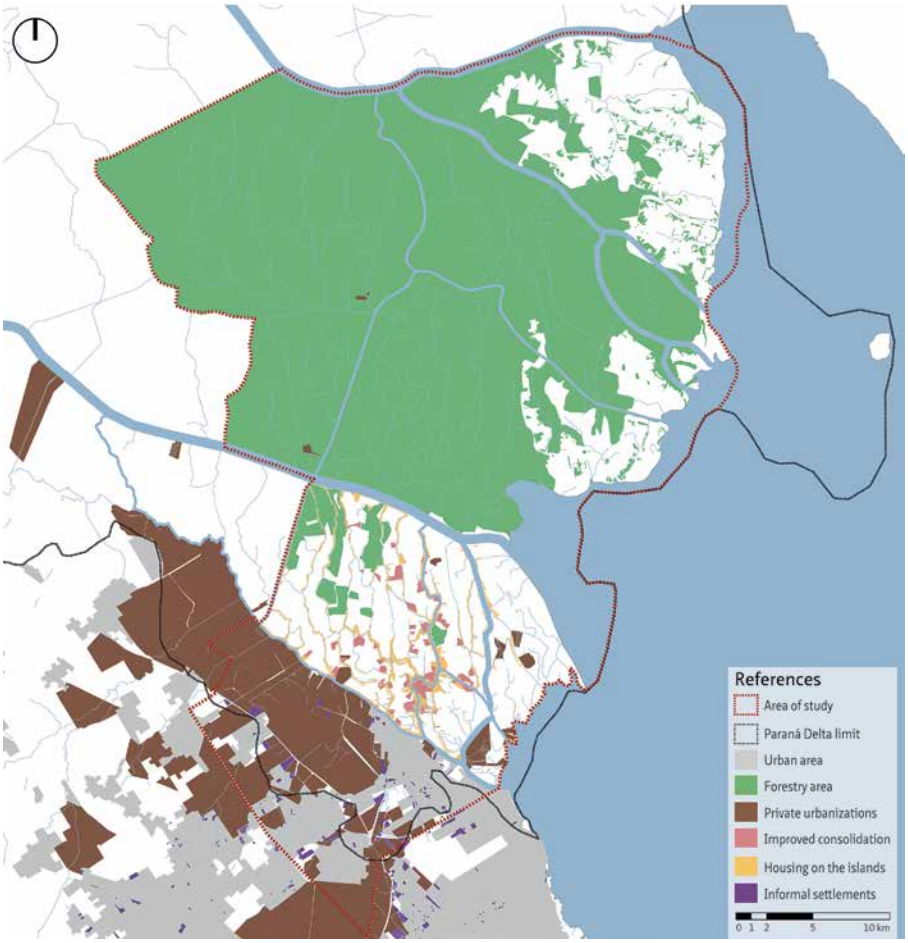

FIGURE 5.13 Map of the high impact scenario of the occupation layer (Zagare, V. & Kesarovski T., 2015).

In the low impact scenario, the forestation areas were expected to increase by around 4,600 ha, reaching 27,100 ha. The surface occupied by gated communities was estimated to rise to 5,700 ha, while informal settlements were expected to decrease by about 20% (73 ha). Also taken into account in this scenario was a consolidation of Tigre's first section of islands according to the expectations and delimitation established in the Plan for the Development of The Islands of Tigre (Municipio de Tigre, 2012, 2013d). The medium impact scenario contemplates an increase of forestation surface up to 46,000 ha, a rise of 4,750 ha of gated communities (reaching a surface of 9,500 ha) and a stabilization of informal settlements of 350 ha. The delimitation of the Tigre island's consolidation nucleus was also increased up to 415 ha. For the high impact scenario, when mapping a combination of trends and the densities and land uses allowed by legislation, the result even exceeded the area of the case study, for example regarding forestry. The estimates for the forestation area for a high

impact scenario rose up to 85,000 ha, gated communities increased up to 23,750 ha, and informal settlements also increased to 438 ha. In this scenario, the consolidated area of the islands of Tigre also increased (Figures 5.11, 5.12 and 5.13).

Low, medium and high impact scenario maps as input for the development of the second workshop

The developed scenarios were the consolidation of the quantification of the storylines and served as the basis for the second workshop, which was carried out with the participation of the scenario team and the scenario panel. In addition to the scenario maps, other maps were prepared for the workshop that functioned as a framework for the discussion. A first map was the satellite image of the area (*Figure* 5.14), a second map included the legislation (land uses, special restrictions, categorization of the islands) (*Figure* 5.15) and a third map illustrated the advance of the urban fringe of the Metropolitan Area of Buenos Aires moving towards the Paraná Delta and the advance of the Delta front, also including the transportation network system (*Figure* 5.16).

FIGURE 5.14 Satellite image of the area (Zagare, V. & Kesarovski T., 2015).

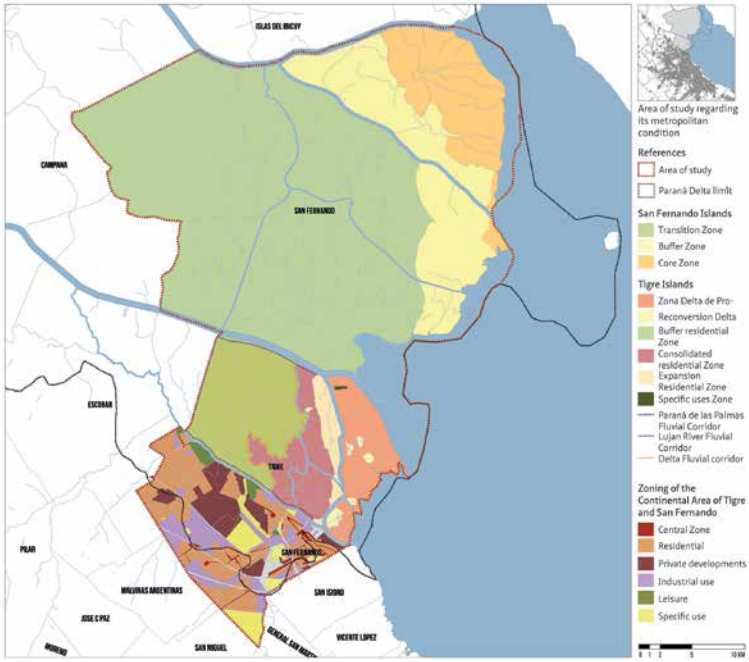

FIGURE 5.15 Legislation map (Zagare, V. & Kesarovski T., 2015).

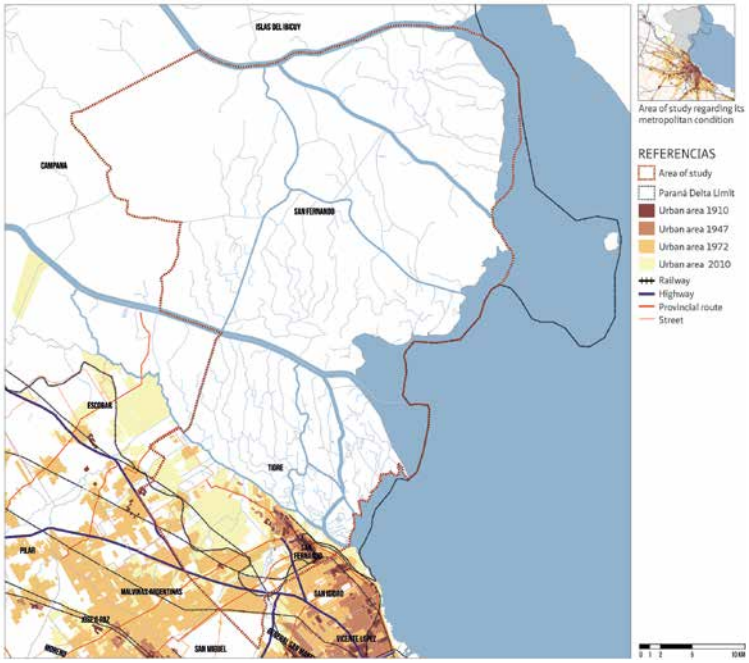

FIGURE 5.16 Advance of the urban fringe (Zagare, V. & Kesarovski T., 2015).

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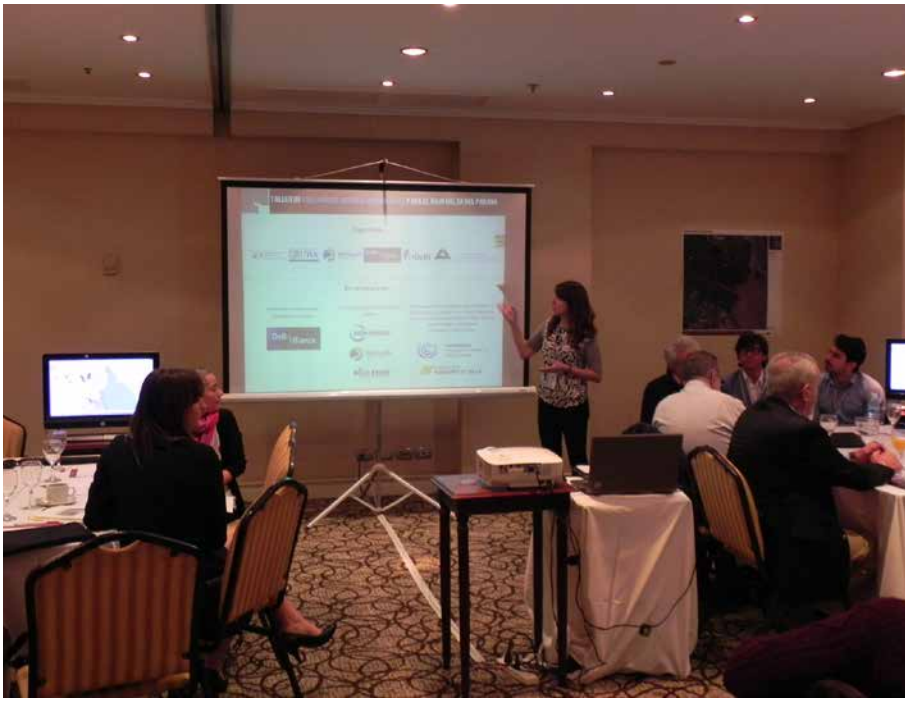

FIGURE 5.17 Second Workshop.

The second workshop

The Second Workshop[21] included the scenario team and the scenario panel, with an increase of around 15 new participants in the latter, in order to broaden the representation of the actor-network. Also included in the scenario team was a team of facilitators that conducted the workshop. Among the stakeholders were the islanders of the San Fernando and Tigre regions, representatives of the Working Group on Aquatic Resources of the Secretariat for Planning and Environmental Policy, the National Institute of the Agrarian Technologies (INTA) Delta, and the Provincial Organism for Sustainable Development (OPDS). Also present were the director of the Strategic Plan on the Conservation and Sustainable Development of the Paraná Delta (PIECAS-DP), the Provincial Direction of Islands, the Argentinean Forestry

21 The Second Workshop: "Urban-Environmental Scenarios for Lower Parana Delta" (April 24th, 2015) organized by the Instituto Superior de Urbanismo, Territorio y Ambiente (ISU) of the University of Buenos Aires, Fundación Humedales / Wetlands International Argentina and Delft University of Technology. It was accomplished within the scope of Delta Alliance International - Argentinean Wing, the Argentinean Program of Ecosystem Alliance and the Nairobi work Program on impacts, vulnerability and adaptation of the United Nations Framework Convention on Climate Change, through Fundación Torcuato Di Tella.

Association (AFOA), the Cooperative of Forestry, Consumer Affairs and Public Service of the Delta, representatives of the government of San Fernando, the Ombudsman's Office, the National University of La Plata, the Group of Wetland Ecology of the University of Buenos Aires, the M'Bigua Foundation, Fundación Humedales/ Wetlands International, the Foundation for Democratic Change and the Superior Institute of Urbanism, Planning and the Environment (ISU) of the University of Buenos Aires (Figures 5.17, 5.18, 5.19, 5.20, 5.21).

The workshop consisted of three parts (Figure 5.22). In the first part, after the opening by the organizers and the representatives of the Strategic Plan on the Conservation and Sustainable Development of the Paraná Delta (PIECAS-DP), the facilitator team explained the dynamics of the work. After that, a presentation on the methodology of the workshop took place, including the explanation of the area of study, the main drivers of change and some conceptual remarks on the territory's present situation. The Layer Approach methodology was presented (De Hoog et al. , 1998; McHarg, 1969; van Schaick & Klaasen, 2009) as a way to synthesize and analyze the delta's complexity and explain each layer (Substratum, Network and Occupation layers) together with the two main representative indicators chosen to be mapped in each case. Then, the set of maps illustrating future low, medium and high impact scenarios were presented to explain the main ideas behind the projections and the sources of information consulted to estimate the developing trends. Also, the idea of desirable scenarios vs. real scenarios was presented, considering that a desirable scenario is based on the existing (but not yet fully implemented) Plan on the Conservation and Sustainable Development of the Paraná Delta -PIECAS-DP-.

In the second part, participants formed three groups of around 12 people per group, who participated in three workstations in concordance with the presented layers (workstation #1: Substratum Layer; workstation #2: Network layer; workstation #3: Occupation Layer). In each workstation, there was a printed map with the present situation of the layer and the three possible future scenarios for low, medium and high impacts of development. There was also a touchscreen computer with GIS software where stakeholders were able to operate and interact with the different scenario maps. A facilitator led the discussion within each group while a moderator on behalf of the scenario team took notes and helped the participants to manipulate the digital maps. Each group focused the discussion on the drivers of change of each specific layer, the availability of information, the validity of the presented data and the viability of the possible scenarios. The groups were also able to add new indicators to the analysis or introduce modifications. Following a "carousel" dynamic the participants alternated their participation successively in the three work-stations until having participated in each group. Then, at the end of the first part of the workshop, the facilitator and the moderator documented the conclusions of each group.

FIGURE 5.18

FIGURE 5.19

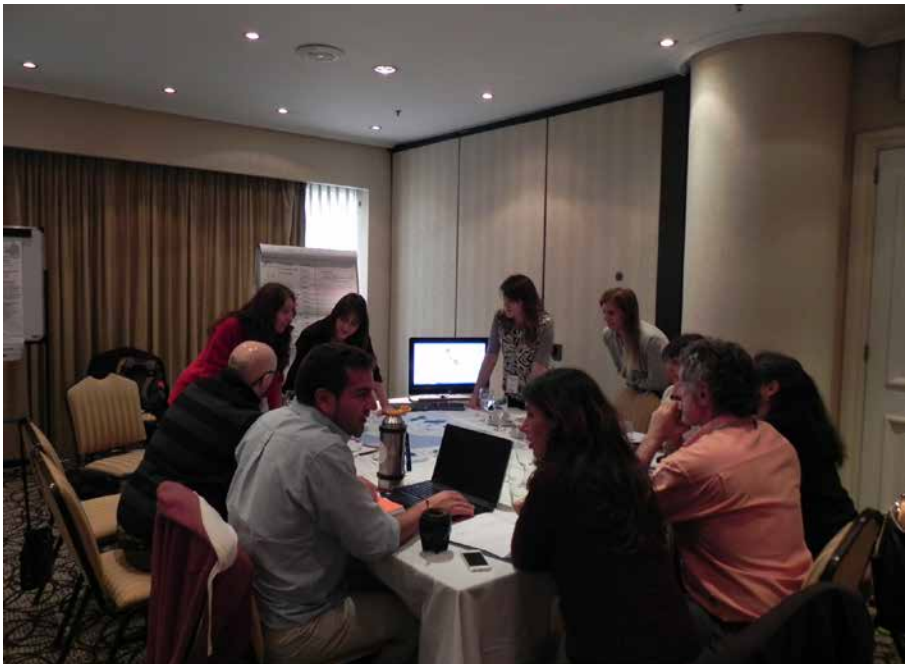

FIGURE 5.20

FIGURE 5.21

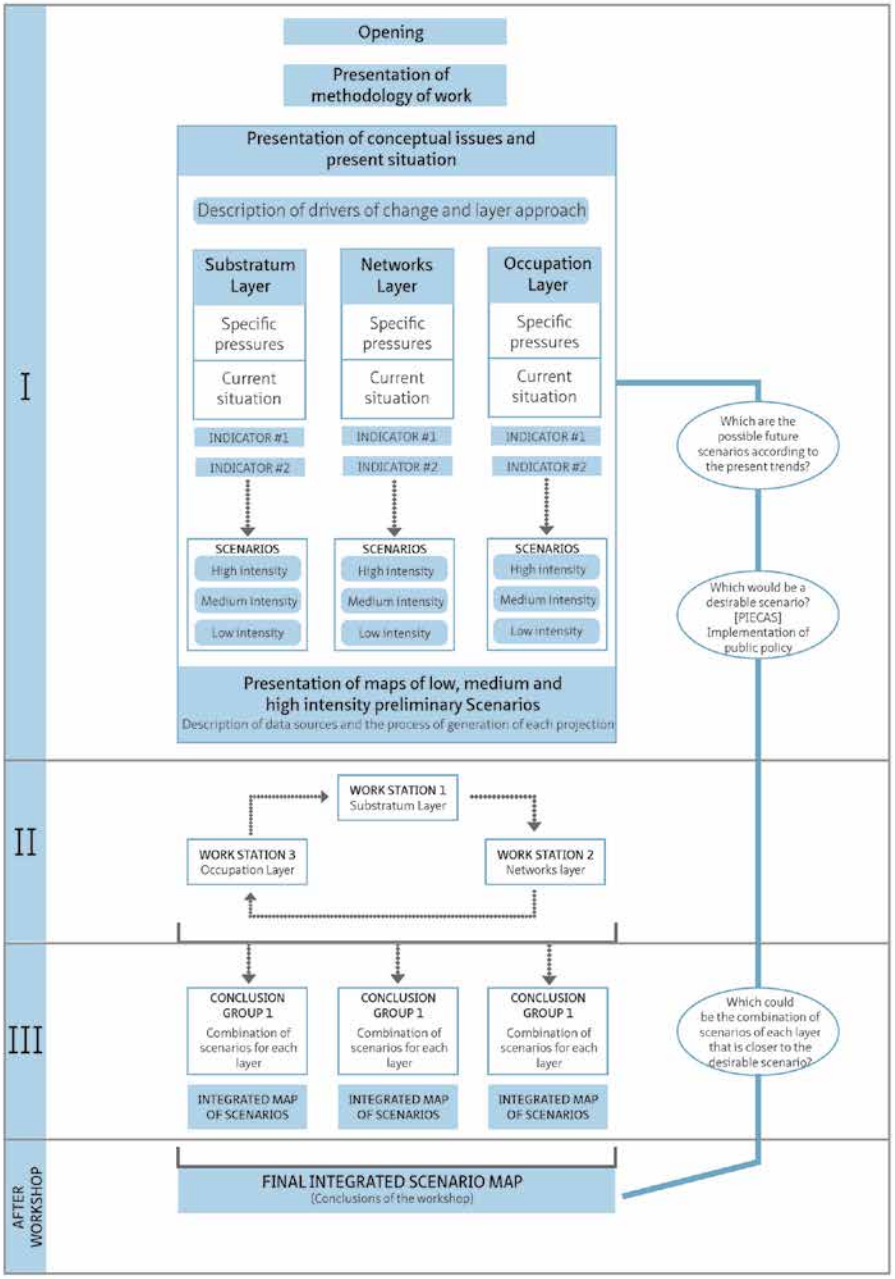

FIGURE 5.22 Structure of the workshop.

LAYER	INDICATOR	SCENARIO	SELECTION
Substratum	Loss of wetland	Low impact	**X** (on the continental area)
		Medium impact	**X** (on the islands)
		High impact	
Networks	Roads, dikes and endikements	Low impact	
		Medium impact	**X** (limiting the access of vehicles)
		High impact	
	Fluvial	Low impact	
		Medium impact	
		High impact	**X** (increasing connectivity)
Occupation	Forestry	Low impact	
		Medium impact	**X** (growing towards East; promoting productive diversification; avoiding the terrestrial model; avoiding agro-chemical use).
		High impact	
	Residential purpose	Low impact	**X** (no increase of gated communities)
		Medium impact	
		High impact	

NOTES Group 1

The group argues that it is necessary to develop a more sectoral view of the zone, dividing it into at least seven sub-regions. In this way, it could be possible to elaborate more realistic trends for a desirable scenario.

The suggestion of areas is the following:

1. Dikes forestry nucleolus.
2. Reserve area.
3. Open trench forestation and housing on stilts.
4. New islands.
5. Highly touristic area.
6. Low touristic activity and no forestry production.
7. Urban area (in discordance with the legislation of the Lujan River coastline).

TABLE 5.1 Conclusion and notes of the Group 1

The final section of the workshop "integrated" the information from the previous sections. Each group chose the combination of the low, medium and high-intensity scenarios for each layer that is closer to a desirable scenario for them. That means that the participants saw the real trends and their possible evolution in the territory and discussed realistic future scenarios considering policy. The output of each group was a table with all the indicators, where they made their choices regarding low, medium and high impact scenarios (Tables 5.1, 5.2 and 5.3). After the conclusion of the group phase, the facilitators shared the results of each group in a plenary. The scenario team's technical expert simultaneously generated a conclusion map for each group applying the chosen combination made in the tables on a GIS map and making all the required modifications to feed the discussion of the plenary (Figures 5.24 and 5.25).

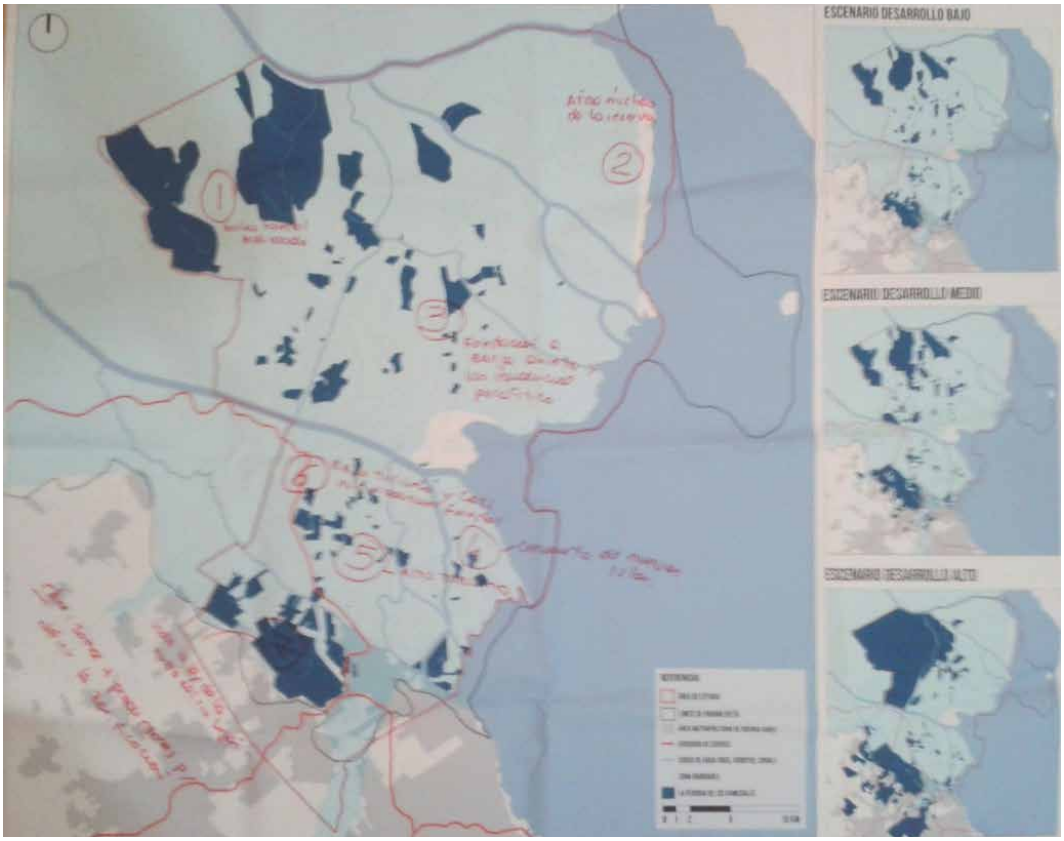

FIGURE 5.23 Diagram over the map of Group 1.

It is important to comment that at this stage, contrary to Groups 1 and 2, the third group was not able to simplify the variables due to an in-depth discussion that took place during the meeting. The idea of thinking about a possible positive scenario triggered a discussion about the paradigm of land use planning and economic development in the area. Regarding that discussion, the group proposed distinguishing different areas: The Continental area of Tigre from the islands of Tigre and the San Fernando islands. Therefore, they restricted the visions to each of the three areas, as it was impossible to generate a conclusion map for the Group. In Group 1, there was also a discussion about the possibility of distinguishing different areas within the municipalities so seven areas were proposed as new categories, considering natural and urban characteristics (Figure 5.23). At the closure of the workshop, the scenario team and the scenario panel arrived at a consensus about how to develop a general map for the area's desirable future addressing all the discussed issues, and what would be the actions taken to reach that desirable situation. A preliminary map was drawn in real time (*Figure* 5.26), and then it was finished considering all comments received and sent to the workshop participants (Figure 5.27).

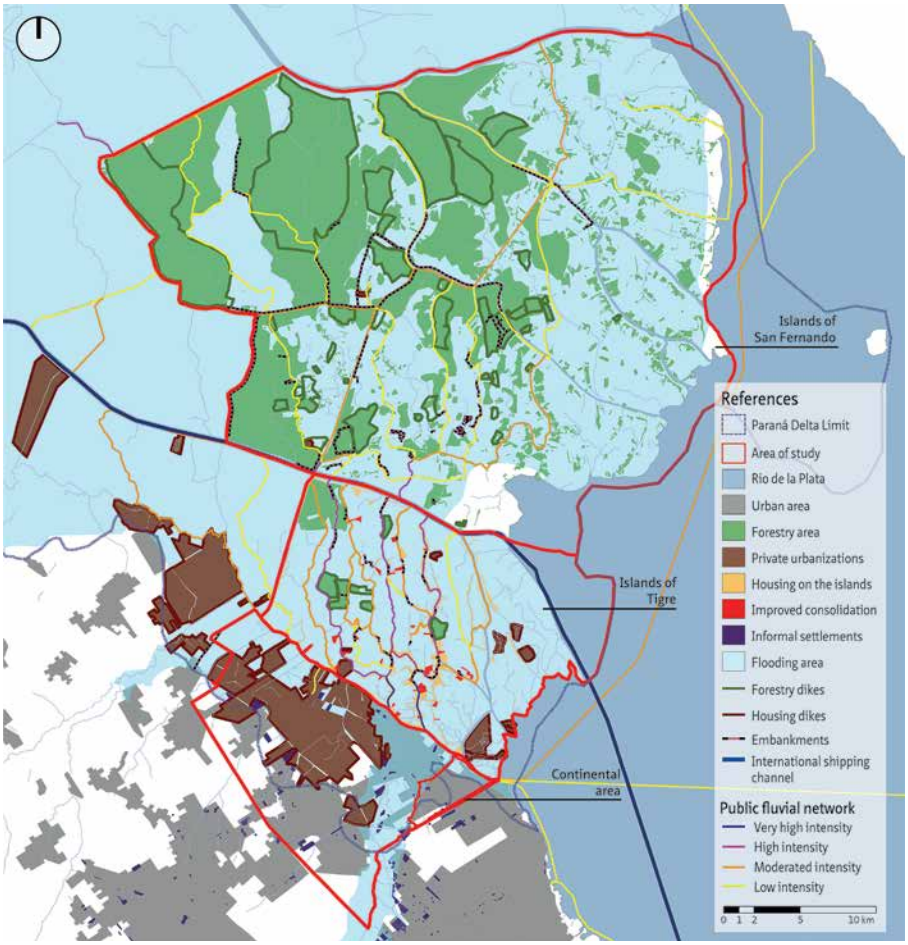

FIGURE 5.24 Conclusion map Group 1

LAYER	INDICATOR	SCENARIO	SELECTION
Substratum	Loss of wetland	Low impact	X
		Medium impact	X (on the islands)
		High impact	
Networks	Roads, dikes and endikements	Low impact	X (chosing water management strategies over dikes)
		Medium impact	X (chosing water management strategies over dikes for roads)
		High impact	
	Fluvial People Cargo	Low impact	
		Medium impact	
		Medium impact	it must be high to allow inhabitants of the islands to circulate, but not reaching a high fluvial transit
Occupation	Forestry complementary and traditional productive activities.	Low impact	Lower / Medium
		Medium impact	Medium / Medium
		High impact	Medium / Medium
	Residential purpose Sustainable Tourism	Low impact	Towards none in San Fernando
		Medium impact	In Tigre
		High impact	High, just in cases of sustainable tourism

NOTES Group 2

NOTE 1: With respect to Indicator 1 of Occupation, 3 types of productive activities were categorized and there were different perspectives to qualify them (that is why there were 2 options of Medium Impact Scenarios).

NOTE 2: Reflections that fill the previous table:

- The premise must be that everything remains as natural as possible: the focus is the conservation of the wetland.
- Conceptual clarification: the level of loss is given by:
  - Components
  - The relationship between them
  - The functions of the wetland, the environmental goods and services it provides
- The type and form of productive development must be in accordance with the wetland fulfills its functions, but will be harmed in the future.
- The Delta is not the Pampa, therefore the development model must respect the particularities of this ecosystem and not copy models that correspond to other ecosystems.
- The human development of the islander must be considered, they must have access to appropriate services.
- Perform infrastructure works in the area that respect the operation of the system.
- The preferred scenario must be defined in relation to the uses, a question to answer before analyzing scenarios is whether tourism development is desirable or not.

TABLE 5.2 Conclusion and notes of Group 3.

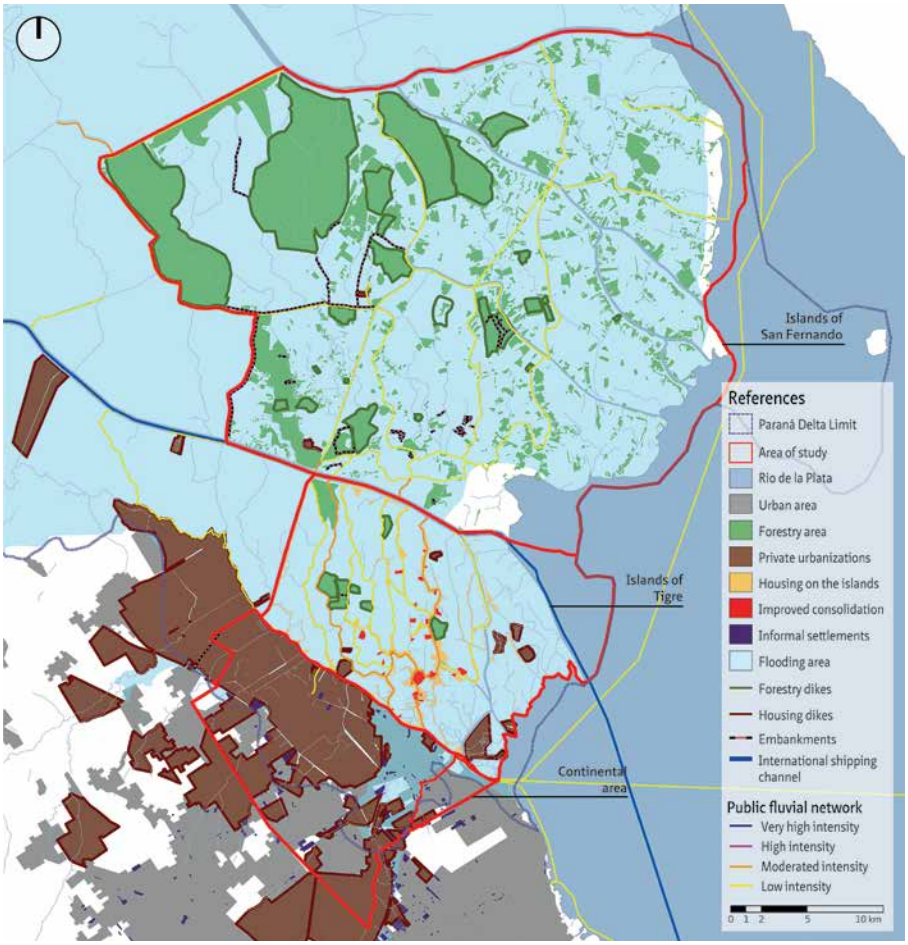

FIGURE 5.25 Conclusion map Group 2

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LAYER	INDICATOR	SCENARIO	Current			Desirable		
			Tigre		San Fernando	Tigre		San Fernando
			Continental area	Islands	islands	Continental area	Islands	islands
Substratum	Loss of wetland	Low impact			X			X
		Medium impact		X	X		X	
		High impact	X					
Networks	Roads, dikes and endikements	Low impact					X	X
		Medium impact						
		High impact	X					
	Fluvial	Low impact					X	X
		Medium impact						
		High impact	X			X		
Occupation	Forestry	Low impact		X	X			
		Medium impact						
		High impact						
	Residential purpose	Low impact		X	X			X
		Medium impact		X		X	X	
		High impact	X					

NOTES Group 3

Note 1: general reflections that allowed filling the table

- Consider environmental heterogeneity and zoning
- The informality / illegality of land tenure is considered as an important issue to be taken into account in the construction of scenarios. This is for both activities as junkers and fishermen (in these cases in relation to the island's identity), as in the developers of private neighborhoods and illegal productive dykes.
- Lack of political will to make serious studies as a basis for standards.
- Importance of islanders' participation in decision-making processes.
- Consider the productive development models, which according to the case would determine different scenarios (forest production). For the forest production indicator, it is necessary to review the development paradigm and plan accordingly, for this reason it is difficult to determine the expected scenario to 30 years.
- Consider the importance of the tourism industry for Tigre. There is a clear trend towards an increase in residential occupancy.
- Take into account the external influence on the study area and how it influences future scenarios.
- Problems with the information used in the maps:
  - What appears as a forest includes many abandoned forestations.
  - The levee map does not include the small dykes that would be important in Tigre.
- For the integrated scenario it is necessary to differentiate between the continental tiger, island tiger (1 island section) and San Fernando islander.

Note 2: In relation to the conversation about the current scenario in the Continental Tigre, participants point out that it is necessary to reverse trends, especially in the residential use indicator.

TABLE 5.3 Conclusion and notes of Group 3.

§ 5.5 Evaluation Stage

The design was carried out using a systemic approach methodology as a start point, and reinventing it with the aim of creating an innovative method to be applied in the context of the Argentine case. This method allowed the generation of knowledge regarding each area through an exchange platform between knowledge-oriented and practice-oriented stakeholders. Academia, government agencies, producers, civil society organizations and other stakeholders were actively involved in the generation of knowledge that served as support for discussion about the area's future and for the proposed actions to be taken to increase adaptation by ensuring socio-economic and territorial development. This method can also be understood as a Joint Fact-Finding activity, in which different stakeholders with dissimilar backgrounds, interests and views gather together to generate information "to facilitate decision-making" (Pel, Duijn, Janssen, & Edelenbos, 2013, p. 4).

This method also carried on a development of interactive maps, which allowed stakeholders to visualize and think spatially about the impacts of legislation, socio-economic development and climate change. Visualization, defined as "communication that uses visual structures to represent objects, concepts and relationships" (Vervoort et al. , 2010, p. 605), amplifies stakeholders capacity to manage parallel information as it is better retained in their memory and triggers emotional responses instantly (Vervoort et al. , 2010, p. 606). It was crucial for this method because it was a pilot experience that has never been applied in this context and was a new experience for the stakeholders involved. The visualization of the maps generated a high impact on the actors as they could actually "see" the possible effects of the application of law to the territories and the limits on issues such as density and permits for land use change, in a dynamic way. Another aspect that increased the impact of visualization was the possibility of operating the maps in real-time. The stakeholders could interact with the maps through a touchscreen, which made it possible to alter the indicators according to their perception or background knowledge, or even following their assumptions on the future evolution of certain trends. Online media was also used as needed, to search for information and to visualize the presented data in greater detail for some areas of the case study through the use of Google Maps.

Within the collaborative environment that was generated through this collective planning experience, it was suggested that the evaluation of the area's indicators and relations should be extended to adjacent localities, raising the need to repeat the workshop in other municipalities. With regard to policy, by including representatives of national, provincial and municipal agencies, it emerged as necessary to revise some indicators in specific codes which are pending approval, such as the Plan for the Development of The Islands of Tigre (Municipio de Tigre, 2012, 2013d). Through the visualization of the indicators, some inconsistencies or incompatibilities were found when combining them with other indicators of the same standards. Another positive result of the generation of this platform for dialogue laid in the communication established between actors who make decisions in the same territory, but do not often share spaces as equals, to each present their experience and vision on the subject and have it been considered. Also important was the possibility of redefining already-defined categories through the discussion that took place in each group taking new insights into consideration of the same problem and broadening the possibilities of the future scenarios while improving the adaptation measures that can be generated from that starting point.

The limitations of this model regard the lack of information vital to the development of maps. Thus, some indicators could not be mapped accurately, such as the extent of the floodplains. Furthermore, during the workshop, different information for the same indicators arose according to stakeholders, as there is no official database for the

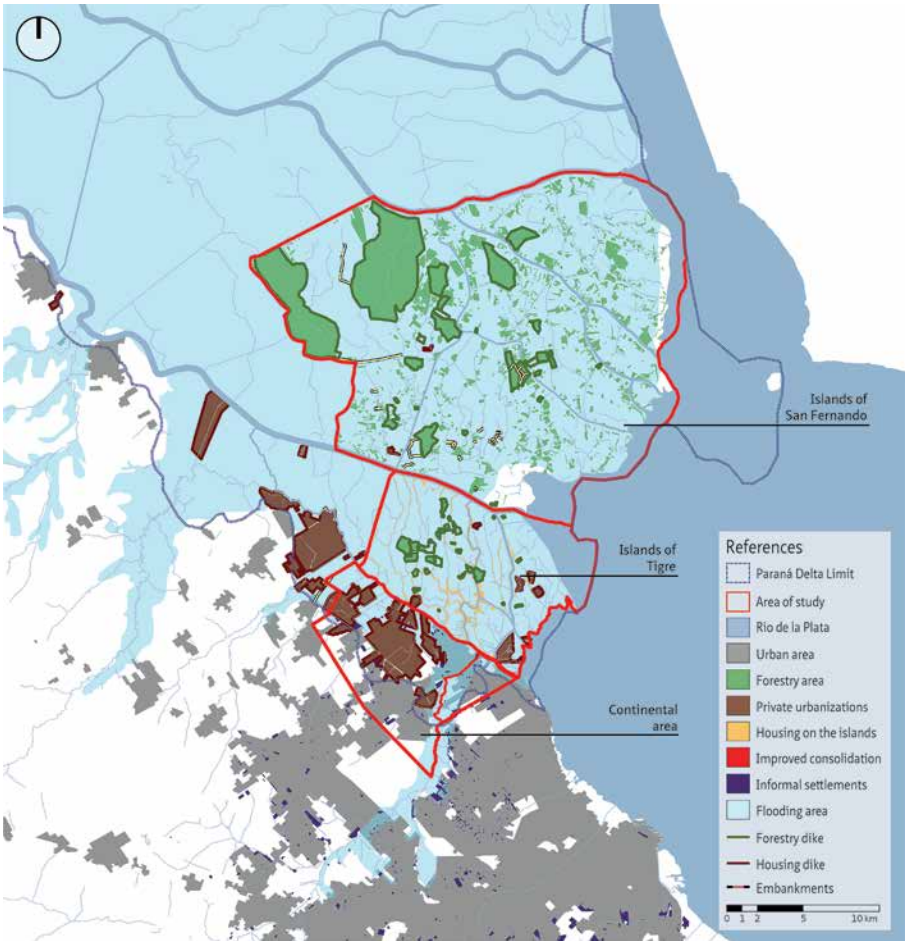

FIGURE 5.26 Integrated map of the three groups.

area, especially regarding climate change and floods. This limitation was leveraged to generate more discussions in the workshop on the quality and quantity of information needed and to fill gaps in this regard. Another limitation encountered was the non-inclusion of adjacent municipalities in the study because they generate pressures in the area and the initial scenario maps did not include them. However, having encountered this limitation during the workshop, the scenario team could design a final map, which included adjacent municipalities and the scenarios.

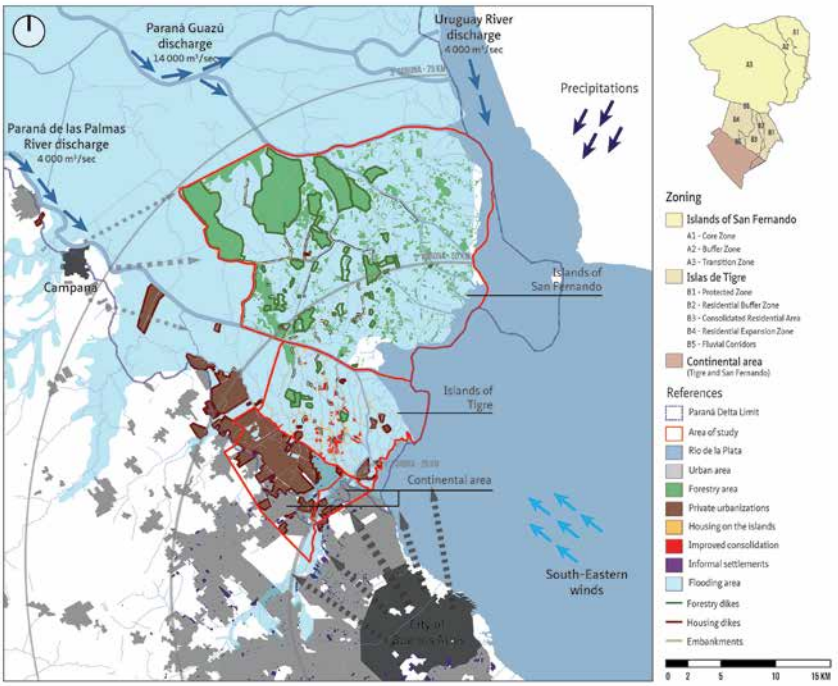

FIGURE 5.27 Final conclusion map of the workshop.

§ 5.6 Concluding Remarks

The designed method (Figure 5.28) aimed at developing a collaborative planning activity considering a complex adaptive system and a context of the application as a way to find integration that may generate an impact at the system's level, through a revisited structure of Layer Approach. According to Vervoort et al. (2010, p. 606), participative scenario building developed from a complex adaptive systems perspective serves as a basis for knowledge generation and building of consensus in the face of future uncertainties and complexities. The challenges that these new communication and interaction strategies must undertake are based on (a) the fact that systems thinking does not pervade all sectors of society; (b) the lack of assiduity with which people make non-linear projections; (c) the difficulty of making all participants think in a multi-scalar way; and (d) the bond that the people have with their implicit perspectives and backgrounds (Vervoort et al. , 2010, pp. 605–607).

The construction of realities through a Joint Fact-Finding process of immersive simulations such as the ones developed within this exercise encouraged stakeholders to collaborate further and generated interest in expanding the application of these types of strategies along the delta to make an impact at a broader level. Although this method considers jointly constructed knowledge from the start, which is specifically developed within a contextual case, the generated knowledge and indicators are independent of the structure of the method. The designed structure could be adapted to other contexts, broadening the use of the research developed in this thesis to further field investigation.

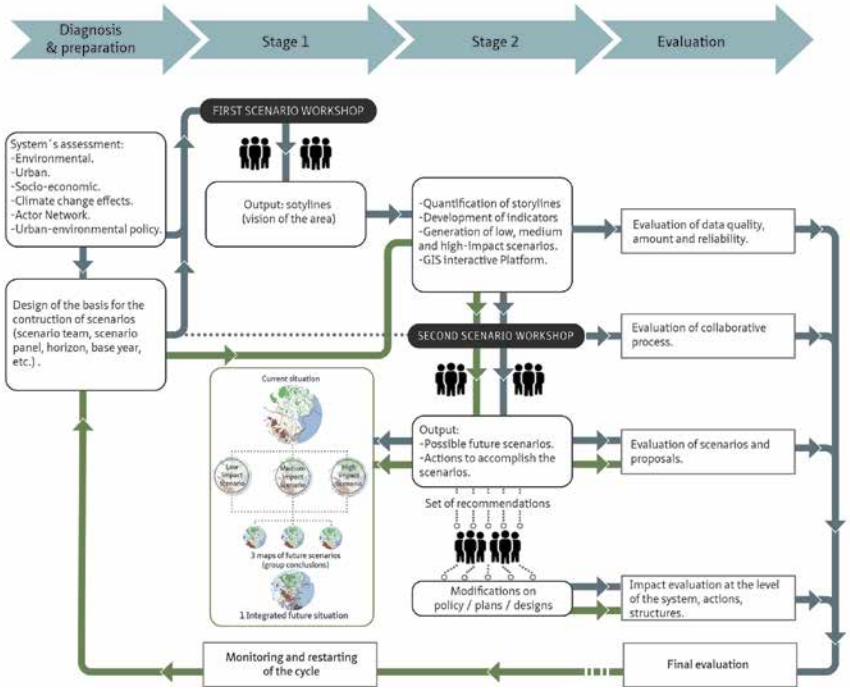

FIGURE 5.28 Structure of the method.

6 Conclusions and Recommendations

§ 6.1 Introduction

This research focused on reflecting about urbanizing deltas, as well as on approaches to deal with the complexity that characterizes these territories. In a first place, the concept of *emerging metropolitan delta* was defined as a complex adaptive system, paying attention to bottom-up processes that take place as a result of self-organization. This conception, together with the recognition of the high level of uncertainty that leads future changes in climate and land uses, makes necessary the development of flexible and participative approaches to increase the adaptive capacity of these areas.

From the base of the methodological aspects presented in Chapter 3, regarding planning, design and governance in emerging metropolitan deltas and the relevance of collaborative approaches, this thesis presented a scenario-based method for the participatory design of adaptive spatial plans, developed for being implemented in the Lower Paraná Delta in order to bring stakeholders together for building knowledge and consensus around delta issues and the future. This method was developed based on the hypothesis that this kind of approaches, which includes the development of scenarios through public participation, can contribute to the understanding of the complexity of the systems, as well as to increase their capacity to adapt to future uncertain conditions. The method was implemented at the local scale of the Municipalities of Tigre and San Fernando, located in the Lower area of the Paraná Delta, Argentina, which is considered a very complex case study due to its large extension, the multiplicity of overlapping jurisdictions and actors involved. Both municipalities have contrasting visions on delta conservation and urban development, and that reflects on the legislation and spatial interventions, which lack of common points.

§ 6.2 General Discussion Addressed in this Thesis

As it was already presented in Chapter 3, the concept of "metropolitan delta" defined as a large river delta with a big conurbation (Smeets et al. , 2004, p. 104) is not comprehensive enough to describe the complexity of the different processes that take place on those territories. On the contrary, the combination of geomorphologic characteristics and natural dynamics, and specific land use changes resulting from urbanization and production processes, imply the need to find a definition that makes it possible to reveal the dichotomies and interactions within and between these systems them and with the larger context. This thesis proposes a comprehensive definition of emerging metropolitan deltas based on complex adaptive systems approach, recognizing the processes involved and their interactions. This approach is linked to the "General System Theory" (McLoughlin, 1985; von Bertalanffy, 1968) and to "Complexity Theory" (Batty, 2007; Batty & Marshall, 2012; Portugali, 2006).

Following that idea, emerging metropolitan deltas can be understood in this thesis as "complex adaptive systems where the dynamic confluence of deltaic and metropolitan subsystems takes place in constant transformation due to the emergence of self-organizing processes". Those emerging processes are not linear and generate path-dependent events within a context of uncertainty and unpredictability, challenging the entire system and its components to adjust in order to maintain a non–static equilibrium (Batty, 2007, pp. 11–13; Durlauf, 2005, p. 226). Given that these systems are formed by ecological, social and physical components, they are vulnerable to suffer from the consequences of natural events (climate variability and extremes) and of human-induced interventions. As a result, these systems need to adapt to such sudden and uncertain changes. The adaptive capacity of an emerging metropolitan delta is related to the ability of the system to adjust to those changes, to reduce the vulnerability associated with hazards, to moderate potential damages, to take advantage of opportunities and to cope with the consequences (Brooks, Adger, & Kelly, 2005; Newman & Dale, 2005). Thus, adaptive capacity is related to the concept of resilience, as the latter regards the disturbance that the system can absorb before changing to another state (W Neil Adger, 2006, p. 268).

As expressed by Bertolini (2010, p. 81), the recognition of the complexity of spatial systems and their uncertainty as well as the importance of adaptation are crucial issues for designing and planning these territories. In Chapter 3, the implications of complex adaptive systems approach on design, planning and governance in emerging metropolitan deltas were addressed through a review of the different theories that led these disciplines throughout the history. From an object–based conception of urban planning focused on a stable and static city (Hall, 2011, p. 337; Taylor, 1998, p.

4), to a perspective of the discipline based on the methods of planning a city formed by interrelated components in constant interaction (Alexander, 1979, p. 90; Batty, 2007, p. 7; Jacobs, 1961; Taylor, 2011, p. 391), traditional theories and practices had been challenged. The cities are no longer conceived as a physical phenomenon but as a mixture of interactions among systems and subsystems which also includes the social realm as a relevant component, being the reality seen as a social construction (Habermas, 1984; Innes & Booher, 2010). Therefore, the notion of the planner as a unique expert and controller has turned into to a vision of planner as an advocate and coalition builder, giving space to other stakeholders to participate in the design and planning processes (Davidoff, 1965; Forester, 1987; Habermas, 1984; Murdoch, 2006). In this context, governance systems must be flexible and adaptive enough to cope with extremely dynamic systems, with a high level of uncertainty, a significant number of actors involved and multiple governmental jurisdictions with different (and sometimes contrasting) agendas (Young, 2017).

Beyond the advantages and limitations of collaborative approaches presented in Chapter 3, adaptive and participatory strategies are possible to be combined with formal regulatory systems introducing innovation at different scales and sectors (Philip. Allmendinger, 2009; Bertolini, 2010). In this context, and considering successful international experiences applied in complex areas such as the Rhine–Meuse–Scheldt Delta and the Mississippi Delta, adaptive and participatory strategies position as valid tools for design and planning in emerging metropolitan deltas.

Furthermore, the use of scenarios also contributes to increaseing the awareness of the effects that the different pressures may have on the territory, through the collective creation of possible future situations. It also encourages community and decision-makers to reflect on the actions to take (or to avoid) to reach a sustainable development of the area. In a context of irreducible unpredictability, awareness and preparation for possible future events play a key role in increasing the level of adaptive capacity of the Delta.

Returning to the characteristics of complex systems, it is possible to state that a small change in the parameters at a low level can trigger a qualitative change in the aggregate properties of the whole system (Durlauf, 2005, p. 227). The examples described in Chapter 3 show that participatory adaptive planning can generate synergy between different scales and sectors, as well as empowering local stakeholders and increasing the legitimacy of regulations, enhancing adaptive capacity of the system.

§ 6.2.1 Answer to the research question

How can a scenario-based method for participatory design of adaptive spatial plans be designed and implemented in the Lower Paraná Delta, and which effect can it have on higher scales of the system?

The emerging metropolitan dynamics that characterize Paraná Delta´s complex system require to be tackled through planning strategies that consider the processes that occur within the system, and the path-dependent relations between the components, in a context of uncertainty. The Paraná Delta is a particular case that requires specific solutions, towards an increase of the adaptive capacity of the system. It is an objective of this thesis to design, implement and test an innovative method for the participatory design of adaptive spatial plans.

A great complexity characterizes planning context in Paraná Delta due to its large extension and multiplicity of jurisdictions and actors involved. In Chapter 4, the situation of the Delta was described addressing its natural conditions, the networks of development, the patterns of occupation and the regulatory framework. Concerning the analysis, which was carried on from a historical perspective, it is possible to observe that the combination of this context with pressures related to land use changes and extreme climate events, turns the Delta into a vulnerable territory lacking strategies to face that complexity.

Considering the emergent dynamics and path-dependencies that occur within metropolitan deltas, and especially within the case study, the local scale seems to be the proper level to design and implement adaptive and participatory strategies. The structure of the methodology for the participatory design of adaptive spatial plans developed in this thesis is based on stages that include assessments, development of scenarios and social involvement, in order to guarantee robust results, high level of representation among the stakeholders, and feasibility of the proposed actions.

The design and implementation of this method at the local level presents several advantages. First, being that the Paraná Delta territory is large and heterogeneous, working at the local level makes possible to manage controlled information and therefore to select proper indicators to analyze with the stakeholders. Second, it is also possible to generate a specific map of actors to be included within the method to reach a high representation of the different sectors. Third, all the participants, despite their different backgrounds, are capable of participating in a discussion because they are close to the problems and they also share common spaces. Participation is also encouraged when the meetings are developed within the local territory, facilitating

the attendance of the stakeholders. Fourth, among all the local actors, the inclusion of some strategic stakeholders of other levels (provincial, regional, national) encourages communication vertically (among scales) and horizontally (between governmental offices) as well as empowers civil society generating channels of communication and dialogue with the authorities.

Furthermore, the use of scenarios, as it was previously addressed, contribute to enhancing preparation for future disruptive events and for the identification of successful policies, which is crucial for reaching agile governance systems (Bertolini, 2010; Young, 2017, p. 7). According to Albrechts (2004, pp. 743–744) the combination of strategic visions and short-term actions including the design of "shared futures" and the discovery of "common assets" among actors are crucial for the solution of complex problems in complex systems.

The method also allows to be replicated in other sectors of the Delta or at higher levels, by changing the variables of analysis, and basing the study on the specific actor-network of each area without any structure adjustment. Furthermore, the method can be applied within the existing planning context, without requiring any political or regulatory adjustment, only requiring the will of the stakeholders (including decision-makers) to debate about the past, present and future condition of the delta, and to experiment themselves the spatial implications of the trends and legislation standards over the territory. Through this experience, it was possible to bring actors together following the same goal, creating future scenarios and to discussing about the actions that will be necessary to take to prevent adverse effects and promote positive results.

§ 6.3 Future Work

Regarding the case study, one of the findings that emerged in the Evaluation Stage of the *Scenario-based Method for the Participatory Design of Spatial Plans* focused on the need to replicate the method in other municipalities of the Delta. It was also mentioned in the workshops, the convenience of repeating the methodology at other scales, taking advantage of the dialogue platform and the inputs generated at the local level. Also, throughout the workshops, inconsistencies and incompatibilities were found in the normative, which captured the attention of the actors involved in regulation approval and control agencies. The resulted dialogue and the visualization of the indicators and normative standards, contributed to promote a positive reaction of

decision-makers, who expressed the need and intention to implement some changes on the normative.

Furthermore, it is possible to observe an auspicious scenario for developing innovative strategies such as the one designed in this thesis, being that at present, some wills have aligned towards increasing the sustainable development and adaptive capacity of Paraná Delta. Firstly, Argentina has recently become a member of the "Delta Coalition", the first international coalition of governments created towards increasing deltas´ adaptive capacity. According to the Delta Coalition Ministerial Declaration, signed on Rotterdam in May 10th, 2016, Delta Alliance, an international network of knowledge institutes, can "provide the knowledge base for government-to-government dialogues in the Delta Coalition". Considering that Delta Alliance Argentinean Wing has been working in the country since 2014 developing activities of knowledge generation and transfer towards the increase of Paraná Delta´s adaptive capacity, the possibilities broaden. In fact, as it was already mentioned in Chapter 6, the Scenario-based method for the participatory design of spatial plans was developed within the scope of the activities of Delta Alliance International in Argentina, being that the Argentinean Wing coordination role is being carried on by the author of this thesis. Delta Alliance Argentinean Wing is also participating in the 10-year program of "Corredor Azul", developed by Wetlands International Argentina and implemented in Brazil by Mulheres em Ação no Pantanal MUPAN, with the support of DOB Ecology. This program intends to safeguard the connectivity of the Paraná- Paraguay wetland system regarding the natural conditions of the waterway and livelihoods of local communities. Within this program, some relevant actors along the waterway are going to be trained in adaptive planning methods, which will give visibility to the one designed in this thesis. In fact, this method is being adapted to be applied in some of the municipalities of the Paraná Delta.

Finally, adaptive and participatory perspectives, especially the methodologies developed following Dutch models, are starting to catch the attention of local decision-makers and other institutional or civil actors, given the fact that the Argentinean and Dutch governments are strengthening their cooperation through the signing of agreements. This interest is generating new horizons for the application of innovative initiatives such as the one designed in this thesis.

Regarding a planning perspective, the scenario-based method for the participatory design of spatial plans presented in this thesis could provide the methodological framework to operate within emerging metropolitan deltas, such as the Paraná Delta. Following this perspective, not only assessments but also territorial decisions can be revised and modified, taking into consideration uncertain evolution of social, political, natural, urban and climate changes.

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Appendix 1

"Zero Order Draft" of Storylines

Presented next are the diagnosis of the present situation and the "zero order draft" of storylines and final storylines developed in Stage I: Results of Development and Implementation.

Zero order draft of storylines for a desirable scenario:

Substratum Layer

- The natural condition of the Lower Delta is preserved and acquires a new significance according to the regional, metropolitan and local contexts. Any action carried on over the Delta takes in consideration its special natural condition and also its social dimension.
- The community and the government identify, measure and respect the services of the ecosystem. As the community is aware of the value of the Delta's natural services, they are an active part of the conservation process.
- The protocols for biodiversity conservation, water management and productive activities are respected throughout the diverse scales from the La Plata Basin to the local levels.
- The Delta's topography is not allowed to be modified if it alters the natural circulation of the waters or the natural habitat of the native species negatively.
- A change in the paradigm of natural conservation takes place. The impact of every new intervention is considered in an integrated way, not only measuring natural harm and benefits but also considering the population's economic and cultural development.
- The environmental impact of the activities carried out on both the islands and on the continental area is measured, as part of the same system.

- Biodiversity loss is reversed. Innovative ideas are being developed to preserve the native species, such as the ideas of introducing "biologic corridors", which gives biodiversity the chance to find continuity along the islands. The preserved area of the Delta in formation, which is constituted by the new islands of the Delta front, is linked with other protected areas regarding both spatial connections and the possibility for species to remain and maintain their natural habitats.
- Creation of new green spaces on the mainland to connect urban areas. Recovery for public use of existing green spaces including the coast.

Network layer

- Public infrastructure: connections are improved regarding coverage and quality. It includes the increase in the quantity and quality of the roads and the coverage of the fluvial transportation system (That means new boats and technologies to reduce environmental impacts such as coastal erosion or air and water pollution).
- The coverage of services extends to both the continental lands and the islands reducing the number of homes without sewer service, current water, electricity, and natural gas.
- Flood defense: in the continental area, the drainage system is improved to respond to extreme situations. On the islands, the pulses of flood and drought are respected. The flood defenses are being strategically designed to reduce artificial intervention and to be integrated with landscape and occupation.
- Natural species are being used to counteract erosion caused by ships and boats (mostly along the international channel).

Occupation Layer

- New developments do not alter either the natural topography or the identity of the urban patterns of the original city cores. New developments balance the inequities of the territory and shorten the social gaps.
- Any new urban development takes into consideration the natural characteristics of the wetland, planning occupation on suitable lands (avoiding floodplains). The transition towards the islands is gradual and controlled.
- Construction on the islands follows different rules from construction on continental lands. Building techniques increase their quality and technology to reduce the impact on the environment.
- Construction permits are granted following normative instead of being considered on a case by case basis that needs to be revised separately. No exceptions are made as a response to private pressure.
- The productive matrix distinguishes the area and is considered a tool for local development and distinction of the area. The social dimension of productive development is as important as the production itself.

- Encouragement of native low-impact productive activities (wickerwork, forestry or stockbreeding) with specific regulations to lower environmental harm while allowing the population to improve economically. Low-scale tourism is also promoted, accurately regulated, and differentiated from mass tourism.
- Alternative sources of energy are being tested and applied to the territory.

Three additional dimensions added to the 3-layered analysis:

The conceptual idea of the Delta

- The high potential and unique identity of the Lower Paraná Delta is recognized as being a natural area immersed in a context of metropolitan growth.
- The conservation of the natural landscape does not imply a production set-back and urban issues concerning development. Citizen participation in the decision-making process is key to finding a balance.
- The Delta is considered to be an experimental pilot area for the development of innovative plans and programs addressing environmental and urban dimensions in the context of the uncertainty of climate change.

Climate change-related impacts and responses

- The establishment of agreements is set up between governments, institutions, international agencies and the population for the generation and communication of knowledge. The creation of a free-access database decreases overlapping research about similar subjects.
- The generation of knowledge about the natural Delta and its urban condition helps to define the maximum level of occupation and intervention of the natural environment in the context of climate change.
- The effect of the changes in the Paraná's streamflow (which causes floods and droughts) is counteracted by a strategic low-impact water management plan over the inland territories. This plan is developed through a joint effort of governmental institutions and the area's inhabitants. Specialists give support and participate with the population in the generation of ideas for flood and drought management to preserve the productivity of the lands and also the quality of the inhabitant's life.
- Studies of vulnerability to floods and droughts are developed covering all aspects (physical, economic and social). Consequently, floodplains are no longer occupied for residential purposes, and an innovative solution for a system of public parks is developed.
- The drainage system of the urban fringe is capable of responding to regular pulses of droughts and floods coming from the Paraná River and also to Extreme Hydrological Events related to Sudestadas.

– The Delta front is a protected and not intervened area which helps decrease the effects of positive and negative storm surges, acting like a buffer that preserves the most consolidated territories from dangerous variations.

Planning and policies -governance layer-

– Conservation and development of the area is present in the governmental agenda and considered from an integrated perspective. It is a priority for the local governmental authorities and agencies to understand and deal with the entire territory (islands and continental lands) as a whole and to create spaces of dialogue for citizen participation. There is free access to information and a high level of interrelated governance systems.
– A territorial development plan is carried out in concordance with the Strategic Integral Plan for the Conservation and Sustainable Development of the Delta (PIECAS), developed by the National Government. As the PIECAS only considers the island territories, existing legislation is revised, and complementary legislation is developed to include continental lands, which are the most jeopardized areas due to the unplanned urban development and socio-economic oscillations and climate change. The government also asks civil society sectors (organizations of producers, National Institutes, etc.) to discuss some aspects of the PIECAS to revise the document from an integrated point of view.
– Land use planning evolves into spatial and territorial planning considering the effects of the actions over the territory and the urban processes.
– The government willfully prioritizes social interests over individual pressures. The legislation reflects this criterion providing a robust set of tools coherent to a concept of integrated development instead of giving fragmented responses to specific cases.
– Governments at the local and provincial scale discuss the legislation over each territory (San Fernando's islands and continent and Tigre's islands and continental areas) to find and correct any overlapping or contradictory information to improve each plan. They also search for reaching agreements between the diverse levels of government because of the potential it has to determine the capacity for economic development.

Zero-order draft of storylines for an undesirable scenario:

Substratum Layer

– The actions carried on over the Delta do not consider the condition of wetland and affect the system's environmental services, which are still not measured or identified.

There is confusion within the society about the real significance of the Delta regarding the services it provides.

- The protocols for biodiversity conservation, water management and productive activities are not respected.
- The topography of the Delta is continuously modified by new developments, negatively altering the natural circulation of its waters and the natural habitat of the area's native species.
- There is a lack of transparency concerning the information about the environmental impacts of different activities. Each development is measured independently.
- Unregulated activities developed on the islands isolate native animals causing their extinction. There is no biological continuity between the islands.

Network layer

- The islands are still not connected concerning fluvial transportation.
- Flood defense: in the continental area, the drainage system is not improved and does not respond to extreme situations, causing severe floods. On the islands, flood defenses are developed independently by each land-owner, so they act in a disorganized way, directly affecting inhabitants as well as the whole environmental system. The interventions are not adequate for counteracting the floods and drought pulses of the river, and for responding to the increasing water levels during Sudestadas.
- All infrastructures are built with strong materials without considering the use of native natural elements.

Occupation Layer

- The urban sprawl of the Buenos Aires Metropolitan Area continues its expansion towards the Delta. The developments on the islands are designed from a "continental" point of view.
- New developments on the islands and the continent that have flood protections continue modifying the topography vs informal and non-private constructions that do not contain those protections. Thus, causing further social polarization and spatial fragmentation.
- The construction of the islands follows similar rules to construction of continental lands. Building techniques are not improved and construction is developed without following any Delta tradition.
- Exceptions are still made when granting constructions permits as a response to pressures from private investors.
- There is an increase in mass tourism.

Three additional dimensions added to the 3-layered analysis:

The conceptual idea of the Delta.

- The myth of the unproductive wetland is still present. Its complexity, identity and potential are not recognized.
- There is no awareness of the cumulative impact that the activities developed on the continent and the island are having on the environment.
- The contrasting visions and developments between the continental area and the islands exacerbate regarding possibilities for economic development, accessibility, services and opportunities for the population.
- There is an increase in the differences between the Tigre and San Fernando islands.

Climate change-related impacts and responses

- The fragmentation of the research carried out by different institutions does not allow the generation of a database for climate change effects on the territory.
- There is no definition of a maximum level of occupation and intervention of the natural environment in a context of climate change.
- The effects of the changes in the Paraná's streamflow are not able to be anticipated, and there is no awareness about the possible risks.
- There are no studies of vulnerability to floods and droughts developed for the area, so the floodplains are still composed of formal and informal residences.
- The drainage system of the urban fringe is not capable of responding to regular pulses of droughts and floods coming from the Paraná River or to Extreme Hydrological Events related to the Sudestadas.
- The Delta front loses its natural buffer capabilities due to practices developed following sustainability precepts.

Planning and policies -governance layer-

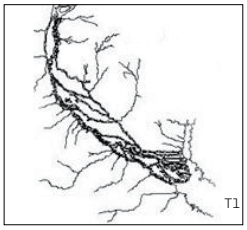
- Conservation and development of the area are still not present on the governmental agenda and are considered from a fragmented perspective. Environmental information is not transparent enough or communicated to residents.
- The Strategic Integral Plan for the Conservation and Sustainable Development of the Delta (PIECAS), developed by the National Government is still not articulated with other programs, and the Committee does not meet or carry out actions to achieve the main goals of the Plan. The PIECAS only considers the island territories, and it still does not consider the activities developed on the continent as a menace to the Delta's environment.
- Individual pressures rule over social interests, thus private interests shape the territory.

– Governments at the local and provincial scale are fragmented and do not collaborate or coordinate any actions together. Legislation regarding the area is not coherent to the reality of the context.

Appendix 2

Evolutionary process of the Delta in relation to its Metropolitan Condition

Territory and Climate



Delta Hydrology 1778

Delta front 1800

Rio de la Plata and Delta 1806

Networks and Regional Development T1

Río de la Plata and Paraná Delta water routes.

View of Buenos Aires 1794

Occupation

Before **1536**, the delta territory was occupied by indigenous groups (Guaraníes and Querandíes). After the colonisation, the lands of the Delta were occupied by foreign travellers, Spanish and criollos in dispersed and precarious settlements located in lands with fiddicult access.

by **1800** - Settlements of "colonies" in Santa Fé, Entre Ríos and Córdoba, mostly from Switzerland, Germany, Italy, etc.

Historical map of Tigre (Las Conchas)

Society | Economy | Politics | Legislation

1536 - First foundation of Buenos Aires by Spanish Crown (Pedro de Mendoza).

1580 - Second foundation of Buenos Aires (Juan De Garay) the city had 500 inhabitants.

Buenos Aires is part of the Viceroy of Peru.

1806 - First British invasion.
1807 - Second British invasion.

1810 - "Revolucion de Mayo". Begining of the process of independence from Spain.

Primera Junta: First government.

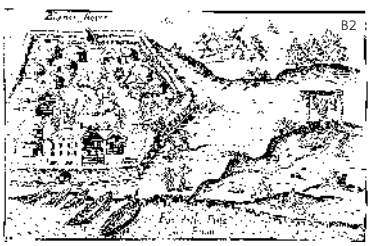
1816 - Independence from Spain. Congress of Tucumán.

1817 - The Congress moved to Buenos Aires.

1819 - Constitution of the United Provinces of South America.

1500

First settlements in Buenos Aires (first and second foundations of the city)



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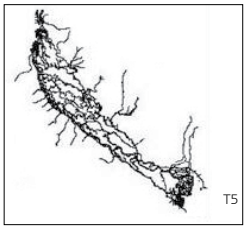
1820 - Sudestada in Tigre causes a great flood.

Delta front 1850



Delta Hydrology 1895

Flood in Santa Fe 1905

1820s- Buenos Aires port: the largest port of Argentina, receiving ships from Denmark, England, Spain and the United States of America.

N4
Buenos Aires Port 1856

1857 - First Railway: 9km long

1865 - The railway connected the city with downtown TIgre

1870 - Railway 2,555 km long

1897 - Construction of Puerto Madero.

Railway 1870

1833 - French occupation of the Martin García Island.

1825 - San Pedro was the first agricultural and livestock colony, in the banks of the Paraná River.

1820 - "Las Conchas" (nowadays Tigre) is moved to Lujan River's shoreline.

1856 - A decree granted to the Municipalities of Tigre, San Fernando and others, the right to exploit and cultivate the lands. Before that, the lands were not regulated by the State.

Port of Tigre 1866

1887 - Beginning of the design of General Paz highway and iniciation of the works of Puerto Madero.

1888- Provincial Law 2072 for measurement and distribution of the lands.
55% of the plots were transferred to private domain.

1898- Electric Tranway

Buenos Aires market 1867

1845 - Battle of "Vuelta de Obligado". Anglo-French army advanced along Parana River.

1847 - End of Anglo-French blocking.

1853 - Constitution of the Argentine Confederation. New National Organization.

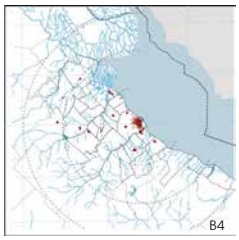
1860 - Second Residences, mostly owned by wealthy families were built in Tigre and Lower Paraná Delta.

1862 - Buenos Aires entered into the Confederation.

1880 - Federalization of Buenos Aires city.

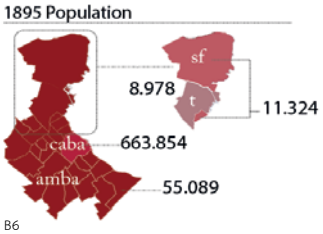
Agro-export model articulated with the British Empire.
Economical development.

1820



Urban agglomeration (1850)

Port of Rosario, Paraná River (1895)



TOC

T

Flood
River discharge (**1905**) 56,025 m3/sec.
(largest historical river discharge)
Increase of the Delta area (**1905**) : 12,199 ha.

Ebbs (low discharges)
1911-1949 - During this period tookplace the ten historical lowest discharges.

Flood
River discharge (**1929**) 41,964 m3/sec.
Increase of the Delta area (**1926**) : 5,562.8 ha.

T7

T8

Buenos Aires, Sudestada 1940

N

1909 - Construction of Retiro railway station (Buenos Aires).

1913 - First subway in Buenos Aires.

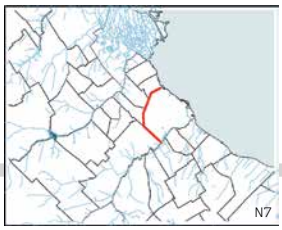
1914 - Railway 33,884 km long

1916- Railway Electrification.

1928- Bus (Colectivo)

N6

Railway 1914


N7

General Paz Highway map.

1937-1941 - Construction of General Paz Highway.

N8

General Paz Highway.

O

1911 - 1926- Construction of Puerto Nuevo. Ing. Luis Huergo

O4

New Port of Buenos Aires

1930 - 25,000 people were living on the Delta.

New actors in the Delta: large companies.

1930 - 1950 - Development of new centralities around the city of Buenos Aires. First suburban private developments appeared in the Metropolitan Area of Buenos Aires.

Tortugas club´s entrance ▶

1930- First country club (Tortugas)

1937 - First informal settlement (villa de emergencia) in the city of Buenos Aires.

O5

O6

S

1910 - 1920 - Migration of people from the provinces and suburban areas to the Metropolitan Area of Buenos Aires.

S2

1929 - World Economic Crisis

1930 - Uriburu's coup d'etat. "golpe de estado"

1930 - Industrialization. Economic model of Industrialization by Imports Substitution (ISI).

S3

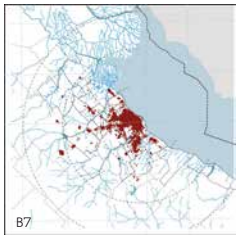
◀Buenos Aires city in 1950

1945 - Peron gets to the presidency.

S4

Port in 1927▲

1900


B7

Urban agglomeration (1910)

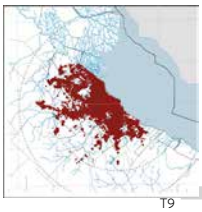
B8

Family living on the Delta (1930-1940)

Housing on the Delta (1930-1940)

B9

T


T9

Delta front 1950

T10

Flood in Entre Ríos 1959

T11

Sudestada 1958

Flood
River discharge (**1966**)
48,602 m3/sec.

Increase of the Delta area (**1969**) : 12,153.5 ha.

T12

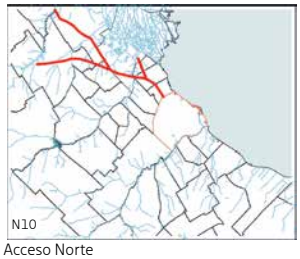
Sudestada 1958

N

N9

Railway 1947

1940-1965 - Construction of the "Acceso Norte" Panamericana Highway.


N10

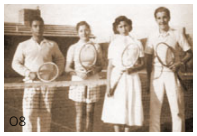
Acceso Norte

N11

Acceso Norte

O

O7


O8

Tennis at Highland country.

◀ Highland country publicity.

1952 - Tigre Municipality officially receives its current name.

O9

O10

Ford industry 1963

1960-1970 - 8 million people living in the metropolitan area. Lack of Estate control or planning towards the urban sprawl occuring

1963 - Industrial area is consolidated in Northern Buenos Aires.

S

1945- Second country club (Highland Park)

1952 - Peron gets elected a president for a second term.

1955 - Peron is derrocated by the "Revolucion Libertadora"

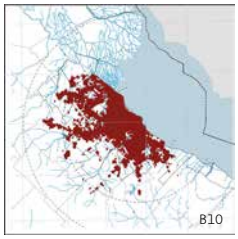
S5

S6

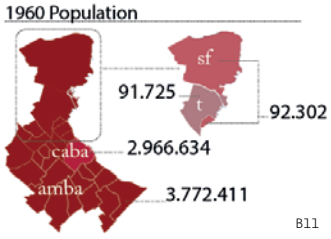
1968 - "Esquema Director Año 2000".

1973 - Peron's 3rd term as president.

1950


B10

Urban agglomeration (1950)

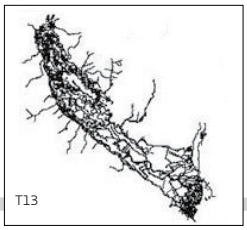


B11

B12

TOC

T


T13

Delta Hydrology 1970

Flood
River discharge (**1983**) 53,992 m3/sec (third largest historical river discharge)
Increase of the Delta area (**1984**) : 13,659.8 ha.

T14

Flood in Santa Fe 1983

T15

Flood in Santa Fe 1983

N

1971 -1977- Construction of Zárate Brazo Largo complex.

N12

"Zárate Brazo Largo" complex

1974- Construction of Atucha Nuclear Station (Argentina).

1974- Construction of JupiáDam (Brazil).

1978- Construction of Ilha Solteira Dam (Brazil).

1976 - Reorganization National Plan. Highway construction plan.

N13

1984- Construction of Itaipú Dam (Paraguay & Brazil).

O

O11

Loteo Popular

1975-1985 - The "Country Club" urbanization model consolidates. More than 200 private gated communities are created in the northern metropolitan area.

O12

Nordelta Masterplan

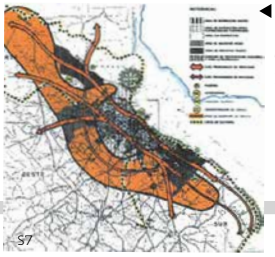
1945-1977 - "Loteos Populares". Division of lands without infrastructure for middle and low income groups.

S

End of "Loteos Populares"

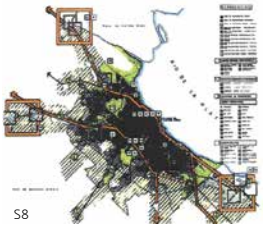
1977 - Law 8.912 "ordenamiento territorial y usos de suelos" territorial order and land uses law, forbidding the urbanization of low and flooded areas, and including the term "Country Club".

1976-1983 Military Government. (Dictatorship)
-No state investment
-Privatization


S7

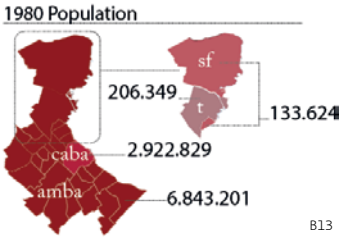
◀**1978** - Study on the Metropolitan System of Buenos Aires SIMEB

1983 - Return to the democracy: National elections, start of the presidence of Alfonsin.


S8

1989- Metropolitan Area of Buenos Aires project.

1970



B13

B14

B15

T

Flood
River discharge (**1992**) 54 925 m3/sec.
(second largest historical river discharge)
***Increase of the Delta area* (1994)** : 17 490.7 ha.

Economic loss 8 000 UDS millions
Affected people: 25 000

T16

T17

Flood in Corrientes 1998

N

1991 - Privatization. Concession of the trains and tracks infrastructure

N14

Puerto Madero before works

1990s - Railway reduction from 47,000 km long to 34,059 km.

1992 - National Achitecture Competition for developing Puerto Madero abandoned area.

1992 - " Tren de la Costa" A turistic railway that connected the northern area of Buenos Aires city to the center of Tigre

1993 - Beggining of the works in Puerto Madero urban development, as an important key for external relations.

N15

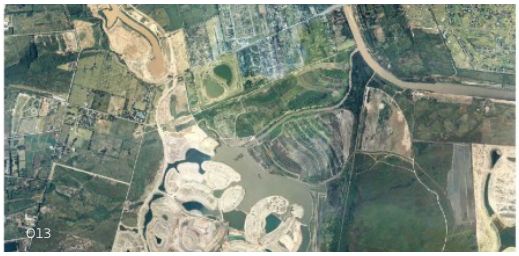
1994- Yaciretá Dam (Argentina).

O

1990 - Gated communities via "Master Plan" model. First gated communities over Lujan River shoreline and Parana.

Gated communities increase in the Lower Parana Delta (Tigre and San Fernando)

1992 - Construction of Parque de la Costa, an amusement park in coast of the Delta.


O13

Topography change in Nordelta

S

1989-1999 -
Neoliberalist model.
Washington consensus

Deregulation, Privatization and Reduction of government control of the economy

S9

1991- Creation of Mercosur.

1995 - Unemployment rate reaches 15.2%

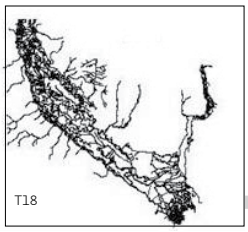
1994 - Constitutional Reform. New articles including Article 41 - Environmental laws.

1991/1993 /1994- Recognition of Ramsar Convention on Wetlands (**1971**), United Nations Framework Convention on Climate Change (UNFCCC) and Convention on Biological Diversity (United Nations **1992**).

1990

B16 - Paseo Victorica, Tigre.

T

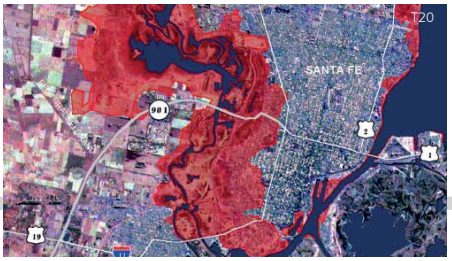

T18

Delta Hydrology 2000

T19

Floods in Santa Fe in 2003

Increase of the Delta area (**2002**) : 20 213.9 ha.



T21

Floods in Santa Fe in 2003

N

1998-2000- Creation of the Puerto Madero Coorporation for the area´s management.

2000 - start of the process of external large inversions in Real Estate developments.

2000- Construction of Porto Primavera Dam (Brazil).

N16

2001- Puente de la Mujer.

2003- Construction of Rosario-Victoria 4 Km-long Bridge (RN174)▶

N17

O

O14

Nordelta (Tigre)

◀ **1999** - creation of the big gated community named Nordelta

2000 - Changes in consumption: rise of Hypermarkets outisde of the city.

2000 - Over 300 km2 of gated communities in the entire Buenos Aires Metropolitan Area.

Tigre 2004 ▶

O15

S

2001 - Institutional and economic crisis: five presidents 11 days.

Crisis of political representations

End of convertibility and Devaluation of national currency.

ClarínX

Renunció De la Rúa

El PJ analiza la devaluación

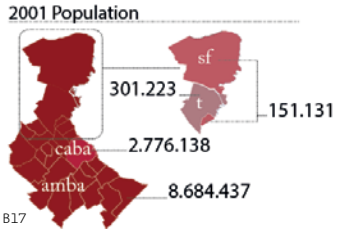
S10

S11

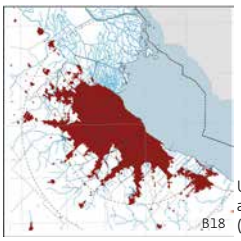
2002 - New Economic activities and technology towards a more global economy.

2004 - inclusion of **San Fernano islands** in the World Network of **Biosphere Reserves of UNESCO's Man and the Biosphere Programme** (MAB),

2000



B17


B18

Urban agglomeration (2010)

B19

T

T22

2008 - Almost 12% of the Delta Area was burnt due to the practice of biomass burning carried on during a drought period.

T23

T24

Smoke in Buenos Aires city (2008)

T25

N

N18

N19

2011- Escobar re-gasification port =Environmental risk.

O

Decrease of population in San Fernando Islands.

Increase of population in Tigre Islands.

O16

O17

Abandoned houses in San Fernando Islands vs. turism increase in Tigre

Spatial polarization ▼

O18

O19

Gated communities on the islands (Costa de Este, Tigre)

S

New actors. NGO and other civil organizations, Increase of touristic activities, Sustainable languaje.

S12

◀**2007** -"Lineamientos Estrategicos Para la Region Metropolitana de Buenos Aires".

2008 - Management plan of sustainability for the Parana Delta area (National government). PIECAS-DP.

2012 - State Regulations. Currency control

Imports sustitution.

Interventionist Economic model.

2005

B20 - Dichotomy between the continent -island

TOC

T

Delta landscape 2016

N

Delta front 2015

Delta front 2119

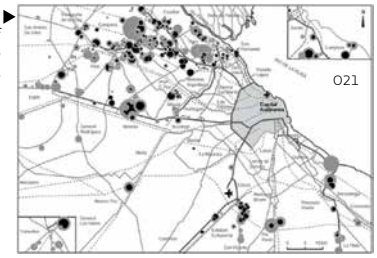
2011 - Paraná ▶ Paraguay International Ship Channel.

Railway 2014

O

◀Tigre 2014

Location and densities of private developments ▶



First floating houses in San Fernando.

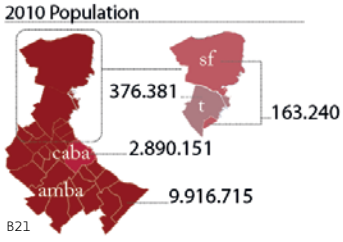
S

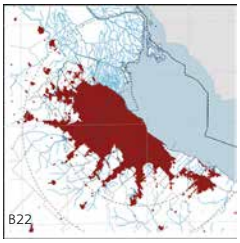
2013 - Development of an inventory of Wetlands along the Paraná-Paraguay fluvial corridor.

2013 - Management plan for the Islans of Tigre (Municipality of Tigre).

2014 - PIECAS-DP is revised.

2010





List of Figures of the timeline -Appendix 2-

Images of Territory (substratum layer):

T1: Delta hydrology (1778) [Online image]. Retrieved March 1, 2018 from http:// www. histarmar. com. ar/DeltaParana/ AnalisisAvanceDelta. htm

T2: Delta Front (1800). Elaborated from the basis of Sarubbi (2007).

T3: Map of Rio de la Plata and Paraná Delta [Online image]. Retrieved March 1, 2018 from Colección del Museo Histórico Nacional. https:// videoteca. prefecturanaval. gob. ar/ archivofotografico/displayimage. php?album=7&pid=23879#top_display_ media

T4: Delta Front (1850). Elaborated from the basis of Sarubbi (2007).

T5: Delta hydrology (1895) [Online image]. Retrieved March 1, 2018 from http:// www. histarmar. com. ar/DeltaParana/ AnalisisAvanceDelta. htm

T6: Flood in Santa Fe (1905) [Online image]. Retrieved March 1, 2018 from http://www. paraconocernos. com. ar/?p=286

T7: Sudestada in Buenos Aires (1940) [Online image]. Retrieved March 1, 2018 from British Pathé. "Floods in Argentine" https://www. youtube. com/ watch?v=BXkoX-QkSOA

T8: Sudestada in Buenos Aires (1940) [Online image]. Retrieved March 1, 2018 from British Pathé. "Floods in Argentine" https://www. youtube. com/ watch?v=BXkoX-QkSOA

T9: Delta Front (1950). Elaborated from the basis of Sarubbi (2007).

T10: Flood in Entre Rios (1959) [Online image]. Retrieved March 1, 2018 from http://www. aimdigital. com. ar/2015/12/29/ la-gran-inundacion-de-1959/

T11: Sudestada in Buenos Aires (1958) [Online image]. Retrieved March 1, 2018 from British Pathé. "Argentine Record Floods " https://www. youtube. com/ watch?v=1nS1rFFEKHg

T12: Sudestada in Buenos Aires (1958) [Online image]. Retrieved March 1, 2018 from British Pathé. "Argentine Record Floods " https://www. youtube. com/ watch?v=1nS1rFFEKHg

T13: Delta hydrology (1970) [Online image]. Retrieved March 1, 2018 from http://www. histarmar. com. ar/ DeltaParana/AnalisisAvanceDelta. htm

T14: Flood in Santa Fe (1983) [Online image]. Retrieved January 16, 2018 from http://www. paraconocernos. com. ar/?p=286

T15: Flood in Santa Fe (1983) [Online image]. Retrieved January 16, 2018 from http://www. paraconocernos. com. ar/?p=286

T16: Flood in Corrientes (1998) [Online image]. Retrieved January 16, 2018 from http://noticiasitati. blogspot. com. ar/2013/07/a-30-anos-de-la-mayor-crecida-del. html

T17: Flood in Corrientes (1998) [Online image]. Retrieved January 16, 2018 from http://noticiasitati. blogspot. com. ar/2013/07/a-30-anos-de-la-mayor-crecida-del. html

T18: Delta hydrology (2000) [Online image]. Retrieved March 1, 2018 from http://www. histarmar. com. ar/DeltaParana/AnalisisAvanceDelta. htm

T19: Flood in Santa Fe (2003) [Online image]. Retrieved February 15, 2018 from http://www. agenciacta. org/spip. php?article8221

T20: Flood in Santa Fe (2003). (Comisión Nacional de Actividades Espaciales, 2006).

T21: Flood in Santa Fe (2003) [Online image]. Retrieved February 15, 2018 from http://www. agenciacta. org/spip. php?article8221

T22: Fires in Parana Delta (2008) Source: Aqua/MODIS 2008/109 17:50 UTC Fires and smoke in Argentina.

T23: Malamud, P. (2008) Paisaje desolador después del fuego [Online image]. Retrieved March 1, 2018 from https://es. wikipedia. org/wiki/Incendios_en_el_delta_del_r%C3%ADo_Paran%C3%A1_de_2008#/media/File:Incendios002a. jpg

T24: Malamud, P. (2008) Isleño luchando contra los últimos focos del incendio. [Online image]. Retrieved March 1, 2018 from https://es. wikipedia. org/wiki/Incendios_en_el_delta_del_r%C3%ADo_Paran%C3%A1_de_2008#/media/File:Tierraarrasada001a. jpg

T25: Smoke in Buenos Aires as a result of fires in the Delta. [Online image]. Retrieved March 1, 2018 from https://es.wikipedia.org/wiki/incendios_en_el_delta_del_rio_parana_de_2008#/media/file:humo_en_buenos_aires-2424784303.jpg.

T26: Delta Front (2015). Elaborated from the basis of Sarubbi (2007).

T27: Delta landscape [Online image]. Retrieved March 10, 2018 from https://losaliados. wordpress. com/

T28: Delta Front (2119). Elaborated from the basis of Sarubbi (2007).

T29: Delta landscape [Online image]. Retrieved March 1, 2018 from https://losaliados. wordpress. com/

Images of Networks and Development (network layer)

N1: Rio de la Plata and Paraná Delta [Online image]. Retrieved March 1, 2018 from http://faggella. com/histoargenta/hispanos/mardulce. htm

N2: View of Buenos Aires (1794) [Online image]. Retrieved March 1, 2018 from http://www. arcondebuenosaires. com. ar/puerto_bs. htm

N3: Port of Buenos Aires (1800) [Online image]. Retrieved February 1, 2017 from http://www. histarmar. com. ar/InfHistorica/BreveHistArqBsAs/BreveHistArqubase. htm

N4: Buenos Aires Port (1856) [Online image]. Retrieved January 11, 2018 from http://www. arcondebuenosaires. com. ar/puerto_bs. htm

N5: Extension of the Railway network (1870) [Online image]. Retrieved March 8, 2018 from https://www. educ. ar/recursos/20091/la-red-ferroviaria-en-la-argentina-actual.

N6: Extension of the Railway network (1914) [Online image]. Retrieved March 8, 2018 from https://www. educ. ar/recursos/20091/la-red-ferroviaria-en-la-argentina-actual.

N7: Location of General Paz Avenue.

N8: Construction of General Paz Avenue. Municipalidad de la Ciudad de Buenos Aires. Revista "La Ingeniería" nº 773. Marzo de 1939 (año XLIII) 24 September 1938.

N9: Extension of the Railway network (1947) [Online image]. Retrieved March 8, 2018 from https:// www. educ. ar/recursos/20091/ la-red-ferroviaria-en-la-argentina-actual.

N10: Location of Acceso Norte.

N11: Acceso Norte [Online image]. Retrieved January 16, 2018 from https:// www. pagina12. com. ar/12204-los-aumentos-vienen-marchando

N12: Zarate Brazo Largo complex [Online image]. Retrieved December 16, 2017 from https://www. flickr. com/photos/ lrargerich/3424672294/

N13: Itaipu Dam (Paraguay and Brazil). [Online image]. Retrieved December 16, 2017 from https://www.comboiguassu. com.br/noticias/itaipu-binacion-al-comienza-el-ano-con-record-de-produccion.

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N18: Protest against Escobar Re-gasification port. [Online image]. Retrieved March 5, 2018 from http:// www. opsur. org. ar/blog/2015/03/16/ perez-esquivel-es-necesario-desplazar-el-puerto-regasificador-de-escobar/

N19: Escobar Re-gasification port. [Online image]. Retrieved March 1, 2018 from https://www. eldiadeescobar. com. ar/ interes_general/65903

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N21: Zagare, V. (2015) Ship sailing along Paraná de las Palmas River.

N22: Extension of the Railway network (2014) [Online image]. Retrieved March 1, 2018 from https:// www. educ. ar/recursos/20091/ la-red-ferroviaria-en-la-argentina-actual

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O5: First country club (Tortugas) in 1930. [Online image]. Retrieved November 11, 2017 from https://www. tiempodetortuguitas.com.ar

O6: Villa in Buenos Aires (1930s) (Pascual, 2013).

O7: Advertisement of Highland Park country club [Online image]. Retrieved March 11, 2018 from http://www. highlandparkweb. com/sigmacontent313/hpccwebsite/ historia. html

O8: Tennis group playing at Highland Park country club [Online image]. Retrieved March 11, 2018 from http://www. highlandparkweb. com/sigmacontent313/ hpccwebsite/historia. html

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O19: Private developments on the islands of Tigre (2018). Google Earth.

O20: Tigre (2014). Google Earth.

O21: Location and densities of private developments (Thuiller, 2005, p. 8).

Curriculum Vitae

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Born in Buenos Aires, Argentina, 06-04-1977.

EDUCATION

– 2010-
PhD Candidate
Delft University of Technology (Delft, the Netherlands) Department of Urbanism
Thesis: Towards a Method of Participatory Planning in an Emerging Metropolitan Delta in the Context of Climate Change. The Case of Lower Paraná Delta, Argentina.
Promotor: Prof.dr.ir. Han Meyer

– 2005-2011
Master in Urban Economics.
Torcuato Di Tella University, Buenos Aires

– 1995-2000
Architect
University of Belgrano, Buenos Aires.

AWARDS

– 2001
Honour Diploma, University of Belgrano, Buenos Aires.

PUBLICATIONS

- Zagare, V. (2017) Deltas Metropolitanos Emergentes. Hacia una Planificación Colaborativa. In: Charriere, M. (ed.) *Costas y Cuencas de la Región Metropolitana de Buenos Aires: estudios, planes y proyectos*. Consejo Profesional de Arquitectura y Urbanismo, Buenos Aires. pp. 156-162.

- Zagare, V. (2016). El Delta del Paraná en comparación con otros deltas del mundo. In: Peña, C. (Ed.) *Solución Bambú: Guía para el manejo sustentable del Género Phyllostachys.* Dirección Provincial de Islas, Gobierno de la Provincia de Buenos Aires – INBAR (International Network of Bamboo and Rattan). ISBN 978-987-33-8429-5. pp. 241-260.

- Zagare, V., Sepúlveda, D. (2016). *Scenario Development and Participatory Processes as a Tool for Integrating Urban and Environmental Planning*. International Journal on Climate Change: Impact and Responses, Volume 8, Issue 4, pp.65-88 (ISSN 1835-7156).

- Zagare, V. and van Dijk, W. (2014). Paraná Delta, Argentina. In Meyer, H. and Nijhuis S. (eds.) *Urbanized Deltas in Transition.* Techne Press, Amsterdam. pp. 33-40.

- Zagare, V. (2014). *Transformaciones, desafíos y oportunidades en la planificación y diseño de los Deltas Urbanos.* Revista M., Bucaramanga, Colombia, Vol.11, Issue 1, pp. 2-7 (ISSN 1692 – 5114).

- Zagare, V., Manotas Romero, T. (2014). *Procesos Naturales y Urbanos en el Delta Inferior del Paraná: Actores, Conflictos y Desafíos de un área en constante transformación*. Revista M, Bucaramanga, Colombia, Vol.11, Issue 1, pp. 24-37. (ISSN 1692 – 5114).

- Zagare, V. (2014). *Dichotomous Delta: between the natural and the metropolitan. The case of the Paraná Delta, Argentina.* Built Environment. Alexandrine Press. Volume 40, Number 2, pp. 213-229(17).

- Zagare, V., Blanco, D., Machain, N., Carlino, H., Quintana, R., Kandus, P. and Ceballos, D. (2014) Paraná Delta. In: Bucx, T., van Driel, W., de Boer, H., Graas, S., Langenberg, V., Marchand, M., van de Guchte, C. (Lead Authors) Work Document. *Comparative Assessment of the Vulnerability and Resilience of Deltas – Extended version with 14 Deltas*. Pp -107-145.

- Zagare, V., Sepúlveda Carmona, D., Massin, T., Janchez, F. (2013). *Scenarios for an integral approach to urban and environmental dimensions in the Lower Paraná Delta (Argentina)*. Working Paper, Call "Políticas de Suelo y Desarrollo Urbano en América Latina", Theme "Cambio climático, riesgo medioambiental y uso de suelos urbanos" del Programa para América Latina y el Caribe del Lincoln Institute of Land Policies (USA).

- Zagare, V. (2012). *Spatial Analysis of Climate Change Effects on Urbanized Delta Territories as a Tool for Planning*. The International Journal of Climate Change: Impacts and Responses, Vol 3, Issue 4. Pages 19-34. Common Ground Publishing (ISSN 1835-7156).

- Zagare, V. (2008). *Buenos Aires: en busca de un modelo de gestión integral del transporte*. Revista M. Nº8. Bucaramanga, Colombia, (ISSN 1692 – 5114) (pp 46-56).

- Zagare, V. (2006). *La Arquitectura del afuera: una crítica arquitectónica tangencial*. Published online: www.antroposmoderno.com.

CONFERENCES

- 2016: **IFOU 2016 -International Forum of Urbanism** (Buenos Aires, Argentina, October 26-28). Zagare, V.; Sepúlveda, D. Oral Presentation: "*Desarrollo de escenarios urbanos y ambientales a través de procesos participativos como herramienta de planificación hacia la integración. El caso del Bajo Delta del Paraná, Argentina*" (Development of urban and environmental scenarios through participatory processes as a planning tool towards integration. The case of the Lower Paraná Delta, Argentina).

- 2015: **36th IAHR Congress.** Rotterdam, (Holanda) September 24-26. Zagare, V., Sepúlveda, D. Oral presentation: *Scenario development for reaching urban and environmental planning integration in the context of climate change*.

- 2015: **IAHR World Congress**. The Hague (the Netherlands) June 28th - June 3rd. Oral Presentation: *Scenario development through participatory processes as a tool for urban and environmental planning integration in the context of climate change*. The case of Lower Paraná Delta, Argentina.

- 2014: **Deltas in times of Climate Change II.** Rotterdam (the Netherlands) September 24-26th. Oral presentation: *Scenario development for reaching urban and environmental planning integration in the context of climate change*.

- 2013: **Research Seminar on Land Policy and Urban Development in Latin America**, México City (México), September 25-27th. Organized by Lincoln Institute of Land Policy. Presentation of the project *Scenarios for an integral approach to urban and environmental dimensions in the Lower Paraná Delta (Argentina).*

- 2012: **Argentina y Ambiente 2012**, Mar del Plata (Argentina) May 28th- June 1st**.** Oral presentation: *Ambiente urbano e implicancias espaciales en el Bajo Delta del Paraná: estudio de tipologías residenciales.*

- 2011: **Climate Change Conference,** Rio de Janeiro (Brazil) June 27-28th. Online Presentation: *Spatial Analysis of Climate Change Effects on Urbanized Delta Territories as a Tool for Planning: The Case of the Lower Paraná Delta.*

- 2010: **Deltas in times of Climate Change.** Rotterdam, (the Netherlands) September 29th - October 1st. Oral presentation: *Challenges and opportunities. The estuarine delta unit of Río de la Plata and Paraná River.*

- 2010: **Deltas in times of Climate Change**. Rotterdam, (the Netherlands) September 29th - October 1st. Poster Pitch: *Adaptation strategies in urban areas. Climate change, urban dynamics, and (lack of?) governance: a Latin American case.*

LECTURES AND OTHER PARTICIPATIONS

- 2017: Webinar "Rural-urban linkages combining safety and quality of living in delta cities". (The water channel, April 19), Organized by The water channel and Delta Alliance International.
  Speakers: Wim Timmermans, Verónica Zagare, Ken Kinney, Dirk Wasscher.

- 2016: Webinar "What makes an Urban Delta Resilient?". (The water channel, December 15) Organized by The water channel, Delta Alliance International and TUDelft.
  Speakers: Han Meyer, Verónica Zagare.

- 2016: Taller TAU Delta, Universidad Nacional de San Martín, Buenos Aires. Lecture: Comparative assessment of urban deltas. Indicators, resilience, intervention trends and innovative strategies.

- 2015: Workshop: Urban and Environmental Scenarios for the Lower Paraná Delta, Buenos Aires (Argentina) April 24th. Organization and general coordination of the activities, Presentation, opening, and closure of the Workshop.

- 2013: Round Table: Research by Design / Investigaciones proyectuales. Architecture Faculty Auditory National University of La Plata, La Plata, Argentina. Methods for the research and design processes.

- 2013: Seminar Research Randstad, Delft, (the Netherlands) June 21st. Second meeting of the International and Comparative Planning Research Theme of the Department of Urbanism, TUDelft, together with OTB Research Institute. Lecture: Presentation of PhD project.

- 2013: Master of Science Architecture, Urbanism and Building Sciences. Delft University of Technology, Delft, (the Netherlands) May 27th. Specialization Complex Cities and Regions in Transformation. Lecture: Urban Deltas and the metropolitan dimension.

- 2013: Master of Science Architecture, Urbanism and Building Sciences. Buenos Aires (Argentina) May 6th. Specialization Complex Cities and Regions in Transformation. Lecture: Natural pulses – Urban processes. Analysis of the relation between natural dynamics and urban processes in the Delta within the metropolitan context. Lecture developed during a study trip to Buenos Aires.

- 2013: Seminar – Workshop: Escenarios Urbano Ambientales para el Bajo Delta del Paraná, Buenos Aires (Argentina) May 10th. Organization and general coordination of the activities, Presentation, opening, and closure of the Workshop.

- 2013: Café Amsterdam. 39° International Book Fair, Buenos Aires (Argentina) April 27th. Participation in Round Table together with Maarten Asscher and Niek Boot. Presentation of Maarten Asscher book called H2Olland. Organized by the Netherlands Institute Buenos Aires (NIBA).

RESEARCH PROJECTS

- 2012-2013. Research Project "**Scenarios for an integral approach to urban and environmental dimensions in the Lower Paraná Delta (Argentina).**" Lead Researcher. Winner Project of call 2012 "Políticas de Suelo y Desarrollo Urbano en América Latina," of the Program for Latin America and the Caribbean of the Lincoln Institute of Land Policy (USA).

TEACHING AND RESEARCH

- 2008-2016: Researcher. Instituto Superior de Urbanismo, Territorio y Ambiente - ISU. University of Buenos Aires.
- 2003-2004: Professor of Theory and Critic of Architecture. University of Belgrano. Chair: Arch. Jorge Mele.
- 2001-2004: Assistant Professor of Theory of Architecture. University of Buenos Aires. Faculty of Architecture. Chair: Arch. Jorge Mele.
- 2001: Visitor Professor in Architecture Design V. Urban Planning. University of Buenos Aires. Faculty of Architecture. Chair: Arch. Horacio Baliero.

OTHER POSTGRADUATE COURSES

- 2006. **Postgraduate course on Urban Law.** Lincoln Institute of Land Policies (LILP). Universidad Nacional General Sarmiento (UNGS) -Buenos Aires-.