JOHANNA HEDLUND

TRANSFORMING DELTA TERRAINS

Research and design for a site in a telecoupled river system

Faculty of Landscape Architecture, Horticulture
and Crop Production Science
Swedish University of Agricultural Sciences

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Transforming delta terrains
- research and design for a site in a telecoupled river system

Transformering av deltalandskap
- forskning och design för en plats i ett sammankopplat flodsystem

Johanna Hedlund

Supervisor: Lisa Diedrich, Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences and Flavio Janches, Faculty of Architecture, Design and Urbanism, University of Buenos Aires

Co-supervisor: Henrik Olsson, Ramböll

Examiner: Maria Kylin, Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences

Co-examiner: Diego Sepulveda, Department of Urbanism, Delft University of Technology

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SLU, Swedish University of Agricultural Sciences
Faculty of Landscape Architecture, Horticulture and Crop Production Science
Department of Landscape Architecture, Planning and Management

The earth to be spann'd, connected by network [...]
The oceans to be cross'd, the distant to be brought near,
The lands to be welded together.

\- *Passage to India,* Walt Whitman, 1900.

Summary

In this study, telecoupled and local impacts on flooding in the Paraná River Delta in Argentina are analysed and described. A sustainable design strategy is then proposed for a newly developed site in the delta.

Land systems are not only affected by their direct surroundings, but also by interconnections with distant areas. The accelerating pace of globalisation and new anthropogenic drivers produce novel relationships between previously disparate geographical places. This situation can be observed in the lower Paraná River Delta, north of Buenos Aires, Argentina. Characteric for the delta is it being a heterogeneric area where a number of different human and natural pressures converge. The drivers behind these pressures are direct and indirect interactions, couplings, from local and distant places in the connected river system. Research on upstream and local events reveals changes in the conditions of the river system. Telecoupled and local impacts are historically major forces which form and govern the delta processes, but as the impacts are amplified, new challenges in the form of large environmental transformations are currently emerging in the delta.

Growing urbanisation in the delta makes it clear that the area is increasingly becoming a part of the urban conurbation of Buenos Aires. Since the expanding delta front is expected to reach the city, this could result in major challenges in adapting to changes in flooding and sedimentation. The analysis in this study shows that, in order to manage the telecoupled and local impacts, the delta needs to function as an open system rather than as a landscape in isolation. Many current local interventions, such as new private developments, run counter to this principle. While the traditional human lifestyles were previously able to coexist with the natural environment and hydrodynamics of the delta, human and natural processes are today increasingly beginning to collide. This thesis sets out to explore the possibility of conducting design interventions that are in line with the natural processes of the delta, as an alternative to the many unsustainable actions that are taking place in the area at the moment. A recently developed site on one of the most fragile islands along the delta front, the Colony Park project, serves as a case in point and exemplifies the transformation from natural wetlands into a closed, private settlement constructed on embankments. The site has therefore been selected as an area of focus in this study.

The results of this work are the implementation of a research approach based on interconnectedness, as well as a case study involving a design strategy which relates the theoretical findings to design practice. It concludes that taking into account interconnectedness in the physical construction and in new integrated design solutions has the potential of generating benefits for this problematic, closed site. Creating a more open system can help to decrease vulnerability in the delta, as well as to support its future sustainability.

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Contents

Definitions

Catchment area
Area defined by a surface or underground watershed and drained by a river with all its tributaries.
(Prominiski, 2011, p. 284)

Delta
A deposit partly subaerial built by a river into or against a body of permanent water.
(Barrell, 1912, p. 381)

Estuary
An enlargement of a river channel near its mouth.
(Barrell, 1912, p. 402)

Feedback loop
The mechanism that allows a change in a stock to affect a flow into or out of that same stock, which further can amplify or mitigate change within the system.
(Meadows, 2008, p. 189)

Floodplain
Terrestrial margins of a watercourse particularly subject to its discharge processes, especially flooding.
(Prominiski, 2011, p. 284)

Interconnectedness
The relationships that hold the elements of a system together.
(Meadows, 2008, p. 13)

Private gated development
Neighborhood with a closed perimeter, isolated from the rest of the urban fabric.
(Zagare, 2014, p. 218).

Resilience
The ability of a system to bounce or spring back into shape after being pressed or stretched.
(Meadows, 2008, p 76)

Social-ecological system
Linked social and ecological systems.
(Berkes et al., 1998, p. 4)

Telecouplings
Socioeconomic and environmental interactions among coupled human and natural systems.
(Liu et al., 2007, p. 639)

Tributary
Watercourse that flows into a larger watercourse or into a lake.
(WMO & UNESCO, 2012, p. 356)

Watershed
Area having a common outlet for its surface runoff.
(WMO & UNESCO, 2012, p. 31)

1. Introduction

1.1. Background

Interrelations between distant places are becoming increasingly influential with forces of globalisation and expanding social-ecological systems (Berkes et al., 1998). These dynamics result in complexity and non-linearity in the behavior of systems. Due to the interplay between natural and human processes, places are often embedded in larger regional systems which emphasises distant interconnectedness. Changes in land use as well as events of climate change make regional and global effects apparent on the local scale. The implications can form profound challenges for the sustainability practice of land systems. Especially so, disruptions across large distances create uncertainties in the understanding and design of local sites. Despite numerous studies on sustainability, little attention has been given to understand and integrate transscalar solutions as a response to the complexity of interactions between different places. But to consider macro effects as part of the local design process becomes important in the light of interconnected places. A given example of a social-ecological network that connects distant landscapes to each other is the river system, whose impacts on the surrounding terrain are often visible both in the larger and the local scale.

Since river systems are a common component of urban landscapes of today, landscape architecture holds an intrinsic role in design practice related to the land-water interface. Where design intersects with terrestrial processes as well as with hydrodynamics, places of constant transformation evolve. The Paraná Delta, north of Buenos Aires, Argentina (Fig. 1), materialises such an interaction between terrestrial and hydrological dynamics. The delta remains interconnected by being the mouth of the Paraná River system, which constitutes an essential carrier of renewable freshwater into the Atlantic Ocean (Zagare & van Wijk, 2014, p. 37). By forming a 300 km long funnel (Fig. 2), the delta drains the entire La Plata Basin, the second largest hydrological river basin of South America (Bucx, 2014, p. 109). The water of the river system empties out in the estuary of Rio de la Plata, making the delta unique in the way that it has no direct contact with the ocean. Instead, the delta represents the transition between the river and the estuary. The delta thus has an inherent capacity of regulating the river flow as well as the water from Rio de la Plata and the Atlantic Ocean, coming from the other direction.

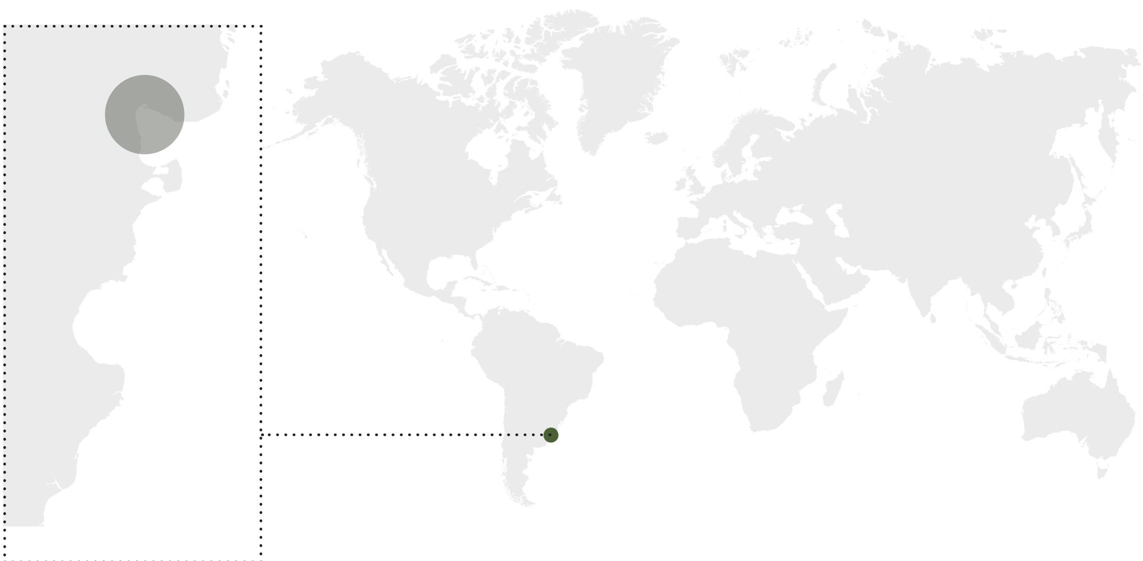

Fig. 1. The Paraná Delta, Argentina.

Due to the major area that the delta floodplain forms, many dissimilar landscapes intersect within and around its borders. Its strong contrasts become clear in the transition between land and water, and are especially visible in the lower delta adjacent to the metropolitan area of Buenos Aires. The lower delta constitutes the focus of this study, and this area is referred to when further mentioning the delta. Within the lower delta area, conversions of various regimes cause issues for the environmental conservation. In recent years, hydrological events have occurred more frequently and increased the level of water in the delta. Water is converging from different directions and in stronger magnitudes than before. Ecosystem services are provided by the delta through the maintenance of hydrological and biogeochemical cycles (Baigún et al., 2008, p. 250), such as regulation of water level, fixation of sediments and pollutants, and carbon sequestration. The flow of water is essential for the delta to remain a wetland structure. The regulative processes are circular, which means that if an increase in water flow and a decrease in wetland area occur simultaneously, unbalance will be generated. This conflicting complexity is most apparent in the 1st section of the lower delta, closest to the mainland. The influence of water flow creates a constantly transforming landscape. In addition, a growing collision between natural processes and effects from increasing urbanisation can be observed. As a result of private gated developments, land is dredged and areas in the delta are remade into static sites of raised land and gated communities. In this study, the site of the privatised area called Colony Park illustrates an example. In contrast to the dynamic wetland complex, where the natural processes of water flow (flooding and sedimentation) can take place, such private construction sites may cause consequences for surrounding areas in the delta. Traditional island living and construction techniques developed over years of experience are compatible with the wetlands in the delta environment, but when new residential areas are built, natural drainage is often destroyed by changes in topography and soil structures. This will, in the course of time, have considerable consequences not only for the delta, but also for the areas it is influenced by and the areas it affects.

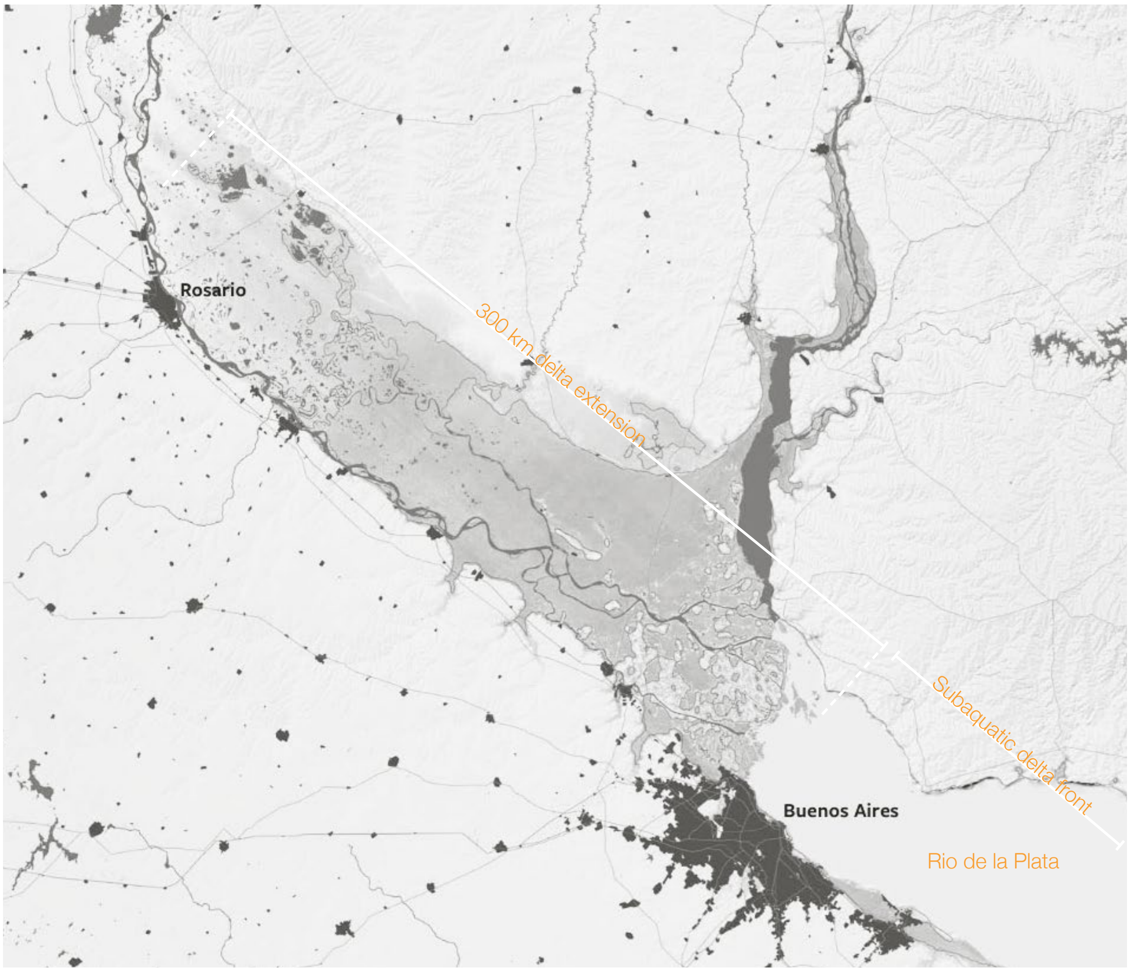

Fig. 2. The entire delatic platform of the Paraná Delta.

1.2. Problem context

Deltas are in their nature systems of heterogeneity. The water flow carries physical material that impacts and transforms the environments into layered structures. Shaped by processes of flooding, sedimentation and ecological succession, deltas are strongly characterised by constant changeability. The activity of water flow and hydrodynamics governs the course of this changeability. In this sense, deltas are process-driven. The processes act on the local scale, but by being enclosed in physical systems the processes also provide elements that emerge from events in distant places. For instance, the processes can materialise in built-up sediments from upstream soil erosion, river discharge from distant rain events or floods from changing wind currents. This exchange of material demonstrates site interaction.

A paradox may emerge in the design process of places characterised by flows. To determine the encompassing forces that impose on such a place requires an explorative conception of site. Design practice often delimits site into an enclosed entity, which further constrains the understanding of given locations to isolated territories (Burns & Kahn, 2005, x-xii). This perspective is especially problematic in the case of sites that are physically connected to larger systems by flows, such as the water cycle or geomorphological formations. The influencing elements that have actually shaped the place into its current state are missed and ignored. Design interventions can further reshape features of the site in relation to the larger pattern, which might change topographies, channel watercourses or bury existing vegetation. Every built project will form new forces that govern the site, but will also modify the ability to handle impacts that operate beyond the area itself.

The complexity of the delta is generated by human and natural forces. The first are mainly related to urbanisation and land use changes, while the latter are associated with transscalar environmental changes, such as climate change. For a qualitative design, it is therefore necessary to analyse where these forces originate. The forces that put pressure on the delta can be divided in two major groups: telecoupled impacts that are interconnections within systems that indirectly influence a distant place (Liu et al., 2013, n.p.) and the local impacts that act within the place itself. The impacts are both anthropologic and ecologically induced, and cannot be regarded as simply negative or positive. But in relation to these, the delta is incorporated in a larger social-ecological system, which constantly shapes and reshapes its on-going processes. As far as the Paraná Delta is concerned, four distinguishable processes that have distinct effects on the delta can be identified as telecoupled impacts: 1) soil erosion, 2) hydrological effects of climate change 3) land use change and deforestation 4) dam building. In addition, strong impacts occur within the local system of the delta: 5) southeastern winds 6) urbanisation. The local impacts (5-6) aggravate the capacity of the delta to manage the telecoupled impacts (1-4), which mainly express themselves through increased flooding and sedimentation.

Current local constructions decrease the ability of the delta to take care of impacts from the telecoupled system it is a part of. For example, unsustainable land practices strongly contribute to worsen flood events, as in the case of the Colony Park site. Since all telecoupled impacts are likely to increase, the right type of local landscape interventions are therefore of considerable importance for future sustainability of the delta. This opts for a need to create an alternative and more systematically founded design solution to manage water resources and urban development.

1.3. Purpose and research questions

Problem statements

On the basis of the described problem context, two key challenges can be identified:

- Impacts from distant areas form and transform the delta in its current state. If these impacts are not included in the understanding of the delta, the vulnerability of its local sites might be misread and thus left out of consideration in design interventions. The question is if this can be done, and if so, what would be an effective design intervention.

- Current urban developments are transforming sites in the delta into closed and static environments, that aggravate impacts from the telecoupled river system. A great challenge is to make the transformation flexible and dynamic in order to manage telecoupled and local impacts and to form sustainable and adaptive site design.

Purpose
The purpose of the thesis is to disentangle the described challenges through a landscape architectural approach, that incorporates current research on climate change, land use change and social-ecological systems. This implies a holistic viewpoint, both in terms of the types of questions that are raised, but also in the way the work is conducted in design practice. My purpose is accordingly to find a explorative way to research impacts from telecoupled systems by a specific approach to delta design.

Research questions
With this background, I aim to investigate *what constitutes a delta area, in this case the Paraná Delta, characterised by water flow variability and constant landscape transformation, affected by a telecoupled system.* In a delta of natural changeability, static constructions will aggravate telecoupled impacts. A further inquiry is thereby how a design can be implemented in this context: *what design strategy that is in line with natural dynamics can be developed for a dysfunctional delta site?*

1.4. Aim and limitations

Many different professional disciplines work with deltas, owing to the numerous and diverse processes that interact in these areas. Changing climate and rapid urbanisation are two of the largest forces that involve deep consequences for deltas in general. Important findings today emerge within the scientific research world and the design discipline respectively. Increased interconnectedness requires more interdisciplinary and collaborative studies. The importance of innovative spatial planning and design strategies in climate change adaptation was recently emphasised at the conference Deltas in Times of Climate Change II (de Pater & van Steenis, 2014, pp. 154, 178, 188). Within the practical field, there has also lately been a shift from climate change adaptation being a civil-engineer- and economist-dominated field to a domain for landscape architects, urban designers and spatial planners (Meyer, 2012; *Pierre Bélanger on Landscape Infrastructure*, 2013).

This thesis sets out to test the downscaling of a research problem to the practical level, more specifically the integration of concepts, disciplines, scales and techniques into an understanding and transformation of a problematic site in the delta. One objective of my study is to enhance effectivity in the planning of the delta, by bridging the gap between research and design. My hope is that the synthesis of a more theoretically orientated field and a more practically oriented field will increase the potential of reaching site-specific sustainability in the delta.

Constant change is the new paradigm.
- Henk Ovink, senior advisor and principal of the initiative "Rebuild by Design" implemented by the Hurricane Sandy Task Force

Even though chemical and biological processes exert influences on the characteristics of the river, the physical processes remain the focus of study as they dominate the shaping of the spatial form of the river delta. The main focus of this thesis will further be to concentrate on how to approach the delta from a perspective of river systems, land interventions and climate change adaptation. Certainly, the delta region also faces many infrastructural, economical, social and environmental problems that are incorporated in analyses of the area. For example, contamination from Buenos Aires is a growing problem that is acknowledged but not concentrated on further. Moreover, growing interconnections are affecting land systems through strong economic and social impacts in addition to the ecological dimension. These aspects have been beyond the scope of this thesis.

2. Theoretical framework

To build a connection between current research about climatic and social-ecological systems and design theory, the use of theoretical concepts grounded in each of the disciplines will enable a more nuanced view of the Pananá delta.

2.1. Three levels of site - a design theoretical approach

To analyse the impacts and processes of the Paraná Delta, the delta and its connected river system is investigated through a framework that describes three levels of site. This helps to explain an area's complexity and relation to larger systems (Burns & Kahn, 2005, xii). Areas of influence are according to Burns and Kahn encompassed by the forces that govern a site without necessarily being confined to act within its borders. This comprehension makes it possible to explore upstream events and activities that can transfer effects from one place to another within the river system. Area of control is simply described by Burns and Kahn as a site within its property boundaries. This is the level which is most confined in its territorial and temporal limits, and commonly the field where design action takes place. The area of control is part of a chain reaction, not at the end of the chain. Finally, Burns and Kahn describe the third level of site, area of effect, as "the domains impacted following design action." Areas of effect might not necessarily be spatial or materialistic, but could also be social or political effects that occur as a consequence of a design intervention. Certainly, the three areas may also coincide, despite possible divergences in territory and timeframe.

This view of site leaves out the idea that places are spatially finite. It reflects the complexity that sites are embedded in, and mirror two dimensions of scale: the physical specific place and an extensive surrounding context. The areas of influence and effect in most cases lie outside direct design control, eliminating concerns regarding unpredictable changes propelled by the design action. Even though the design intervention still follows a spatially defined form, conceptualising site in three levels envisages an understanding that can help to anchor design strategies in line with natural processes.

2.2. Networks of telecoupling - a climatic and social-ecological approach

In climate science, distal flows and its related implications on land systems are sometimes discussed in the context of teleconnections (Fragkias et al., 2012; Adger et al., 2009). The concept is then normally defined as climate anomalies that are linked by flows over large geographical distances (Fragkias et al., 2012), such as in the ocean or in the atmosphere. One example is El Niño events, i.e. warming of parts of the Pacific Ocean, that are related to variation in precipitation in Africa and western United States. Even though the concept of teleconnection is most commonly used in climate science, it has also been adopted outside the physical world as "societal teleconnections" (Moser & Hart, 2015). Through the socioeconomic lens, the focus has been to study the effects of globalisation by human-created linkages via people, institutions, and economic structures. Furthermore, Fragkias et al. (2012) apply the concept to explore linkages between land use and urbanisation patterns. Urban-rural linkages are an example where teleconnected impacts might become visible. Previously, urban centers were strongly connected to their rural surroundings. Today, these centers might be more linked to far distance places by various flows, such as water, people or money (Fragkias et al., 2012).

In a similar sense, Liu et al. (2013) apply the concept of teleconnection specifically to the formation of human and natural coupled systems, synonymously termed social-ecological systems (Berkes et al., 1998, p. 4). Coupling effects between systems emerge from direct to indirect interactions (Liu et al. 2007, p. 639), across multidimensional scales and from proximate to distant spaces and time. Distant environmental interactions involve contextual factors from large-scale processes that shape local conditions. These linkages have existed historically, but are in the light of climate change and significant land use changes more prevalent than ever. Liu et al. (2013) therefore suggest an interpretation of the concept of teleconnection in the social-ecological discipline through the concept of telecoupling. While the concept of teleconnection focuses on the connection itself in a structural and functional sense (mainly applied in climate science as well as in the socioeconomic perspective described above) (Moser & Hart, 2015, n.p.), telecoupling illustrates the influences formed by interconnected natural-human systems (most commonly in the field of land use and land change science). Telecoupling encompasses both environmental and socioeconomic interactions, and therefore functions as an integrative concept across the two disciplines. Coupled human and natural systems describe the interactions between particular geographical locations. The concept incorporates two dimensions: 1) a geographical dimension: distant (telecoupled) and local scale and 2) a disciplinary dimension: social-ecological systems. Eakin et al. (2014) further describe the significance of telecouplings in land science, by claiming that all land systems are now affected by these forms of connectivity. The authors mean that not only is the intensity and rate of connectivity higher today than in the past, but the increasing claims for resources also place connections between land systems into a new context (Eakin et al., 2014, p. 144). Following this argument, they emphasise that significant thresholds of change in land use and associated ecological and social processes are a particular concern for land science. Sudden land-cover conversions or shifts in land governance might have negative consequences for broader system resilience and the capacity to manage shocks over the long term (Eakin et al., 2014, p. 159).

The concept of telecoupling is an extension to theories of systems thinking. While teleconnection is mainly used for describing the linkages between global systems, telecoupling highlights the impacts on social-ecological relationships that occur as a result of environmental change. Telecoupled impacts describe how local vulnerabilities can be nested in systems which might bring unforeseen implications from events that originate somewhere else. Despite the close relation of the social-ecological significance to the core of landscape architecture and planning, the concept has not yet been implemented in these fields (Eakin et al., 2014, p. 114). The analysis and design of landscapes are always enclosed in some kind of system, whether it is ecological, social or economical. Landscape sites are and should not be treated as objects of isolation. Moreover, telecoupled impacts can be seen as transferred via different kinds of flows that operate across the system. An obvious example is the river system, which functions as a network of water flow and can carry effects that influence the social-ecological environment around it. Actors facilitate flows in coupled systems, and at the same time, flows develop effects that influence the system around it and in turn can create rebounding effects to the system where these originated.

A coupling is synonymous to an interaction between two places. Coupled human and natural systems emphasise the nesting of local systems and processes in regional and global systems (Liu et al., 2007, p. 645). Thus, the approach is different from a large-scale analysis. It represents the embedding of smaller-scale processes in large-scale processes, as well as the influence of large-scale processes on smaller-scale processes. As Liu et al. (2007, p. 645) write, a coupled system includes interaction on multiple scales:

> Understanding even the most local human-nature interactions requires 'progressive contextualization' in which local actions are understood in terms of landscape, regional, and national factors, which in turn depend on global forces.

In order to study the concept of telecoupling, it is essential to define what constitutes a local system. In the context of this thesis, the local system is formulated in relation to the telecoupled system, and more precisely the system within close distance of the area of control. Liu et al. (2013) further describe local couplings relative to telecouplings. While a local coupling occur within one coupled human or natural system, telecouplings involve interaction between two or multiple human and natural systems (Liu et al., 2013, n.p.). Further, local couplings solely concern flows, agents, causes and effects on a local level, whereas in regards to telecouplings, these are both local and distant. The flows, agents, causes and effects constitute the components of a coupled system. The components of local coupled systems are confined to being merely local, whereas the components of a telecoupled system include both local and distant interactions (Liu et al., 2013, n.p.). With increasing global connections, local systems will not function without external ties, which should be recognised in the conception of place.

One idea of a local system is that it can be identified where similar types of characteristics are expressed. Since impacts in the context of this thesis are largely geographically bounded, events that occur within or outside the local system can help to define what impacts can be expressed as telecoupled.

2.3. Applying the theories

The development of the previously highly scientific concept of teleconnection has started to form a more interdisciplinary meaning. Still, the concept of telecoupling is more applicable in the field of landscape architecture due to the closer disciplinary connection to socioecology. Hereafter, the conceptual lines for this thesis will therefore follow the concept of telecoupling rather than the concept of teleconnection to explain interconnections between places in the Paraná River system. However, the term teleconnection will still be used when referring to purely climatic interconnections.

Investigating telecoupled impacts means adding a second layer of complexity to the analysis of a site. There are no studies found that integrates Burns and Kahn's framework within landscape architecture with a more complex social-ecological approach. The framework of three areas of site strongly conforms to the idea of a telecoupled system, and can clarify difficulties in disentangling impacts of flows in a multilayered network structure. The framework further integrates site-specificity with the system theories of teleconnections and telecouplings. A similar research gap applies to the inverse situation, represented by the lack of application of the telecoupling concept in the landscape architecture or planning context. The complex systematic concepts used in this thesis are regularly described in theory, but seldom seen implemented in land practice. This has encouraged an empirical study.

> Understanding the issues and finding solutions on the larger scale are better underpinned when they are tested against the smaller local scale.
> *- Meeting report, Deltas in Times of Climate Change II, session DP 3.4, p. 146*

The river flow composes a system between the three areas of site. In the case of the Paraná Delta, there are different layers of scales that interplay through the areas of influence, control and effect. As the delta can be seen as representing the downstream end of the river system, areas of influence are more represented in the regional scale. Due to current developments in the delta, the area of control as well as areas of effect are in the context of this thesis mostly represented on the local scale.

Based on this theoretical framework, my research questions can be further specified into subquestions: *How can the three areas of site be distinguished in regard to the Paraná Delta?*

> *1) Area of influence: What forces shapes the site and where do these originate?*
>
> *2) Area of effect: How does a site need to function to minimise negative consequences for other areas?*
>
> *3) Area of control: What design strategy is required for the site to be a sustainable part of a local and telecoupled system?*

Intervention in the area of control
Applying the theories specifically to the area of control, empirical delta studies raise the question of how new hydraulic systems dominated by environmental qualities and urban design can be combined with the complexity of expanding urban areas (Meyer, 2012).
To overcome disciplinary separations, Meyer suggests an approach to urbanising deltas by developing scenarios for the integration of hydraulic engineering with urban design and planning solutions. Based on empirical studies of deltas, Meyer analyses the possibility to turn double vulnerabilities (vulnerability of flooding as well as social, cultural and economic vulnerability of urban expansion) into a double profit by using systematic measures of design. Following this, he identifies different adaptive strategies to define the relations between hydraulic concepts and the urban environment, resulting in seven parameters for consideration (Meyer, 2012, p. 95):

a) the regional strategy concerning flooding etc.
b) the local condition of the river in the metropolitan region
c) the urban flood defence system
d) the typology of buildings and urban patterns
e) the water edges
f) cohesion between floodplain area and inside the dykes areas
g) the port

As a response to the above described parameters, Meyer defines scenarios as

> [...] a coherent set of spatial interventions. Each scenario will create specific conditions for future spatial developments. (2012, p. 95)

A version of Meyer's approach has been applied in the empirical study of this thesis. Three parameters (c-e) have been considered in the study in terms of the following: the difference between flood protection systems traditionally and today (c), different urban typologies in the delta (d), and people's connection to the water in the island shores (e). The remaining parameters have been excluded due to the inability to tackle these within the area of control, or due not being of high relevance to the delta. From this analysis, two scenarios that can be resembled in the design have been developed: an open system and a closed system. These systems have different potentials of minimising negative consequences for areas of effect, which in turn influences the choice of design strategy.

In regard to scenarios of intervention, the consideration of where to intervene in a system adds further input to this study. In her research, Meadows (1999, p. 1) describes twelve leverage points within a complex system that possess the potential of producing large changes to the system by a small shift in its individual parts. Each of the twelve points holds a different effectiveness to realise this change. The twelfth point, *parameters*, are defined as the rate at which flows increase (inflow) or decrease (outflow) the system's constant volume, and are identified as the least most effective leverage point to achieve change within the system. However, Meadows emphasises the strengths of parameters as leverage points in case they give rise to change in other elements of the system (Meadows, 1999, p. 6). This can be exemplified and explored by the application to the version of Meyer's parameters that is used here. If these five parameters are combined, developed into scenarios, and finally elaborated in a detailed strategy, they can become leverage points of the system.

3. Methodology

Three main methodological components lay the ground for the work process of this thesis (Fig. 3): research review, on-site field studies and design work. A few different techniques have been used to gather material for the three areas of site.

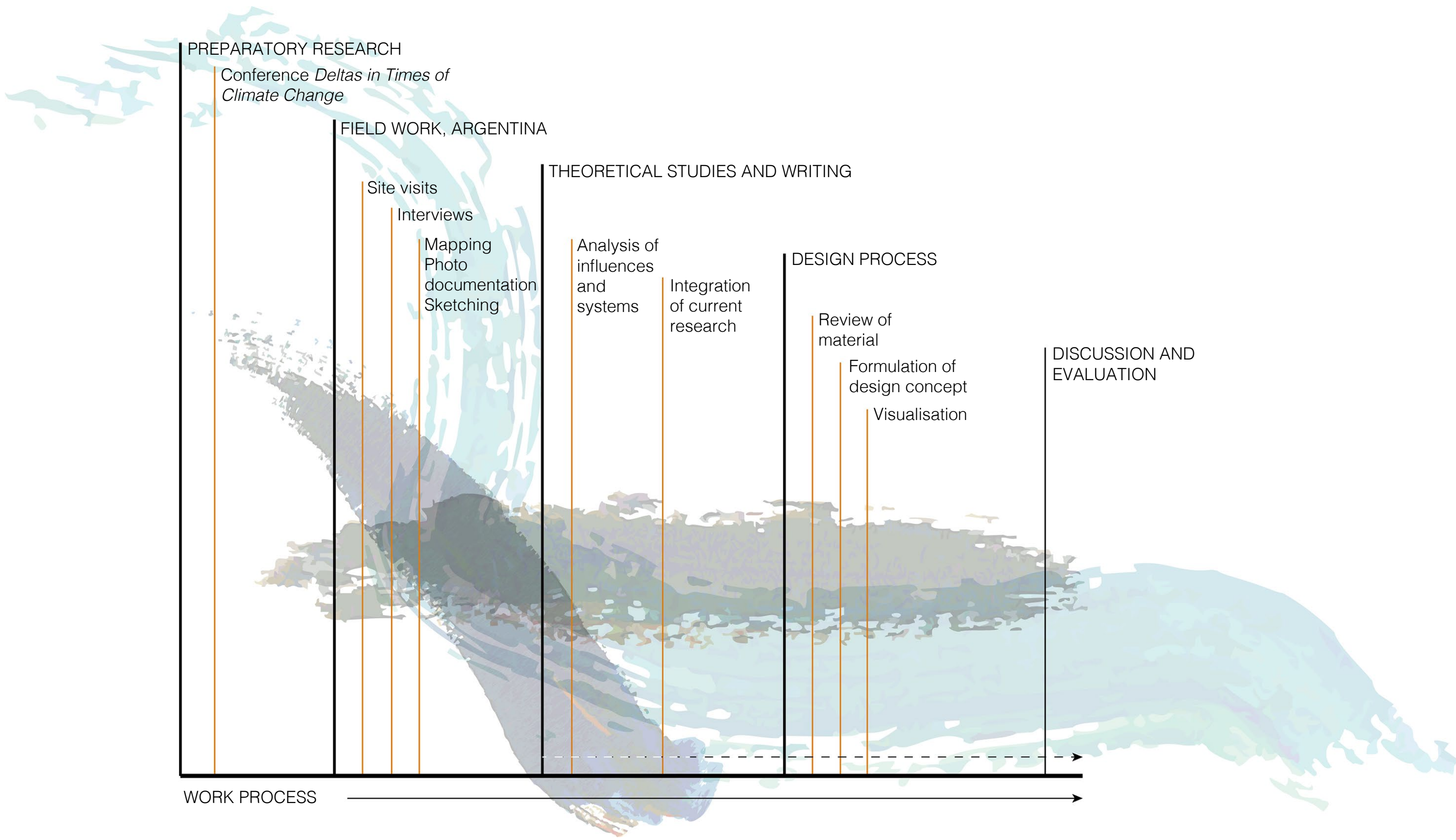

Fig. 3. Planned work process.

3.1. Research review

The research review was conducted with an open viewpoint and an attempt to gather information from both social-ecological theories, climate science and the design discipline. First, in relation to the areas of influence, a review of environmental studies and current research as well as previous analyses and maps of the river system have largely formed the foundation for conclusions. This material has been valuable to gain additional insights on the entire river system as well as the concept of telecoupling from a macro perspective.

Some interviews were conducted as part of the preparatory work before on-site field studies in Argentina[1]. These were unstructured and mainly aimed to receive a first introduction to delta processes and the Paraná Delta in particular.

3.2. On-site field studies

Second, work focusing on the area of control on the micro scale has been based on material from the lower Paraná Delta and my own observational analysis of this site. The most valuable source of information has thus been site visits and observations of the delta itself. The content of the material mainly aims to illustrate different perspectives of flooding, sedimentation and urbanisation in the area. During fieldwork in the delta[2], on-location material was collected such as drawings, sketches, photos, local city plans, municipal reports, maps, field notes, news articles and samples of water and vegetation (Fig. 4). The observations were carried out during daily visits by boat as well as during longer stays in different islands of the delta.

Aiming to gather both ephemeral and atmospheric site qualities, the work was supported by the Deviant Transect method (Diedrich et al., 2014). The purpose of the method is to enable designers to pursue specificity in their transformations by shedding light upon situational qualities. It encourages traveling and the relational exploration of a site

Fig. 4. Material collection from the delta, and on-site sketches illustrating views from boat trips on the delta rivers.

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[1] Magnus Larson, Flavio Janches

[2] Spring and early summer, October 23rd, 2014 to January 16th, 2015

grounded in experiences from geographical and cultural territories of the observer. Focus objects were in my case for example technical elements such as constructions, social elements such as accessibility and spatial structures, and aesthetic elements such as light, colours and rooms. Relational details of the site were recorded by on-site sampling, by means of the tools described above. Following the traveling phase, evaluation and analysis of the material were conducted.

It should be noted, that even though trips to the delta were frequent, visits to the specific Colony Park site were limited due to it being a private development under legal investigation. No public boats are currently allowed to enter the area. My on-site record from that particular site was thereby constrained to observe the area from the outside, traveling on the river. In this way, I gathered photos and field notes.

In addition to the individual observation and collection, unstructured interviews with locals living in the delta area have added insights to ground the work in its authentic context. This type of participatory observation gave site-specific information on experience and knowledge. At three occasions I stayed at the homes of delta locals, two of which were during major flood events.

Furthermore, interviews with architects from Universidad de Buenos Aires[1], representatives from Tigre municipality[2], as well as delta researchers[3] were also an essential part of collecting information and viewpoints.

Finally, material for the areas of effect was dominated by current research investigations and documents from the municipality, news articles, interviews and photos. While systematic impacts are more established in research when it comes to areas of influence, areas of effect are more conjectural, with negative effects from closed system developments still being investigated. Still, the validity of these effects was supported in a number of interviews. The areas of effect from my own design intervention are speculative and based on information about how the delta processes function in different scenarios.

3.3. Design work

The area of control was determined by two key points: a place of convergence between telecoupled and local impacts in the delta and the possibility to present an alternative design strategy to an unsustainable land practice. These two key points were materialised in the Colony Park project. The aspiration to create a functioning system in the site grounded in both the urban system, the water system and the social infrastructure system led the way to the design strategy. A layered approach was used to achieve an integration of these systems and their components. This resulted in the development of a design strategy illustrated by a site plan, followed by the designs of its components such as the constructed wetland, groynes and urban typologies. The design of the water system was supported by a brief review of the technical procedures of constructed wetlands[4]. Instruments of representation for the design and layout were further inspired by work by Mathur and da Cunha (2009; 2014). The maps, photos, sections, typologies, topography models and flow diagrams together form a toolkit of techniques when designing for telecoupled impacts in deltas.

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[1] Flavio Janches, Matias Llere, Fernando Schapochnik, Álvaro Arrese, Ana Luisa Artesi

[2] Leticia Beatriz Villalba

[3] Veronica Zagare, Dilip da Cunha & Anuradha Mathur, Mark Schürch, Emily Vogler

[4] Per-Åke Nilsson

3.4. Research approach and analytical framework

To dive into systems thinking implies taking on added levels of complexity. This can make us return to what we already know, rather than take on problems of large uncertainty. But places are increasingly being integrated into more systems and ignoring this can also endanger our understanding of them. In this study, I have tried to meet the complexity of systems and disentangle it into tangibility by applying the three levels of site to identify interrelationships in the telecoupled system. This approach translates into an analytical framework.

This study thus travels through a wide range of horizons. From a conceptual viewpoint of how to approach impacts of regional river systems, it downscales to the practical intervention of response to these impacts in a local delta site. This journey challenges a mind-set that is focused on isolation, rather than interconnectedness. It envisages a stepping out of much previous territorial as well as unidisciplinary thinking. In the creation of this thesis, I have been aided by engineers, geologists, architects, climate researchers and municipal authorities. The crossectorial approach has enriched my findings. The result is an example of the integration of a design framework with a concept developed from social-ecological research. It is implemented in a climate adaptive design for an urban water landscape (Fig. 5), that is able to manage impacts from interconnected areas.

> Deltas and watersheds should never be seen as separate entities,
> they are inevitably related and connected to each other.
> *- Meeting report, Deltas in Times of Climate Change II, session DP 3.4, p. 146*


Fig. 5. The Paraná Delta, Argentina

4. The Paraná Delta

4.1. History

The Paraná fresh water delta was largely formed during the last 6,000 years (Iriondo, 2004, p. 153) and late Pleistocene landscape processes have developed it into a vast littoral complex. The delta evolved from a fluvial period of river flood deposits (Fig. 6). The interplay between morphological and marine ingression formed sand layers, coastal lagoons and minor tributary deltas and estuaries (Iriondo, 2004, p. 143). The delta terrains (Fig. 7) are characterised by continental edges, which are ancient, as well as delta islands, that are young due to built up sediments that have accumulated over time (Fig. 8). The emergence of vegetation slowly creates wetlands that contribute to regulating the water level and

Fig. 6. The delta landscape is a heritage.

maintaining the water quality. Compared to the contaminated water of Rio de la Plata, the water of the delta is clean. The high extent of sediments however colors the rivers of the delta brown and reduces its transparency.

4.2. Geography and territories

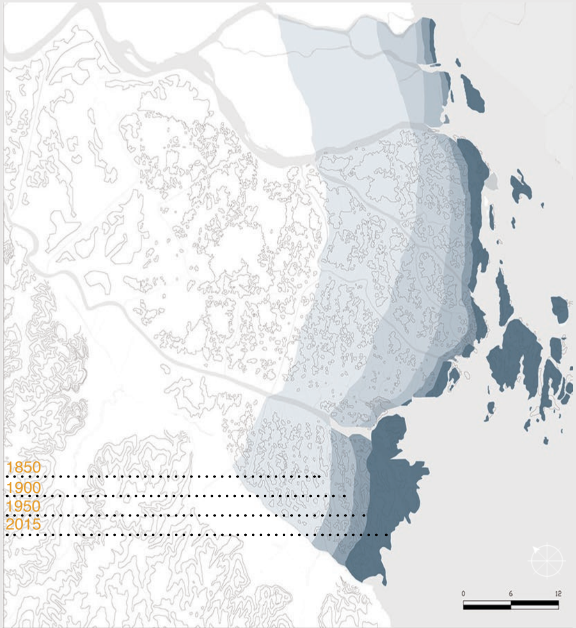
Today, the Paraná Delta is unique in the way that it does not discharge its sediments directly into the ocean, but through the estuary of Rio de la Plata (Parker & Marcolini, 1992, p. 243). Hence, the delta is not in direct contact with the sea, which is a rare characteristic in comparison to other deltas. The territorial boundaries of the delta front are hard to define, since the subaqueous part of the delta almost covers the entire Rio de la Plata riverbed (Zagare, 2014a, p. 121).

When analysing the Paraná Delta, it is crucial to understand the vastness of the area, an extension of more than 22000 km^2 (Bucx et al., 2014, p. 108). For comparison, this territory is larger than the island of Sardinia. The entire floodplain divides into the upper, the middle and the lower delta and are characterised by different geographies. The upper delta is situated in the northwest and then develops into the middle and lower delta in the southeastern direction, towards Buenos Aires. The lower delta, incorporating thousands of islands, borders the continental area by the river Luján. More than half of the population of the delta resides in the lower subdivision (Bucx, 2014, p. 108). The lower delta area is divided into three main administrative sections, which are simply named the 1st, 2nd and 3rd sections (Fig. 9). Generally speaking, tourism and residential purposes are concentrated to the lower delta, mainly in the 1st section, while production such as forestry, livestock holding and agriculture are widespread activities in the upper and middle delta. While the 1st section of the delta belongs to the municipality of Tigre, the 2nd and 3rd sections stretch northeast and are encompassed within the administrative borders of San Fernando municipality. Due to its coastal location and the administrative jurisdiction over the 1st delta section, Tigre constitutes the link between the urban conurbation of Buenos Aires and the most populated delta area. Buenos Aires metropolitan area is currently the home of 12 million people (Bucx, 2014, p. 108) and Tigre is located approximately one hour away from the city core by train. The population of the islands varies due to permanent and temporary inhabitants, but it is estimated that roughly 10,000 people permanently inhabit the islands of Tigre municipality and another 3,000 reside in the islands of San Fernando (Janches & Zagare, 2013, p. 9).

As previously mentioned, this thesis will concentrate on analyses of the lower delta, even though impacts from the telecoupled system prompt considerations of larger regional contexts. Furthermore, focus will also lie on the 1st section of the delta islands.The reason behind the areal selection is the large number of contrasting impacts that converge here. Hydrological impacts from the river system and the estuary (Fig. 10 & Fig. 11) are met by urban expansion and economic developments (Fig. 12). The fragmentation of the lower delta becomes rooted and intensified through the contrasts between growing urbanisation and the conservation of the natural environment (Zagare, 2014a, p. 227), which can be noticed through planning practice.

4.3. Regulations and governance

Integrative management efforts have been carried out in the Paraná River system, being a part of the greater La Plata Basin. In 1969, Intergovernmental Coordinating Committee of the Countries of La Plata Basin *(CIC - El Comité Intergubernamental Coordinador de los países de la Cuenca del Plata)* signed a comprehensive agreement that included plans and programs for the management of the La Plata River Basin (CIC, 1969). Another agreement



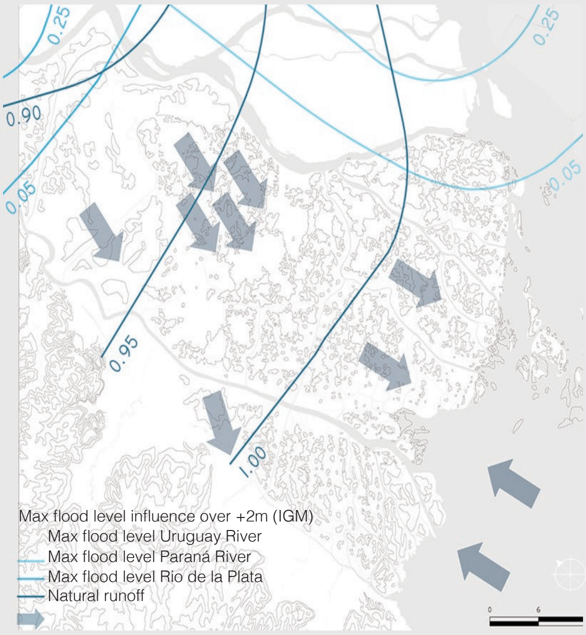
As seen from above: Fig. 7. Topographic lines. Fig. 8. Delta expansion over time. Fig. 9. Sections of the lower delta.

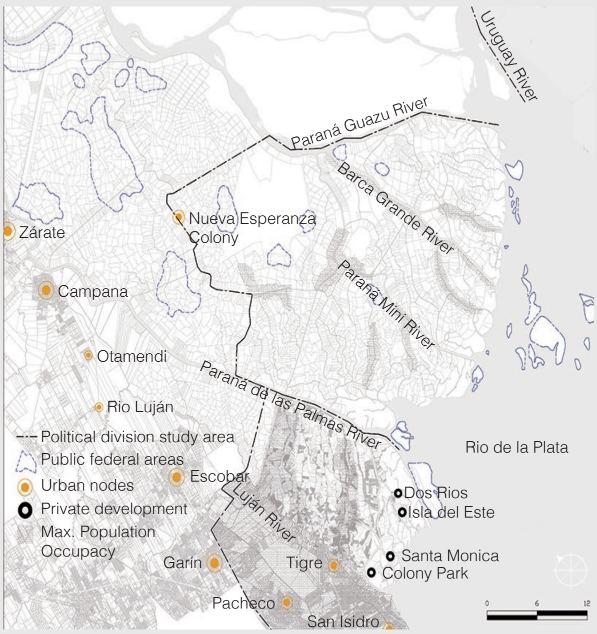
between Argentina and Paraguay was enforced in 1971 *(COMIP - Creation of the Argentinean-Paraguayan Joint Commission of the Paraná River)*, that aimed to jointly study the development and care for the administration of the Paraná River stretch.

The entire delta includes 25 protected areas of different jurisdiction, size and level of implementation, covering 488,000 hectares of land in total (Bucx, 2014, p. 123). 6,4 hectares of this area is located in the 1st section of the lower delta, in the institutional context of Tigre municipality (Municipio de Tigre, 2012, p. 32)

In 2008, the National Plan for the Sustainable Management and Conservation of the Delta *(PIECAS-DP - Plan Integral Estrategico para la Conservacion y Aprovechamiento Sostenible del Delta del Paraná)* was introduced through a collaboration between the state and the provinces. The plan aims to ensure protection and development for the entire delta, but has to this day failed to become fully implemented (Zagare, 2014a, p. 220). On the other hand, according to the National Law No. 8912 from 1977, each municipality holds responsibility for local urban planning practices (Zagare, 2014a, p. 220). The local authorities are hence entrusted to integrate jurisdictions into their urban development. In line with this, the Plan for the Management of the Islands of Tigre *(Plan de Manejo Islas del Delta - Tigre)* (Municipio de Tigre, 2012) represents an effort by the municipality to coordinate environmental law with local urban planning practice. The management plan contains historical analyses, identifies different characteristics and changes, describes legal aspects and initiates the first ordinances for land use planning of the delta islands.

A large majority of the delta land is privately owned, due to the Law No.





As seen from above: Fig. 10. Hydrological river impacts. Fig. 11. Flood areas. Fig. 12. Urban elements.

2072 *Ley de Islas,* enacted in 1888 (Zagare, 2014a, p. 219). This law involved the measurement and distribution of the delta islands, focusing on procedures to sell it. Accordingly, 55 % of the land was transferred to private actors and today, public federal areas constitute a marginal part of the islands in the 1st section. It was not until 2009 that the first building regulations in the delta were enforced (Villalba, 2014). A later example of more detailed building regulations is included in the municipal act *Ordenanza 3344/13 - Ordenamiento Territorial Particularizado para la Localidad Delta del Tigre*, signed in 2013. For example, the act entails that areas of development are to be located no closer than 15 meters from the island shore. The late regulations and the privately owned land weakens the municipality's position during processes when inadequate constructions are developed. Many negotiations between private stakeholder and the municipality are prevalent during constructions of new areas (Villalba, 2014). The situation has been somewhat improved due to new regulations that give the federal province ownership of the new land that is arising from river sedimentation.

4.4. Changing regimes in the delta

Traditionally, people have lived in simple conditions in the delta (Fig. 13). The locals residing in the delta islands *(isleños)* express a need for additional social functions and infrastructure in the island area (Batista, 2014). Even if the traditional lifestyles still exist, contrasting lifestyles are claiming more space than before, such as vacation houses for high-income people from Buenos Aires. Economic and terrestrial processes are now advancing and are leading the way towards creating spaces of instability. The new residential areas related to tourism and private real estate developments are increasing and creating conflicting conditions in the delta.




Fig. 13. Traditional living in the delta.

PART I

Areas of influence

Context and interpretation of a delta and its river system

This section addresses the first subquestion of this thesis:

> *1) What forces shape the site and where do these originate?*

It will thereby describe the context and systems which the delta operates within. The text is divided into two parts. First, a general description of deltas, their natural processes, as well as their relations to the systems they are a part of will explain the manner in which they are directly and indirectly connected to local and distant events. Taking into consideration Burns and Kahn's three levels of site and Liu's telecoupled systems, this section applies the theories to identify interconnections that influence the delta. The second part is thereby site-specific, describing the Paraná Delta and the transformations it currently undergoes. A description of naturally and anthropogenically induced events that occur in areas of influence helps to convey the drivers that are causing these transformations. By changing conditions of the system, the events result in that local and telecoupled impacts can be localised in the delta. Finally, the section provides conclusions and identified needs to serve as a base for meaningful interventions.

1. Deltas and the flow of water

Deltas are highly site-specific and every delta region undergoes different natural processes that give it unique physical characteristics. Not all rivers form deltas (Meyer & Nijhuis, 2014, p. 9), but at lowland territories where sea or lake meets a river, deltas can arise when the geological activity is dominated by sedimentation, subsidence and rise in water level (Jerolmack, 2014, p. 76). In the shaping of the deltaic lowlands, the water must slow down in order for sedimentation to occur. The more it slows down, the more sediment the river deposits. These strong processes of land formation and transformation make the deltas multilayered complexes (Meyer & Nijhuis, 2014; McHarg, 1992). Deltas are further made up by interacting subsystems and external systems that influence their conditions. The surrounding topographic gradients drive the river's current, and the closer the distance to the ocean, the more the land flattens out which reduces the velocity of the water (Jerolmack, 2014, p. 76). Consequently, the river successively looses its ability to hold sediments and deposition starts to take place. A delta can in this sense be defined as the area where the terrain makes the river transform into a zero slope towards the ocean, forcing it to deposit its sediments into the floodplain (Jerolmack, 2014, p. 76). An earlier definition can be derived from 1912, of a delta as

> "a deposit partly subaerial built by a river into or against a body of permanent water."
> (Barrell, 1912, p. 381)

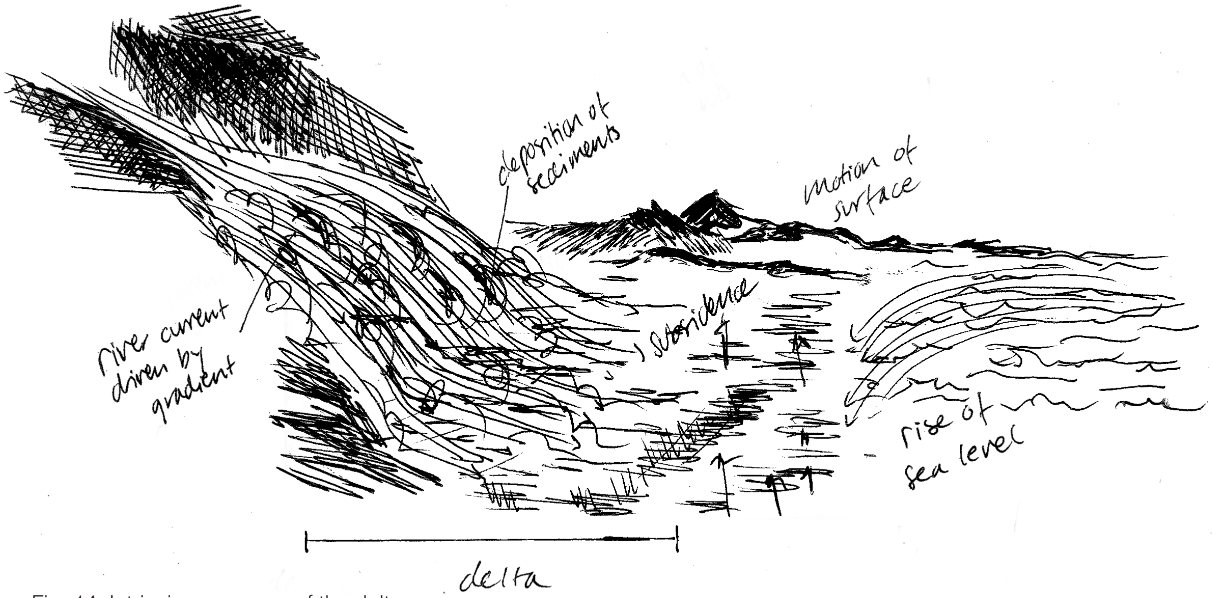


Fig. 14. Intrinsic processes of the delta.

By transformations in sedimentation and water level, deltas exhibit dynamics that constantly aim towards creating equilibrium in its intrinsic processes (Fig. 14). The fundamental forces of energy are revealed in the effort to achieve this equilibrium. Mass cannot be destroyed. In the strive to create balance, the deposited river sediments settle under their own weight moving water away from their pores. This process, subsidence, produces a motion in the land surface which shifts the ground downward in relation to the level of the sea. Equilibrium is reached when subsidence drives the delta surface lower as the rise of the sea level occurs simultaneously. The amount of deposited sediments is balanced where the water creates space in the ground. The classic definition of a delta is in other words associated with accumulated sediments in relation to the river that transports them (Zagare, 2014a, p. 215).

2. River flow and telecoupling

It is essential to analyse the nature of the water flow and its origin to be able to understand a delta. Rivers are highly complex and interconnected systems where temporary flow fluctuations and morphological processes simultaneously reshape the river space with elements from upstream (Prominiski et al., 2011, p. 20). Flow fluctuations are distinguishable in the vertical rise and fall of the water level, but also through lateral spread across the floodplain. The fluctuations correlate immediately to discharge from the catchment area, which in turn determine the water level in the river spaces further down the watercourse. High and low water levels can cause both problems and benefits for the river ecosystem as well as for human life in the riverside areas.

River flow and telecoupled impacts are hence strongly correlated. The flow of the river system works as the carrying mechanism of effects from upstream events or activities that are transformed into consequences somewhere else. The river delta is a crucial regulator of these two elements: controlling the river flow and managing a number of converging impacts from far away places. Being connected to the river system, the delta is relying on a telecoupled system in its nature.

3. The interconnected system

Complex social-ecological systems produce so called feedback loops that amplify or mitigate changes between interconnected places (Fischer et al., 2015, p. 145). For example, feedbacks can be created in the looping transferral of impacts between areas of influence, areas of control and areas of effect. Telecoupled systems add new challenges to governance and planning of sites, as well as for the management of transboundary river systems. Adaptive management aims to deal with interlinked and unpredictable outcomes from feedback mechanisms within the social-ecological system (Berkes et al., 1998, p. 10).

A telecoupling can be presented as the interconnection within a system by which causes and effects interplay through the carrier of flow. Systems can act as sending systems, receiving systems or spill-over systems (Liu et al., 2013, no page numbers). River systems act in all three dimensions. To exemplify, the river system can both send impacts (such as sediments from erosion) as well as receive them in another part of the system (where sediments create new land mass). Further, river flow might also carry impacts along the way, such as pollution from the soil or species migrating with the water flow. In that sense, they can also be characterised as spill-over systems, that affect the interactions between the sending and the receiving systems.

4. Direct and indirect impacts

The impacts that are transferred within a telecoupled system can in a similar vein be described in the terms of direct and indirect impacts. In the definition of Liu et al. (2013, n.p.), both local and distant interactions operate within the telecoupled system. In a development of this definition, direct impacts could be regarded as often being more local whereas indirect impacts generally are placed in regional or global contexts. Certainly, this distinction is not a general rule, but can simplify interpretations of different forces within the telecoupled system. It should be noted that many diverging definitions also exist regarding the characterisation of indirect impacts. In this context, they are defined as impacts that are transferred from one place to another through the biophysical system, for example by water or wind.

5. The resilience of a system

The resilience of a system can be explained as the ability of a body to recover after deformation or temporal stress from an extreme event (Meyer & Nijhuis, 2014, p. 8). Systems can benefit from telecouplings as these might provide resources that enhance the local capacity to withstand pressures and impacts. An example in the case of the Paraná Delta is the river discharge that helps to push away water entering from Rio de la Plata, reducing effects of sea level rise and pollution from the estuary. A system limited to local couplings can lack resilience in the case of disasters. However, telecoupled systems can also create interdependencies when places fully depend on influences from other areas. This might result in an increase of encountering risks in the case of a disruption in the telecoupled system (Liu et al, 2013, n.p.). For example, if fundamental changes were to occur in the soil erosion in the Bermejo River basin, the delta would most likely lower its current rate of expansion.

A system that can adapt to a changing context can further be named a complex adaptive system (Meyer & Nijhuis, 2014, p. 8). When extreme events or changing contexts are imposed on these systems, they face challenges finding a new equilibrium in order to deal with the critical transition. This equilibrium is reached when the different subsystems, such as the ecological system, the water system or the urban system, manage to redefine themselves and shape new relations with each other. Meyer and Nijhuis (2014, p. 8) emphasise this adaptive balance in regards to deltas that encounter challenges from contextual natural and urban processes (Fig. 15):

> That is exactly what is necessary in urbanized deltas and delta-like regions today: a transition to a new 'state' of the urbanized delta, one that is able to adapt to changing conditions in the immediate future but also in a far future which is still rather uncertain and unpredictable.

> Given enough time, all land is fluid.
> - *Dredge Research Collaborative*

Fig. 15. The Paraná Delta and the city of Buenos Aires, a meeting between natural and urban processes.

6. Transformations of the Paraná Delta

The coexistence of natural and urban processes creates a dichotomy in the delta (Zagare, 2014a, p. 213). Due to proximity to the metropolitan area of Buenos Aires, these contrasts are most apparent in the lower delta. The two strongest forces are made up by flood events and the increasing pressure from the urban fringe.

Every river evokes individual flood patterns. The hydrological regime of the lower Paraná Delta is dominated by the combined effects of the river flow discharge, tides, local rains and southeastern wind patterns (*sudestadas*) pushing water into the delta from the estuary of Rio de la Plata. The heterogeneity of these events causes flooding of different natures. Foremost, river flow changes dominate the water level variability. Even though proper flow data is not available for the inner delta branches, satellite images confirm that the flood pulses of the Paraná River represent the main flood source in the upper parts of the delta (Baigún et al, 2008, p. 247). The river flood pulse is irregular, resulting in peak flood periods in the delta during the end of the summer (March) and during winter (June-July) (Baigún et al, 2008, p. 247). The periodical river floods are an important regulatory process to retain the ecosystem services provided by the delta, as well as for making the delta create new land formations by the accumulation of sediment that is carried by the floods. The delta islands are also frequently exposed to floods from astronomical freshwater tides, increasing the water level by a few meters. In a study on ecohydrological resources of the delta, Baigún et al. (2008, p. 254) state that:

> Unlike other Parana basin areas, future hydrological scenarios for the Delta will result from basin-wide and local rainfall events, flow regulation by hydrotechnical works across the basin, sea level increase, sediment dynamics at the delta-estuary interface and tides and wind circulation in the Rio de la Plata estuary.

Subsidence that is natural or accelerated by human processes is another contributing factor to the transformation of the delta terrains. It occurs at a rate of 60 mm per year due to porosity losses in the top 10 cm of the surface soil layer of the lower delta (Ceballos et al., 2012, p. 367). During the biochemical processes of the wetlands, natural subsidence results in spatial changes in the sedimentary layers (Syvitski, 2008, p. 28). Anthropogenic activities, such as soil drainage, further contribute to accelerated subsidence which can exceed the natural changes in volume reduction. The vulnerability of a delta to subsidence is an outcome of sediment compaction when water is removed from the delta's underlying particles (Syvitski et al., 2009, p. 1). According to Syvitski et al. (2009, p. 5), the Paraná Delta is among the most vulnerable deltas in the world in this perspective, since its rate of aggradation (increase in land elevation due to deposition of sediments) has been reduced and can no longer balance local sea-level rise.

Anthropogenic forces also transform the delta. As urban development in the area increases, the need for flood protection rises. The residential areas are today mainly protected by small-scale embankments, constructed by the property owners themselves (Fig. 16). But the delta also builds up natural levees. No public flood protection exists among the delta islands or in the delta front. Traditionally, the Paraná River has been an important navigation route, leaving a strategic trade position for the delta. The fluvial transport network that the Rio de la Plata together with the Paraná River system represents also contributes to modifications of the delta environment, when shallow rivers in the lower delta are dredged to allow accessibility for large ships. The debated issue remains (Baigún et al., 2008, p. 251; Tucci & Clark, 1998, p. 169) whether an increase in major infrastructure work along the Paraná River as well as in Rio de la Plata might result in terrestrial changes and erosion of the riverbanks. Apart from the dredging, wave action from the ships also damages the shores of the delta islands by erosion, causing disappearance of coastal vegetation (Fig. 16).

Anthropogenic interferences in the natural environment further involve pressure from urbanisation. The lower delta is mainly influenced by the growing urban fringe of Buenos Aires metropolitan area, and remains important by providing fresh water for the area. The delta islands are not yet perceived as a part of the city, but as the metropolitan expansion challenges the availability of urban space, the land in the delta is increasingly domesticated. The urban development still remains unplanned and involves radical land use changes that contest the ecological as well as social sustainability of the area (Zagare, 2014a, p. 224) (Fig. 16). For example, the area is lacking solutions for the present growing need of public infrastructure (Zagare & van Dijk, 2014, p. 40). Both local architects (Llere & Schapochnik, 2014) as well as representatives from the municipality (Villalba, 2014) mention a network of public space as something desired which could bring many qualities to the delta. Student design work from Universidad de Buenos Aires also proposes network ideas for the islands, adding nodes of public space and functions to the network. They call it ”an adaptive net”, and stresses the integration of ecological elements, production and social life elements.

Lack of spatial and social connections creates an inaccessible landscape without public space. Zagare and van Dijk (2014, p. 40) however describes the new land formations as being areas of high potential for creating public spaces in combination with wetland restoration, which would help to regulate flood instability.

Fig. 16. Above at the top, shoreline erosion and small-scale flood protection. Above at the bottom, new radical landscape transformations as a result of urbanisation. Below, the conurbation of Buenos Aires and the changing delta front.

Experiences from floods in field work

During my stays in the delta, I experienced two major flood events that were different in nature (Fig. 17 & Fig. 18). On the 2nd of November 2014, I travelled out to the delta when the entire Buenos Aires province was severely hit by large floods arising from strong southeastern winds, *sudestadas*, as well as local heavy rainfalls. The winds pushed sea water into the delta from the Rio de la Plata at a wind speed between 45-70 m/s (Buenos Aires Herald, 2014a). Apart from the winds pushing water into the delta, it also rained heavily locally and upstream during these days which increased the river discharge. The combination of the hydrological events raised the water level by almost 6 meter (Buenos Aires Herald, 2014b), and resulted in huge consequences in the delta as well as in its surroundings (Buenos Aires Herald, 2014c). Three people died and around 5,000 people were evacuated from the delta islands (Buenos Aires Herald, 2014d). The flood was described as one of the worst flooding events in the history of Buenos Aires (Buenos Aires Herald, 2014a).

The second flood event occurred in early November and was caused by a periodical river flood, when I was stranded in a house in one of the delta islands. Water started rising from the back of the property (the inner island) and the channel in front of the house at around 3 pm. By 6 pm the water level had risen to cover the entire property. It was possible to notice the strength of the current in the water, and how quickly the water moved inland. Plastic bottles and garbage floated with the current. By 10 pm, the water level reached the second floor of the house, covering the entire basement area at ground level. It did not rain during the time of the flood, but the previous night had been a full moon night, indicating high tidal water levels. The next morning the flood level was still as high. I waded through the water, which was warm, to reach the pier. The unpaved ground was oozy. Despite the persistence of the high water level, the atmosphere on the island lay silent and calm. The islanders are used to this type of flood, which happens with a one to several times a month interval. Still, all islanders that I spoke to (Gamba, 2014; Batista, 2014; Flanagan, 2014) meant that the floods have increased significantly during the last years.


Tuesday, November 4, 2014

Death toll in BA province flooding rises to three

A man tries to cross through the water as the province of Buenos Aires faces one of the worst flooding events in i

A young man has become the third victim of the heavy rains and flooding that have slashed the province of Buenos Aires over the past days, the provincial Emergency Sanitary Board has confirmed.

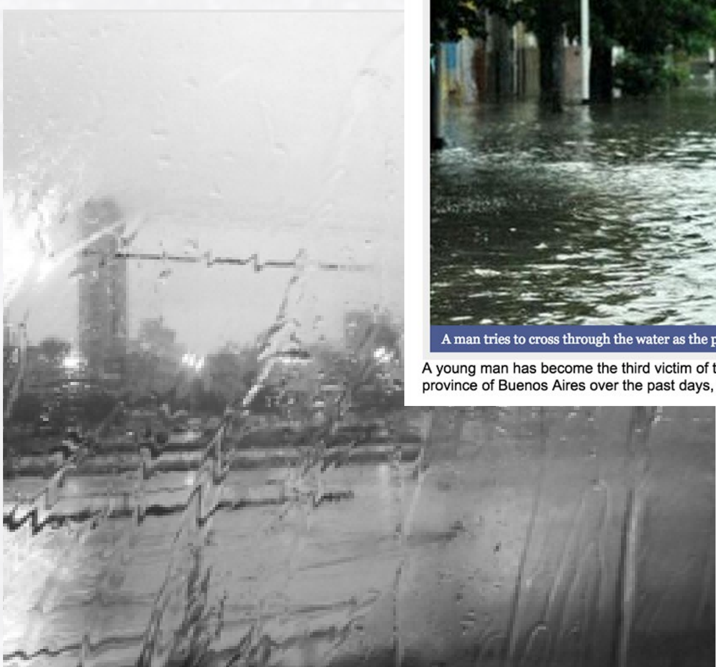


Fig. 17. Rain and floods during early November 2014, here reported by Buenos Aires Herald.

Fig. 18. Four pictures above: Flood event due to high river levels in the delta islands during November 2014.

At the bottom: Flood event due to southeastern winds in the continental delta during November 2014.

7. Areas of influence

The water flow of Paraná River system follows the terrain of land. Topography and currents directs the watercourse from upstream areas to the low-lying lands around the Rio de la Plata estuary. In the last decade, a number of events taking place in the upstream part of the river system have changed the flow patterns in the lower reaches of the Paraná Delta (Baigún et al., 2008, p. 246). These environmental issues originate in areas of influence upstream the delta (Tucci & Clark, 1998, p. 157; Baigún el al., 2008, p. 245), and can therefore be associated with the telecoupled system that the river creates. The interconnection between the upstream environmental issues and the lower reaches of the Paraná Delta is tied to the river system. The issues can hence be regarded as resulting in telecoupled impacts in the delta.

Tucci and Clark (1998) identify a number of environmental issues on the La Plata river basin (Fig. 19). Four of these, here analysed as telecoupled impacts, are in focus in this study: 1) soil erosion 2) hydrological events of climate change 3) land use changes and deforestation 4) dam building, even though there might be more impacts enclosed in the social-ecological system. While sedimentation from soil erosion is a telecoupled impact that naturally influences the flow by its material that shapes the delta mudflat, it is accelerated by changes from human activities. The following three are anthropogenic transformations that cause environmental issues and create new challenges for the conservation of the delta. The transformations entail large landscape changing effects and range from natural to artificial, across the global, regional as well as local scale. The four events all have their origin in distant but interconnected areas to the delta. They thereby make up areas of influence.

The regional drivers that are above presented as telecoupled impacts influence the river system and the delta through changes in flooding, as well as the sedimentation that occur during flood events. Here they are described in detail.

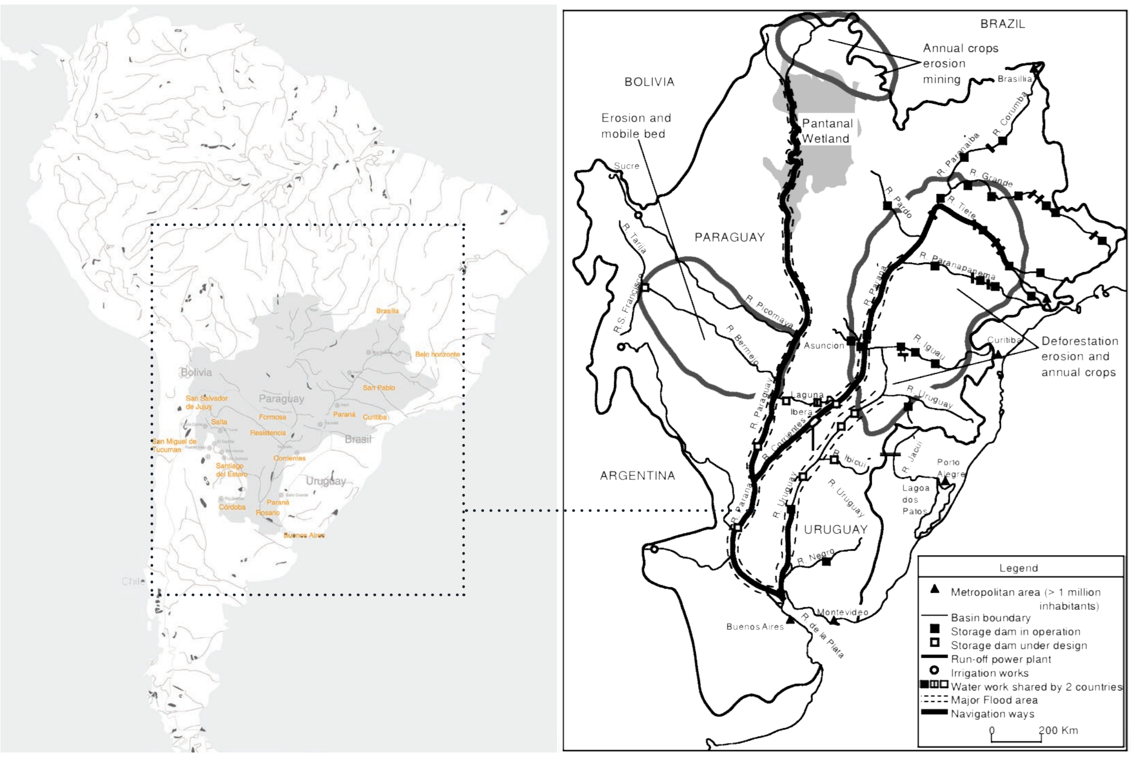


Fig. 19. Impacts observed in the La Plata basin.

Soil erosion from the Bermejo River basin

The Paraná Delta can be characterised as an enormous mudflat, its soil consisting of approximately 56 % mud, 28 % clay and 16 % sand (Bucx et al., 2014, p. 120). The soil structure is heavily dependent on sediment loads transferred via river discharge from the Bermejo River, with its tributary in Bolivia (Depetris et al., 2003, p. 656). When sediments are deposited in the river mouth, silt aggregates and expands the dimension of the delta, creating new land surface. This process mainly takes place during flood events, when the water reaches higher velocities. Consequently, the delta builds seaward at around 617 km^2 per year, expanding the land into deeper waters (Bucx et al., 2014, p. 120; Nijhuis & Pouderoijen, 2014, p.11). The expansion however, is not confined to the surface level, but sediments are also aggregating under water level and build up the delta from the bottom. Accordingly, the delta front is expected to reach Buenos Aires in about 110 years (Bucx et al., 2014, p. 120). The new land formation creates a fragility gradient in the delta from east to west.

The tributary of Bermejo contributes with about 50 % of the sediments in the Paraná Delta. Its fluviomorphological dynamics largely influence the processes of formation of the delta. The large load of sediments in the Bermejo River does not depend on the sediment transport capacity of the river, but on the capacity of the given watershed to yield sediments. In other words, there is a strong correlation between soil erosion in the watershed and washload (portion of sediment carried in the surface of a water flow) transported in a river system. Despite that the river discharge from Bermejo to the Paraná River system is only about 5 % of the total, the Bermejo contributes with 95 % of the sediments flowing down to the delta (Garcia, 2014, p. 17). The washload in Bermejo River is thus extremely large. Numerous events contribute to this characteristic. In contact with rocks or slopes, kinetic energy (energy of motion) of water can create erosion and in that way erode underlying material into the water flow as well as shape the terrain (Prominiski, 2011, p. 19). For example, in the town of Iruya, Salta, in northern Argentina, strong hill slope erosion collects a large amount of sediments that transfers to the lower part of the river system (Garcia, 2014, p. 18). Most of the sediments gathered here then becomes the washload resulting in the large siltation of the Paraná Delta (Garcia, 2014, p. 18). Even though natural conditions of high river bed slope rainfall and soil are large drivers of river bed mobility, erosion is also accelerated by human activities such as changing land use (Tucci & Clarke, 1998, p. 165).

Hydrological events of climate change

In their Fourth Assessment Report, IPCC *(Intergovernmental Panel of Climate Change)* identifies the coasts around Buenos Aires to be among the most vulnerable to future climatic changes (Magrin et al., 2007, p. 586). Even though floods are a natural phenomenon that is necessary for preservation of the delta wetlands, climate change exacerbates these events. The Fifth Assessment Report projects robust positive trends for streamflow in the Paraná River with very high confidence (Magrin et al., 2014, p. 1521). Also the previous report supports this trend, suggesting increases by up to 50 % in the Paraná River (Magrin et al., 2007, p. 588). Projections[1], constrained by usual levels of climate projection uncertainty, also point to increases in heavy precipitation in the southern part of the La Plata Basin (Magrin et al., 2014, p. 1517). These events can be associated with the increase of flooding in the Buenos Aires metropolitan area that has been observed from 1980 to 2000 (Magrin et al., 2014, p. 1532). Accordingly, the greatest flood events in the South America continent are found in the Rio de la Plata area (Magrin et al., 2014, p.

[1] Based on CMIP3 models and Eta-HadCM3 general circulation models and A1B greenhouse gas scenario.

1525) and are projected by strong trends to become more frequent[1]. The projections hence suggest implications of climate variability in the hydrological cycle of the Paraná Delta. However, the Paraná Delta is said to be at a lower, but still substantial and increasing, risk of sea level rise, compared to deltas that face a high or severe risk (Magrin et al., 2007, p. 586; Global Change, 2014, p. 12). Changes thus appear to be dominated by increased river discharge, as well as an increase in storm surges from strong southeastern winds, mentioned in the Fourth Assessment Report (Magrin et al., 2007, p. 600).

The climate change impacts that influence the delta in the hydrological scheme are both direct and indirect. Direct impacts may create changes in the flows in one or multiple systems. This change can in turn result in geographically distant places also being affected. In regard of climate change, teleconnected impacts transferred via river flow can be described in a similar vein as indirect impacts. Indirect impacts of climate change can be interpreted as impacts that are observed or expected in one place, but brought about by climate change or extreme events somewhere else (Benzie et al., 2013, n.p.). A relevant example is when impacts that occur in one place are transferred through a river system to affect a downstream area. This situation is highly applicable on the Paraná River system and delta. For example, a heavy rainfall upstream can cause transferred flooding by the river flow down to the delta area.

Indirect impacts are complex and difficult to predict. However, the natural interconnected conditions of a river system make it possible to argue that major events upstream might later result in consequences downstream. A new index on the indirect impacts of climate change (Hedlund & Benzie, 2014) also maps Argentina as being highly exposed to indirect impacts of climate change from transboundary river systems, since a large percentage of the country's water originates in upstream countries. The index points to a high exposure of indirect water flow impacts due to the level of biophysical interconnectedness with distant areas. Previous research (Baigún et al, 2008; Tucci & Clark, 2010) also supports the idea that the delta will receive an increased flow from climate impacts on the upstream river tributaries. Much research thus verifies the connection of influences from the upper basins to the lower delta (Baigún et al, 2008, p. 254).

Hydrological patterns in the lower basin show that before 1980 the Paraná River had a flood peak at the end of the summer due to heavy rainfall in the upper Paraná basin and another peak during the end of the fall by influences from Paraguay (Baigún et al, 2008, p. 256). These flood pulses can also be significantly imposed by the climatic teleconnected phenomenon El Niño Southern Oscillation, determining excess rainfall and thereby affecting the flood regime of the Paraná River among others (Depetris, 2007, p. 657). In 1983, the Paraná Delta suffered a devastating flood resulting in the loss of its buffering capacity, leaving an area of 40,000 km^2 waterlogged (World Bank, 2000, p. 18; Zagare, 2011, p. 6). The flood, which repeated again in 1998 with similar effects, was related to El Niño (Berbery et al., 2006, p. 70). In 2003, another huge flood caused damage in the city of Santa Fe, located along the Paraná River proximate to the border of the upper delta (Ullberg, 2013). The Argentine city suffered severe impacts from floods caused by the sudden growth of one of the tributaries of the Paraná River system, the Salado river (Zagare, 2011, p. 6). The flood hence occured as a result of both local and upstream rain, indirectly transferred down by the river.

The report *The comparative assessment of the vulnerability and resiliency of deltas* (Bucx et al., 2014) acknowledges that the Paraná Delta is affected by indirect impacts of climate change. Today, the most observed climate change-induced threat in the lower delta is storm surges

[1] Combining a 5 mm yr –1 change in storm surge with SLR changes in extreme flooding levels.

caused by landward winds from the estuary of Rio de la Plata. Indirect impacts transferred from rain events are more visible in the region of Entre Rios, located in the middle part of the delta (Zagare, 2014b). Meandering of the delta rivers mitigates the effect of heavy water flows from upstream, which reduce the exposure of the lower delta to these effects. Still, the increasing and converging amounts of water flow will in the future change the dynamics of the delta. Coupled with anthropogenic transformations of the delta environment, these changes might cause the water regulation capacity and ability to hold large amounts of water to become disrupted. In addition, locals (Gamba, 2014; Batista, 2014; Flanagan, 2014) express concerns regarding the higher water level and increased periodic floods from the river. Floods from tides are however mentioned by the locals as a phenomenon with which the delta people always have coexisted and lived in acceptance with.

Land use change and deforestation
A change in anthropogenic activities upstream also results in telecoupled impacts on the delta. The study done by Tucci and Clark (1998) confirms the relationship between river discharge and land use changes upstream. Due to deforestation for agricultural and settlement purposes in areas along the upper Paraná basin (as well as the Paraguay and Uruguay basins), river flow has increased in the Paraná River system (Tucci & Clark, 1998, p. 168). Deforestation associated with intensified agriculture and urbanisation is expected to be one of the most severe environmental disasters in the region (Zagare, 2011, p. 8). Moreover, changes in the choice of crop from coffee to soy has made the agricultural practice contribute more to higher river flows, since soy requires large areas of vegetation cover and needs to be managed by machinery. The latter technique commonly increases mean flow (Tucci & Clark, 1998, p. 168). Later research (Vajpeyi, 1998, p. 86; Mugetti et al., 2004, p. 40) also confirms that effects from deforestation and agricultural activities along the upper part of the Paraná River can be noticed as far down as the delta. This will ultimately result in more extreme flood events in places further down the river, as well as changes in the river bed and riparian landscape (Tucci & Clark, 1998, p. 166).

Even though the downstream impacts of these events are still predictions and people from the municipality not expressing fears about the problem, an interview with a geologist living in the delta (Gamba, 2014) also suggests that the effects of deforestation are visible in the area. According to Gamba, who was brought up in the delta, the activities are noticeable from tropical animals and Amazon wood stranding in her garden.

Dam building
A number of dam building projects in the upstream rivers of the Paraná Delta are also threatening the natural processes of sedimentation and river flooding. Tucci and Clark (1998, p. 163) argue that the construction of dams will have important consequences for the downstream environment. Five large scale dam projects have so far been conducted along the Paraná River upstream from the delta: Ilha Solteira (1973), Engineer Souza Dias Dam (formerly Jupía) (1968), Porto Primavera (1999), Yacyretá (1994) and Itaipu (1984) (Bucx et al., 2014, p. 109). The dams that are built for hydropower are inevitably dependent on flow. In contrast to the other upstream events, dam-building might result in a decrease of river flow and function as a barrier for sediments. Dam developments will hence have clear impacts on the two most important natural elements of the delta. Bonetto el al. (1989, p. 342) emphasise the need to evaluate new projects with great care, since new dams can reverse the expansion of the delta by accumulated sediments. The consequences on the lower reaches of the delta in particular can in the case of new dams be highly tangible, by changing the depositional regime to erosional. This could ultimately result in risk for salinisation, which would have negative implications for the production and water supply in the delta as well as for the city of Buenos Aires (Bonetto, 1986, p. 545). In more recent research, Baigún et al. (2008) confirm that dams most certainly have modified the river

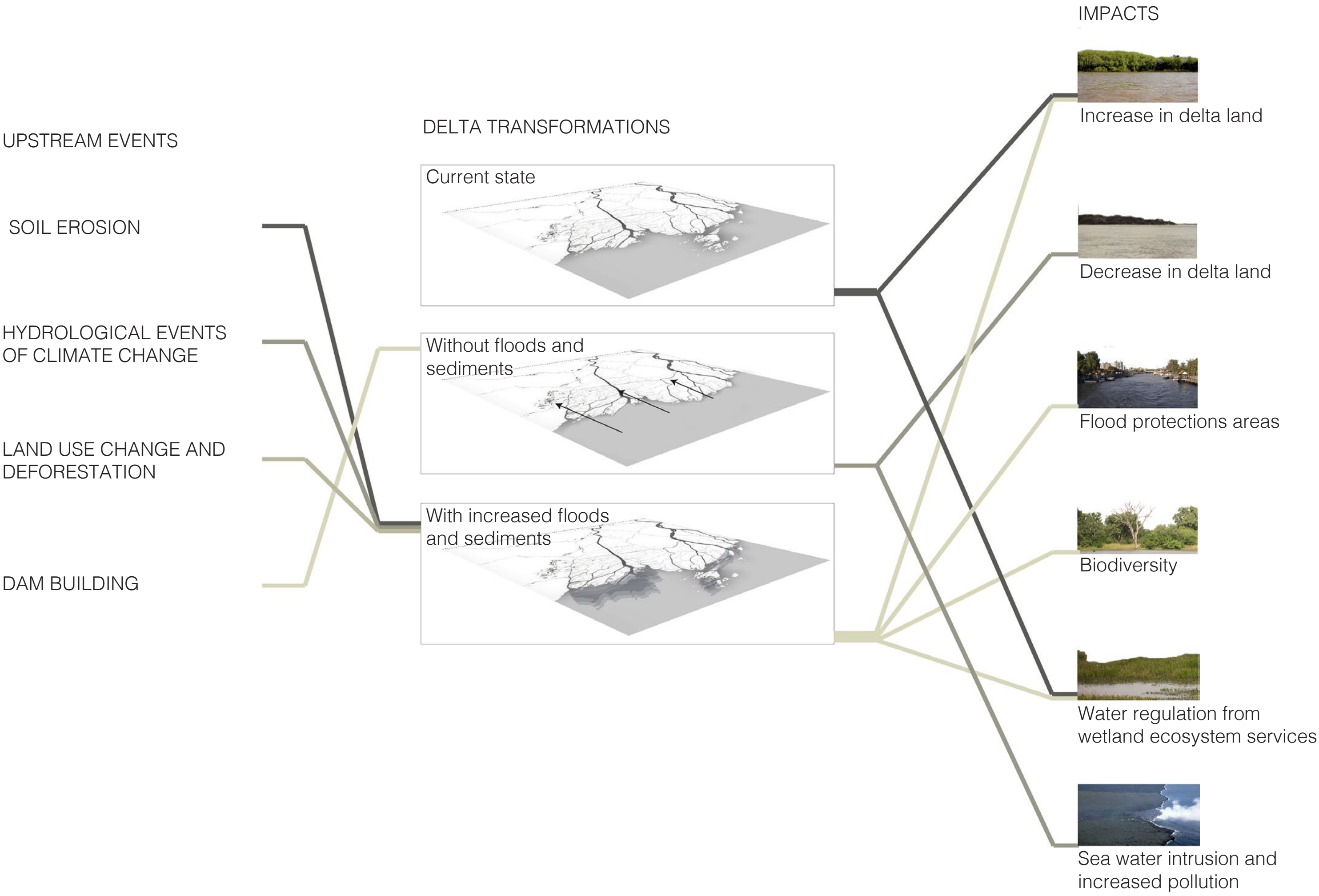


Fig. 20. Telecoupled impacts transforming the delta,
with lines representing the course of effects following a specific event.

flow behavior which will ultimately transform the environmental conditions in the delta into becoming dryer.

Summarising, the described telecoupled impacts are based on the selection of prevalent environmental issues in the Paraná River system emphasised by Tucci and Clark (1998) as well as additional sources. These may have various effects on the downstream environment (Fig. 20). However, other upstream events may also influence the delta. Navigation, waterway construction, industrial pollution and ecological migration could potentially constitute telecoupled impacts that alter the delta environment. In addition to the telecoupled impacts, two distinct local couplings infer with the delta system: 1) southeastern winds affecting the delta through flooding from Rio de la Plata and 2) the expanding urbanisation from Buenos Aires.

Southeastern winds (*sudestadas*) from Rio de la Plata

The *sudestada* wind phenomenon arises from an anticyclone in southern Argentina and the nearby ocean, and produces a rise in the water level that is exacerbated by the Coriolis effect[1] (Garcia et al., 2009, p. 21). The strong southeastern winds are thus the source of major storm surges that are most remarkable in the Rio de la Plata and along the coast of Buenos Aires. During strong events of southeastern winds (Fig. 21), the entire delta is affected by intense floods entering from the ocean. The winds are hindering the outward river flow by pushing the water back into the delta. Consequently, the wind currents cause large fluctuations in the water level, which are at times intensified into severe floods

[1] The deflection of moving objects from its path caused by the rotation of earth.

Fig. 21. Storm surges during southeastern winds, *sudestadas*.

(Bonetto, 1986, p. 567). The water level can during these events be raised by several meters. In combination with sea level rise, the storm surges produce large water quantities that are entering the delta from the southeastern direction, in the opposite direction from the river flow. Flood events can hence be caused by both telecouplings and local couplings, and in devastating situations, both. When floods from the southeastern winds coincide with local precipitation and floods from the river flow, the clash of water impacts results in a disastrous situation at the water front (Zagare, 2014a, p. 221).

Urbanisation from Buenos Aires

During the middle of the nineteenth century, the metropolitan area of Buenos Aires expanded rapidly due to increased integration in the global market (Zagare & van Dijk, 2014, p. 38). The production systems of the lower delta (such as forestry) were of high value for the agricultural and industrial growth of the metropolis. This change implied new ownership of land by actors such as large companies or prosperous entrepreneurs, who bought the land from the original owners. In the last part of the twentieth century, the area was characterised by a spatial dispersal but global integration. New peripheral urban centralities developed due to economic liberalisation, resulting in a considerable sprawl of Buenos Aires. Political, economic and social reforms as well as the withdrawal of the state as a land regulator further restructured the territorial planning, enabling foreign private investors to expropriate land. The new spatial configurations have resulted in a mixed urban pattern of exclusive gated communities developed by the private investors, traditional urban areas adapted to the delta environment, and vulnerable informal settlements.

The expansion of the urban fringe is still introducing new metropolitan patterns in the delta, and increased urbanisation constitutes a strong local force. Even though more remote areas of the delta has lost population due to inaccessibility and decrease of productivity (Zagare & van Dijk, 2014, p. 38), there is today a clear trend towards land use concentration and an increasing pressure on space in the 1st section of the lower delta. The high demand for properties as well as the aspiration from authorities to make the delta a part of the city highlights that anthropogenic forces are becoming increasingly prevalent.

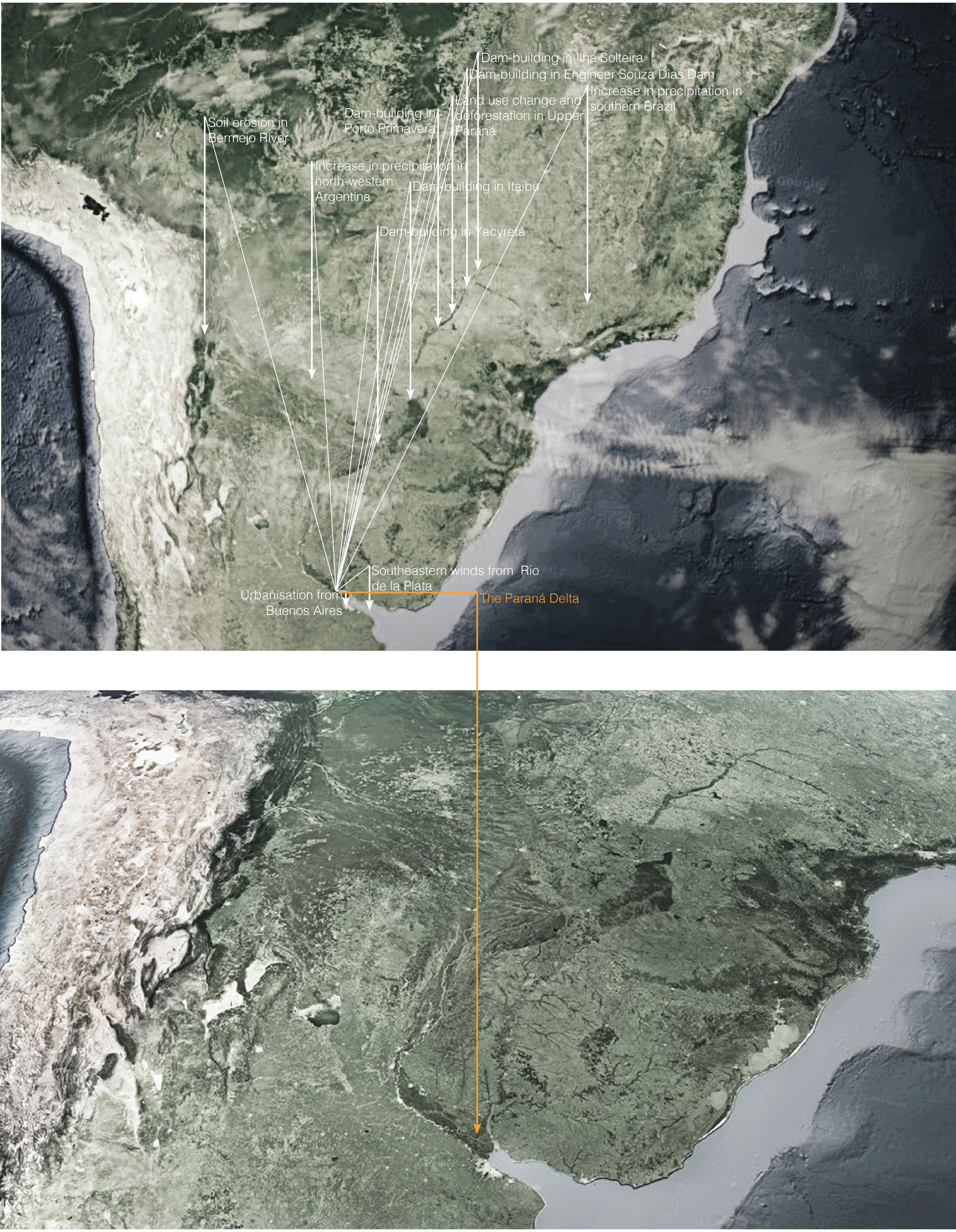


Fig. 22. Telecoupled and local impacts affecting the Paraná Delta.

8. Identifying components of the system

The delta is a system in itself, in interplay with other systems at multiple scales. By being connected to the Paraná River system, the Rio de la Plata and the metropolitan area of Buenos Aires, the Paraná Delta can be characterised as a system influenced by both telecoupled and local impacts (Fig. 22). The components of the telecoupled and local system are summarised in Table 1 (after Liu et al., 2013):

Systems	Flow	Agents	Causes	Effects (telecoupled impacts)
Paraná River system Rio de la Plata and the southeastern wind system Buenos Aires metropolitan area	Water Winds People	Natural forces Urban and economic development	Soil erosion Hydrological events of climate change Land use change and deforestation Dam building Southeastern winds Urbanisation	Flooding Sedimentation Pressure on land

Table 1. Components of the telecoupled and local system.

Thereby, it is possible to interpret the interconnections of the system as seen in Table 2:

	Telecoupled	Local
Natural	e.g. soil erosion	e.g. southeastern winds
Human	e.g. land use change, deforestation, dam building	e.g. urbanisation

Table 2. Characteristics of interconnections in the river system.

Different geographical levels of site can be identified in systems of the delta, in Table 3:

Areas of influence	Areas of control	Areas of effect
Bermejo River basin Northwestern Argentina and southern Brazil Upper Paraná River basin Ilha Solteira, Jupia, Porto Primavera, Yacyretá and Itaipu dams Rio de la Plata Buenos Aires metropolitan area	Construction sites in the delta	Places surrounding the area of control can possibly be affected

Table 3. Identified areas organised by three levels of site.

The telecoupled impacts may vary in their effect on the downstream environment. Some consequences might not be seen in the delta for many years to come. Still, it lies within the nature of a river system to connect places and events to each other. In their research on the effects of urbanism on the delta wetlands, researchers Pintos and Narodowski request a peripheral approach to investigate flooding in the area, integrating regional and global processes (Pintos & Narodowski, 2012). There is also an indication in empirical studies as well as in field work interviews towards an increase in all of the mentioned impacts. Further, studies on impacts along the river system do not take into consideration the influence that local developments might have to reduce or amplify these impacts. There is thus a need to investigate how the delta can become resilient towards the synergy between telecoupled and local impacts. To be able to manage future changes that emerge from the river, the estuary and the urban development, the delta must function as an open system.

9. Conclusions and identified needs

For the delta to be able to manage telecoupled impacts as well as the pressure from urbanisation, the delta area needs to be a combination of adapted human lifestyles and a healthy and sustainable water system. A few points are concluded upon from Part I, to constitute a base for the two remaining parts:

- The delta is highly influenced by the entire water system it is a part of, telecoupled impacts of flooding and sedimentation that converge in the area, and local urbanisation patterns.

- The complexity of the water system requires equilibrium in the water flow, due to the potential clash of hydrological effects colliding in the delta. The water flows into the delta from opposite directions due to the combined prospect of increase river discharge from upstream climate change impacts and land use changes, more frequent and intense storm surges from Rio de la Plata and elevation of the sea level in the Atlantic ocean. If the water regulation capacity of the delta is lost, this collision of water flow effects can have devastating flood consequences for the delta.

- Retaining floods of the delta wetlands are crucial in order to preserve ecosystem services for water regulation. But flood protection is also needed for people residing on the islands. The hydrological clash does hence not only involve water flow coming from the different directions, but also concerns the fact that flooding is both a threat and a requisite for the area.

- Catchment of sediments to enable the natural expansion of the delta is also essential to keep away erosion and withstand rapid subsidence. This is preferably done by natural enhancement of island shores.

- A request for a public domain that can coexist with floods has been observed from interviews with both local islanders as well as professionals. There is also a demand to integrate social infrastructure functions in the delta environment.

PART II
Areas of effect

Open and closed systems

In this part, the problem statement about manners of transformation in the delta is addressed. The section focuses on answering the second subquestion:

> *2) How does a site need to function to minimise negative consequences for other areas?*

Meyer (2012) presents parameters which can help to form scenarios for the delta. To address the subquestion above, three of these parameters have been considered and developed into two scenarios: an open system and a closed system. These inhabit different potentials of minimising negative impacts for areas of effect, which in turn lays the ground for the choice of specific design interventions (which is elaborated on in Part III). The scenarios are exemplified through two existing typologies in the delta that materialise the different systems. The benefits and problems of these systems related to transformations in the terrain and areas of effect, mainly seen from closed systems, are described.

1. Scenarios embodied in two polarised systems

As previously mentioned, the concept of telecoupled linkages is closely related to systems thinking. To provide a historical background, Von Bertalanffy, biologist and the father of general systems theory (Odum, 1994, p. 4), distinguished between open and closed system concepts. By his description, an open system is one that has one or more inflows and outflows, which is perhaps most easily exemplified by the flow of energy traveling in and out of these systems. In the case of water, an open system can invite and temporarily store water before releasing it again. A closed system is, by Von Bertalanffy's definition, conceived as one in total isolation. This means that no inflows or outflows influence the content of the system. A closed system will reject the entrance of water, or control its state inside of the system.

The comparison between different kinds of land transformations in the lower delta becomes understandable in the light of open and closed systems. This justifies the resemblance of the delta wetlands to open systems, compared to the private communities that materialise the idea of closed systems. Von Bertalanffy's characterisation of open systems as those that let many in- and outflows pass through indicates that open systems are responsive to natural processes. Wetlands in this sense highly embody the principles of an open system, by their ability to allow for water flow and material to infiltrate and pass through.

According to Burns and Kahn (2005), areas of effect are places that are affected by a design construction. In this case, the design construction can be formed as a closed or an open system. The two scenarios have been developed based on Meyer's parameters (see section 2.3), and have different ways of influencing the delta environment. This study will argue for the resemblance of open systems in the design intervention.

1. Open systems in the delta

The scenario of an open system acknowledges Meyer's parameters (see c-e in section 2.3). The system minimises the transferral of impacts to areas of effect, due to conforming with natural flood space (c), stilt houses (d) and naturally vegetated shores (e). The delta as an open system is below described in detail.

Landscape units of the Paraná Delta are dominanted by wetlands, grassland and forest. The delta is a depositional complex system of wetlands, which depend on the in- and outflow of water and sediments. The wetland ecosystems are environments whose processes and functions depend on the substrates being flooded or water-saturated during long periods of the year. The delta wetlands *(humedales)* allow for this process to occur by their ecological and spatial organisation. By the processes of flooding and sedimentation, the delta builds up natural levees *(albardóns)*. The presence of reeds is essential for the delta to catch the sediments that originate in the Bermejo riverbed. Further, 0,4 hectares of wetland can store 6000 m^3 of flood water without any need for engineered structures (Davis, 1993, cited in Zagare, 2014a, p. 216). The delta thus functions as a large drainage basin.

The delta wetlands generate ecosystem services in the form of hydrological regulation (flood control, groundwater replenishment and water retention) as well as biogeochemical regulation (transformation and degradation of nutrients and contaminants (Zagare & van Dijk, 2014, p. 37). The municipality of Tigre arranges the ecosystem services provided by the delta wetlands as seen in Table 4.

Apart from regulating services, Fernández (2007, p. 18) identifies two additional functions that are produced by the delta wetlands: provision of biodiversity habitat and creation of

Hydrological regulations	1. Reduction of impacts from storm surges and navigation. 2. Reduction of flood effect due to lessening of water velocity during high water level peaks and storage of the surplus water. 3. Retention and fixation of sediments and pollutants.
Geological regulations	1. Moderation of variations in temperature and water vapor source for precipitation. 2. Regulation of salinity of the soil or substrate. 3. Supply of fresh water for human consumption. 4. Supply of water and fodder for extensive cattle.
Ecological regulations	1. Storage of organic carbon in the soil. 2. Provision of key habitats for maintaining viable populations of commercial interests and conservation. 3. Livelihood of local inhabitants.

Table 4. Regulating ecosystem services (Municipio de Tigre, 2012, based on classifications by de Groot, 2002).

cultural and recreational values. The wetland structures enable species to root and create an important biodiversity habitat for vegetation and animals. More than 600 vegetation species can be found (Janches & Zagare, 2013, p. 33) in the lower section of the delta. Different types of sedges and reed *(Schoenoplectus californicus, Typha spp., Scirpus giganteus)* grow on the shores and inlands of the islands, and both tree species that are grown for production as well as species that are part of the wetland systems *(Salix babylonica)* exist here. The presence of the wetland vegetation allows for carbon sequestration to take place. Anaerobic wetland soils produce large amounts of organic matter, which during stable decomposition can store carbon instead of releasing it to the atmosphere (Baigún et al., 2008, p. 250).

Traditional living means coexisting with the wetland as an open system. Rivers constitute the only public space in the delta, where all transportation and contact with the continental land occur through public and private boats. There are no roads or cars on the islands, and all properties are connected to the river through their private decks. The current urban organisation of the islands does hence not offer much connectivity for the island residents except on the large rivers. Moreover, the urban pattern can be characterised by disperse housing (Fig. 23) (Zagare, 2011, p. 5). Traditional living in the delta islands (Fig. 24) uses constructions such as stilt houses *(casas de palafitos)*, wooden building materials, footbridges between housing units, and few buildings per property (ca 2000 m^2) that creates minimal land use. These developments have allowed for floods to enter the grounds of the properties without affecting the lives of the people to a large extent. In combination with narrow river passages and flourishing vegetation, the constructions contribute to a high atmospheric feeling in the delta. The traditional lifestyles are commonly also socially open systems. In many islands, there is a strong feeling of solidarity towards the island community (Batista, 2014). Because the lack of social services on the islands, neighbors often assist each other with basic needs. Today, the islanders are collecting storm water and construct simple pumps to obtain water for their household needs. The islanders' (*isleños*) attitudes are also highly adapted to the tidal and periodic flood pulses, since these occur regularly. In other words, they are used to living with the floods. Floods from storm surges are however a different matter, always leading to major challenges for the simple lifestyles and at times also evacuation of the islanders.

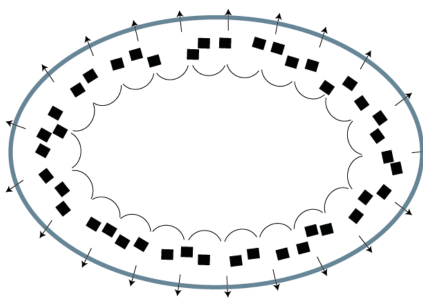


Fig. 23. Spatial structure in traditional delta islands, with blue line representing the river, black rectangles representing houses, arrows how these are facing the river, and arcs as existing spatial connections.

Fig. 24. Isleños and wooden stilt constructions associated with traditional living in the delta, representing an open system.

The ecosystem services of the delta wetlands function as negative feedback loops that regulate change within the system. Sites that function as open systems have the ability to incorporate telecoupled impacts, and hence, areas of effect are limited. Interpreting the delta as an open system envisages a domain with the capacity to manage the impacts that converge there, without aggravating or transferring negative impacts to other areas of effect.

3. Closed systems in the delta

The scenario of a closed system responds differently to Meyer's parameters (see c-e in section 2.3) compared to an open system. The system instead has the potential of aggravating flood impacts by constructions of embankments and polders (c), gated private communities (d) and concrete shore structures (e). The delta as a closed system is below described in detail.

Even though the delta requires the process of flood to preserve its natural state, flood protection is an adaptive measure that is increasingly taken when the delta islands now become more densely populated and urbanised. As described above, traditional protection has been constructed through techniques that are compatible with the wetland ecosystems. Today, an increasing amount of land projects modify the topography and soil structures of the ecosystems, that have previously held and purified large amounts of water flow. The projects, which are mostly developed for high-income housing, club enterprises as well as agricultural production purposes, involve movement of land and changes to the level of the surface. This change approaches a closed system. Over the last three years, the poldered area in the entire delta has increased in around 16,5 %, representing 240,748 hectares of polders (Bucx et al., 2014, p. 116). The large majority of privately owned land in the delta is a factor that enables these types of constructions. As a consequence, a rapid decrease in wetland area now takes place at an estimated rate of 10,500 hectares wetland loss per year (Bucx, 2014, p. 120). Drainage also exposes more wetland area to oxygen, which results in the release of carbon to the atmosphere. This process thus alters the open system wetlands from functioning as carbon storages to instead emitting carbon dioxide.

During the development of private gated communities *(barrios cerrados)*, land is raised by several meters in order for the properties to remain unaffected by floods. This blocks the natural drainage, and thereby aggravates floods in other areas (Frayssinet, 2014). The raising of the land is conducted through dredging and hydraulic sand fill (Astelarra, 2013, p. 7). Most of the private gated communities are still located in the continental area of the delta, but due to the urban progress in the municipality of Tigre, these are advancing among the islands in the delta front. Estimations from Tigre municipality show that there is a growing share of inhabitants residing in the island area (Municipio de Tigre, 2012, p. 74). In the private gated communities in the delta island area *(barrios náuticos)*, houses are located on the embankments that surround internal artificial channels and lagoons, and are connected to the river through private docks. The urban pattern does not offer public connectivity (Fig. 25). Many of the developments are relatively new, currently taking up an area of 450 hectares in the delta (Municipio de Tigre, 2012, p. 88). In a recent study (Fabricante et al., 2012, p. 14), 48 barrios náuticos were identified in the entire delta. Judging from calculations based on numbers from the study as well as the management plan for the delta (Municipio de Tigre, 2012), around 6-7 % of the total land area exploited for barrios náuticos is located in the 1st section.

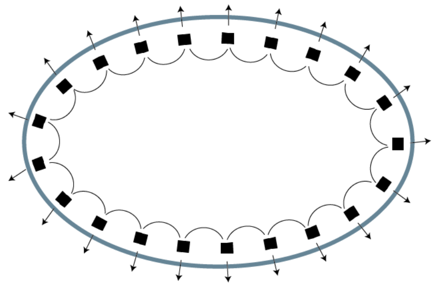


Fig 25. Spatial structure in private gated communities, with blue line representing the river, black rectangles representing houses, arrows how these are facing the river, and arcs as existing spatial connections.

Interviewees (Janches, Arrese, Villalba, Llere & Schapochnik) confirm research findings (Astelarra, 2013; Fabricate et al., 2012; Municipio de Tigre, 2012) that these developments cause damage in the delta front due to the high level of fragility of the new land. During the private developments (Fig. 26), vegetation is removed from the water front which makes the reed and sedges unable to catch sediments and in the long run, the delta expansion to decline. Moreover, along with the increase of private developments, there has been a noticeable decrease in flora and fauna biodiversity (Arrese, 2015), that will be accelerated in the case of further degradation of the wetland systems.

As a result of dredging in the terrain during the creation of artificial channels and ponds, saltwater is also beginning to intrude in areas in the lower delta close to Rio de la Plata (Bucx et al., 2014, p. 120; Arrese, 2015). One example is the private development *Isla del Este*, where saltwater has been let in to form an artificial lagoon in the center of the area (Arrese, 2015). These types of constructions can ultimately lead to colonisation of new saltwater species into the fresh water delta environment, as well as contamination from Rio de la Plata (Arrese, 2015). Consequently, saltwater intrusion into the delta is a process of total ecological degradation.

As previously mentioned, building regulations for new constructions in the delta do exist. For example, buildings cannot be located closer to the shore than 15 meters and new properties are imposed to an area not covering more than 10,000 m^2 (Arrese, 2015; Municipio de Tigre, 2012). It is however apparent that these codes are not complied with in the constructions of the new private developments.

From a social perspective, the system is also closed or at least confined to a certain group of people. The attitude towards floods among the people living in the private developments also appears as different compared to the attitudes of the traditional islanders (Llere & Schapochnik, 2014). Since floods are prevented instead of integrated into the private community lifestyles, there is an impression that the behaviour of people living in the communities is not very adaptive to the flood conditions. To fully adopt the delta as an open system, it is also important for people to embrace the natural processes.

To summarise, the case where development of closed systems in the delta reaches uncontrolled levels will produce numerous consequences (Arrese, 2015). In ecological terms, it will be the end of the wetland ecosystems as well as the composition of organic matter. Natural flora and fauna species will decrease or disappear as it will be more difficult for these to access the artificially controlled landscape. Further, the delta landscape as a socially open system will be transformed into one that excludes certain groups of society. This will not least happen with the reduction of public space. Today, the rivers represent the area where public activity can take place. With the developments of private communities, there is for the first time a privatisation of water in the delta, which occurs when parts of the rivers are integrated in the closed neighborhoods. This violation of public space endangers the traditional social environment of the delta previously described. The large interventions and increased human activities that closed systems produce will also present risks of further pollution and degradation of water quality. Both after and during the building phase, these interferences generate contaminating disturbances from transport and material use, as well as noise and vibration that threaten species in the island habitats.

In contrast to the understanding of the delta as an open system that is able to regulate converging impacts of flooding and sedimentation, the private developments can be viewed as closed utterly controlled systems that pass on and worsen impacts for surrounding areas of effect (Fig. 27). Instead of being an integrated part of the system, the closed system isolates the site from the surrounding landscape.

Fig. 26. Private gated developments on raised land, representing a closed system.

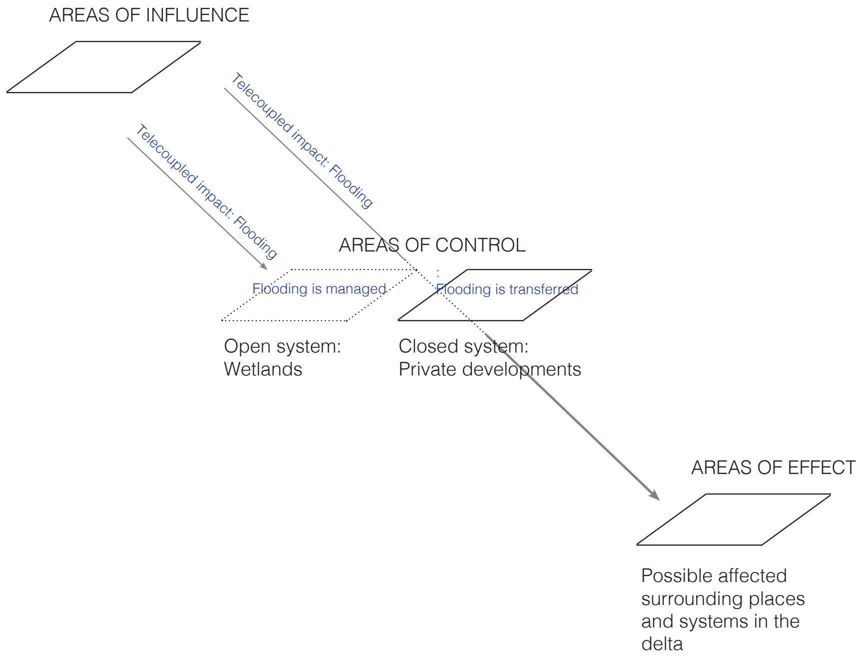


Fig. 27. Difference between open and closed systems in the management of telecoupled impacts, applied in three levels of site.

4. Areas of effect from the closed system

The private communities are not very vulnerable to floods due to their location on raised land, but the construction can impact surrounding islands. By the use of concrete to construct walls around the developments, the rhythm and wave action of the water becomes rougher towards the shores of the surrounding delta islands during flood events (Arrese, 2015). This accelerates erosion of the natural levees of nearby islands and decreases growth of coastal vegetation (Municipio de Tigre, p. 90). In addition, the velocity of the water also increases as a result.

During flood events, private communities can cause spill-over effects in proximate areas. The situation of spill-over floods is most severe in low-lying urban slums (*villas*) surrounding the land-raised gated communities (Barros et al., 2006, p. 25). These are mostly found in the continental part of the delta among neighborhoods with low socioeconomic status and informal settlements (mainly in the valleys of General Pacheco and Los Trances del Talar according to Villalba, 2014). The areas become water-logged when the water level of the surrounding channels increase and spill over. This is due to the fact that the water is not given any space to infiltrate the ground because of the raised private communities. During flood events, the communities also have the power to shut gates connected to the channels to stop water from entering (Zagare, 2014b). The low-lying slum areas then face severe consequence from spill-over floods since they often lack resilience and flood protection. Even an increase by a few centimeters in river level could have widespread effects for these neighborhoods.

Reducing the capacity of flooding will result in chaos for the delta area (Janches, 2014). In terms of the ecosystem services it generates, the areas of effect involves consequences for the entire water regulating system. If the delta looses its water management functions from the destruction of the wetlands this might not only result in an increase of local floods, but also increase the possibility of affecting the surrounding water systems by rebounding floods upstream as well as higher water levels of Rio de la Plata. Leaching from the illegal landfills also impact the water availability, affecting the entire Buenos Aires metropolitan area (Aguas Argentinas, 1997; Virgone, 1998, cited in Mugetti et al., 2004, p. 37).

Summarising, the most extreme terrestrial form of open systems can be symbolised by the wetland structures, while the most extreme form of closed systems are here illustrated by the private development structures (Fig. 28). The wetlands can take care of telecoupled impacts, but must also meet the local challenges of increased urbanisation. The private developments in its current shape cannot integrate telecoupled impacts, but are a response to the pressures of urban development in the area. Although it should be acknowledged that the fragile parts of the delta should not have been urbanised in the first place, not addressing the problems by proposing alternative solutions would be to strengthen the vulnerability of the area further. As Dammers et al. (2014) put it in their description of the situation:

> More frequent and extreme storm surges may put the population and economic capital more at risk. The direction, impacts and even occurence of such trends and events are in many cases highly uncertain and subject of fierce political and scientific debates. Often, these uncertainties are used as arguments for taking familiar rather than alternative solutions into consideration.

If open systems can be created in the delta, there is a chance that areas of effect from the design intervention can become limited.

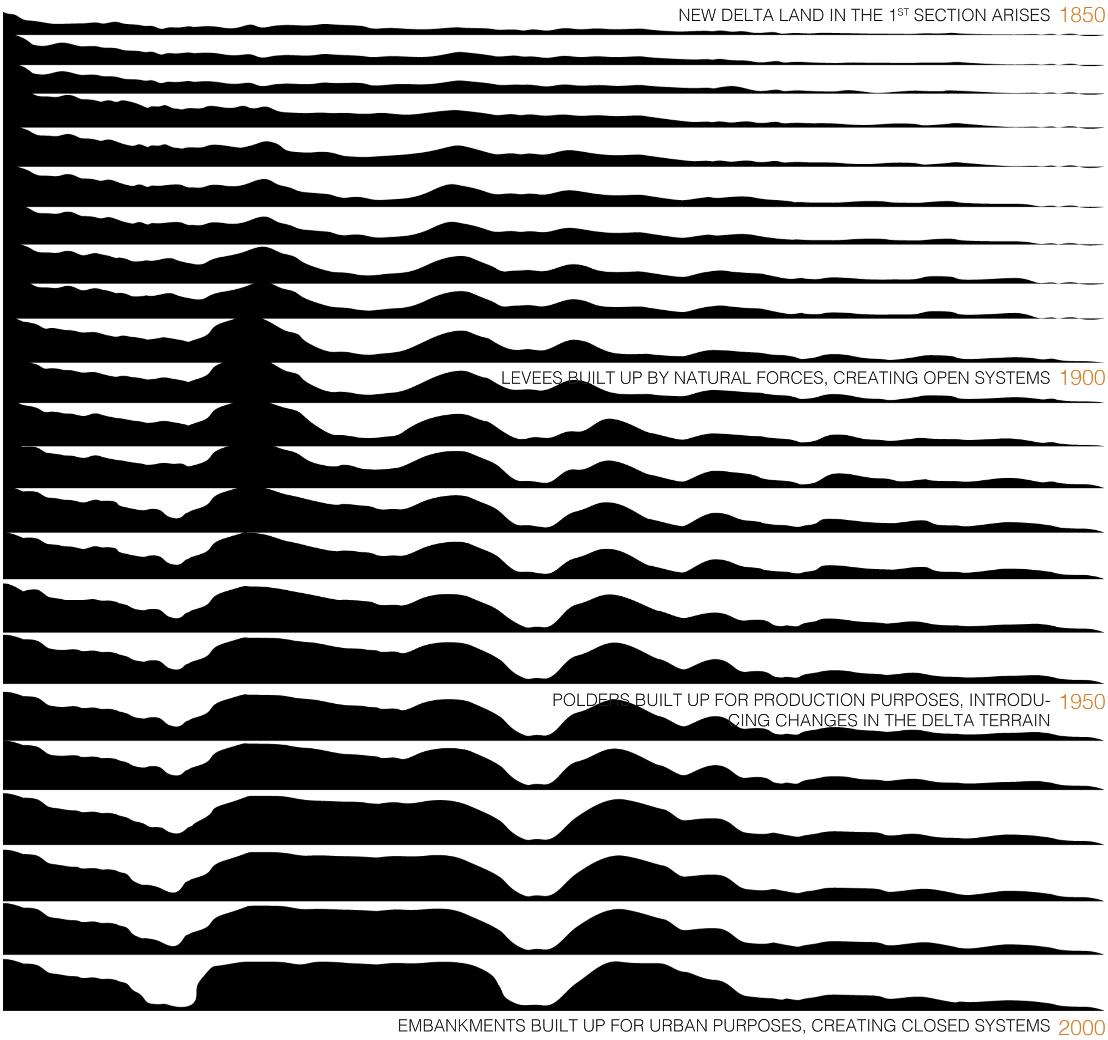


Fig. 28. Changing topographies of the delta islands.

PART III
Area of control

A transformative design strategy

This section aims to show that the idea of open and closed systems is not limited to function as a theoretical concept, but can be transferred into practice. It will hence respond to the third and final subquestion:

> *3) What design strategy is required for the site to be a sustainable part of a telecoupled and local system?*

To explore this, an area of control in the delta is framed. The site of the project Colony Park, a private development in the fragile delta front, was selected to investigate how a closed system can be transformed. A design strategy that aligns with the characteristics of an open system identified in Part II-1, grounded in Meyer's three parameters, is developed for the site. The application of integrated functions with both ecological, social and productive elements contribute to the creation of a new network with added functions to the site.


Fig. 29. New fragile delta islands.

1. Fragility of the new delta islands

As previously mentioned, the lower delta is heavily impacted by the floods caused by the southeastern winds and the river discharge. Severe river floods transferred from upstream have up until today mostly occurred in the middle delta area. It is however possible to imagine that if river discharge increases, there will be a clash of flood events in the lower part of the delta. Intensified river floods in combination with the strong storm surges from Rio de la Plata will amplify the fragility of the lower delta islands. Due to the direction of the moving sedimentation load, the Paraná Delta is subject to a gradient of fragility from west to east. In other words, fresh soil that builds up the newest islands facing Rio de la Plata (Fig. 29) in the east is yet in a forming state where fundamental ecosystem processes take place (Fig. 30). The islands are thus not more than approximately 40 years old (Municipio de Tigre, 2012, p. 48). At times, some of the islands are not even possible to embark on due to the large transformations in sedimentation, topography and water level (Janches, 2014). The fresh soil also makes the new land extremely fertile and subject to rich biodiversity.

The municipality only owns a marginal part of the delta land in the 1st section (see section 4.3, Fig. 12). This limits their capacity to intervene when inadequate constructions are developed. However, by a new law, all land that now arises from the expansion of the lower delta is owned by the province of Buenos Aires and is prohibited to build on (Arrese, 2015). At the same time, a number of private developments (Fig. 29) have already developed in this area (e.g. *Isla del Este, Santa Monica*) and the extent of private communities are also still increasing in the rest of the delta. There is also a strong urge from the municipality themselves to increase its territories of growth and at the same time conserve the fragile delta environment. A large role of the municipality is further to negotiate with private

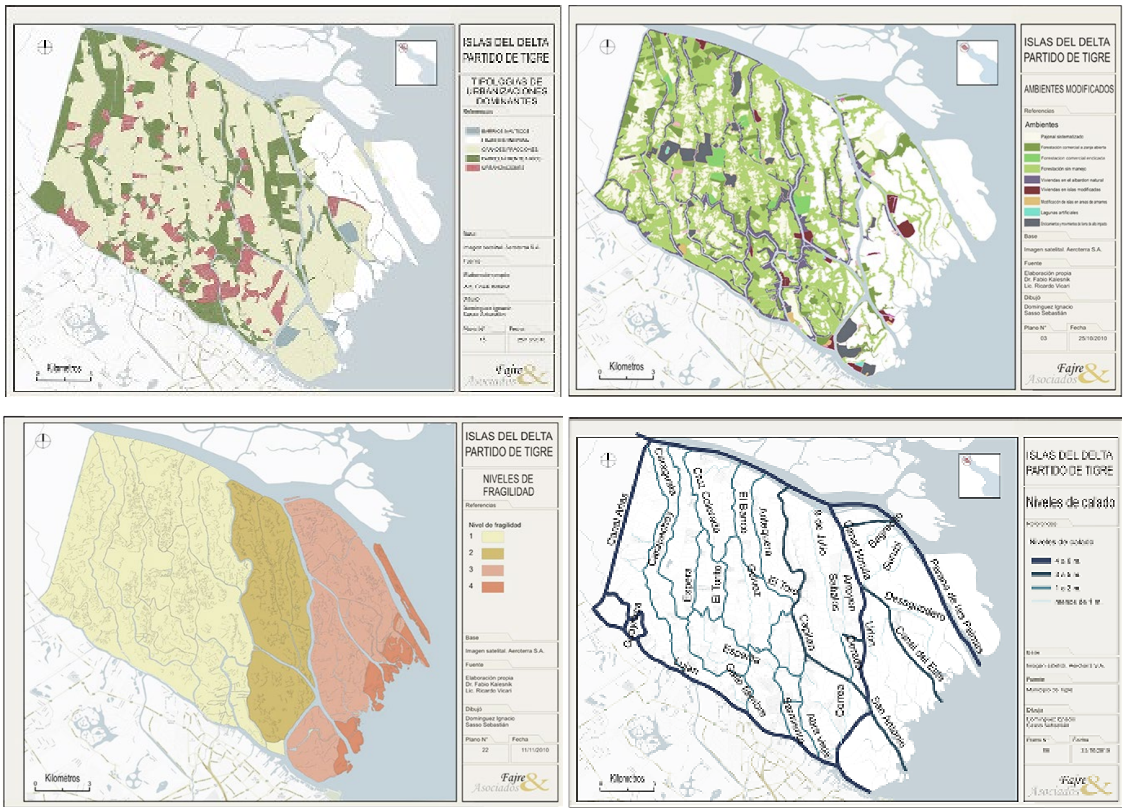


Fig. 30. As seen from above left to right: Dominant urban typologies (such as barrios náuticos); Modified land areas; Levels of fragility of the land; Names and depth of rivers.

stakeholders to inform about and argue for harmless solutions of expansion. Presenting sustainable plans and alternative ways of construction might be a key driver to change when closed systems are developed.

2. Colony Park - a closed system

Colony Park is a construction project initiated in 2007 (Desafío Economico, n.d.) in one of the youngest islands in the fragile zone of the delta front, developed on newly formed land (Fig. 31). The private development, a new barrio náutico (gated community on embankments surrounding artificial lagoons, see Part II-3), was planned to cover an area of 300 hectares in the delta island without any physical contact with the continent.

A provincial law states that any work that is likely to degrade the environment must undergo the process of an environmental impacts assessment (Lavaca, 2011). Around ten years ago (i.e. before the regulation of provincial land ownership of new islands was enacted, see section 4.3), the municipality of Tigre received a letter from a private actor stating that they were making a study of the privately owned islands southeast of Canal de Viniculacíon (Arrese, 2015; Fig. 32). Following this, the construction of Colony Park was rapidly undertaken without any form of legal permission. Plans were not submitted and damage to the new islands was already done when formal proceedings started. Entrances to the area were blocked. The aim of the private actors was to design the island as an exclusive neighborhood for housing. The development however met resistance from the municipality of Tigre and from the delta islanders, who carried out major protests against the project.

Fig. 31. Transformation of the Colony Park island from 2003 to 2010.

As it turned out, emotion is a strong driver of action. On the 25th of August 2009, an injunction to postpone Colony Park was issued. At the time of writing, the legal process regarding Colony Park is still on-going and construction work is on hold. According to attorney Yenni Rojas, the completion of Colony Park would equal a total transformation of the entire 1st section of the delta (Lavaca, 2011). Subsequently, the transformation of the wetlands would have resulted in telecoupled impacts being aggravated. Documentation from the field study, such as maps, photos, interviews, reports and observations, reveal that the initiated construction of Colony Park has transformed the delta landscape system from open to closed in many of the ways described in Part II. The project materialises the concept of a closed system. Today remains an inhabited, landfilled structure with 4 meter high embankments (Astelarra, 2013, p. 8) that has been overtaken by vegetation. Further, the project has modified the previously open system by restricting social values in the area. The canal of Arroyo Anguila (Fig. 32) has been incorporated in Colony Park and is no

Fig. 32. The Colony Park island, the area of control for the design intervention.

longer a public waterway due to the obstruction of the river entrance (Theomai, 2009, n.p.). Rivers, the only existing public space in the delta, have for the first time been claimed by private stakeholders. Furthermore, the planned urban structure of Colony Park consists of isolated property patches and almost no local network exists between them. The planned space-demanding houses, usually constructed as single-stored buildings, are located in the island edges and are faced outwards towards the rivers.

The Colony Park site here serves as an area of control (Fig. 32). The development of Colony Park (Fig. 33 & 34) creates a landscape in both social and spatial isolation. Its principles go against benefits of social, infrastructural and natural interconnectedness. Hence, it does not add any values to a sustainable system, aggravating local and telecoupled impacts (Fig. 35).

The ground of Colony Park has already started to be transformed into embankments (Fig. 36). In that way it is different from the physical organisation of the natural delta islands. Even if the embankments are a destruction of the wetlands, it is at this point important - and also possible - to turn the constructions into benefits for the island. Urban development in the delta will most likely have its course, but the manner of constructions determines whether this transformation is accomplished sustainably or not.

Fig. 33. Development of Colony Park.

Fig. 34. Construction of Colony Park.

Fig. 35. Local and telecoupled impacts on the area of control.

Fig. 36. The existing land structures.

3. Reaching equilibrium - an alternative design

Despite their negative effects, it is inevitable to acknowledge that land-raised private communities exist and are still developing in the delta. Even though the negative effects from these developments should be continuously communicated, the issue of closed systems will not solve itself only by problematising their presence. Additionally, the question of how a closed system by smaller design interventions and techniques can be reformed into an open system should be raised. This can help to develop an approach that makes the system function again, on a local scale as well as regulating distant telecoupled impacts. To accomplish this transformation, alternative strategies should be supported for urban development to take place in line with the continuous regime of the ecosystem. In addition, these solutions need to add beneficial values to be tangible. An example of such an alternative strategy also exists among the islands in the delta front. The project *Dos Rios* represents a combination of housing sites and nature preservation (Dos Rios, 2009), where all property owners are obligated to follow the municipal construction codes. Wooden houses are built to resemble traditional styles of the delta, to adapt to the watery environment (Fig. 37). Plots are no more than one hectare and located at a minimum of 75 meters from the water front. Half of the overall area is protected by a nature reserve in the center of the island, which integrates public networks for outdoor activities. Each resident is a coowner of the reserve. The project demonstrates that it is indeed possible to successfully unite urban development with the natural processes of the delta.

Fig. 37. Urban typologies in the Dos Rios project.

Judging from Meadows' ideas on where to intervene in a system (see section 2.3), parameters in the system can be leverage points in case they trigger change in other elements of the system (Meadows, 1999, p. 6). Meyer's parameters conform to this criterion. Since Meyer's parameters lay the ground for whether the system is open or closed, relating design interventions to the parameters thus has potential of changing the system. Interventions in negative feedback loops, those that work to reduce change, entail control of the system as they can work to delay positive feedbacks that instead amplify change.

The idea of interconnected systems is not limited to serve as a research approach, but can also be applied as a model for physical construction. Since the new delta islands are systems of large fragility, being transformed into isolation through private developments is highly destructible. The question can be raised how it is possible to increase local interconnectedness that can function across social, ecological and productive landscapes. Besides managing impacts of flood and sedimentation from the telecoupled system, interconnectedness in the physical structures can become a means to create resilience against local natural disasters, as well as social and economic segregation due to urban development. How can such a local system be developed?

4. Design strategy - a new island network

Design concept - a new network with integrated functions

The design concept is developed with inspiration from systems researcher Duncan Watts' network model. In his research on network theories, Watts explains how levels of complexity can be interpreted through models of networks (Watts, 1999). Complexity and integration are very limited in a regular and ordered network as well as in a complete random network (Fig. 38). However, if both ordered and random patterns exist, the level of integration and connectivity is higher. As Watts puts it, "only a few random links can generate a very large effect" (Watts, 1999, p. 89).

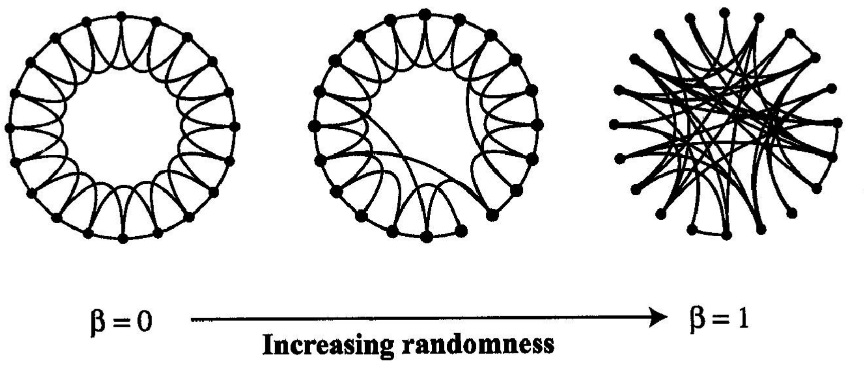


Fig. 38. Watts' network structures.

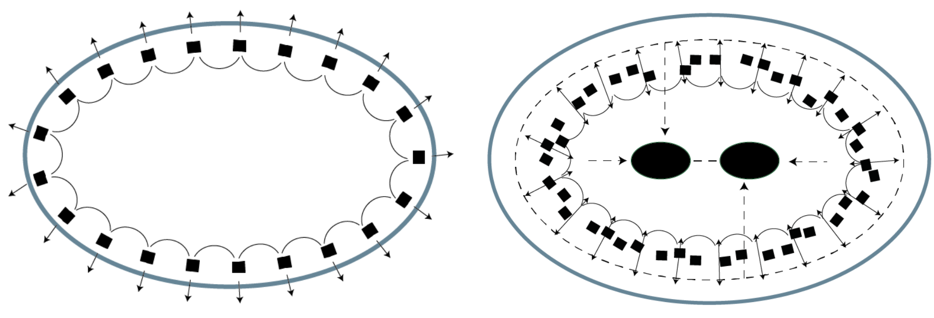


Fig. 39. To the left, the urban structure of private developments. The planned urban pattern of the Colony Park island, seen to the left, is similar to Watts' regular model. The right image shows the proposed new structure plan for the island (where black squares represents houses, dotted line network of public space and large black ovals represent social nodes), which mirrors the traditional urban structure (see Fig. 23) but also includes added connections and nodes.

The network model is similar to the existing spatial structure of the islands (Fig. 39). By creating a few links and adding nodes to the network, a new dynamic of connectivity is enabled. Proceeding from ideas of an integrative network as a planning prototype for the delta, it would be possible to develop a micro network structure with integrated functions and values for a single delta island.

Components of the new network
The point of departure for the design strategy are impacts from the local and telecoupled system, the three parameters (c-e) by Meyer applied to the open system (see Part II-1) as well as the conclusions and identified needs from Part I (Fig. 40). By integrating a healthy water system with added water treatment functions, new urban typologies and connectivity anchored in public space in the existing landscape structure (Fig. 41), the networks can be built (Fig. 42).

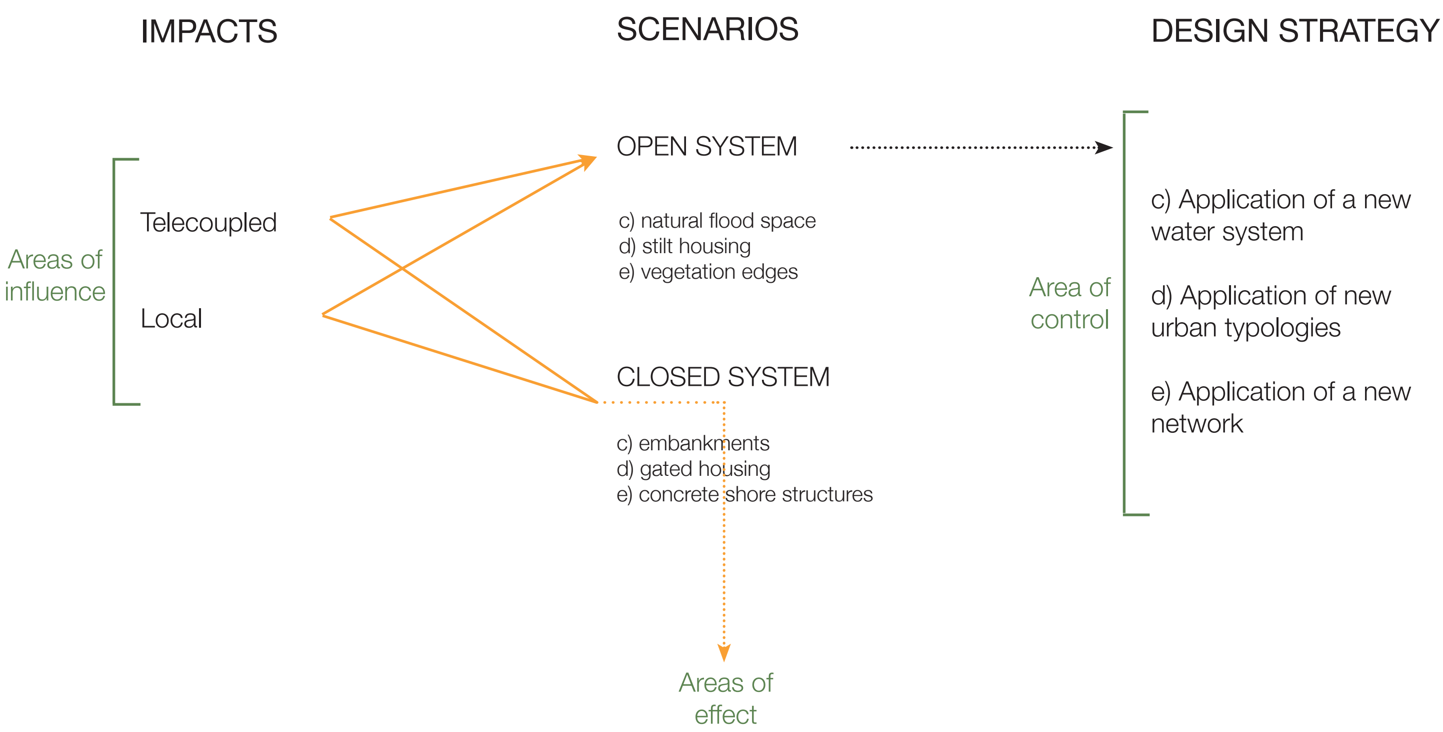


Fig. 40. Scheme over integrated research and design procedure.

Application of a water system (the urban flood defence system, see section 2.3)
To form the site in the delta as an open system, the water requires its natural space in the terrain. Water influences the islands in both a horizontal and vertical direction, since it flows as well as soaks. Thus, when connected to a higher level of urban development, the water system (Fig. 43) requires integration of water infiltration and flood protection that delays the water. Wooden structures along the island shores can provide flood protection as well as strengthen natural enhancement by catching sediment. In addition, the water system should manage an increasing level of sewage and grey water as the urban structure grows denser and new housing typologies are introduced (Fig. 44). The combination of technical and natural solutions in the site plan (Fig. 45) can reduce negative effects of urbanisation on the ecosystem as well as transform the site into a water supply system. Two main responses can thus be integrated into the water system:

1) Wetland edge zone and groynes for flood protection and natural enhancement

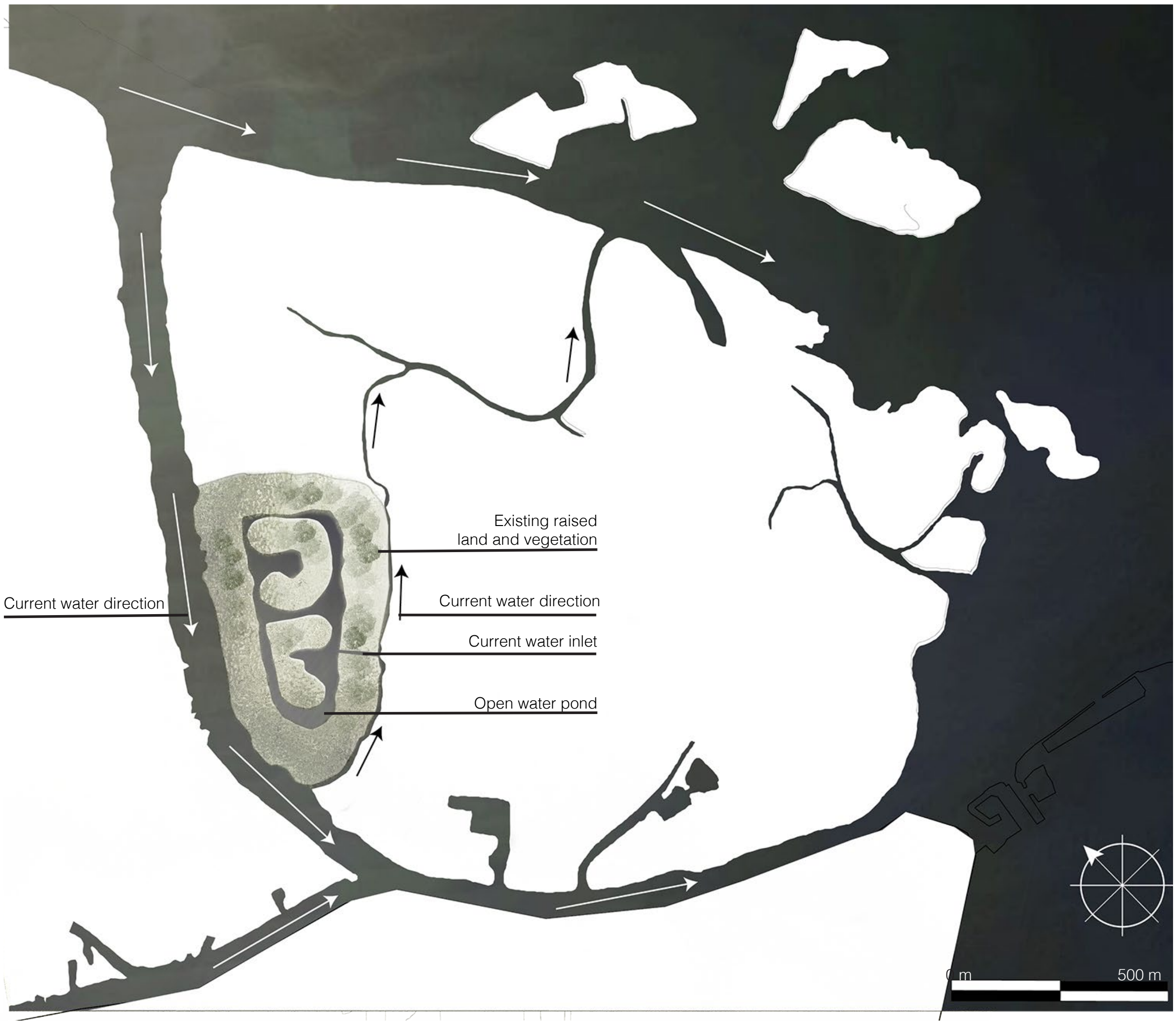


Fig. 41. Existing land structure.

Fig. 42. The alternative design strategy.- a new network with integrated functions.

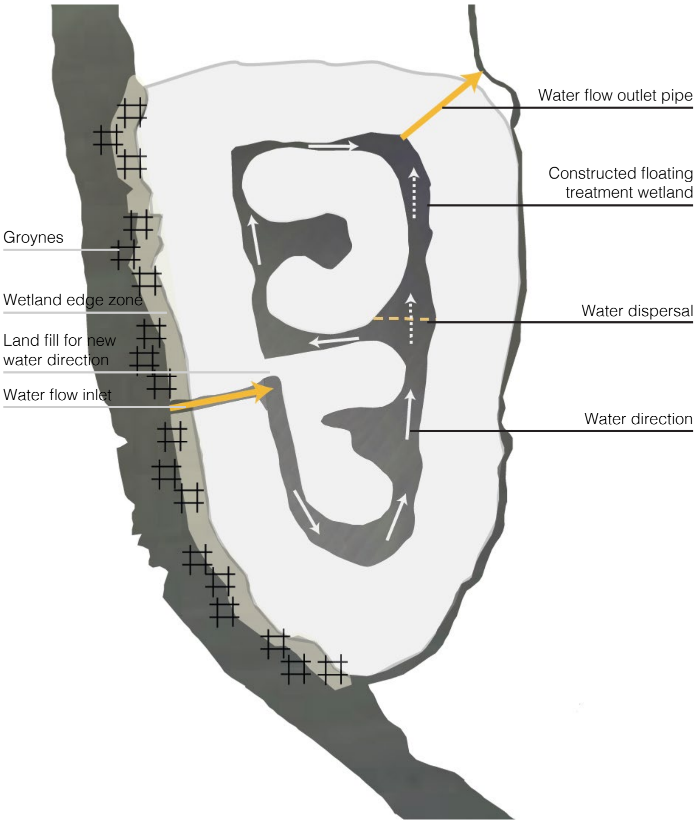


Fig. 43. An alternative water system as an integral part of the design strategy.

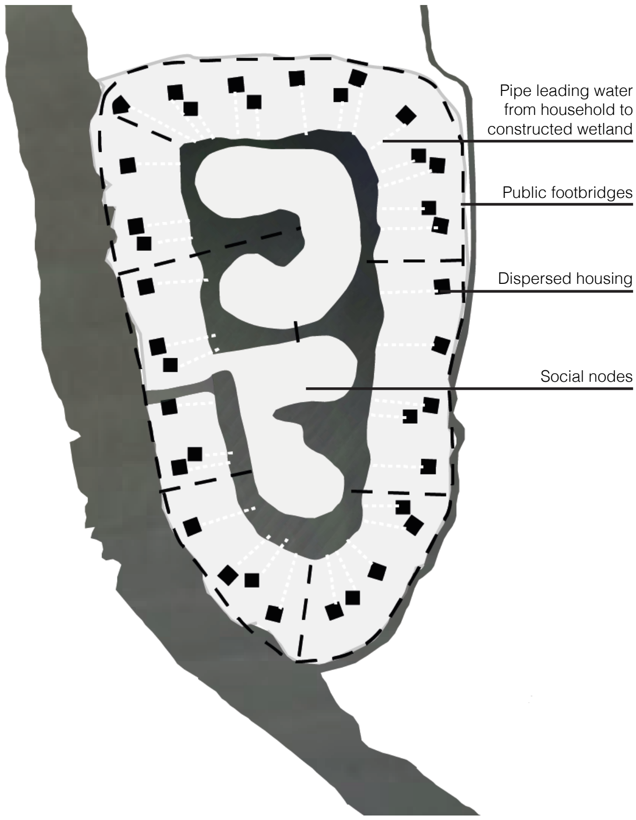


Fig. 44. An alternative urban system as an integral part of the design strategy.

Fig. 45. Site plan of the design strategy with combined components.

To manage telecoupled impacts of flooding and sedimentation, *a wetland edge zone* can function as flood protection as well as help to accumulate sediments. The edge zone has a buffering capacity that helps delaying water during flood events. In addition, the catchment of sediment can be further enhanced by constructing poled wooden structures, permeable *groynes*, in the shores of the island. Groynes (Fig. 46) inhabit the possibility to simultaneously protect the island from floods and limit the movement of sediment from the shore, decreasing erosion and loss of sedimentation by reducing the water flow velocity (Mahmoud et al., 2013, p. 302 & 318). In doing so, they are regular components of sediment control systems. They can regulate telecoupled impacts by managing flooding in case of an increase in water levels, as well as to retain sediments that build up around the structures, given that there would be a decrease in river discharge due to upstream dam building. To be most efficient, they have to be constructed in a range along the shoreline and in this case be semipermable, slowing water down but enhancing sedimentation rates (Papenborg & van der Togt, 2012, p. 97). The groynes further create a possible wildlife habitat for birds and oysters, and also enable the connection to other islands by joining the wooden structures across the rivers. Together with a vegetation edge zone consisting of a reed bed, the groynes and vegetation together form natural coastal protection towards vertical flooding from the edges of the island as well as contribute to the delta expansion. As a type of managed realignment, the vegetation edge zone constitutes a soft engineering approach to bind sediments and subdue strong floods.

2) Constructed wetland for water treatment

Another type of natural flood defense can be enabled by letting the water soak into a *constructed wetland* in the inner channels of the island. The constructed wetland area includes approximately 50 hectares, meaning that it can hold up to 750 000 m^3 of flood water (calculation based on Davis's figures, see Part II-1). Additionally, this type of water

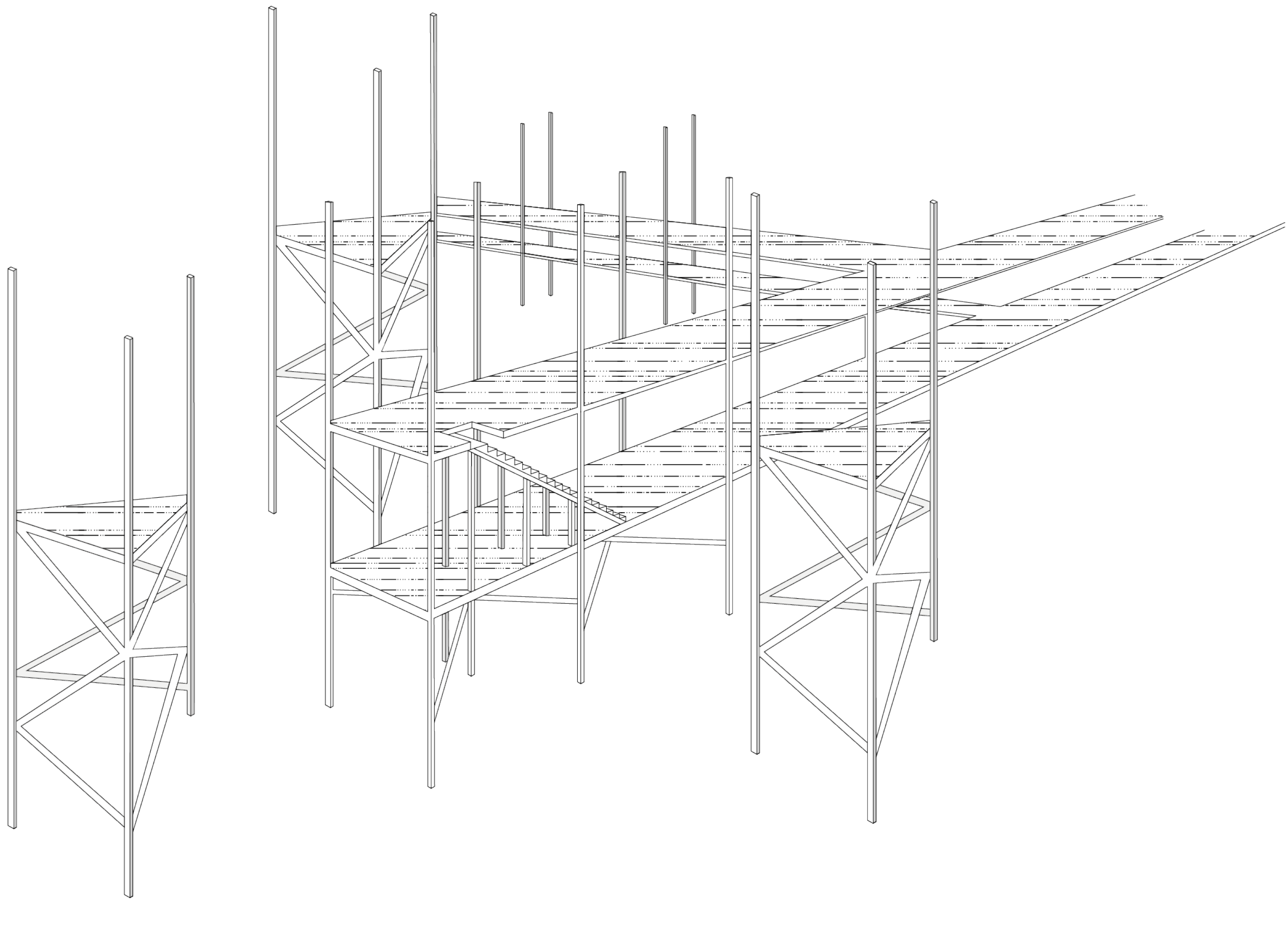


Fig. 46. Wooden groynes in combination with footbridges.

system can integrate functions to manage a higher level of urbanisation. Intensified urbanisation amplifies the risk for an escalation of pollution in the delta, implying local impacts such as sewage and grey water that might be released into the delta rivers. By developing a local water system that can manage sewage and grey water from new housing, the area can regenerate clean water and bring it back to the delta (USEPA, 2000). The existing dredged and raised land structure enables the development of the constructed wetland. The channels of the basin already constitute low points in the terrain, where water can infiltrate. A constructed wetland, that requires a surrounding land mass to enclose its basin, can facilitate an efficient water cleaning process from the urban developments. The constructed wetland separates itself from a natural wetland in the sense that water flow and ecosystem functions can be optimised to the conditions of the site. The water is purified as pollutants stick to the roots of the plants, which are later harvested and can be used as biomass. Production, which may have a possibility to generate money for the site, is in other words also integrated in the plan. Today, the current embankments surrounding the water basin, that was dredged to create artificial ponds, prevent the movement of water. Water flow can however be generated by creating an inlet and an outlet connected to the existing rivers, as well as by creating a gradient in the topography of the dug out channels towards the outlet. The form and conditions of the constructed wetland is highly important for water cleaning to occur. First, constant flow in the wetland basin is a requisite. To create maximum flow, the inlet has to be moved from its original position (Fig. 41 & Fig.

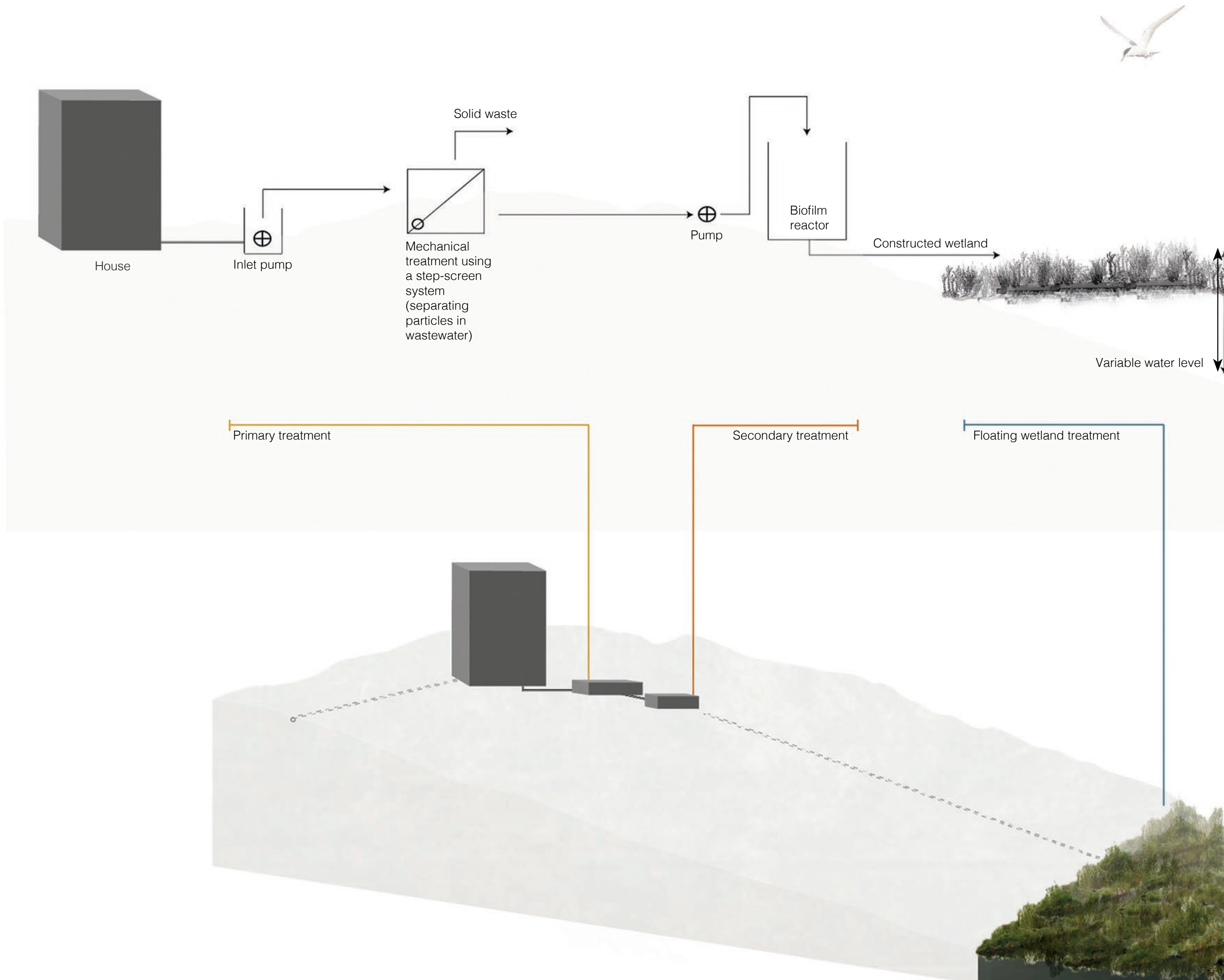


Fig. 47. Water treatment system.

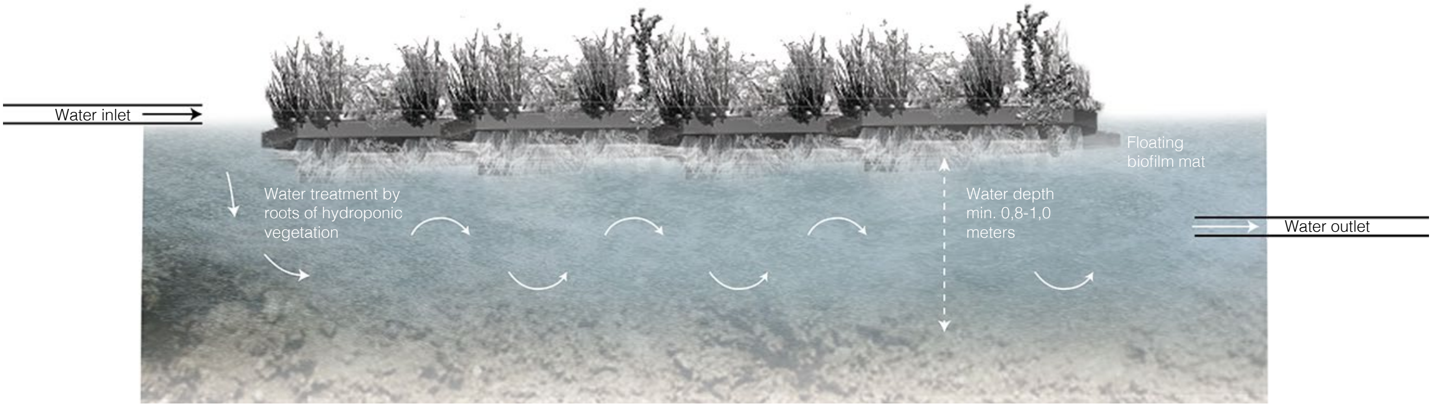


Fig. 48. Floating treatment wetland.

42) to be located where it can contribute to most flow through the entire basin. In other words, water inlets to the constructed wetland will be connected to the river as well as to the houses. Second, the water needs to be branched off and distributed to make sure that a middle stream is not created and that the entire basin is provided with water flow (Nilsson, 2014). This can be done by the use of a wall of stones, letting the water trickle through in smaller portions, but directing the main flow to curve along the alternative path in the later part of the basin.

The raised embankments enclose the basin where the water flow can help to clean water from the urban developments. This is conducted by creating a small cleaning system of the sewage and grey water that can be connected to the households. The system (Fig. 47) consists of three purifying steps: a mechanical cleaning, a biological cleaning and finally, the constructed wetland (Nilsson, 2014). The household water is pumped through pipes to the mechanical and biological cleaning processes, which take place in two enclosed reservoirs. The mechanical cleaning removes larger fractions from the water. Subsequently, the biological cleaning filters organic matter. Thereafter, the natural gradient of the levees can be used to direct the water down to the constructed wetland. Due to the depth of the water in the inner channels, a floating treatment wetland (Fig. 48) can be created with the use of vegetation that has the capacity to remove fine particles and nutrient salts from the water. Using this type of hydroponic treatment technique where the vegetation is not rooted in the sediments forces the plants to acquire their nutrition from the water, which accelerates the uptake of chemicals into biomass. The plants grow on a floating mat, producing a hanging root-biofilm network underneath it, and thus tolerate wide water depth fluctuations (Headley & Tanner, 2008, p. 1101). However, a minimum water depth of 0,8-1,0 meters is preferable to reduce the possibility of the plants attaching to the basin bottom (ibid., p. 1103). The water depth in the basins today most likely exceeds this level. Aquatic plants such as *Carex virgata, Cyperus ustilatis, Juncus edgariae and Schoenoplectus tabernaemontani* are examples of vegetation that can be utilised in floating treatment wetlands. Altogether, the wetlands allow for flexibility and low maintenance in the design. Compared to a constructed wetland where roots are attached to the ground, the plant assimilation of nutrients in a floating treatment wetland is also of higher efficiency, as the roots in this case are in direct contact with the nutrients (ibid, p. 1105).

The constructed wetland constitutes an efficient remover of the salts that are left after the primary and secondary treatments in the reservoirs, in which mainly nitrogen and phosphorus are removed. The installation of potabilisation plants can further enable households to purify water to make it drinkable, a technique already in use in the Dos Rios project (Dos Rios, 2009). As a last step, the water can leave the constructed wetland through an outlet pipe placed in the southeastern part of the area, releasing clean water out to the delta.

Application of urban typologies and social nodes (d. urban typologies, see section 2.3)
Intensified urban development opens up for an exploration of typologies that use minimal areas of land by being constructing in two- or three levels. The site in the delta constitutes an excellent location for inventive building structures that preserve the earthy environment as well as the ability for the river to flood, while still providing denser settlements. To be in line with construction codes, these should mainly use natural materials, such as locally produced wood, and be located at a fair distance from the shore (i.e. 75 meters). To resemble a traditional urban pattern, the houses can be structured in a disperse organisation (Fig. 44). The Chilean architect Alejando Aravena[1] designs *modul houses* (Fig. 49) that demonstrate how efficient building structures can function in line with nature. The model houses could provide the possibility of poling in the same way as traditional delta houses. Their purpose is to function as a frame for people to build onto, as a step towards participatory design. The houses can hence develop into featuring unique characteristics, similar to the diverse and colorful housing that characterises houses in the delta today. The houses constructed in the Dos Rios project (see Part III-3) are also examples of typologies that allow for the occurrence of floods and thus are compatible with the delta environment. Using these types of building structures, providing a denser urban area that uses minimal land and is in harmony with floods, equals a way towards an agreement between the urban and natural.

Moreover, the spatial change in living area that the new typologies introduce can establish a need for common *social nodes* where community services and social functions can be developed, such as resource buildings. As explained in the earlier parts of the thesis, this desire already exists among inhabitants of other parts of the delta (see Part I-4). These could be located on the two inner islands of the site. This kind of structure, with housing still being distributed along the shores with societal functions in the center of the area, results in the movement of boats only occuring on the main rivers where they can connect to the housing properties. The constructed wetland in the center of the island can hence be left undisturbed.

Application of a public space network (e. water edges, see section 2.3)
Denser typologies that inhabit a larger amount of people and social nodes require enhanced connectivity in the water front. Since Aravena's building structures imply housing where people will no longer have their own space-demanding properties, an even stronger need for a public domain arises. *Footbridges* along the shores that are attached to the groynes enable the connection between people and water. Further, integrating the footbridges into the constructed wetland and along the buffering wetland edge zone can form a dynamic hydro-urban network. The construction of the footbridges in two levels results in an adaptive structure that functions during both high and low water levels (Fig. 50). Since the delta islands are still free from larger vehicles, access to the inner social nodes can be gained by connecting the footbridges to the central land areas. The footbridges make it possible for people to move freely around the island, beyond a limited area as is the case in the proposed plan for Colony Park. Increased mobility is an important step for urban life in the delta to grow stronger. As previously mentioned, the footbridges connected to the groynes can also provide a linking infrastructure to other islands by having these crossing the larger rivers. The integration of public infrastructure can connect people to added functions and create social adaptability. Apart from forming a public domain and providing connectivity, the new network of footbridges would provide landscape aesthetics to the site as well as to visually connect people to the wetlands.

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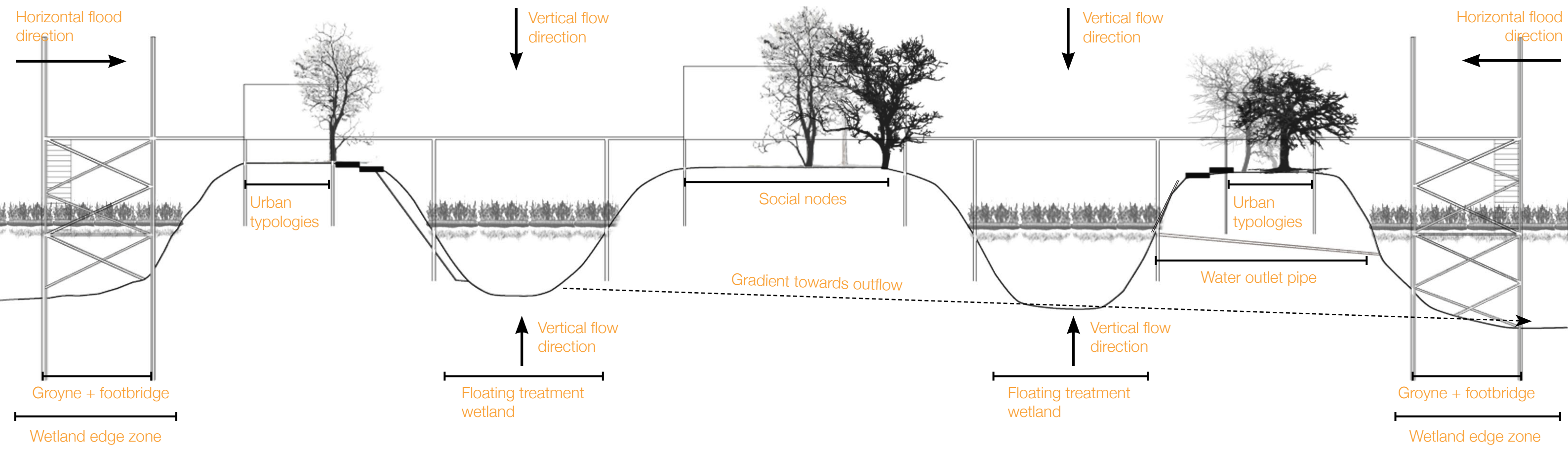
[1] http://alejandroaravena.com/obras/vivienda-housing/elemental/

Fig. 49. Urban typologies by Aravena.

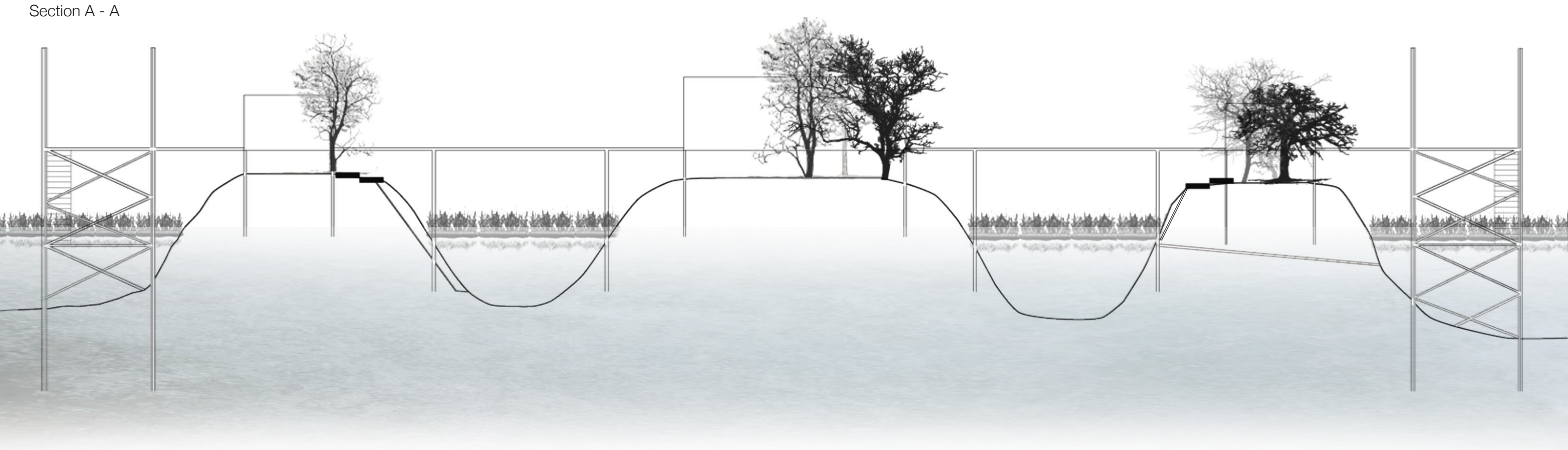
New network with integrated functions

Section A - A



Low water levels

Section A - A



High water levels

Section A - A

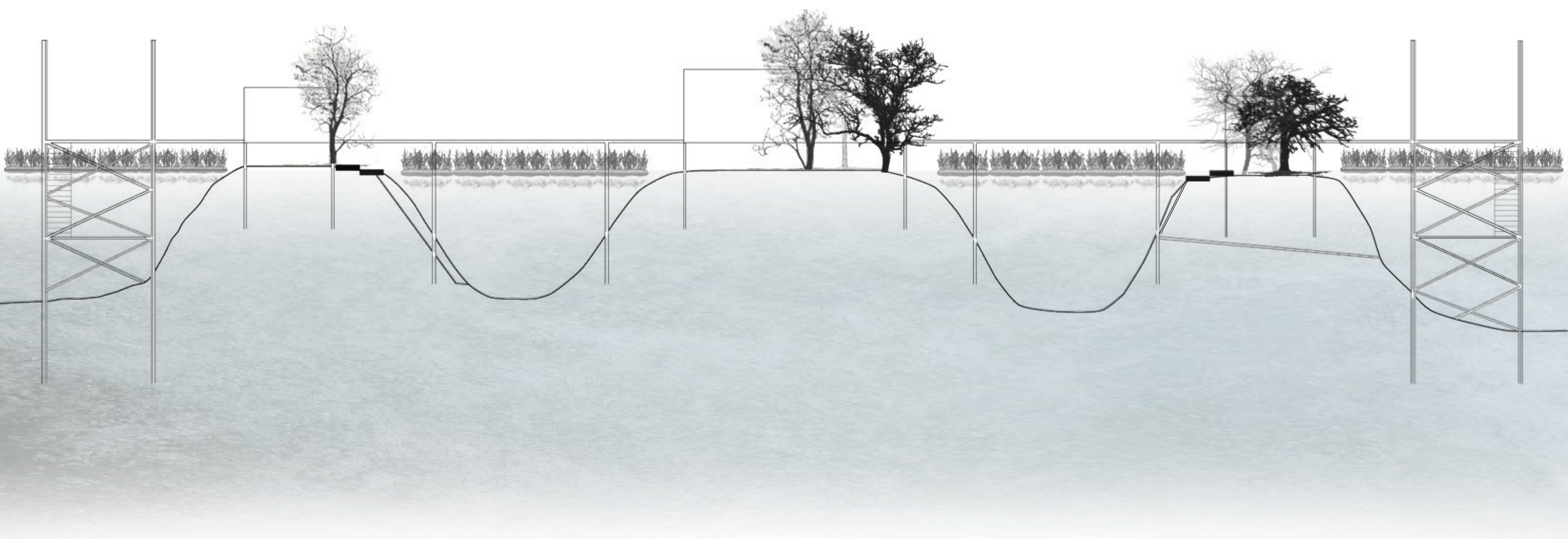


Fig. 50. Principal sections of the design strategy during low and high water levels.

In sum, fluvial spaces are compatible with the motion of water and the terrain. In the proposal of a multifunctional site grounded in a new network structure with components such as the constructed wetland and public nodes, equilibrium in the water system as well as in the social patterns can be reached. This way, the island of Colony Park can be restored into an open system (Fig. 51) that recognises natural as well as urban processes that occur locally in the delta, and that can manage telecoupled impacts from distant places.

5. Areas of effect of the proposed design strategy

The proposed design strategy aspires to limit the amount of areas of effect in regard to flooding. Even though the effects of a constructed wetland should be researched in detail, the system now has a larger potential of managing telecoupled and local impacts in the site instead of transferring flood impacts to other areas in aggravated conditions. In addition to managing flood impacts, the site creates opportunities to generate clean water and strengthened ecosystem services. This way, it can bring back values to the delta, which is not the case of the current private development. In the long run, the strategy also minimises the risk of Buenos Aires metropolitan area being affected by fresh water shortages due to developments in the delta.

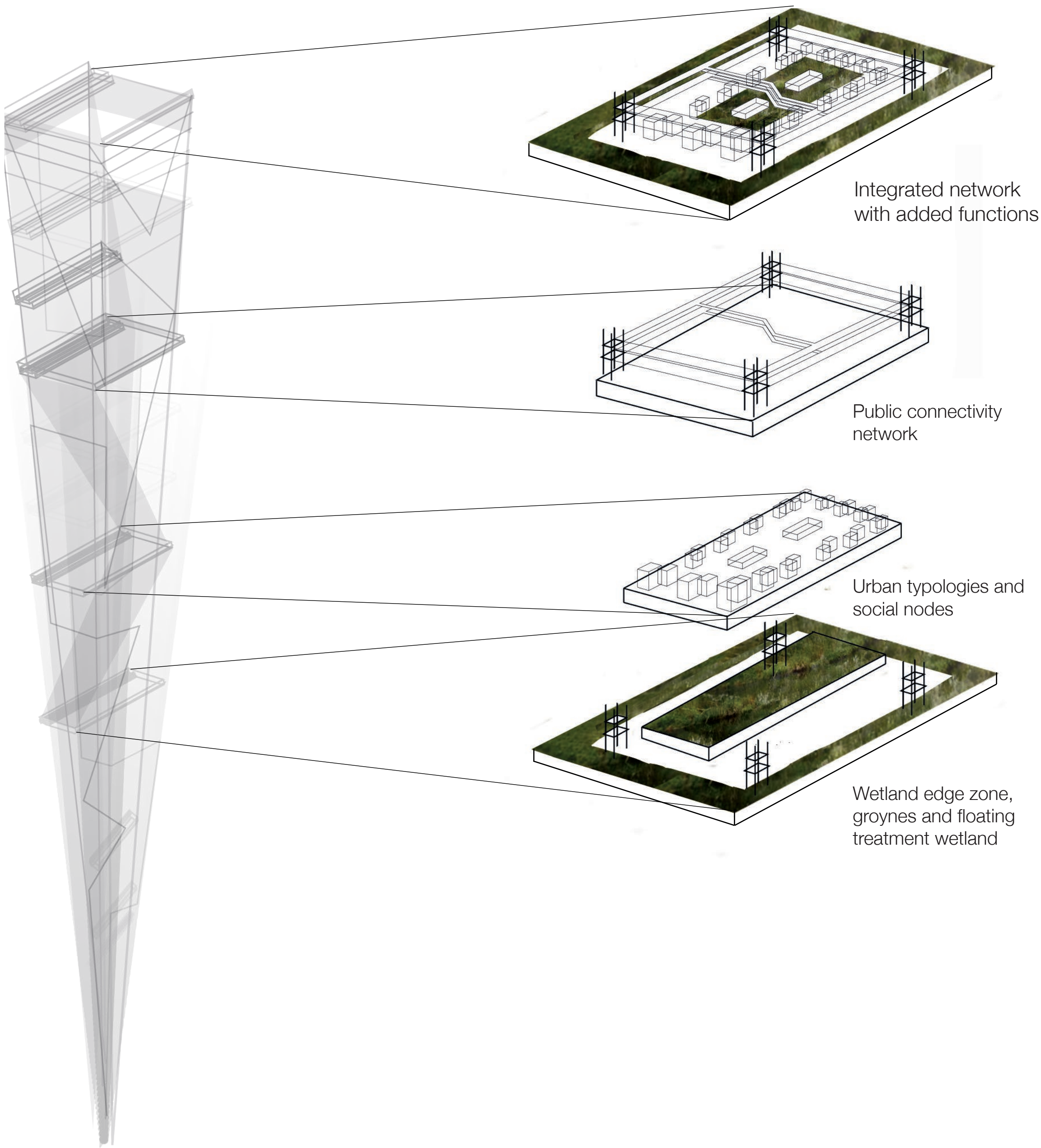


Fig. 51. Components of the network.

5. Discussion

The three parts will here be discussed to reflect critically on the various aspects included in this thesis. The discussion will respond to the questions raised in the beginning of the thesis (see section 1.3). Limitations in the theoretical concepts as well as the design strategy will be outlined, and ways forward suggested. The following points of view represent my findings during the creation of the thesis, in hope to create advancements in the dialogue regarding the delta environment and suggest means of improved innovation for its sustainability practice. Last, reflections on the method and the crossing of different disciplinary perspectives will be analysed.

PART I

Burns and Kahn's three levels of site and the concept of telecouplings are adequate to apply in research about impacts and adaptation of the physical environment. The concepts can communicate that the understanding of adaptation does not necessarily have to occur on a local level, where adaptation strategies are most commonly represented today. In adaptation to natural and anthropogenic changes of the environment, it is essential to consider a wider network of impacts and responses. It can thereby be discovered that a site is highly influenced by indirect, telecoupled impacts, as in the case of the Paraná Delta. Further, the concept of telecouplings and teleconnection should be extended to more significantly embrace a landscape planning dimension.

Telecoupled systems and the confrontation of natural and human processes raise unprecedented challenges, but also opportunities, for sustainability practice. It ultimately requires the designer to deal with levels of uncertainty and non-linearity. Certainly, this raises a few issues associated with using a telecoupled systems approach. First, the timeframe is not direct. Many of the telecoupled impacts are long-term and may be visible only after many years, depending on future developments of the different triggering events. While some local impacts, such as the impacts of southeastern winds, are visible in an immediate timescale, telecoupled impacts such as intensified river discharge from increased precipitation upstream might only be more clearly observed a long time from now. This indicates that applying a telecoupled systems thinking implies a precautionary approach to the influence from future impacts. Second, evaluating interconnected systems remains complex due to appropriate procedures. For example, data gaps on downstream effects of upstream events still exist due to measurement difficulties (Benzie et al., forthcoming). This can be reflected in practice, and my research during the process of this thesis indicates that robust network-based methods are still lacking in design interventions. With increased globalisation and transboundary systems, there is a need for an enhanced implementation of these and especially so in connection to river system sites. In addition, if the delta is to be part of Buenos Aires, this means that it will be a part of a megacity. As megacities are the nerve centers of the global interconnected system, this will increase the level of interconnectedness of the delta in many more aspects than the purely ecological one. Integrating methods for understanding and managing telecoupled impacts is thus an essential step towards enabling systems thinking in design.

Following this, another issue can be identified in terms of the great effort that is required when disentangling the interconnections behind telecoupled impacts. A mapping of interconnections is what research should bring into the design discipline. Looking at the case of the delta, it can be argued that this information does matter. Design interventions have become adaptive measures that will fail to increase resilience if not recognising the entire social-ecological system and the events that change its conditions. In order to conceive the design as an open system, the investigation of areas of influence is essential. The transscalar approach that inevitably follows when implementing the concept of telecoupling in design practice is beneficial because it can combine the strengths from work at the different levels. While the telecoupled system increasingly can be identified in the regional or global perspective as a result of globalisation, interventions in the landscape most often occur locally. In other words, the macro scale contributes to the understanding of the system, while the micro scale has the power to change it.

How to identify a site in a telecoupled system is described in Part I:8, based on the formulation by Liu et al. The authors however limit their formulation to not include the identification of possible areas of effect. The process of approaching, implementing and finally developing the telecoupling concept was in my work highly dynamic and non-linear, but can in retrospect be boiled down to a methodological approach that integrates the theories of Liu et al. (1-3 below) with Burns and Kahn (4-5 below). My approach hence demonstrates a systematic model for the study of areas in telecoupled systems, disentangling complex interconnections between places. A few principled points can guide future applications of the developed telecoupling approach:

1. What things influence the site? Where are the areas of influence situated?
2. What is the system and its components?
3. What are the dominant local impacts?
4. How can my intervention manage the impacts?
5. What areas of effect will my intervention give rise to? How can my intervention bring back benefits to the system?

It can here be noted that an intervention is not limited to include constructions, but also comprises other actions affecting a system, such as policies.

In regard to the prevalent and studied telecoupled impact of this thesis, flooding, the complex issue remains that floods can be regarded neither as simply beneficial nor problematic. As mentioned, the natural wetland ecosystem requires floods to maintain its services, while the floods also raise challenges for the delta inhabitants. There is not a certain threshold to which floods are beneficial and serve the ecosystem while not at the same time threathening urban life in the delta. This duality creates a strong demand for multifunctional space and the creation of a living systems infrastructure, using a layered approach as means of analysis (Fig. 52). In that regard, it also requires the designer to apply the water system as a fundamendatal layer in the design intervention, composing urban patterns and infrastructure according to its conditions.

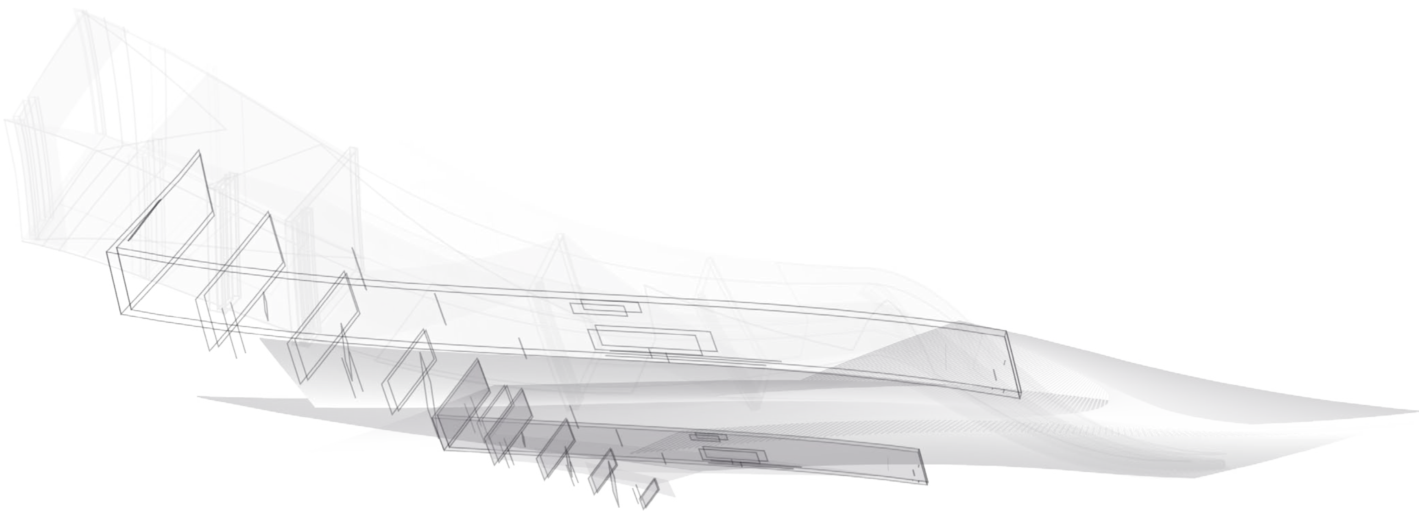


Fig. 52. Free interpretation of a layered approach in the design process.

PART II

As mentioned, interlinkages in land systems imply great complexity. It is possible to speculate if this complexity is too vast to grasp for the actors involved in solving issues related to the system. Does a systems approach imply more compromises when implemented in practice? With the background of this thesis I would argue that even if its perfection is at times elusive, it is nevertheless possible to optimise the system. Polarising open and closed systems provides a design method that can help to simplify the application of a systems approach to the practical level. In short, the construction of an open system entails the examination of how the design intervention influences possible areas of effect. Even though areas of effect are many times characterised by uncertainty and are highly specific to the situational conditions, closed systems seek to replace the uncertainties of the dynamic system by supposed certainty associated to the control of human techniques. Accordingly, creating an open system might imply letting go of some control in the design of a site. Natural processes are unpredictable, and designing for the uncertainty that these processes bring can involve unforeseen consequences. By doing this however, possible damage of impacts might decrease in magnitude. If the system and its impacts are uncertain, the design must deal with this uncertainty. So how can uncertainty be met? The traditional way of living in the delta demonstrates that controlling the natural system is not a requisite for human life here. Still, control can be enforced in alternative ways and should here be concentrated to being implemented in negative feedback loops, meaning delaying change in the water level which reduces fluctuations in the system. The wetland edge zone and the constructed wetland could for example contribute to this.

Meyer's parameters are helpful both as a method for analysis of the site as well as to distinguish what should be the core of the design strategy. In his own case studies, the parameters have directly served to lay the ground for detailed design strategies. In this study, I have adopted the method but divided the intervention into two steps. First, the method has served to form comparative design scenarios that have analysed different characteristics of the site in relation to the system, and thereby determined the core approach of the design. As a second step, a detailed design strategy based on preservative qualities from the first step was created. Providing the additional first step enables a better understanding of site interventions in relation to the system and possible areas of effect. The refinement of characteristics of site interventions into being open or closed simplifies the creation of the intervention into being a valuable part of the system. This step can add a more systemic angle to Meyer's parameters.

As previously mentioned, issues regarding the closed systems of the delta, such as the private gated communities, are very much a product of an institutional problem grounded in legal frameworks. The system is currently overwhelmed by the low capacity of regulations and institutional power, and environmental policies and urban planning practices are currently not complementary. Similar projects to Colony Park have also already been realised in the fragile islands of the delta front. The institutional obstacles raise the question of how policies can be followed and implemented on a local level, for example hindered by corruption. If policy does not transfer into reality, how do you reach alternative practices? In the case of the delta, there is a clear risk that policy might not reach all the way to a change of actions. The need for more comprehensive and integrative land use planning that acknowledges sustainability goals for the delta is urgent. Further, this thesis has argued that providing alternative examples of other solutions of change that integrates added functions might have a potential of encouraging stakeholders to reconsider current design interventions. The pressure that designers and researchers can create might be able to circumvent legal regulations if stakeholders realise the values of the alternative plans. Still, without a functioning legal system, the development of sustainable practices in the delta will in all probability be a slow and inefficient process.

PART III
In the design strategy, this study set out to explore the possibility of optimising and changing the system in the Colony Park site. The design suggested here is not developed beyond a ”design strategy”, meaning that further work could take up this as a prototype and develop a site project with detailed engineering, horticulture and form finding. It is therefore relevant to also question uncertainties in the design strategy (compare Papenborg & van der Togt, 2012, p. 177). Just as uncertainty is prevalent in regards to the complexity of telecoupled and open systems, this also concerns the design strategy. Since the design is formed around the inhibited functions of natural processes, the dynamics of the system in combination with the proposed interventions would need to be researched on a deeper level to estimate the value of such transformation. For instance, it has been difficult to find reference projects that demonstrate the procedure of creating a constructed wetland *in* a natural wetland. The water treatment processes would also benefit from being investigated further by hydrological engineers and chemists, even though the proposed solutions have been developed in discussion with two professionals from these disciplines. Furthermore, the rate of sedimentation that is enabled through the use of groynes remains imprecise but can be optimised through placement and construction techniques. Having said this, the strategy can help to convey a number of different interventions that can spark interest or further thinking into these lines. In essence, a dynamic system requires more empirical testing to be understood fully.

Still, the question remains how sustainable a design intervention can be if it interferes with a natural system. A design alternative that has not been presented in this thesis is that of complete retreat. But letting the delta build back its natural wetlands in the Colony Park site is unfortunately not a very realistic possibility. The landscape has been damaged to the point that it will be difficult and take the delta a long time to retransform itself again. In addition, Colony Park is no longer located in the very precise front of the delta where the main sedimentation processes occur. It is also important to note that even alternative solutions, like the one presented in this thesis, should continuously not be undertaken in the fragile delta front. This area should ideally be under the transformative power of the natural processes. The design strategy however represents a way forward for a destructed site. There is a large need to present sustainable future actions for the Colony Park site, which also can stimulate ideas for other developments in the delta.

Moreover, it should be noted that there is a difference between preventing the area of Colony Park, where a dredging process has already been initiated, from developing into a closed system compared to applying the strategy to the untransformed delta islands that still live in balance with the wetland system. However, the alternative design strategy for Colony Park can serve as a model for what could be developed in the future when the urbanisation process in the delta requires more and more space. The main components of the strategy: new typologies, groynes and the wetland edge zone, the inner island constructed wetland, social nodes and the network structure not only provide values when combined with each other, but would also be beneficial if implemented individually. The first two would be applicable to most islands in the delta. The constructed wetland requires more effort and prerequisites to apply because of the need of an area enclosed by land masses in order to separate it from other water inlets. But since the delta builds up natural levees in the edges of the islands, additional dredging might not be required if natural processes are allowed and vegetation can be enhanced to stop erosion of the shores. It would still be necessary to cut off certain in- and outlets to ensure that the water passes in the right direction, and that no still water areas would remain. If this was successful, a constructed wetland in the natural terrain might be possible. This could be researched empirically in order to find the most effective construction techniques.

The regeneration of environmental systems is not limited to being a concern of nature, but it is a design process nonetheless (Fig. 53). In open systems, the water and sedimentation processes are given space. In closed systems, they are not. In other parts of the world, such as in European and Asian deltas, diking the waterfront is already or becoming a common response to flooding (Schürch, 2014). In the long run, this however accelerates problems with subsidence and increases vulnerability (ibid, 2014). In addition, constantly heightening embankments will eventually make places unattractive as well as being very economically ineffective. Using that approach for flood protection in the Paraná Delta would destroy many values that exist today, but also lead to a degradation of the land and ecosystems that subsist here. In most Asian cities, allowing sediments to accumulate is not possible due to the lack of land area and extreme urban density in the delta areas (Schürch, 2014). This highlights another point, which is that water retention requires space. One of the drawbacks usually described in connection to ecosystem-based adaptation, and also specifically in association with constructed wetlands, is that it is space demanding. Adaptive design actually has a potential of working successfully here since, compared to many other deltas, the Paraná Delta still has space. This entails opportunities for the delta to achieve a hydro-urban environment, illustrating a pioneering example among world deltas. For example, connecting groynes and wetland edge zones between islands could in the future develop into a common ecosystem-based network of flood protection in the area.

Much could be gained by finding incentives for private developers to contribute to more sustainable practices. The alternative design strategy supports the creation of a regenerative site, meaning a site that gives back to the system instead of aggravating its problems. In this view, the terminological focus should not necessarily be about flood protection, but about water supply for the entire metropolitan area of Buenos Aires. For example, a future development of the design would be to investigate more specifically how the cleaned water can be used and possibly also profited from. There is an extra step of treatment needed between cleaning the water from pollutants through a constructed wetland and making it drinkable. Directing the point of view towards water supply could perhaps bring incentives to private developers and make them more approachable in regards to sustainable long-term solutions for the delta. In addition, regenerative solutions should be encouraged by political incentives. Creating such incentives could provide a true opportunity for authorities to complement their policy efforts and to reach out in negotiations with private stakeholders.

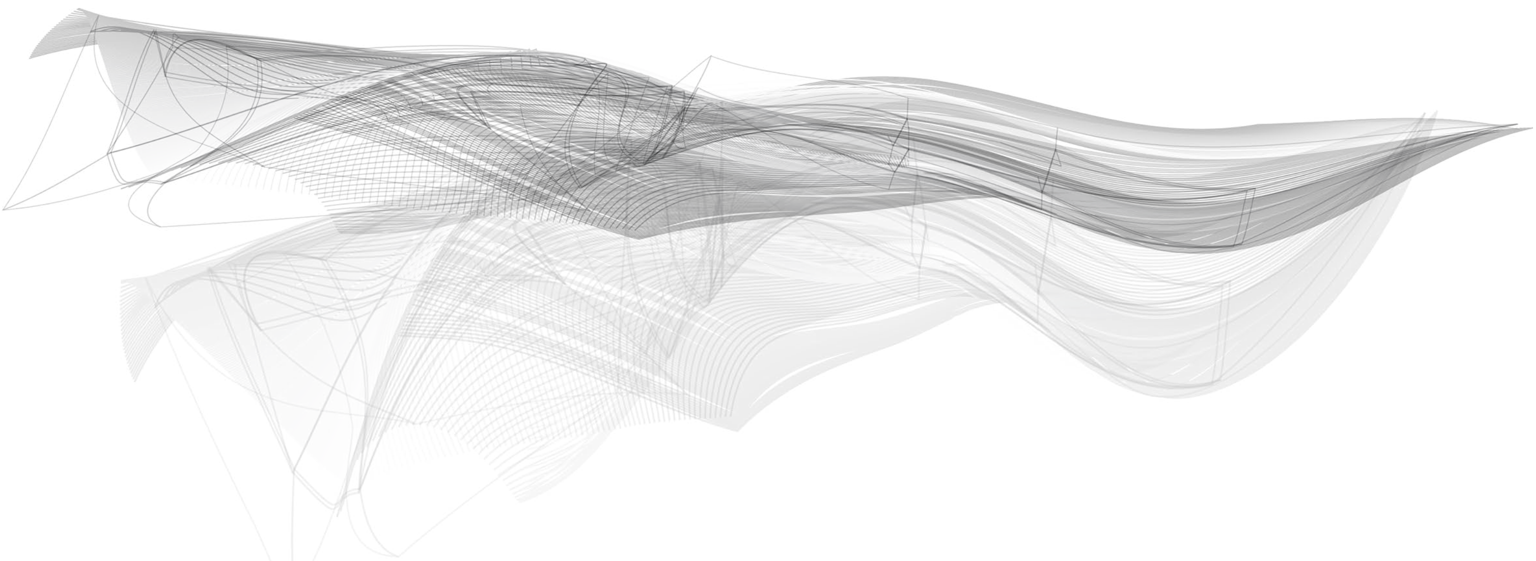


Fig. 53. Free interpretation of natural flow and human constructions in combination.

Method and disciplinary
Landscape architects and planners should recognise new interconnections. The concept of telecoupled systems should not be intangible to the landscape architecture discipline. Its components: flows, human and natural processes, and interconnected systems are already central in the thinking that permeates the profession. During the process of writing this thesis it has appeared that if designing local systems, the entire design thinking also needs to be grounded in interconnected systems from the beginning of the process. Uncertainty and complexity will prevail this approach. Methods to make it tangible should therefore be incorporated into the work scheme. In the application of these methods, landscape architects and planners can work more as researchers, but with technical competence still have the capability to practically implement research results. Another strength of landscape architects and designers is the ability to graphically represent research. This can complement the methodological experience of researchers and provide a mutual exchange between professions.

Inspiration from earlier research findings as well as the intriguing complexity of the Paraná Delta mainly gave rise to this study. The work process of disentangling the system connected to the delta has proven to be anything but linear. Rather, it has been exploratory, rewinding and at times, challenging. Delimiting where a system begins and ends proved to be a laborious task. In addition, the interweaving of different systemic theories and the application of these to a land system demonstrated that working with a systems approach still requires more time and effort than most practitioners usually have. For example, it proved challenging to implement Meyer's parameters in combination with the other theories. Integrating two theoretical concepts with a practical approach meant that I had to form my own angle and interpret the approach so that it was in line with the other theories, as well as significant for the Paraná Delta. The integration of different theories and concepts in the end shaped a model applicable and relevant on my site specifically.

Finally, it was instrumental to me to question familiar knowledge connected to a European perspective, in order to put the design in its authentic context. This has been important both in terms of my own thinking but also related to the ideas of Meyer. On this matter, studying the characteristics of open and closed systems on the site proved to be another situation where it was valuable to adjust Meyer's approach.

6. Conclusions

I set out to investigate 1) *what constitutes a delta area, in this case the Paraná Delta, characterised by water flow variability and constant landscape transformation, with influences from a telecoupled system?* and furthermore *2) what design strategy that is line with natural dynamics can be developed for a dysfunctional delta site?*

1) Interconnectedness, that constitutes one of the delta's strongest characteristics on the macro scale, results in uncertainties in the delta environment. Telecoupled and local impacts compose great transformations in the delta environment, especially so with regard to flooding. To manage these transformations, this study shows that traditional open systems are more resilient towards telecoupled and local impacts of flooding in the delta. Modern urbanisation on the other hand, that is today increasingly dominating new developments in the delta, often functions as closed systems that might aggravate telecoupled and local impacts of flooding.

On the micro scale, interconnectedness is however lacking in the spatial structures of housing and infrastructure. There is also an absence of qualities that are needed if sustainable urbanisation is to continue, such as public space.

2) The intervention is enhanced by resembling an open system. In turn, the intervention as an open system is supported by a network structure. The network structure optimises the site to the encompassing system, which is not the case with a closed system. If stakeholders consider increased interconnectedness in the physical site and develop open systems that are in line with telecoupled processes caused by nature and people, they could decrease the vulnerability of the delta islands. The alternative design strategy presented in this thesis provides different examples of ways to create open systems in the delta.

One of the most important conclusions from this work is to demonstrate the possibility to research *by* design to tangle out complex challenges. If implemented properly, it can result in valuable collaborations and innovations. The combination of applying a telecoupled systems thinking and presenting alternative design strategies has the potential of functioning as a merger of a top-down with a bottom-up approach, the former being grounded in policy and research interventions and the latter in local practice. Researching telecoupled impacts through design techniques can thereby help to simplify the difficulties in systemic approaches.

During my work process, I have also explored disciplinary and interdisciplinary terminologies. Landscape science or land systems science should, with the growth of interlinked social-ecological systems, incorporate the crossing and circularity of theory and practice. Landscapers have the strength to research empirically, due to the combined knowledge of human and natural systems as well as possible design techniques to meet the impacts.

Future research
Examples of relevant design solutions for telecoupled impacts are provided in this thesis. However, there is still a need to develop more practical techniques and design toolkits for areas under influence of telecoupled impacts. The strategy in this thesis demonstrates a way to research by design, and is also aimed to explore the implementation of a research concept to a practical site. By continuing the exploration of the effects and design of sites in telecoupled systems, a language by which to design these places could eventually come forth.

Some elements of the research findings as well as the design strategy should be further investigated. Regarding areas of influence, there is need for more up-to-date research on the impacts of land use change and deforestation on the delta environment. Areas of effects from aggravated floods due to private developments should also be further researched and mapped in detail. In regard to the area of control, a deeper investigation of constructed wetlands in the natural delta terrain and the redirection of fresh water to housing or services is to be encouraged. Last, it would be valuable to investigate how the idea of designing open systems can work in relation to other impacts besides flooding.

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List of figures and tables

Oral references
(by date of interview)

Susann Ullberg
Senior Analyst, CRISMART-Swedish Defence University.
October 1st, 2014

Flavio Janches
Architect and Prof. Dr., Facultad de Arquitectura, Diseño y Urbanismo, Universidad de Buenos Aires
October 13th 2014, November 13th 2014, January 7th 2015

Magnus Larson
Prof. in Water Resource Engineering, Faculty of Engineering, Lund University
October 20th 2014

Mark Schürch
Postdoctoral researcher in Coastal Geography, Geographical Institute, Kiel University
October 26th, 2014

Maria Teresa Gamba
Geologist in Environmental Risk Management and delta local
November 5th-6th, 2014

Leticia Beatriz Villalba
Subsecretaría de Gestión Ambiental, Tigre Municipio
November 6th 2014, December 10th 2014

Dilip da Cunha & Anuradha Mathur
Adjunct Prof. and Prof. in Landscape Architecture, University of Penn School of Design
December 3rd, 2014

Dana Batista
Delta local
December 10th, 2014

Matias Llere & Fernando Schapochnik
Architects
November 10th 2014, January 7th 2015

Marcos Flanagan
Delta local
December 1st, 2014

Verónica M.E. Zagare
PhD candidate, Department of Urbanism, Delft University of Technology
December 9th, 2014 (2014b)

Ana Luisa Artesi
Architect and counselor at Consejo Profesional de Arquitectura y Urbanismo and IFLA
December 13th, 2014

Emily Vogler
Assistant Prof., Department of Landscape Architecture, Rhode Island School of Design
December 22nd, 2014

Álvaro Arrese,
Architect and Prof. Dr., Facultad de Arquitectura, Diseño y Urbanismo, Universidad de Buenos Aires.
Co-author of Plan de Manejo.
January 14th 2015

Per-Åke Nilsson
Process engineer, Hässleholms vatten
June 18th, 2015

Roaring comes the water of the Paraná [River],
flooding steadily day and night
Homestead, gully, trunk it will take,
with wind and heavy rain, the Paraná

- From the song "Los inundados" by Isaac Aizemberg and Ariel Ramírez in Ullberg, 2013.