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URBAN FLOOD MITIGATION THROUGH LAND-USE ADAPTATION: A SOCIOECOLOGICAL PERSPECTIVE OF PARATY

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Tese de Doutorado apresentada ao Programa de Pós-graduação em Engenharia Civil, COPPE, da Universidade Federal do Rio de Janeiro, como parte dos requisitos necessários à obtenção do título de Doutor em Engenharia Civil

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PARAMATMA PARATY

To my daughter Mina, for a peaceful future on Earth.

“We shall require a substantially new manner of thinking if mankind is to survive. The significant problems we have cannot be solved at the same level of thinking with which we created them.”

Albert Einstein

“No, no, you are not thinking, you are just being logical.”

Niels Bohr

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My first words of gratitude go to my mother, to whom I owe my life experience, my curiosity to learn about the state of the world and my travels around it. I remember that I was 13 years old when she gave me a book of stamps. In the introduction of this little book, the Portuguese anthropologist Pedro Castro Henriques wrote: “Look at the environment… everything around us: the natural world of water, soil, atmosphere, animals and plants; indeed, everything that came millions of years before us and which is the indispensable basis of human activity: the world of social institutions and artefacts created by the work of human associations.” Many years passed before I revisited this book of stamps, and many readings and miles I did with my own feet. I first travelled to Brazil in 1996/7, where I stayed one year doing my professional internship with Professor Paulo Mendes da Rocha. My daily contact with this great Brazilian architect during this period not only had a fundamental influence on my intellectual interests, but also made me believe that we are called to assume the political implications of our own professional practice in the face of the challenges that the world is at stake.

My interest in urban floods started with my first scholarship to India, where I stayed in 1998/9, just after finishing my architecture degree. I am grateful to Professor Alexandre Alves Costa, who provided sound advice to my application, and to Fundação Oriente, which supported the costs of that research project and hosted me during the time of the field work. Later on, in 2006/7, while I was working as Municipal Technical Advisor at the United Nations Development Program (UNDP) in Angola, a flood disaster in Luanda killed more than fifty people in a couple of hours. It was also around that time that I met my dear friend and excellent advisor Nicoletta Feruglio, who encouraged me to invest in a doctoral research program, and Doctor Nick Devas, to whom I am thankful for facilitating my preliminary contacts at The University of Birmingham (UB). At the International Development Department (IDD) of UB, I am especially grateful to Doctor Philip Amis, who accepted my research proposal and supervised the first drafts of this research. I am equally grateful to Doctor Dan Van der Horst, who also accepted to supervise my research from the early beginning and continued as supervisor after transferring this research to the Federal University of Rio de Janeiro (UFRJ) in Brazil. Doctor Van der Horst was also the main person responsible for the Visiting Fellowship that was generously offered to me in 2011 by UB.

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MITIGAÇÃO DE INUNDAÇÕES URBANAS ATRAVÉS DA ADAPTAÇÃO DO USO DO SOLO: UMA PERSPECTIVA SOCIOECOLÓGICA DE PARATY

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Abril/2016

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Este estudo explora as possibilidades de adoção de medidas de adaptação do uso do solo à Função Social da Propriedade e da Cidade enquanto potencial instrumento para a mitigação de inundações urbanas. A cidade Brasileira de Paraty constitui o objeto empírico de análise, considerando as bacias hidrográficas dos rios Mateus Nunes e Perequê-Açu onde se localiza. Os processos de mudança de uso do solo no território em estudo são analisados em duas vertentes interativas: na sua dimensão física, avaliando os impactos da expansão urbana nas inundações através de modelação hidrológica; e na sua dimensão sócio-política, analisando os processos de decisão relativos ao uso e apropriação do solo urbano, considerando fatores sociais, económicos e institucionais que influenciam essas decisões. A análise física consiste na modelagem hidrodinâmica das bacias hidrográficas em estudo para avaliar, quantificar e visualizar os efeitos da expansão urbana, estabelecendo um nexo de causalidade entre mudanças de uso do solo e os impactos positivos ou negativos sobre as inundações. A simulação de cenários hipotéticos de urbanização permite medir custos e benefícios hidrológicos de diversas opções de uso do solo. A análise socio-política foca nos desafios de governança para a integração de medidas preventivas de mitigação de inundações urbanas, abordando as causas que estão na raiz dos riscos ambientais e vulnerabilidades sociais, que tem vindo a se intensificar na virada do milénio, em periferias urbanas do Sul.

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URBAN FLOOD MITIGATION THROUGH LAND USE ADAPTATION:
A SOCIOECOLOGICAL PERSPECTIVE OF PARATY

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This study explores the possibilities of adapting land-use change dynamics in peri-urban floodplains to the Social Function of Property and the City, as a potentially effective way of mitigating urban flood risks. The Brazilian city of Paraty is the empirical object of analysis, considering the Mateus Nunes and Perequê-Açu river basins where it is located. Land-use change processes in the study area are analyzed in two interactive dimensions: the physical dimensions, assessing the impacts of urban expansion in the aggravation of floods through hydrodynamic modeling; and their sociopolitical dimensions, analyzing the decision-making processes relating to the use and appropriation of urban land, considering social, economic, and institutional factors that influence these decisions. The hydrodynamic-modeling exercise intends to assess, quantify, and visualize the effects of urban expansion, establishing a causal link between land-use changes and the positive or negative impacts on flooding conditions. The simulation of hypothetical scenarios of urbanization measures localizes hydrological costs and benefits according to different land-use options. The socio-political analysis focuses on the governance challenges of integrating preventive land-use measures for urban flood mitigation, addressing the root causes of the increasing environmental risks and social vulnerabilities, which are increasing with particular intensity at the turn of the new millennia, in urban peripheries of the South.

Contents:

EXECUTIVE SUMMARY (in Portuguese language)

PART ONE: PROPOSITIONS OF THE STUDY

PART TWO: THEORETICAL FOUNDATIONS OF THE RESEARCH

PART THREE: POLICY ANALYSIS

PART FOUR: SPATIAL ANALYSIS

PART FIVE: ARGUMENT SYNTHESIS

List of figures:

List of tables:

I – Introdução

Ao escolher o tema *Mitigação de inundações urbanas através da adaptação do uso do solo*, proponho explorar um conceito original para a operacionalização efetiva de teorias de mitigação e adaptação numa *praxis* concreta de política pública. Tal proposição consiste em duas ideias fundamentais: a primeira parte de uma redefinição do conceito de mitigação enquanto conjunto de funções socioecológicas, e o segundo circunscreve o conceito de adaptação a uma política urbana dirigida ao necessário ajustamento das dinâmicas de mudança de uso do solo às características geo-hidrográficas de uma dada estrutura urbana. Adianta-se como hipótese central deste trabalho, que a interligação destes conceitos permitirá informar uma política urbana capaz de transformar os atuais padrões de depredação de recursos naturais no processo de produção do espaço urbano, com ênfase na mitigação de seus efeitos no agravamento das inundações e correspondentes vulnerabilidades sociais. No contexto do presente estudo, esta abordagem permite vincular teorias de mitigação e adaptação a um princípio fundamental consagrado na Constituição Brasileira: a Função Social da Propriedade e da Cidade, que estabelece limites externos para o exercício dos direitos de propriedade, incorporando dimensões sociais e ecológicas. Assim se sustenta que o reconhecimento da mitigação de inundações urbanas como função socioecológica, não é apenas uma questão de rigor teórico, mas representa também uma ferramenta conceptual poderosa para uma fundamentação mais concreta do interesse público relativo ao uso do solo urbano. Deste modo, a presente tese alinha-se por um viés de conceitualização de problemas do ambiente urbano que busca um caminho de sustentabilidade na “reprodução adaptativa das estruturas urbanas que têm por foco o reajustamento das bases de legitimidade das políticas urbanas” (ACSELRAD, 1999), enfatizando a necessidade de uma maior politização das questões urbanas, mas tomando em conta também uma visão espacializada destas questões.

Enquanto estas proposições enfatizam o papel das mudanças do uso do solo nas inundações urbanas enquanto um problema físico de hidrologia e de ciências naturais relacionadas, também consubstancia claramente um problema envolvendo ciências sociais e políticas. Essas múltiplas dimensões tornam particularmente difícil enquadrar o objeto de análise e a escolha dos temas a serem explorados, colocando imediatamente uma série de dilemas: se a adaptação do uso do solo inexiste ainda no debate acadêmico sobre políticas urbanas, quais os aspectos essenciais a colocar em primeiro plano de modo a justificar esta frente de investigação?; como cobrir um campo teórico tão amplo sem ignorar a profundidade que cada uma das questões envolvidas exige?; e como podem ser apresentados estes aspectos dentro dos limites do presente trabalho, permitindo estimular uma dinâmica de pesquisa voltada para uma maior compreensão de sua relevância teórica e prática?

A fim de responder a estas questões, foi feito um intenso esforço de revisão da literatura, mapeando e caracterizando discussões relacionadas em diversos tópicos. Um deles é o debate político sobre as alterações climáticas, essa dimensão global da geopolítica onde os problemas decorrentes do processo de "transição do ambiente urbano" (McGRANAHAN et al 2001) parecem ser, paradoxalmente, reconhecidos e obscurecidos por uma crise ecológica de escala planetária. Se depara também o problema de algumas ambiguidades na noção de adaptação quando aplicada a sistemas sociais, e as alternativas epistemológicas oferecidas pelas noções de "adaptação transformadora e adaptação transformativa" (IPCC, 2014). Temos o debate socioecológico em torno dos serviços ecossistêmicos e o conceito de adaptação baseada nos ecossistemas. E regista-se uma evolução conceitual dos diferentes modos de lidar com inundações urbanas, que podem ser entendidos como um campo emergente de conhecimento, provisoriamente chamado aqui como "ciência integrativa de inundações" - este campo científico em evolução envolve necessariamente todos os outros tópicos e, portanto, será discutido adiante em que medida se justifica um investimento na sua redefinição de uma perspectiva mais integradora. Na mesma linha de questionamento, a adaptação do uso do solo pode contribuir para o enriquecimento desse campo, partindo de um diálogo interdisciplinar entre estas discussões, e explorando o seu significado para o desenvolvimento de políticas urbanas.

O problema que se evidencia a partir destas considerações preliminares, é a impossibilidade prática de cobrir todos os aspectos que mereceriam aqui um exame exaustivo. O que é possível dentro das dimensões modestas deste trabalho, é mostrar como alguns destes problemas fundamentais estão interligados, e como as suas consequências para o desenvolvimento de políticas públicas podem ser melhor compreendidas através de uma visão integradora destes desafios. São aqui impostos também à partida, alguns limites à possibilidade de reconstruir o contexto teórico difuso acima referido num campo científico relativamente autónomo, uma vez que, neste caso, a condição de "autonomia relativa" apontada por Bourdieu (1974) na sua noção de “campo”, pode ter aplicação limitada. Mais do que um campo de análise científica, a adaptação do uso do solo surge como uma questão urbana, no sentido dado por Castells (1974). Mas os comentários que serão oportunamente apresentados a este respeito ao longo deste trabalho deve ser lido como uma tentativa de ir além de uma mera discussão ideológica[1], rumo ao desenvolvimento de novas ferramentas metodológicas e suporte teórico e prático para analisar problemas de definição do interesse público nas decisões de uso do solo urbano. Isso traz uma segunda ordem de desafios relacionados com a escolha das teorias que podem ser utilizados para interpretar o contexto sociopolítico em que os processos de mudança de uso do solo e decisões relacionadas ocorrem, bem como as lógicas dos diversos participantes que estão por trás desses processos e decisões. Estas escolhas serão apresentados no próximo capítulo, depois de descrever o problema central da pesquisa, e a abordagem teórica adotada para lidar com este problema.

II- Formulação do problema

Hoje, os meios técnicos-científicos disponíveis para investigar objetivamente o funcionamento hidrológico de bacias urbanas permite verificar, a um nível bastante detalhado, os impactos das mudanças territoriais sobre inundações, bem como as possibilidades de adaptação dos processos de mudança de uso do solo de acordo com funções de regulação do ciclo hidrológico de uma determinada bacia. No entanto, os estudos existentes sobre riscos de inundações urbanas ainda carecem de um tratamento mais completo dos problemas políticos relativos à adopção de medidas preventivas e mitigadoras, exigindo também uma consideração mais integrada de aspectos sociais e econômicos para sua efectiva implementação. De um modo geral, quando são realizados este tipo de estudos, o mapeamento de áreas de risco e os impactos de novas urbanizações

[1] Castells (1977) enfatiza que " a questão urbana (...) é uma questão ideológica”. Mas Foucault (1994). acreditava que explicações para os problemas sociais têm de ser procuradas "não em uma ideologia, mas na existência dessa tecnologia política que temos formado nas nossas sociedades".

são mais ou menos exaustivamente analisados, mas poucos consideram os problemas de governança que conduzem finalmente para a sua integração nas decisões do uso do solo. Por outro lado, a devida consideração dos benefícios de longo prazo resultantes da adaptação de planícies peri-urbanas a usos compatíveis à preservação de serviços de regulação do ciclo hidrológico, é ainda mais improvável no contexto brasileiro, onde semânticas de "desenvolvimento" e "crescimento econômico" dominam o jargão político, e a batalha pela conservação da natureza está majoritariamente focada em áreas naturais pristinas.

O enfrentamento dos desafios colocados pelo crescimento urbano em àreas sensíveis a inundações exige não só a utilização de um conjunto maior de instrumentos para visualizar os serviços ecossistêmicos associados com uma certa bacia hidrográfica, mas também da consideração dos fatores políticos que influenciam os processos de mudança de uso do solo. O enfoque da gestão de riscos ambientais em aspetos políticos no seu sentido mais amplo, envolvendo aspetos institucionais, sociais e econômicos, é um campo de pesquisa relativamente recente. Aqui reside um desafio metodológico de encontrar um equilíbrio adequado entre a análise de processos físico-espaciais (no campo das ciências naturais) e processos político-sociais (no campo das ciências sociais), que não está ainda suficientemente tratado na literatura. Do ponto de vista prático, esta lacuna reflete-se numa certa dificuldade de conciliar os instrumentos formais de planejamento de uso do solo com os processos que influenciam na prática a ocupação real do território. Em particular, os atuais instrumentos de planejamento do uso do solo e gestão de águas urbanas tem revelado suas insuficiências face às dinamicas de expansão em planícies peri-urbanas, que quando localizadas a montante de núcleos urbanos consolidados, acarretam no agravamento das inundações a jusante. No sentido de averiguar a raiz destes problemas, este estudo situa o seu enfoque nas tensões entre a compreensão da natureza do problema das inundações urbanas, os fatores socioeconômicos que influenciam o fenômeno de suburbanização, e os fatores institucionais que condicionam as dinâmicas de mudança de uso do solo.

Um dos temas mais problemáticos na discussão sobre inundações urbanas vem da dificuldade dos atores envolvidos em compreender relações sistêmicas no território (PEARCE 1998, BOYER E POLASKY 2004). Considerando tais limitações, o mapeamento de inundações em áreas urbanas constitui um elemento importante para informar os atores envolvidos nas decisões de uso do solo. É particularmente relevante considerar que os serviços de regulação do ciclo hidrológico constituem serviços ecossistêmicos não transferíveis que produzem benefícios para uma dada comunidade urbana como um todo, mas através de uma distribuição geográfica desigual. Isto significa que os recursos estratégicos para a mitigação das inundações são locais e precisam ser especificamente identificados. No entanto, a implementação de medidas de adaptação do uso do solo é dificultada pela falta de integração entre conhecimento científico dos riscos, e as racionalidades econômicas, políticas e sociais para lidar com estes riscos. A este respeito, Wojciechowski (2009) aponta a dificuldade de integrar diferentes perspectivas setoriais face a problemas endêmicos e complexidades específicas em cada área de política pública.

Nas palavras de Beck (1992) o que fica claro nas discussões de risco são as fissuras e lacunas entre a racionalidade científica e social em lidar com ameaças potenciais. Na mesma linha de pensamento, se pode afirmar que há uma desconexão entre a análise técnica dos riscos de inundações urbanas e as lógicas dos diversos agentes que participam no processo de tomada de decisão que determina o grau de exposição a esses riscos. Em uma época onde a separação entre as ciências sociais e ciências naturais se torna cada vez menos possível, o debate sobre a capacidade de adaptação das cidades permanece paradoxalmente dividido entre especialistas e pontos de vista. Acselrad (1999) identifica uma linha divisória nos "discursos de sustentabilidade" entre, por um lado, a representação técnica das estruturas urbanas (neste caso, relacionado com o estudo analítico das funções hidrológicas associadas ao processo de crescimento urbano), e de outro lado, sobre a crítica politizada dos modos de produção do espaço urbano e (sua incapacidade para responder a) um ritmo crescente de demandas sociais. Embora seja notória a tentativa de alguns autores de estabelecer pontes entre dimensões físicas e sócio-políticos nos problemas urbanos, a dificuldade de integrar esses pontos de vista muitas vezes resulta em asserções de racionalidade divergentes. Se a investigação teórica sobre políticas públicas segue com algum embaraço nos passos de "tecnofobia" (Beck, 1992), estudos fundamentados sobre riscos de inundações urbanas geralmente não integram satisfatóriamente questões de ordem social e política para a implementação de medidas de uso do solo. Ao contrário, o conhecimento especializado das engenharias contribui frequentemente para a *legitimação técnica* de práticas predatórias, onde cada empreendimento busca soluções autonomizadas analisadas caso a caso, justificando os projetos avulsos promovidos pelo empresariado da construção civil, promotores imobiliários e investidores privados.

Para melhor compreender as dificuldades de um casamento feliz entre o desenvolvimento de capacidades tecnológicas ao serviço de interesses privados e políticas dirigidas para a defesa do interesse público no que toca a decisões de uso do solo, é importante reconhecer que planícies peri-urbanas são, de um modo geral, muito atrativas para o negócio da construção e estão frequentemente sujeitas a fortes pressões econômicas para fins de especulação imobiliária. Do ponto de vista dos agentes privados, os benefícios líquidos da conversão de áreas rurais e florestais em solo urbano, são comumente preferidos aos benefícios de preservação (ver Vuuren e Roy, 1993). Consequentemente, medidas de adaptação do uso do solo são menos atrativas para estes atores, e a adoção de medidas estruturais para redução de cheias é normalmente privilegiada. A este respeito, Corkindale (2007) observa que, enquanto medidas não-estruturais e estruturais não forem avaliadas em pé de igualdade , e com correspondente detalhe e profundidade, é muito provável que as soluções tradicionais de engenharia sejam preferidas. Schuyt (2005) explica que os decisores políticos não compreendem o valor econômico das planícies de inundação, e serviços de regulação natural do ciclo hidrológico são geralmente desconsiderados. Haller (2010) argumenta que subestimar a gama de serviços ambientais que uma área pode proporcionar resulta em usos inadequados, que por sua vez acarretam prejuízos econômicos. Estes argumentos justificam a necessidade de uma maior atenção analítica dos benefícios potenciais da preservação preventiva de áreas vulneráveis a inundações, abandonando um viés analítico exclusivamente voltado para a análise de “risco”, para uma avaliação do “valor” (não necessariamente monetário, mas envolvendo muitas outras dimensões) dos serviços ecossistêmicos prestados por unidades paisagísticas com grande capacidade de retenção e infiltração de águas pluviais.

Embora o papel do uso do solo para a mitigação dos riscos de inundações possa ser medido e espacializado por técnicos especialistas, a integração real desse conhecimento em práticas de planejamento e gestão não é um exercício puramente instrumental. A alocação de usos adequados é tanto um problema técnico-cientifico, como é uma questão da governança e de adoção de políticas eficazes. Até o momento, existe ainda pouco trabalho teórico sobre os caminhos para a integração de medidas de mitigação de inundações urbanas, e do ponto de vista prático ainda não está claro como as autoridades locais podem melhor integrar a adaptação em seus planos e políticas (IPCC 2014). Além disso, pode ser questionado até que ponto a adoção destas medidas tem fracassado através das práticas de planejamento urbano existentes, e quais são as barreiras institucionais para a sua implementação em cada um dos setores envolvidos. As discussões sobre governança, tais como as exploradas por exemplo, por Bulkeley et al. (2011), ou Garschagen e Kraas (2011), tocam aspectos importantes para a compreender como conflitos socioambientais provocados pela exposição de pessoas e bens a inundações reflete um quadro mais amplo de condições institucionais, sociais, políticas e econômicas.

Dentro deste contexto mais abrangente, instituições governamentais com mandatos específicos sobre planejamento do uso do solo, devem supostamente fundamentar suas decisões de uso do solo em informações confiáveis, ciência dos riscos socioambientais, e competência técnica para analisar esses riscos. Também envolve a realização de negociações com o setor privado e a sociedade civil, em que os governos locais ocupam um papel central na harmonização de interesses privados e públicos. Esta harmonização é problemática, uma vez que a deliberação sobre o uso do solo pode ameaçar o *status quo*, ou priorizar os interesses de alguns sobre o bem-estar dos outros (ver MEADOWCROFT, 2009; SMITH e Stirling, 2010). Mais especificamente, Adger et al (2009) observa um conjunto de restrições para a implementação de medidas de adaptação, argumentando que estas dependem da atuação de diversos atores sociais, interesses econômicos, e a consideração de diversos fatores que podem limitar a adaptação. Diante desses desafios, a alocação de usos do solo não é um processo neutro, e a adoção de medidas de mitigação de inundações urbanas requer a ponderação desses interesses conflitantes.

III - Abordagem proposta

Esta tese pretende abordar os problemas acima enunciados através de uma perspetiva socioecológica, desenvolvendo um caminho metodológico em duas mãos, na busca de um equilíbrio entre dimensões espaciais e políticas do objeto que proponho analisar. Enquanto a análise espacial destes problemas será oportunamente descrita mais à frente, algo deve ser dito desde já, sobre a abordagem teórica adotada para a análise e discussão das suas dimensões políticas - estas são entendidas num sentido amplo, partindo do pressuposto de que a alocação de usos de solo adequados a um determinado lugar geográfico depende fundamentalmente de um bom governo urbano (ou seja, o que as instituições do governo fazem para salvaguardar o interesse público no conjunto de decisões sobre o uso do solo urbano) e da boa governação (ou governança) urbana (ou seja, a forma como estas instituições trabalham com outros atores participantes nestas decisões). Discussões recentes em estudos Latino Americanos argumentam que a tenção entre estes dois elementos configuram um dilema de governabilidade (ver BRUERA, 2013) normalmente associado no jargão político com apoio popular e parlamentar para a manutenção do governo. O presente estudo pretende alargar o âmbito desta discussão de uma perspetiva bastante diferente, através da introdução do termo governamentalidade[2].

Como é comumente utilizado na literatura, o uso distintivo das palavras governo e governança permite discernir o papel do Estado no seu sentido mais restrito, da interação

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[2] Governamentalidade foi primeiramente introduzido por Michel Foucault como parte de um curso em "Segurança, Território, e População, entre 1977-78 no College de France. Ultimamente o conceito foi utilizado em sociologia anglófona para estudar tecnicas complexas de gerir problemas relativos à população e regular condutas sociais. Alguns académicos Anglófonos deram um significado especificamente neoliberal - ver Barry *et al* 1996 e Dean 1999, 2007). Para uma abordagem às perspetivas de Foucault's ao neliberalismo ver Foucault (2008) e para uma crítica das suas posições a políticas neoliberais, ver Zamora e Behrent (2016) [3] Para um resumo da tese defendida pelo Clube de Roma ver Meadows et al, (1972). Mais recentemente, um estudo comparativo das tendências atuais de consumo, crescimento e poluição corrobora as principais teses de "Limites de Crescimento" do Clube de Roma, apresentando dados de três décadas após estas a formulação destas teses, com indicações tendenciais de padrões insustentáveis de consumo de recursos do planeta (ver Turner, 2008). Este estudo comparativo conclui que mudanças radicais nos padrões de consumo e tecnologia serão fatores fundamentais para evitar os riscos de colapso de importantes funções socioecológicas globais tal como previstas pelo Clube de Roma, no cenário chamado "standard run scenario", previstas para meados do séc. XXI.

de instituições governamentais com outros agentes que influenciam decisões políticas, como por exemplo, no caso de decisões de uso do solo. A noção de governabilidade, por sua vez, tem sido usado para explicar os compromissos políticos que são feitas dentro dos processos de tomada de decisão relacionados a fim de manter a estabilidade dos governos. Segundo Bruera, (2013) autores como Baiochi e Checa (2007), Leite (2008), Couto (2009), e Hunter (2011) distinguem geralmente dimensões econômicas, políticas e sociais. Tal distinção ajuda a explicar estas dimensões separadamente, permitindo entender como a dinâmica de mudança de uso do solo são moldados pelo equilíbrio de forças entre os vários interesses em jogo. No entanto, a noção de governabilidade não fornece ferramentas conceituais satisfatórias para vislumbrar uma mudança política, contribuindo para um sentimento geral de impotência e frustração. Além disso, a noção de governabilidade não permite superar a sua condição paradoxal, onde a necessidade de estabelecer compromissos políticos entre as várias forças contribui ele mesmo para a persistência de impedimentos crônicos que supostamente deveriam ser evitados por meio de negociação política.

Finalmente, pode ser apontada uma terceira razão para justificar a introdução do conceito de governamentalidade na literatura sobre políticas urbanas e riscos ambientais: é a hipótese de que em países do Hemisfério Sul, e outras regiões fortemente marcadas por um regime de propriedade patrimonial, os impedimentos políticos para a adaptação do uso do solo são fortemente influenciados por padrões de exploração de recursos que não podem ser totalmente captadas pela noção de governabilidade - ou mesmo pior, ele pode servir de instrumento de legitimização de fatores de dominação hegemônica que não são meramente o produto de uma circunstância política nacional. Esta hipótese, embora corra inevitavelmente o risco de uma generalização excessiva, merece talvez algum aprofundamento, para o qual o presente trabalho pode apenas fornecer algumas pistas. Entretanto, através da exploração desta abordagem teórica na análise dos processos de mudança de uso do solo, o presente estudo vai também questionar em que medida o conceito de governamentalidade é ou não útil para explicar dinâmicas de mudança de uso do solo no contexto deste caso.

As técnicas e racionalidades políticas desenvolvidas pelo Estado, foram descritas por Foucault como uma tecnologia política formada numa determinada sociedade. A noção Foucaultiana de racionalidade política e o conceito de governamentalidade parecem particularmente úteis para explicar como dilemas políticos são resolvidos e recriados pela combinação dos interesses mais estreitos das elites com as demandas sociais da população, independentemente dos seus custos ambientais no longo prazo. Enquanto a governabilidade foca nas relações do governo com o *status quo* e demandas sociais, a governamentalidade foca nos procedimentos, ferramentas e técnicas, através da qual ocorrem as relações de poder (FOUCAULT, 2007). De acordo com JOSEPH (2012), a forma como o conceito de governamentalidade pode ser aplicado - seja na teoria ou na prática - é uma questão a ser decidida em cada caso particular, exigindo ser devidamente colocada em seu contexto social. Nesta medida, ao propor explorar esta abordagem teórica na análise dos processos de mudança de uso do solo, o presente estudo vai também questionar em que medida o conceito de governamentalidade é (ou não) operativo neste caso particular. Para Jessop, o conceito de governamentalidade nos permite ver como o estado combina, organiza e direcciona micro-relações de poder existentes, que são então codificadas, consolidadas e institucionalizadas (JESSOP, 2007), permitindo destacar certas racionalidades de instituições governamentais (WALTERS and HARRH, 2005) mas também as suas interações com as lógicas de agentes econômicos e outros atores sociais na configuração de uma determinada tecnologia política na qual interesses dominantes são conjugados.

Como tal, este estudo não está meramente focado na análise dos impactos de processos de mudança de uso do solo nas inundações, mas sobretudo em analisar as relações de poder entre os atores políticos que são mais ou menos diretamente envolvidos nestes processos. No entanto, entende-se como essencial um conhecimento técnico aprofundado dos problemas físicos em questão (i.e. avaliando impactos no seu contexto geográfico) de modo a construir um raciocínio informado capaz de uma enunciação clara dos principais conflitos socioambientais em jogo. Para este entendimento, se reconhece a necessidade de medir e localizar os serviços de regulação do ciclo hidrológico dentro do contexto local de tomada de decisão e na paisagem local, onde o conflito entre desenvolvimento urbano e conservação ambiental está em jogo. Também merece aqui notar que a análise destas dimensões políticas da mudança do uso do solo não pretende ser "neutra" ou simplesmente descritiva, selecionando os aspectos particulares que a análise pretende destacar. Nesta perspectiva, os impedimentos para mitigar riscos de inundações urbanas através da adaptação do uso do solo é identificada a partir da consideração destas duas vertentes de trabalho, levando em conta o contexto geográfico local. O ajuste dos processos de mudança de uso do solo com o objetivo de favorecer a capacidade adaptativa de uma determinada estrutura urbana, é visto como um processo contínuo de questionamento e resolução de problemas, concebida como uma evolução do relacionamento entre o conhecimento político e técnico, num contexto de interação complexa entre interesses econômicos e demandas sociais. A exposição crescente de comunidades urbanas a inundações é, portanto, aqui entendido como um problema que envolve múltiplas dimensões, o que pode ser melhor observado através da análise das dimensões físicas e sócio-políticos em um processo de pesquisa interativa. A crescente exposição de pessoas e bens a desastres hidrológicos é deste modo formulado como um problema eminentemente político, que exige uma aproximação entre as esferas técnica, socio-económica e institucional. Para iluminar este problema a pesquisa será dirigida em duas vertentes interativas:

- No que respeita às dimensões espaciais, é necessário avaliar, quantificar e visualizar os impactos da expansão urbana nas inundações, estabelecendo um nexo de causalidade entre mudanças de uso do solo e os impactos positivos ou negativos sobre as inundações.

- No que toca às dimensões políticas, serão analisados os processos que conduzem à ocupação real do território, no qual indivíduos, grupos sociais e instituições se condicionam, atuam e se influenciam mutuamente, contribuindo para uma determinada dinâmica de uso e ocupação do solo.

A interação entre estas duas vertentes pode ser analisada a partir do: i) levantamento do conjunto de decisores políticos, representantes institucionais e outros interessados com influência nos processos de mudança do uso do solo;ii) mapeamento dos impactos de diferentes cenários de urbanização com auxílio de um modelo hidrológico; iii) comunicação dos resultados hidrológicos da análise, tornando acessíveis novos dados de auxílio à deliberação política; e na iv) observação dinâmica da tomada de posições e análise do discurso dos diversos atores. Este processo interativo permite confrontar o conhecimento técnico-científico e as pressões exercidas por agentes econômicos; identificar conflitos entre individuos, grupos sociais e instituições com interesses divergentes; e observar a tensão entre as regras impostas pelas instituições e as escolhas e os comportamentos reais das pessoas como resposta a estes condicionamentos.

A partir desta abordagem, a conversão de planícies aluviais peri-urbanas resulta de um somatório de decisões individuais influenciadas pelas instituições, mas também por interações sociais e econômicas onde é possível reconhecer uma racionalidade sobre a qual importa refletir. Isso obriga a observar o próprio processo de decisão na realidade política local, interagir com este na introdução de novos elementos, e daí retirar ilações sobre as condições para a sua possível mudança e transformação. O acompanhamento da dinâmica dos diferentes atores envolvidos nos processos de decisão de uso do solo ao longo deste processo permitirá compreender como é que o risco de inundações é percebido pelos indivíduos e instituições, e em que medida este é tomado em consideração nos processos de deliberação coletiva. Finalmente, será na relação entre os constrangimentos impostos pelas características físicas do território, as regras definidas pelas instituições, e as possíveis respostas provenientes de uma determinada realidade socio-económica, que se espera desenhar o quadro explicativo dos problemas em tela. Esse quadro irá constituir o referencial da pesquisa de modo a identificar as mudanças institucionais necessárias para inverter a atual tendencia de suburbanização, com ênfase na prevenção de cheias urbanas.

IV - Questões da pesquisa e objetivos

Partindo da formulação teórica do problema em análise, e tendo como suporte o caso empírico da pesquisa, este estudo persegue uma questão central: quais são afinal as causas que estão na raiz da tendência crescente de exposição de comunidades urbanas a inundações? A fim de responder a esta questão principal, dois conjuntos de questões orientam a pesquisa ao longo do estudo empírico. Designa-se o primeiro grupo como questões factuais da pesquisa: Quem são os principais atores que condicionam os processos de mudança de uso do solo e como estes influenciam as dinâmicas de mudança no uso do solo? E que instrumentos e mecanismos podem ser utilizados para regular estes processos e dinâmicas? As respostas a este primeiro grupo de questões irá fornecer um conjunto de dados que serão confrontados com um segundo grupo - designa-se este segundo grupo como questões especulativas da pesquisa: Como é que os diferentes atores interagem mutuamente, contribuindo para uma determinada dinâmica de mudança de uso do solo? E qual o papel que desempenham as instituições governamentais em seus diversos níveis e setores na reprodução de conflitos socioambientais relacionadas com a produção do espaço urbano? Estas questões tocam problemas difíceis no âmbito mais alargado da governança urbana, mas são essenciais para incorporar medidas preventivas de mitigação de inundações urbanas nas atuais práticas de planejamento do uso do solo.

A partir deste questionamento, o presente estudo pretende investigar os problemas relativos ao agravamento das inundações urbanas em um caso concreto, na cidade de Paraty no Estado do Rio de Janeiro, visando a identificação de um conjunto de medidas de adaptação do uso do solo para a prevenção de inundações urbanas. O principal objetivo do estudo é identificar os impedimentos políticos para a adoção dessas medidas, tendo em conta o contexto social, econômico e institucional do caso concreto de estudo. A pesquisa propõe-se aos seguintes objetivos específicos:

- Modelar as bacias dos rios Perequê-Açu e Mateus Nunes, com auxílio do modelo matemático de células Modcel;
- Quantificar os custos hidrológicos de expansão urbana em Paraty, tendo em conta as propostas contidas no plano diretor de 2010;
- Diagnosticar os principais fatores socioeconômicos e as condicionantes institucionais que contribuem para a atual tendencia de expansão urbana;
- Desenvolver alternativas de uso e ocupação do solo com ênfase na prevenção de inundações urbanas, e medir os seus benefícios hidrológicos;
- Analisar as propostas de uso do solo do Plano Diretor de Paraty de 2010;
- Rever o arcabouço legal e institucional relevante ao planejamento do uso do solo e gestão de águas urbanas no contexto específico do caso de estudo

VI - Enquadramento e pertinência do caso de estudo

Paraty apresenta características ecológicas, históricas e culturais particularmente adequadas aos objetivos deste trabalho. Este município, cuja paisagem cultural foi apresentada como candidata a integrar a lista da Convenção do Património Mundial (WHC/UNESCO), constitui um exemplo paradigmático do interesse comum em conter a tendência atual de expansão urbana descontrolada que se regista atualmente no entorno de muitas cidades Brasileiras. As mudanças de uso do solo que tem ocorrido ao longo das últimas décadas no município, revelam-se particularmente problemáticos nas ocupações ao longo dos cursos água, e nas áreas planas a montante de áreas urbanos, concorrendo para o agravamento dos riscos de inundação, que afetam um número crescente de comunidades com prejuízos materiais e humanos.

Não cabendo aqui uma revisão da historiografia da paisagem onde se insere a cidade de Paraty, é importante notar que o seu entorno foi ocupada por tribos Guianá (Segundo Abreu (1982), chamados de Guaianases-Guarulhos-Maramumis), e frequentada por tribos Tupinambá (conhecidos por Tamoios). Geograficamente, a localização estratégica de Paraty resulta da confluência do limite Sudoeste da Baía da Ilha Grande, com a ancestral trilha indígena que atravessava a Serra do Mar em direção ao interior da Serra da Mantiqueira, e seguia em direção ao Vale do Jequitinhonha para Norte. Nesta perspetiva mais ampla, Paraty se insere num espaço físico muito vasto, ocupando o limite marítimo de um caminho de penetração territorial no continente Americano de importância estratégia reconhecida ao longo de milénios (ver ABREU, 1984; HOLANDA, 1994 e SALES, 2012). Na sua história mais recente, com as primeiras expedições marítimas realizadas por povos Europeus à Baía da Ilha Grande no séc XVI, sucederam confrontos entre Portugueses e Franceses, na qual as duas fações formaram alianças com os Guaianazes e Tamoios respetivamente, pela disputa do domínio deste território. Após firmado o domínio Português da região, a cidade de Paraty foi fundada no séc. XVII. O caminho indígena que ligava a cidade ao interior do território Brasileiro foi sistematicamente utilizado pelos colonizadores no estabelecimento de trocas comerciais e tráfico de escravos. Estas atividades foram incrementadas durante o ciclo de exploração aurífera em Minas Gerais, conhecido desde então como “caminho do ouro”, ou “caminho velho” (ver SANTOS, 2001). No séc. XIX, Paraty conheceu um novo pico de desenvolvimento com as monoculturas de café do vale do Paraíba, afirmando-se então como um centro portuário regional importante. A história da cidade de Paraty é assim fundamentalmente marcada por momentos de exploração extrativista, caracterizada por ciclos econômicos que operaram transformações profundas no território e originaram a sua estrutura urbana.

Fig. 1: Rede hídrica do Brasil (mapas do autor sobre imagem de Wikimedia Commons)
Fig. 2: Primeiro eixo de interiorização urbana no território Brasileiro, séc. XVIII.
Fig. 3: Área urbana de Paraty em 1959 - Mapa do autor sobre fotografia aérea.

Os mapas da figura 1 ilustram a importância histórico-geográfica de Paraty no início do ciclo de extração aurífera, constituindo um dos extremos das vias de escoamento do ouro do Brasil para o exterior do continente Americano. Foi neste período que ocorreu o primeiro momento de interiorização urbana no território Brasileiro, já não apenas constituído por um conjunto de implantes coloniais ao longo da costa, mas estabelecendo uma rede de trocas comerciais no seu interior. Este movimento de integração do espaço nacional no período colonial, e as suas possíveis conexões com um conhecimento muito mais antigo da geografia e hidrografia do continente Sul-Americano, está ainda insuficientemente estudado.

Durante o séc XVIII, a cidade de Paraty beneficiou de investimentos públicos significativos, nomeadamente com importantes obras na sua infraestrutura de drenagem, através da implementação de planos e projetos realizados por engenheiros militares portugueses (ver Cury, 2008). Preocupações com a salubridade da região (devido à ocorrência de cólera e febre amarela em várias regiões do Brasil) contribuíram para a adopção de medidas higienistas, através de um cuidadoso projeto de estruturação viária no qual as ruas foram implantadas com inclinação para uma calha central com caimento em direção ao mar, facilitando o escoamento das águas de chuva e a entrada da maré alta. No seu entorno, as áreas de restinga de floresta Paludosa, que fazem a transição entre o mar e a região montanhosa da Mata Atlântica, foram progressivamente drenadas para exploração agrícola. Com a construção da linha ferroviária, a cidade ficou isolada dos fluxos econômicos dominantes, sofrendo um grande declínio econômico e esvaziamento populacional. Paraty chega ao século XX como um legado do período colonial com rara integridade arquitetónica e qualidade urbanística, cristalizado pelo período de estagnação económica. Apesar do seu relativo isolamento, a cidade beneficiou nas primeiras décadas do séc. XX de investimentos em obras de infraestrutura. A atividade agrícola passou a constituir a principal fonte de receitas dos seus habitantes, escoando a sua produção em pequenas embarcações para as localidades vizinhas. Estas atividades entretanto entram em declínio a partir da década de 1970. Com a construção da nova estrada BR 101 (cujo traçado nas proximidades de Paraty está sinalizado na figura 2) a cidade inaugura um novo ciclo econômico, centrado no turismo e comercialização de terras. A relação deste binómio com o agravamento das inundações urbanas será um tema recorrente ao longo deste trabalho.

A figura 3 mostra a localização do Município de Paraty no Estado do Rio de Janeiro (à esquerda) destacando o centro urbano da cidade de Paraty. A figura 4 evidencia os espaços abertos remanescentes nas áreas planas localizadas nas imediações do núcleo urbano consolidado.

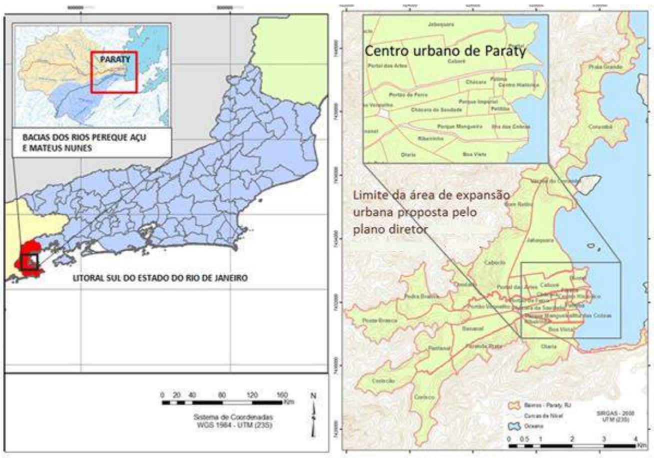

Fig. 4: Localização da área de estudo (imagens recolhidas de Marins, 2013)

Fig. 5: Espaços abertos na planície de Paraty (mapa do autor sobre ortofotomapa)

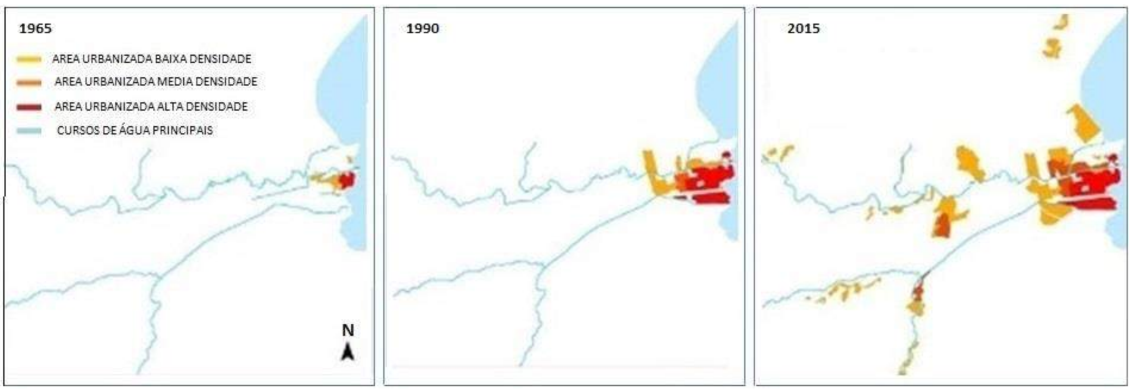

Fig. 6: Evolução da expansão urbana em Paraty entre 1965 e 2015 (mapa do autor sobre fotografias aéreas e de satélite do Google Earth, sobrepostas em ambiente SIG e mapeadas diacronicamente.

A figura 5 mostra a evolução da expansão urbana em Paraty nos últimos 50 anos. O crescimento demográfico foi acelerado nas últimas três décadas, com um aumento de 27% da população nos últimos dez anos (IBGE, 2010). O processo de expansão urbana inicia-se após a construção da BR 101, mas é interessante notar que em 1990 a cidade ainda apresentava uma forma relativamente compacta. Nas últimas duas décadas, as pressões antrópicas sobre o território se tornaram mais intensas e dispersas, e o processo de fragmentação urbana intensificou-se ao longo da última década, com a multiplicação de áreas residenciais em áreas de riscos e subdivisões fundiária por meios formais e informais. Estes padrões de crescimento urbano são estimulados pelos agentes de mercado imobiliário, enquanto as carências de habitação popular e de baixa renda permanece problemático.

Apesar do seu carácter único e peculiar, este município com cerca de 38 mil habitantes enfrenta problemas similares a muitos outros municípios brasileiros, onde o rápido crescimento em torno de cidades de pequena e média dimensão não é suportado por práticas de planejamento e gestão adequadas. No entorno imediato da cidade de Paraty, as planícies peri-urbanas a montante da BR-101 encontram-se por um lado, sujeitas a interesses do mercado imobiliário, e por outro, à ocupação urbana informal e subdivusão ilegal de terras, com o consequente agravamento de conflitos socioambientais. Este processo acelerado de crescimento urbano resulta num "déficit de adaptação" (Quan e Dyer, 2008), i.e. uma incapacidade de se adaptar aos crescentes riscos ambientais, mesmo sem considerar o agravamento destes riscos por mudanças climáticas. É de fácil previsão o resultado da soma de pequenos empreendimentos feitos paulatinamente a montante da cidade sem o seu planejamento adequado, com o progressivo agravamento irreversível dos níveis de alagamento a jusante, onde o problema das cheias urbanas é recorrente. A atual tendência de expansão urbana contribui para um aumento progressivo nos níveis de pico de cheia na ocorrência de chuvas intensas, o que leva tanto ao decréscimo das áreas naturais de retenção hídrica quanto ao aumento das condições de escoamento superficial, resultando em maior degradação ambiental e perda de oportunidades de transformação positiva da sua estrutura urbana.

Em vários estudos que antecedem o presente trabalho Barbedo et al (2013, 2014, 2015a, 2015b, 2016, 2016b) argumentam sobre a relação entre mudanças de uso do solo no município e o agravamento de inundações urbanas. Nestes estudos são exploradas alternativas de desenvolvimento urbano que enfatizam os potenciais benefícios hidrológicos da adoção de uma forma urbana mais compacta usando os espaços remanescentes abertos localizados em áreas a jusante das áreas de inundação. Na tese de mestrado de Marins (2013), foi realizado um primeiro exercício de modelagem hidrológica, mapeando áreas de risco no centro urbano. Estes primeiros estudos serviram de base para o presente trabalho, com a consideração de um grande volume de novas informações e aprimoramento da modelagem das Bacias dos Rios Perequê-Açu e Mateus Nunes.

Enquadrada pelas montanhas da Mata Atlântica, a paisagem de Paraty é ainda fortemente marcada pela presença de grandes espaços abertos no seu entorno. Para uma melhor compreensão da área de estudo, estes são aqui sumariamente descritos, segundo a ilustração representda na figura 4. A montante da BR-101, destaca-se a fazenda vulgarmente conhecida por “Bananal”, (área A na figura 4), onde o rio Mateus Nunes sofreu realinhamentos para a atividade agrícola. Desde a extração do ouro em Minas Gerais, estas fazendas formaram a paisagem econômica da região Sudoeste do Brasil como uma paisagem cultural distinta de outras regiões do Brasil. Com o declínio da agricultura em Paraty, a grande fazenda que ocupa grande parte deste território é usada essencialmente para pasto de gado. Ao Norte da cidade antiga, a área de Jabaquara (área B na figura 4) é principalmente composta por remanescentes de mangue, pertencendo ao maior proprietário de terra urbana de Paraty: embora esta área tenha sido classificada como área de expansão urbana desde o primeiro Plano Diretor de Paraty de 1972, apenas foi urbanizada parcialmente no loteamento aprovado em 1952, ao longo da praia de Jabaquara. A área de aeroporto (área C na figura 4) também representa um importante espaço aberto na cidade. Os remanescentes das planícies de inundação ao longo do rio Perequê-Açu (área D na figura 4) ainda apresentam também grandes áreas abertas, embora o processo acelerado de urbanização seja particularmente visível nesta área.

O grupo de pesquisa de estudos urbanos da Universidade Federal do Rio de Janeiro (PROURB/UFRJ), fez uma análise do sistema de espaços abertos em Paraty, apontando três funções possíveis destas áreas peri-urbanas: i) Aprimoramento dos serviços ecossistêmicos produzidos pelas bacias hidrográficas, com potencial para preservar a estrutura da vegetação, da hidrografia e do solo; ii) Uma área de percepção de paisagem, envolvendo uma relação possível entre as paisagens natural e antrópica; iii) Ocupação urbana como uma oportunidade de estruturar áreas já em perigo de urbanização descontrolada (Tardim et al., 2011). Os perigos decorrentes de urbanização descontrolada referido por estes autores é hoje uma realidade conflitante com um processo natural bem conhecido no município: as águas que descem em regime torrencial das montanhas em direção às planícies aluviais litorâneas, geram o escoamento de grandes volumes de água quando ocorrem chuvas intensas que desaguam na planície. Apesar dos registos existentes da capacidade destrutiva destas ocorrências, o desenvolvimento urbano está ocorrendo aceleradamente o longo dos rios Perequê-Açu e Corisquinho (um tributário do rio Mateus Nunes), bem como em outras zonas ribeirinhas particularmente vulneráveis no Município, como Taquari e Paraty Mirim. Na área imediatamente a montante da periferia das grandes propriedades descritas anteriormente, vários bairros (e.g. Bairros do Pantanal, Condado, Ponte Branca, etc.) crescem aceleradamente, na maioria dos casos na forma de processos de ocupação informal e progressivas subdivisões de terras. De 1990 até hoje, as ações antrópicas têm sido mais intensamente manifestadas através da emergência de novas áreas residenciais em áreas previamente convertidas para uso agrícola, a multiplicação de assentamentos formais e informais em áreas de riscos de inundações, ocupações ilegais e subdivisões de propriedades. Em alguns casos, a ocupação de zonas vulneráveis a riscos de inundação foram financiados pelo Município, como no caso da construção do Hospital Municipal (que não chegou a entrar em funcionamento) e do conjunto de habitação popular do Condado, entre outros. Em alguns condomínios atualmente em construção é possível observar marcas de inundação anteriormente registadas com 1,60 m acima do solo. Esses problemas resultam em sérios riscos à segurança e bem-estar das comunidades locais, contribuindo para padrões de crescimento insustentáveis.

Devido ao reconhecido valor do patrimônio ambiental do Município, cerca de 83% do território municipal é considerada área de proteção ambiental. A preocupação em preservar não só o patrimônio construído de Paraty, mas também o seu ambiente envolvente não é uma ideia nova. Desde 1945, a cidade era reconhecida como Monumento Histórico, tombada pelo Estado do Rio de Janeiro em 1958. Mas foi o Decreto Lei 58 077 de 1966, (Dec. 58.077, 1966), que originou o tombamento da cidade enquanto Património Nacional que menciona expressamente a intenção de considerar o tombamento de Paraty para além da sua zona urbana, incluindo toda a sua zona rural. Em 1974, a intenção de nomear não só a área urbana mas todo o município como àrea tombada foi inscrita no Livro do Tombo Arqueológico, Etnográfico e Paisagístico, o que obrigaria a aprovação do IPHAN de qualquer obra de licenciamento. É interessante notar que esta inscrição tenha sido sucessivamente contestada pela sua "legalidade", contestação esta que foi rejeitada pelo Ministério Público, mantendo-se válida a disposição do IPHAN. Este episódio ilustra também, claramente, as disputas de poder sobre as decisões de uso do solo que tem marcado o município.

Entretanto, o município tem sofrido mudanças de uso e ocupação do solo significativas,com especial incidência nas últimas duas décadas, refletindo um fraco entendimento, tanto por parte da sociedade civil como das autoridades municipais, da importância de preservar áreas específicas para a mitigação de riscos de inundação. Segundo um relatório do SEBRAE, o município é historicamente marcado por conflitos em diferentes aspectos e (...) um problema grave no município relaciona-se à construção civil, que tem causado impactos ambientais negativos sobre as matas ciliares de dois grandes rios - Mateus Nunes e Perequê-Açu – que atravessam a cidade (SEBRAE, 1999). A pesquisa de Gomes et al (2004) sobre conflitos de interesse na região conclui que os conflitos existentes (...) caracterizam-se pela presença de diversos grupos de pressão, onde a especulação imobiliária e o comércio ilegal dos recursos naturais são priorizados.

Estes problemas e conflitos refletem-se na situação ambígua em que o Município se encontra no que diz respeito ao Plano Diretor. As alterações aprovadas ao Plano Diretor de 2006, aprovadas pela Câmara de vereadores em 2007, foram embargadas por decisão do Ministério público, resultando num impasse no qual a Prefeitura defende a validade do Plano, apesar das suas evidentes inconsistências e insuficiente desenvolvimento e detalhe no que diz respeito à Área de Expansão Urbana definida (por exemplo, este plano não define parametros urbanísticos para a área de expansão proposta a montante da BR101). Em 2010, a Prefeitura de Paraty publicou uma proposta de Plano Diretor desenvolvida por uma equipe técnica da Universidade Estadual do Rio de Janeiro, mas este não chegou a ser aprovado. No que respeita ao uso do solo, esta proposta de plano contém uma proposta de macro-zoneamento e mezo-zoneamento na qual define uma área de expansão urbana até à cota 100 para todo o Município, incluindo a planície a montante do centro urbano consolidado (ver Prefeitura de Paraty, 2011). No que respeita aos processos de participação pública realizados no âmbito da elaboração do Plano Diretor de 2010, Matos e Cavalazzi (2011) observaram o despreparo da população aquando da apresentação das propostas do Plano Diretor de 2010, que podem suscitar dúvidas quanto à legitimidade dos processos de participação entretanto realizados. O mesmo autor alerta que a falta de critérios mínimos para a aplicação dos instrumentos previstos no Estatuto da Cidade para a defesa do interesse público, cria o risco de que os próprios objetivos, princípios e diretivas definidos pelos processos de planejamento participativo não sejam respeitadas.

Para além das ambiguidades referidas no que concerne aos instrumentos de regulação urbanística e ambiental do Município, a Prefeitura entrará no próximo mandado eleitoral a ter início em 2016, em incumprimento no que respeita à obrigação de ter um Plano Diretor em vigor, visto estar definida no Estatatuto da Cidade a obrigatoriedade de revisão do Plano Diretor no prazo máximo de 10 anos. Assume-se assim como matéria urgente e de grande relevância para o Município de Paraty, a definição de diretivas, estratégias e propostas concretas para a designação de usos do solo compatíveis com as funções socioecológicas da cidade de Paraty e respetivas propriedades localizadas no seu entorno. É neste contexto que a análise crítica às propostas de uso do solo contidas no plano diretor de 2010, apresentadas seguidamente, se enquadram. Pretende-se assim somar esforços para avançar na construção de uma nova cultura de cidadania ativa na salvaguarda de interesses coletivos, contribuindo neste caso, com um enfoque específico na adoção de medidas preventivas para a mitigação de inundações através da adaptação do uso do solo.

VII - Análise crítica do Plano Diretor de Paraty de 2010

O Plano Diretor Municipal de Paraty publicado em Novembro de 2010, pretende definir as políticas municipais de planejamento urbano e de desenvolvimento municipal de Paraty. Em seu conteúdo é apresentado, nos Volumes 1 e 2 o diagnóstico do município, envolvendo aspectos territoriais físicos e ambientais, como também as condições socioeconômicas da região. Este diagnóstico, embora contenha informações relevantes para a elaboração do plano, não é aqui analisado em maior profundidade. As presentes contribuições para a revisão do plano diretor de Paraty dizem respeito às propostas de uso do solo definidas nos Volumes 3 e 4, com especial enfoque nas diretrizes que pretendem orientar o zoneamento municipal da cidade de Paraty e seu entorno. As considerações que seguem dizem respeito à Área Urbana Macrozona MA-3 e Área de Expansão Urbana proposta nas Macrozona MA-2, que correspondem ao recorte da área de estudo do presente trabalho. Como ilustrado na Figura 6, as 11 Macrozonas e 33

Mesozonas propostas pretendem orientam a elaboração das diretrizes que compõem o projeto de lei do plano diretor.

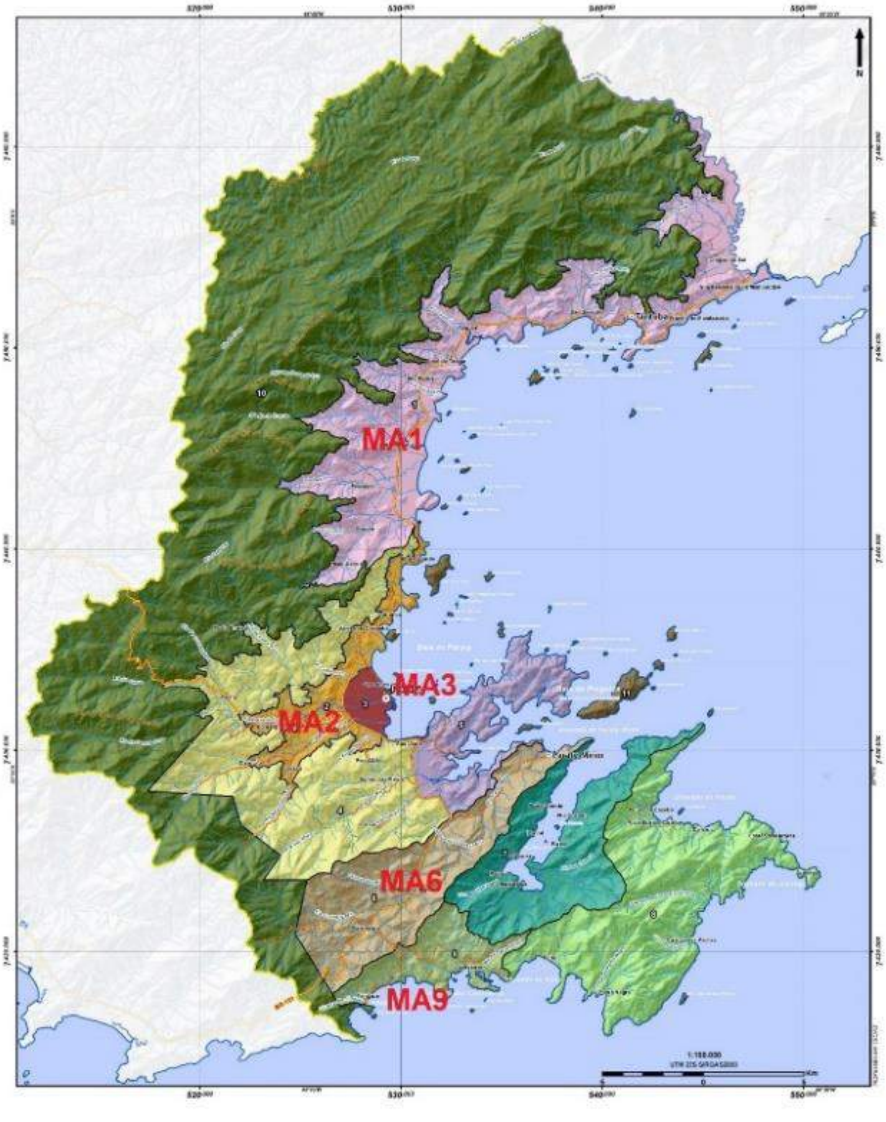

Fig. 7: Macrozonas definidas pelo Plano Diretor de Paraty de 2010 (Mapa do Plano Diretor de Paraty 2010, modificado pelo autor)

Na pag. 21 do Vol. 3, o ordenamento territorial proposto "articula-se em 3 escalas hierarquizadas de zoneamento, aumentando a riqueza de detalhes a partir do Macrozoneamento, para o Mesozoneamento, até o Microzoneamento.(...) como terceira escala, buscar-se-á a particularização de novas zonas (Microzonas) com o objetivo de *espacializar as restrições de uso e ocupação do solo*, assim como, *as principais áreas sugeridas para preservação, recuperação e conservação ambiental* e outras ações mais pontuais (meu grafo).

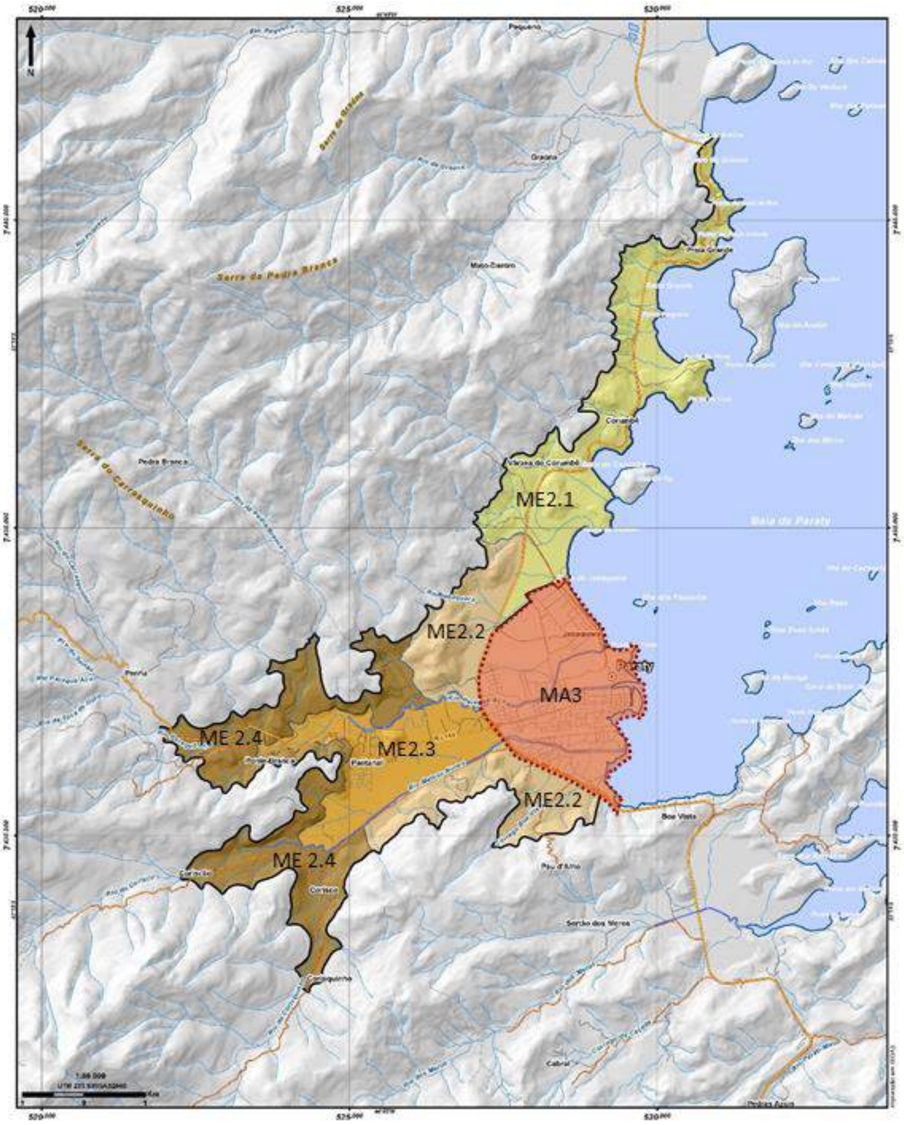

Fig. 8: Macrozona urbana da cidade de Paraty (MA3) e Mezozonas (ME) de expansão urbana propostas pelo Plano Diretor de Paraty de 2010 (Mapa do autor feita a partir da sobreposição de Mapas do Plano Diretor de Paraty 2010)

Segundo o plano, “os Microzoneamentos serão priorizados para as áreas com ocupação humana adensada, sendo definidas “as Macrozonas Urbana e de Expansão Urbana, os Núcleos Urbanos Isolados e a zona costeira com ocorrência de ocupações no entrono da Enseada de Paraty-Mirim, do Saco do Mamanguá e da Ponta da Juatinga, como prioritários na elaboração do Microzoneamento, tendo em vista ser este zoneamento que propiciará a definição dos parâmetros urbanísticos necessários para o complemento da lei de uso e ocupação do solo urbano.”

Na pag. 88 do Volume IV, capítulo VI, o Art. 289 define que “o Zoneamento Municipal estabelecido por este plano diretor se dá em dois níveis, a saber: i). Macrozoneamento Municipal e (…) II. Mesozoneamento (…)”.Na pag.67, as propostas de mezozoneamento “são (...) apresentadas com o objetivo de definir seus recortes finais, criando a possibilidade de continuidade do processo de construção participativa (…) objetivando a definição dos microzoneamentos nas áreas com adensamentos populacionais e elencadas (...) como prioritárias para a definição de parâmetros de ocupação e definições de uso e ocupação do solo municipal.” Assim, convém esclarecer as razões porque as referidas oficinas de discussão dos microzoneamentos foram ou não realizadas, e porque esta componente essencial do plano não avançou no sentido de uma maior definição. De qualquer modo, a elaboração destes planos de microzoneamento são reconhecidos ao longo do texto como instrumentos necessários e complementares às propostas de macrozoneamento e mezoneamento apresentadas. Iremos discutir em seguida as propostas de uso do solo contidas no plano ao nível macro e mezo, com especial incidência para as propostas de expansão urbana apresentadas para a cidade de Paraty e seu entorno.

Macrozona de Expansão Urbana de Paraty MA-2

Na pag. 56 a “Síntese das Características e Potencialidades das Macrozonas” menciona aspetos importantes da Área MA-2, que levantam uma série de perplexidades quanto à classificação desta área como “Área de Expansão Urbana”:

i) “Cerca de 40% de sua área (é) coberta por Florestas (da) Mata Atlântica (30% em floresta em estágio Inicial de Sucessão nas encostas) Unidades de Conservação (UC): 20% de sua área (está) protegida pela APA Cairuçu (Mesozona ME-2.2, 523,29 hectares). (obs: na tabela apresentada na pag. 45 tem-se que 1947, 12 hectares da MA-2 são protegidas por APPs, o que supostamente seria um lapso). Importa aqui questionar se será adequado a conversão desta área florestal (40% do total) em área de expansão urbana, mesmo que seja com “baixíssimas densidades”, como referido pelo plano relativamente à Mesozona ME-2.2. Ver também Tabela 5.3, Gráfico 5.3, Anexo 15: Mapa de Mesozoneamento – MA-2, e características de cobertura vegetal e uso do solo na

Tabela 5.4. No caso de tal proposta avançar, seria no mínimo necessário definir o que se entende por baixíssima densidade, e fazer um estudo rigoroso dos impactos ambientais dessas urbanizações, especialmente no que respeita à extensão de infra-estruturas para essas áreas.

ii) "Quase 60% de sua área é composta por terrenos planos e fundos de vales; dos quais "45% de sua área entre 0 e 5 graus de declividade." É importante avaliar os serviços ambientais que estas áreas baixas prestam (e podem prestar adicionalmente) à população em geral, e ao centro urbano em particular, nomeadamente no amortecimento de cheias. Como tem sido verificado nas últimas grandes cheias, muitas destas áreas são alagáveis. Segundo dados da defesa civil, em 2009, a água proveniente do extravasamento dos rios uniu as duas bacias numa faixa de aproximadamente 500 metros imediatamente a montante da BR101, chegando a atingir uma altura de inundação de 1,5 metros na área onde se está atualmente a construir um condomínio. As marcas de alagamento ainda são visíveis no local. Os bairros do Condado, Pantanal e Ponte Branca também foram severamente afetados, onde automóveis foram arrastados e casa foram destruídas pela força das águas. No bairro Princesa Isabel, foi construído um enrocamento, com o objetivo de proteger este bairro, que entretanto já teve que ser reforçado após nova derrocada. Este tipo de obras, para além de representar grandes investimentos, provocam o agravamento das inundações a jusante, nomeadamente nas áreas mais vulneráveis ao longo do rio Perequê-Açu. A expansão urbana nesta área irá também implicar o progressivo aterro destas áreas (à semelhança do que aconteceu no Bairro do Caborê), o que também irá contribuir para o agravamento das inundações a jusante.Todas estas áreas estão contidas na área ME-2.3. Na pag.70-71, seção 5.2.2. "Mesozonas da Macrozona de Expansão Urbana de Paraty" A Mesozona ME-2.3 é caracterizada no plano "como área mais adensada dentre as Mesozonas desta Macrozona de Expansão Urbana. Sugere-se que as diretrizes levem em consideração um ordenamento da intensificação do processo de adensamento se estabelecendo um padrão de expansão da área urbana de Paraty." De acordo com o texto, pretende-se favorecer a expansão urbana da cidade para as áreas com maiores problemas de inundação. Vale ressaltar que atualmente a àrea edificada total da MA-2 é de 174,92 hectares, enquanto a área de expansão urbana proposta tem cerca de 400 hectares, o que é claramente desproporcional, mesmo se considerado ao nível macro.

iii) Em "outras características" (da MA-2) refere-se a "presença de agricultura mais intensa nas margens dos rios Perequê-Açu e Mateus Nunes. No entanto, e apesar de podermos constatar a presença de vastas áreas com potencialidade agrícola, as atividades agrícola e agroflorestal não são apontadas nas "potencialidades da MA-2", ignorando o uso que estas terras têm tido ao longo de vários séculos, até ao seu recente declínio. Nesta seção aponta-se também como potencialidades o "Turismo Sustentável (desenvolver programas de incentivo ao turismo aproveitando os atrativos naturais, cênicos, culturais, históricos e paisagísticos, através do turismo e dos esportes)"; e a "Preservação do Patrimônio Cultural (incentivo e priorização nas atividades de recuperação e preservação do patrimônio cultural do município (...)"; na potencialidade "Desenvolvimento Socioeconômico" aponta-se a necessidade de "viabilizar atividades socioeconômicas compatíveis com o desenvolvimento sustentável, valorizando a paisagem e a proteção do meio físico, como elemento fundamental da paisagem urbana" e "Recuperação Ambiental (resgatar áreas da orla fluvial, das praias e margens dos cursos d'água, objetivando a proteção e preservação do meio ambiente)". Importa aqui questionar se a classificação desta área como "área de expansão urbana" irá contribuir para estes objetivos, ou se ao contrário, irá contribuir para uma rápida descaracterização desta paisagem cultural, como tem ocorrido com maior intensidade ao longo das duas últimas décadas.

iv) a primeira potencialidade desta área é, segundo o plano, a "Ocupação Humana Ordenada: propiciar o desenvolvimento urbano ordenado de alta e média densidade para os bairros urbanos com ocupação dos vazios urbanos e ordenamento dos padrões construtivos em conformidade com o patrimônio paisagístico e cultural); e a criação de um "Pólo de oferta de Serviços e Infra-Estrutura Urbana". Estes objetivos não estão aqui em questão, mas o que se questiona é a estratégia em si: ao classificar uma vasta área como área de expansão urbana, na qual as áreas urbanizadas existentes representam uma ínfima parte, o plano contraria a persecução destes objetivos, uma vez que favorece o espraiamento urbano por uma grande área, em vez de realmente focar no adensamento e ocupação dos vazios urbanos de áreas já estabelecidas. Abrindo a possibilidade de expansão de infraestrutura para novas áreas, limita-se necessariamente a possibilidade de canalizar os recursos existentes para as áreas atualmente carenciadas.

Pode ser argumentado que esta expansão urbana definida no macro e mezo-zoneamento possam vir a ser limitadas num eventual micro-zoneamento.

No entanto, pressões exercidas em função de interesses privados que operam no parcelamento e construção nesta área, podem limitar o alcance dessas limitações. Nesse caso, a expansão urbana descontrolada irá contribuir para uma pulverização dos investimentos públicos e um progressivo agravamento dos atuais problemas sócio-ambientais. Uma alternativa a esta estratégia seria a indicação, por parte do plano, da necessidade de circunscrever as áreas (sub)urbanas existentes, o que é o contrário de classificar esta vasta área como "área de expansão urbana".

Resumindo, se 40% da MA-2 são cobertas por floresta e uma grande parcela dos restantes 60% é constituída por áreas alagáveis (numa região onde as inundações constituem já um grave problema para o município), qual é a base de sustentação da proposta de expansão urbana para estas áreas? O plano parece embasar-se no fato de que "a área MA-2 é a terceira maior concentração de habitantes e domicílios, e segunda maior densidade de habitantes e domicílio por área edificada dentre as Macrozonas", apresentando um "aumento de 39% no número de habitantes (maior aumento no município) e aumento de 52% no número de domicílios (maior aumento no município)". Nas pags 91-93 do Volume IV, subseção II, o Art. 298 refere que "a Macrozona de Expansão Urbana de Paraty (MA-2) é caracteristicamente marcada como área de expansão urbana pelos dados do censo de 2000 e contagem de 2007 realizada pelo IBGE. Desta forma, a proposta de expansão urbana do plano parece legitimar o crescimento desordenado que se tem verificado recentemente, colando-se a esta tendência ao invés de ir ao encontro de soluções para conter este crescimento.

Nas páginas 62-65, subseção II o Art. 281 recomenda estudos individuais para os bairros e núcleos habitacionais contidos na Área de Expansão Urbana "para sua consolidação (e) expansão". Este artigo reflete intenções contraditórias, sendo difícil compatibilizar na prática estes dois objetivos: ou se pretende consolidar estes bairros, através de uma firme contenção deste crescimento urbano, ou se admite a expansão destes bairros, implicando maiores investimentos na extensão de infraestrutura para novas áreas urbanizadas. É importante considerar que estes bairros não estão ainda dotados de saneamento básico e outra infraestrutura, sendo economicamente mais viável e ambientalmente desejável o seu adensamento e consolidação em vez de promover a sua expansão. Vale ressaltar que estes bairros estão já designados na seção III do Volume 4 como áreas de especial interesse no município, no seu Art. 375. Note-se ainda que no item 4.3.5.3. da pag. 49, a “dinâmica de crescimento populacional” da área MA-3, classificada como área Urbana de Paraty, houve apenas um aumento, tanto populacional como de domicílios, de 16%. A correlação entre estes números é facilmente explicável pela falta de alternativas ao fenómeno de suburbanização: se não se tem verificado um aumento expressivo da oferta de residências nas áreas próximas ao centro urbano, as populações são obrigadas a procurar alternativa em bairros periféricos.

Na mesozona ME-2.3 convém destacar a presença de uma unidade paisagística de grande relevância para o município, antiga propriedade vulgarmente conhecida como “Bananal”. Pela sua dimensão e valor paisagístico, seria adequado para esta área duas das designações descritas no capítulo VIII do Volume 4. Na pag 105, define Área de Especial Interesse Ambiental (…) “espaços (…) cujos elementos do ambiente natural assumem função de interesse público, por serem importantes para a manutenção do equilíbrio sócio-ambiental do município e define Área de Especial Interesse do Patrimônio Cultural aquela(s áreas) destinada(s) à preservação, reabilitação ou compatibilização com o sítio integrante, de sítios (…) de valor e significância cultural, de relevante expressão (..) histórica (…) e paisagística;

É possível prever as consequências negativas da intensificação do processo de urbanização nas restantes áreas de planície e fundo de vale da ME- 2.3, principalmente em relação ao comportamento do escoamento das cheias na bacia. Vale ressaltar que nas pags 89-90, o Art. 292 define áreas com condições físicas adversas à ocupação (…) áreas de baixada, sujeitas a alagamento, inundação ou rebaixamento decorrente de sua composição morfológica. O §2º recomenda ainda que as áreas frágeis de baixadas terão seus usos condicionados à avaliação técnica. Na Pag. 42 do Volume 4, na seção IV – “da drenagem urbana” tem-se no Art. 133 que “O Plano Municipal de Saneamento Básico, de que trata o parágrafo único do Art. 120 - desta Lei, deverá conter “Plano de Controle de Enchentes, que deverá estabelecer(…) ações prioritárias no manejo das águas pluviais, tais como: i) definir mecanismos de fomento para usos do solo compatíveis com áreas de interesse para drenagem, como parques, área de recreação e lazer, hortas comunitárias e manutenção da vegetação nativa; e ii) implantar medidas de prevenção de inundações.

O Art. 137 define também que “O Poder Executivo Municipal criará medidas de incentivo à não impermeabilização do solo e ao reaproveitamento da água da chuva, especialmente nas áreas baixas e planas. No entanto, as diretrizes para a expansão urbana nas áreas a montante, para além do seu impacto ambiental direto de transformação da paisagem de Paraty, poderá acarretar no agravamento das inundações que hoje já atingem a parcela inferior da bacia, pois irão reduzir a capacidade de retenção das cheias nas áreas de preservação natural. Mais ainda, a proposição de ocupação extensiva dessas áreas a montante inviabilizam ações de projeto para a recuperação de funções hidrológicas perdidas ao longo da evolução histórica de crescimento da cidade de Paraty e sua região de entorno. Os desmatamentos da bacia, a retificação do rio Mateus Nunes e a perda de áreas de amortecimento de cheias hoje já penalizam a cidade com importantes alagamentos.

Macrozona Urbana de Paraty MA-3

Nas pags 100-101, seção iii - das mesozonas da MA-3, o Art. 330 define que as diretrizes para as mesozonas desta seção são o ordenamento urbano compatível com o adensamento de ocupação, oferta de serviços e infraestrutura, e o incentivo de ocupação dos vazios urbanos existentes. Neste sentido, o plano sairia reforçado se incluísse um conjunto de diretrizes para os estudos individuais recomendados no Art. 279 (pags. 62 - 65 do Volume 4). Por outro lado, para uma abordagem mais aprofundada das necessidades de expansão urbana na sede do município, será indispensável fazer uma análise objetiva da capacidade de suporte da área MA-3, designada como Área Urbana de Paraty. Numa primeira análise dos espaços abertos existentes nos 594 hectares desta área, cerca de um quinto desta área não estão urbanizados. Vale ressaltar que estas áreas são, tanto do ponto de vista econômico como ambiental, os mais adequados à expansão urbana ordenada assim como foi defendido desde as primeiras iniciativas de planejamento levados a cabo no município (ver Plano Diretor de 1972). Nas pags 100 e 101, seção II, o Art. 324 caracteriza a mesozona ME-2.1, ocupada predominantemente pelo bairro de Jabaquara "por uma área de menor densidade e com perspectivas de expansão futura de longo prazo, tendo como diretrizes a ocupação futura com ordenamento e infra-estrutura apropriados à incorporação de padrões urbanos de maior densidade. Apesar do texto reconhecer esta área como uma área com perspectivas de expansão, não se percebe uma intenção de priorizar a expansão urbana para esta área em um horizonte próximo (dentro do próprio Plano).

A expansão urbana tal como é proposta pelo Plano Diretor poderá acarretar no agravamento das enchentes em Paraty. Para além do fato de que as áreas de expansão propostas estarem diretamente sujeitas a inundação de futuros residentes nessas áreas, as novas urbanizações irão contribuir para o aumento da profundidade e extensão de alagamento no núcleo urbano consolidado. Alterações na cobertura vegetal e uso do solo nas áreas de planície a montante da BR-101, com a redução das áreas naturais e aterro de áreas para urbanização, são limitam a capacidade de absorção e retenção de água da planície, diminuindo a infiltração e aumentando o escoamento superficial.

De um modo geral, nota-se, na leitura do plano que a articulação entre as propostas de uso do solo contidas no Volume 3 e os instrumentos previstos no Volume 4 pode ser melhorada, favorecendo a sua possível e desejável aplicação prática. Por exemplo, o plano não articula a possibilidade de designar a mesozona ME-2.1 como Área de Especial Interesse Urbanístico, tal como previsto na pag 105, capitulo VIII. O Art. 366 define Áreas de Especial Interesse, como espaços do município (…) que são submetidos a regime urbanístico específico, relativo a implementação das políticas públicas de desenvolvimento urbano. No seu parágrafo único, Área de Especial Interesse Urbanístico é aquela destinada a projetos específicos de estruturação (…) urbana.

Os instrumentos previstos nas paginas 21 a 24 do Volume 4 também abrem possibilidades interessantes ao Município para a aplicação de operações urbanas consorciadas, em conformidade com os mecanismos previstos nos artigos 32 a 34 da Lei Federal nº 10.257/2001. Segundo o Art. 65 da Subseção IX do Volume 4 "O Poder Público Municipal poderá, através de lei municipal específica, delimitar áreas para operações urbanas consorciadas". No parágrafo único deste artigo "Considera-se operação urbana consorciada o conjunto de intervenções urbanísticas de grande porte coordenadas pelo Poder Público Municipal, com a participação dos proprietários, moradores, usuários permanentes e investidores privados, com objetivo de alcançar em uma área transformações urbanísticas estruturais, melhorias sociais e a valorização ambiental, em especial para a implementação das seguintes medidas:

i) ampliação de espaços públicos e implantação de infra-estrutura;

ii) implementação de programas habitacionais e de valorização ambiental;

iii) modificação de índices e características do parcelamento, uso e ocupação do solo, bem como em alterações de normas edilícias, considerando o impacto ambiental e o impacto de vizinhança delas decorrentes;(...).

No Art. 67 define que "o Poder Público Municipal deverá promover e estimular a viabilização de operações urbanas consorciadas preferencialmente nas Macrozonas de Ambiente Urbano e de Expansão Urbana. O Art. 69 refere também que: "As áreas de Operação Urbana Consorciada, delimitadas através da Lei Municipal de que trata o Art. 65 desta Lei poderão ter coeficiente de aproveitamento máximo diferenciado" Na pagina 74 lê-se: "De forma geral, para estas Mesozonas (da MA-3) orienta-se que se incorporem diretrizes que incentivem, controlem e restrinjam suas dinâmicas de parcelamento e uso do solo (...)"

Finalmente, considera-se como principal desafio na revisão do presente plano diretor adequar as propostas de expansão urbana à demanda real de habitação no município e da cidade de Paraty, cujo estudo não está ainda consolidado. A introdução ao Volume 4 fala sobre a relação entre o desenvolvimento e a questão ambiental, dos "limites do crescimento" (numa suposta alusão à tese do Clube de Roma de 1972[3]) e do relatório da Comissão Brundtland de 1987 "Nosso Futuro Comum", que "considera o desenvolvimento sustentável como aquele que satisfaz as necessidades do presente sem comprometer a capacidade das gerações futuras de satisfazer as suas próprias necessidades". Não conseguimos entretanto encontrar nas propostas de uso do solo do

[3] Para um resumo da tese defendida pelo Clube de Roma ver Meadows et al, (1972). Mais recentemente, um estudo comparativo das tendências atuais de consumo, crescimento e poluição corrobora as principais teses de "Limites de Crescimento" do Clube de Roma, apresentando dados de três décadas após estas a formulação destas teses, com indicações tendenciais de padrões insustentáveis de consumo de recursos do planeta (ver Turner, 2008). Este estudo comparativo conclui que mudanças radicais nos padrões de consumo e tecnologia serão fatores fundamentais para evitar os riscos de colapso de importantes funções socioecológicas globais tal como previstas pelo Clube de Roma, no cenário chamado "standard run scenario", previstas para meados do séc. XXI.

plano, sobretudo no que concerne à área de expansão urbana proposta, o reconhecimento de "limites ao crescimento", mas pelo contrário, a proposição de vastas áreas destinadas a expansão urbana, sem explorar em maior profundidade a capacidade de suporte existente nas áreas ainda não ocupadas a jusante da BR101. Relevante para a discussão destas opções, o plano define que "a política de habitação do município (seção VI do Volume 4, nas pags 62-65, o Art. 198) "(…) deverá evitar a constituição de grandes aglomerados com concentração de população de baixa renda distantes dos locais de trabalho", referindo no §1º do mesmo artigo que "A solução deverá apontar para projetos inseridos na malha urbana, utilizando vazios urbanos, pertencentes ou não ao patrimônio do Município".

VIII - Referencial teórico da pesquisa[4]

O presente estudo parte da constatação de que a velocidade das dinâmicas de uso do solo nas cidades contemporâneas exige o reconhecimento institucionalizado do interesse público de preservar serviços ecossistêmicos essenciais para o bem-estar e segurança das comunidades urbanas. A expansão urbana descontrolada conduz frequentemente a processos de mudança do uso do solo com impactos irreversíveis no agravamento das cheias urbanas, implicando custos crescentes de manutenção e infraestrutura, degradação ambiental e outros prejuízos para a população. A ocorrência de desastres hidrológicos tem sido documentada, revelando uma tendência crescente e predominante sobre outros desastres naturais (MUNICH, 1999; BERZ, 2000; IFRC, 2010). A literatura recente tem dado uma maior ênfase a fatores climáticos (IPCC, 2007), mas também um reconhecimento crescente dos efeitos das mudanças de uso do solo nas inundações (GFDRR, 2012 IPCC, 2012). A magnitude dos impactos ambientais causados por ação antrópica nos últimos cinquenta anos não tem precedência na história da humanidade (GRAU E AIDE, 2008), gerando conflitos socioambientais e a extinção de importantes contingentes de biodiversidade. Por exemplo, a Avaliação Ecossistêmica do

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[4] Esta seção apresenta alguns elementos explorados com maior profundidade na revisão da literatura. Não se pretende aqui repetir ou (menos ainda) substituir os conteúdos discutidos na contida na Part I – Theoretical Foundations of the Research. Ao contrário pretende-se encorajar o leitor à discussão na primeira parte do trabalho, organizado segundo os temas referidos na introdução.

Milênio estimou que as mudanças de uso do solo ocorridas desde a década de 1950 representam mais de 50% das perdas de “wetlands” em partes da América, Europa e Austrália (CONVENTION FOR BIODIVERSIY, 2005), enquanto não existem dados precisos para a África e Ásia, onde o crescimento urbano descontrolado atinge níveis agudos e a depredação da natureza é mais notória. Os efeitos das emissões de carbono na atmosfera podem contribuir para o agravamento deste quadro, embora seja ainda muito cedo para determinar com segurança seus impactos (QUIGGIN, 2008; STUART et al, 2009). Espera-se que ecossistemas costeiros possam ser afetados pela subida do nível do mar (NICHOLLS, 2011), e mudanças nos padrões de precipitação em regiões tropicais úmidas podem resultar em chuvas mais frequentes e de maior magnitude (DORE, 2005).

Um processo típico de depredação de recursos naturais em planícies aluviais periurbanas ocorre através da reprodução de áreas residenciais de baixa densidade a montante de núcleos urbanos, agravando os riscos de inundação nos distritos urbanos a jusante. Outro problema recorrente é a fragmentação do espaço urbano, com a multiplicação de ocupações desordenadas em áreas vulneráveis a risco de inundações, gerando conflitos ambientais e custos sociais elevados. No cerne destes dois problemas concomitantes está um fraco entendimento dos agentes que operam estas transformações territoriais das funções sociais e ecológicas que as planícies aluviais peri-urbanas desempenham. O papel das planícies peri-urbanas na regulação do ciclo hidrológico tem sido documentado (ACHARYA 2000, BULLOCK E ACREMAN 2003, EMERTON 2005, SHRIER 2010), e a necessidade de adaptar o uso do solo para a mitigação de riscos de inundação tem merecido um reconhecimento crescente na literatura (LIAO 2012, KOUSKI 2011, GFDRR 2012). Diretivas internacionais tem encorajado intervenções no território que “trabalhem com a natureza e não contra ela”, reconhecendo que os efeitos de mitigação dos riscos de inundação através de medidas de adaptação do uso do solo são “melhores opções ambientais” (DIRECTIVE 2000/60/EC, 2000). Esse reconhecimento coloca grandes desafios para a governança urbana: se por um lado, é necessário reunir o conhecimento técnico para a identificação de recursos naturais estratégicos, é fundamental compreender as causas primárias da expansão urbana que ocorre sem a adequada consideração das suas externalidades negativas.

Face a estes desafios, muitos países já reconhecem através de diretivas nacionais e internacionais a necessidade de adaptar o uso do solo ao aumento dos riscos de inundação (e.g. EU-FD, 2007). Segundo esta perspectiva, a boa política urbana para prevenir inundações é evitar a ocupação de áreas inadequadas, sejam estas áreas de risco, ou, não menos importante, áreas estratégicas que prestam (ou podem prestar) importantes serviços de regulação do ciclo hidrológico. Especificamente, um desafio-chave para a governança urbana é assegurar a salvaguarda de planícies peri-urbanas e outras áreas com elevado potencial de infiltração, amortecimento e retenção de águas pluviais. Bullock e Acreman (2003) mostram que as zonas húmidas de várzea podem reduzir a intensidade das inundações a jusante, com exemplos de diversas regiões do mundo. Adicionalmente, em muitos casos, a manutenção de condições de alagamento natural podem também ser um requisito essencial para evitar a degradação do meio ambiente (MALTBY E ACREMAN DE 2011). A proteção destes recursos estratégicos exige, por um lado, a sua identificação e mapeamento, e por outro, o seu reconhecimento efetivo enquanto bem público de modo a garantir (e se possível, incrementar) os serviços ecossistêmicos prestados por estas áreas.

A revisão da literatura irá explorar os conceitos desenvolvidos pela abordagem ecossistémica, adotada pela Convenção para a Biodiversidade (CONVENTION FOR BIODIVERSITY, 2005) e os conceitos de Gestão Integrada de Inundações (WORLD METEOROLOGICAL ORGANIZATION, 2009). A abordagem ecosistémica baseia-se no reconhecimento da interconectividade de fatores bio-físicos e socioeconômicos, promovendo a gestão integrada do solo e da água. A ênfase crescente sobre a importância dos serviços de regulação do ciclo hidrologico para prevenção de inundações é conspícua na literatura sobre serviços ecossistêmicos (e.g. ACHARYA , 2000; EMERTON , 2005; SHRIER 2010). A Gestão Integrada de Inundações, assim como foi definida pela Organização Meteorológica Mundial é consistente com estes princípios, incluindo fatores humanos e naturais através de uma perspectiva holística, e considerando as bacias hidrográficas como unidades indivisíveis.

Os benefícios da adaptação dos processos de mudança de uso do solo para a mitigação dos riscos de inundações tem sido objeto de pesquisas recentes (ver KOUSKY et al. 2011). A literatura sobre requalificação fluvial é particularmente relevante para o conceito de adaptação, mostrando como a reabilitação de áreas degradadas e a recuperação de meandros permite recuperar a resiliência dos sistemas hidrológicos, incrementando a sua flexibilidade. Em relação à implementação dessas medidas, duas abordagens fundamentais são encontradas na literatura. A primeira enfatiza a necessidade de travar a depredação de recursos naturais, promovendo cidades compactas (ROGERS, 1997). O desenvolvimento desta abordagem propõe uma inversão radical da tendência atual do crescimento urbano: por um lado, o adensamento de áreas já infraestruturadas e a ocupação de espaços intersticiais da malha urbana, são apontados como alternativa à expansão de áreas residenciais de baixa densidade. Por outro lado, a adaptação de planícies peri-urbanas permite favorecer a infiltração pluvial e acomodar as águas durante e depois de um evento por meio de armazenamento a montante (MITCHELL et al. 2006). A segunda abordagem procura lidar com os processos de urbanização através do desenvolvimento de conceitos inovadores e de drenagem relacionados, tais como o conceito norte-americano de Desenvolvimento de Baixo Impacto (USDOD , 2004; KLOSS E CALARUSSE , 2006) , o conceito de Sensitive Urban Design desenvolvido na Austrália (BMT WBM , 2009) e os conceitos britânicos de Drenagem Urbana Sustentável (ANDOH E IWUGO , 2002). Tais conceitos enfatizam a necessidade de combinar medidas estruturais e não-estruturais (MIGUEZ et al. 2011), a fim de reduzir os impactos da urbanização, melhorando a capacidade de resiliência às mudanças no ciclo hidrológico, seja por infiltração e armazenamento de água a montante como pela re-conexão dos sistemas hídricos para restaurar propriedades de flexibilidade da bacia hidrográfica. As possibilidades abertas por estes conceitos serão desenvolvidas ao longo do trabalho de tese através da revisão da discussão teórica recente sobre serviços ecossistêmicos enquanto bens coletivos, e o que representam, afinal, os avanços nestes campos de conhecimento para a construção de um paradigma alternativo de governança socioambiental.

A adoção, desenvolvimento e aplicação prática dessas abordagens conceituais suscitam dois problemas fundamentais: i) como promover a preservação de serviços ecossistêmicos de importância crítica à regulação do ciclo hidrológico ii) como gerar um processo político que permita a legitimação de medidas de prevenção de inundações urbanas, tomando em conta os diversos conflitos de interesse em jogo nas decisões de uso do solo. Esta problematização permite fazer uma exploração dialética dos conceitos Habermasianos de racionalidade instrumental (referente o papel das ciências naurais em produzir conhecimento técnico-cientifico) e racionalidade comunicativa (enfatizando a importância de estabelecer diálogo significativo entre as pessoas)

(HABERMAS, 1984). A importância que é atribuída no presente esquema ao conceito de racionalidade comunicativa alinha-se com os conceitos desenvolvidos por Sen na sua teorização da justiça, onde explica que "a natureza da sociedade que resulta de determinado conjunto de instituições depende necessariamente também de características não institucionais, tais como os comportamentos reais das pessoas e suas interações sociais. " (SEN, 2011). Nesta linha de pensamento, as teorizações sobre os bens comuns desenvolvidas por Ostrom e seus colegas (OSTROM 1992, BROMLEY et al 1992), servem como referencial teórico para abordar o que esses autores designam de regras de uso, considerando um largo espectro de condicionantes institucionais, permitindo uma abordagem abrangente dos fatores de influencia nos processos de decisão.

Finalmente, o reconhecimento de serviços de regulação do ciclo hidrológico enquanto bem coletivo implica mudanças na governança urbana, exigindo uma atuação conjunta entre o estado e a sociedade para a salvaguarda de determinados recursos estratégicos. A revisão institucional no contexto específico do Brasil é particularmente relevante para esta discussão, visto existir um conjunto de novos arranjos institucionais que visam a integração do planejamento do uso do solo à gestão de águas urbanas, apoiados por instrumentos legais como os previstos no Estatuto da Cidade. Em particular, cabe discutir no contexto mais alargado da pesquisa, as ineficiências do estado no garante do direito a habitação, reconhecido constitucionalmente no Brasil a partir de 2000 através da Emenda Constitucional nº 26, de 14 de fevereiro de 2000, e reforçado pelo Estatuto da Cidade. Este respaldo legal servirá de referência para questionar a ação do poder público no cumprimento desta obrigação constitucional, trazendo à baila um conjunto de problemas éticos e de justiça social.

IX - Metodologia

A formulação do problema em análise parte da identificação de um "gap" metodológico na literatura sobre riscos de inundações urbanas no que respeita ao tratamento dos seus aspetos de governança urbana. O presente estudo responde a esta lacuna através de uma abordagem metodológica mista, fazendo uso de métodos de pesquisa qualitativos e quantitativos. Como foi referido no capítulo introdutório, esta pesquisa propõe situar o problema de inundações urbanas dentro de seu contexto sócio-político específico, considerando a forma como as instituições públicas condicionam as dinâmicas de mudanças de uso do solo, bem como os fatores sociais e econômicos que influenciam tais processos. A incorporação dessas múltiplas dimensões exige examinar o objeto de análise a partir de vários ângulos e fazendo uso de diversas lentes analíticas, buscando um equilíbrio adequado entre os aspetos físico-espaciais (no âmbito das ciências naturais) e aspetos socio-políticos (no âmbito das ciências sociais). Na próxima seção, irei apresentar o quadro analítico desenvolvido para esta pesquisa, seguido por uma descrição mais detalhada de cada etapa metodológica.

Quadro analítico da pesquisa

O quadro analítico da pesquisa é organizado a partir de uma estrutura metodológica desdobrada em seis dimensões, especificamente concebida para esclarecer as principais etapas de análise da pesquisa, sem perder de vista a unidade do objeto de análise. Os seis passos analíticos são divididos entre análise política e análise espacial. A análise política considera o quadro institucional, o quadro jurídico e os vários "stakeholders" i.e. os atores detentores de interesses e/ou com influência nas decisões de uso do solo. A análise espacial considera as dinâmicas de mudança de uso do solo, o desenvolvimento de cenários de urbanização e o estudo hidrológico da área de estudo.

Relativamente à análise política, a pesquisa é direcionada para a identificação das relações institucionais entendidas no seu sentido amplo, incluindo aspetos institucionais, legais e políticos.

• O quadro institucional foca os aspetos estruturais da governança ambiental, composto por órgãos do governo com funções e responsabilidades específicas sobre o ordenamento e gestão do território e correspondentes arranjos institucionais - esta etapa analítica permite definir os papéis dos organismos do Estado com responsabilidades específicas no planejamento do uso do solo e na gestão de recursos hídricos;

• O quadro jurídico é constituído pelas políticas urbanas e ambientais a nível federal e estadual, entendidos como regras formais externas que condicionam os processos de mudança de uso do solo. Estes incluem princípios constitucionais e legislação relacionada com o planejamento do uso do solo e gestão de recursos hídricos - esta análise permite definir os *instrumentos* que podem servir para a adaptação do uso do solo na prevenção de inundações urbanas;

• A avaliação dos “stakeholders” preocupa-se com os interesses internos, i. e. as motivações dos atores que influenciam e condicionam as dinâmicas de mudança no uso do solo ao nível micro de tomada de decisão. Esta análise terá em conta as prioridades de cada agente e as racionalidades dos diversos grupos de interesse (sejam estes públicos ou privados, incluindo interesses políticos, sociais e econômicos) envolvidos nas decisões de uso do solo - esta análise permite identificar os conflitos de interesse nas decisões de uso do solo.

Relativamente à análise espacial, o foco é colocado nas relações ecossistêmicas entre o solo e a água, mais especificamente, entre as dinâmicas de mudança de uso do solo, os processos de urbanização e as funções hidrológicas de uma determinada bacia hidrográfica, com o objetivo de compreender o modo como as mudanças de uso do solo interferem nas condições de alagamento.

• a análise das dinâmicas de mudança de uso do solo inclui uma descrição pormenorizada das principais características geográficas do território em estudo. Particular atenção é colocada sobre os conflitos socioambientais existentes. Esta análise permite identificar tendências de urbanização no território estudo;

• o desenvolvimento de cenários de urbanização para a área de estudo permite desenvolver alternativas hipotéticas às tendências identificadas.

• o estudo hidrológico inclui a caracterização e modelagem hidrodinâmica das bacias hidrográficas, mapeamento detalhado das inundações na área de estudo, e a estimativa de custos e benefícios hidrológicos dos cenários hipotéticos de desenvolvimento urbano.

Estes componentes analíticos formam um cubo de dados multi-dimensional, que pode ser representada muito esquematicamente no diagrama representado na figura 9. Este esquema analítico condensa os principais componentes de análise e tenta mostrar o confronto relacional entre a análise espacial e a análise política. O estabelecimento dessas relações permite especular sobre os possíveis caminhos para enfrentar os problemas identificados ao longo do trabalho, construíndo um quadro explicativo do problema em tela através de uma permanente tensão entre a análise dos atributos físicos do território, os atributos econômicos, sociais e institucionais do objeto analisado.

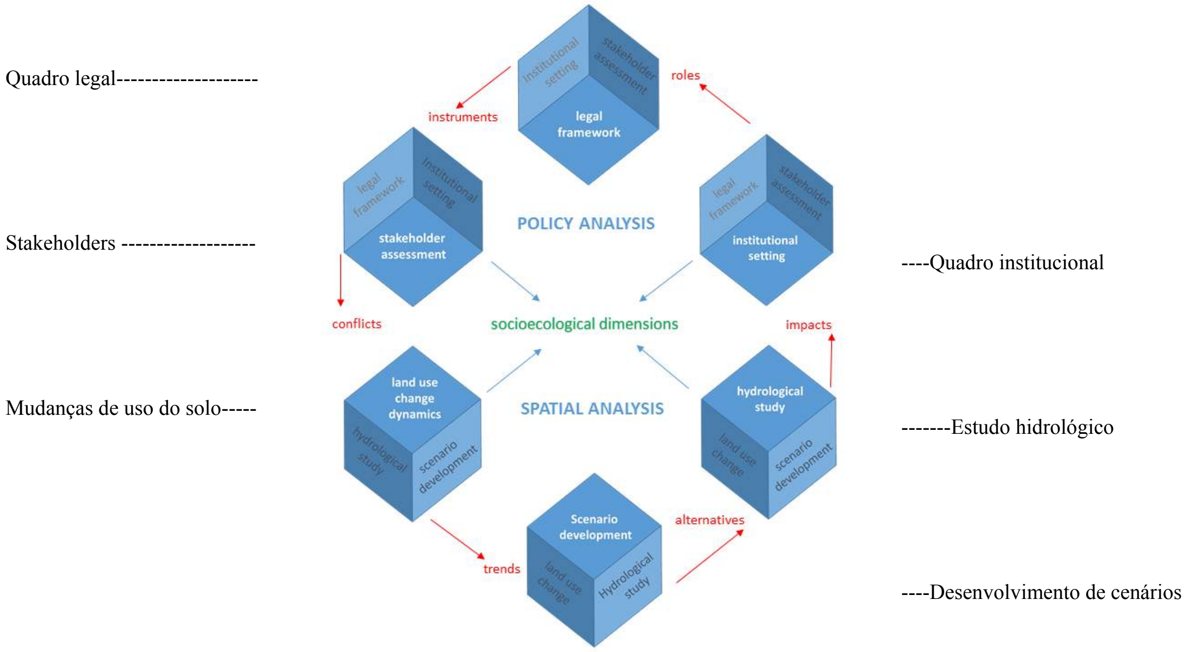


Fig. 9. Esquema analítico da pesquisa, ilustrando as principais componentes do estudo

Os atributos físicos explicitam a natureza do problema, estabelecendo o nexo entre mudanças de uso do solo e inundações; os atributos socioeconômicos definem as relações de interesse dos atores envolvidos nas mudanças de uso do solo; e os atributos institucionais circunscrevem os condicionamentos e mecanismos de tomada de decisão no seu contexto regulatório específico. A análise concomitante destas três classes principais de atributos irá resultar na clarificação de um conjunto de relações entre o ecossistema, a sociedade e as suas estruturas de governança.

O quadro analítico da pesquisa é assim desenhado de modo a articular estas abordagens críticas num processo interativo, gerando informação complementar que irá contribuir para iluminar o problema em escopo. Esta abordagem integrada permite cruzar os resultados das diversas análises realizadas, observando os cruzamentos, interações e interdependências das dimensões socioambientais do objeto de análise. É através deste esforço de reconstrução que a unidade do objeto de análise será reconstruída na discussão, considerando logicas econômicas, governamentais e sociais que contribuem para uma determinada dinâmica de mudança do uso do solo na área de estudo. Uma descrição detalhada de cada passo metodológico é apresentada nas paginas seguintes.

Anãlise do quadro legal e institucional

Esta análise é focada na identificação dos papéis e responsabilidades das instituições que influenciam os cenários social, econômico e ambiental do município. O enquadramento legal merecerá também um exame cuidadoso, nomeadamente no tocante a medidas oriundas de decretos federais e de políticas estaduais e locais para o entendimento de como as diversas representações do município, usando o discurso institucional, reagem em função do poder exercido por diferentes instâncias e esferas de governo. Pretende-se caracterizar os seguintes aspectos:

- os instrumentos formais que regulam e limitam o uso do solo
- os mecanismos de cooperação e gestão compartilhada de recursos naturais
- os condicionamentos externos, de natureza formal ou discreta
- as relações de forças e associações a nível externo
- a importância potencial que cada agência atribui à prevenção de inundações

Este estudo parte de uma concepção alargada do que se entende por quadro político-legal, entendidos como as regras formais que condicionam escolhas individuais e coletivas no tocante a decisões de uso do solo. O estudo da legislação foi feito a partir do levantamento documental das leis de regulação ambiental, planejamento do uso do solo e gestão de recursos hídricos ao nível federal, estadual e local. A participação do autor num grupo de trabalho para a discussão do Plano Diretor de Paraty, organizada pela Prefeitura de Paraty entre Fevereiro de 2013 e Julho de 2014, contribuiu de forma decisiva para formar uma perspectiva interna sobre os processos de tomada de decisões, destacando a relevância de vários problemas a serem analisados no decurso do trabalho de campo. A análise secundária de dados, constantes em documentos e relatórios oficiais, bem como o acompanhamento de processos de deliberação no Conselho Municipal, forneceram informações complementares para a preparação das questões colocadas durante as entrevistas e reuniões, ampliando o âmbito do exercício de coleta de dados.

Análise de atores e conflitos de interesse nas decisões de uso do solo

A análise de conflitos de interesse empregam métodos principalmente qualitativos, particularmente entrevistas semi-estruturadas. Diferentes interesses foram agrupados em diferentes tipologias (interesses econômicos de curto prazo, de médio prazo e de longo prazo, interesses de natureza sócio-cultural, de biodiversidade, de ordem paisagística, etc) com base no número de vezes que cada tipologia de interesse foi mencionada em todas as entrevistas em que cada ator participou. A seleção dos entrevistados e a ordem das entrevistas foi feita segundo uma abordagem "snow-ball", na qual novos atores são identificados ao longo do processo, abrangendo uma vasta gama de agentes. As entrevistas seguiram uma orientação com um conjunto de perguntas realizadas de uma forma flexível, permitindo que o entrevistado inclua outros temas. O momento e o modo como os tópicos foram formulados em questões foi feito com flexibilidade e sem restrição em aprofundar os pontos abordados por meio de questões que foram emergindo durante a conversa. A análise institucional dá uma importância particular à análise de conflitos de interesse. O foco em conflitos justifica-se na constatação de que a gestão dos recursos naturais tipicamente lida com interesses conflitantes de diversos atores, uma vez que estes usam os mesmos recursos para fins diferentes. Por isso, é importante compreender as diferentes perspectivas dos atores envolvidos (REED, 2009), captando as diferentes perspectivas de como o solo deve ser usado. Isso é relevante ao analisar processos de gestão de recursos naturais que não são apenas caracterizados por sistemas "top-down" e processos de decisão centralizada (LIENERT et al, 2013).

No que concerne ao foco deste trabalho, a caracterização das *lógicas* destes atores manifesta nos processos de decisão de uso do solo é focada na apreensão do nível de interesse que cada ator manifesta sobre os problemas relativos a inundações urbanas (Baixo, Médio ou Alto). Interesse é aqui considerado como o nível de importância que os problemas relacionados às inundações urbanas representam para cada parte interessada antes e depois da discussão. Interesse Alto significa que o ator está manifestamente sensível às preocupações relacionadas com inundações, e considera estas como prioridades nas decisões do uso do solo; Interesse Médio significa que cada ator atribui alguma importância aos problemas relacionados às inundações, isso é, ele/ela considera esses problemas mas os mesmos não são uma prioridade; Interesse Baixo significa que cada ator negligencia os problemas relacionados às inundações, desconsiderando os impactos das decisões de uso do solo nas inundações urbanas.

A observação das lógicas dos vários grupos sociais, organizações e indivíduos justifica-se na argumentação que num contexto de participação democrática, cada ator pode, pelo menos potencialmente, exercer um grau de influência que depende em grande medida da sua motivação, motivação que é em grande medida condicionada por uma determinada racionalidade. Neste sentido, observar a sua motivação e o seu potencial de uma forma dinâmica introduz um fator de (possível) mudança no quadro institucionalizado. Estudos congéneres tem procurado classificar os atores num determinado contexto sócio-político segundo o seu nível de influência, importancia e nível de envolvimento (ver DE GROOT et al, 2000). Segundo De Groot et al., importância refere-se ao grau que um determinado ator atribui a uma determinada questão; influencia refere-se ao nível de poder que um determinado ator tem no resultado de uma decisão. Estes atributos são observados na presente análise de uma forma dinâmica, partindo do princípio que grupos sociais influentes (proprietários, especuladores imobiliários, grupos econômicos) estão frequentemente já envolvidos nos processos de decisão enquanto outros atores que podem também ser influentes tendem a ter uma participação reduzida nesses mesmos processos. O último passo da pesquisa consistiu na realização de uma segunda rodada de entrevistas, que permitiram investigar especificamente as lógicas de atuação de cada ator em relação ao problema das inundações urbanas no município, bem como a motivação dos atores envolvidos para colaborarem mais ativamente no desenvolvimento das políticas do uso do solo para a prevenção de inundações urbanas.

Análise espacial das mudanças de uso do solo no Município

A análise espacial resultou da observação direta do território em estudo e do recurso a técnicas de georeferenciamento. Representações diacrónicas do território em análise são realizadas através da sobreposição de mapas e fotografias aéreas correspondentes a diferentes periodos. O georeferenciamento destas imagens em ambiente SIG permite reconstituir o processo de ocupação e uso do solo no território em estudo e proceder a análises quantitativas deste processo. Nesta análise, as principais características do território e o contexto geográfico de Paraty são examinadas em múltiplas escalas. Ao nível das bacias hidrográficas são consideradas as duas bacias hidrográficas em que a cidade de Paraty está localizada. Em um nível mais detalhado, o estudo centra-se na região inferior das bacias dos rios Perequê-Açu e Mateus Nunes, ou seja, na planície de inundação urbana e peri-urbana da cidade de Paraty. Esta área será descrita em maior detalhe na elaboração dos cenários alternativos de desenvolvimento urbano, com foco em riscos referentes às inundações e possíveis formas de mitigar impactos de mudanças de uso do solo através de medidas de adaptação. Finalmente, deve-se fazer uma análise crítica das propostas de uso do solo no Plano Diretor de Paraty. Os dados resultantes destas analises serão representados por meio de mapas e servirão de suporte para a classificaçao do solo em tipologias, que por sua vez serão utilizadas na modelaçáo hidrológica e hidrodinâmica. Nesta análise, os mapas e as fotografias aéreas foram georreferenciadas utilizando ArcView GIS e AutoCAD, adotando o sistema de coordenadas de projeção UTM Mercator.

Estudo hidrológico e modelagem hidrodinâmica

A modelação hidrológica foi realizada com apoio das ferramentas de hidráulica computacional desenvolvidas na COPPE-UFRJ: o modelo matemático MODCEL, (Mascarenhas and Miguez, 2002, Miguez et al, 2011) é uma ferramenta utilizada para estimar fluxos entre células ou compartimentos previamente divididos, que caracterizam uma bacia hidrográfica. A construção deste modelo é baseado no conceito de células de escoamento (Zanobetti et al, 1970) no qual o território é representado através de um conjunto de compartimentos que integram toda a área da bacia, ligados entre si por leis hidráulicas unidimensionais.

A subdivisão das bacias hidrográficas em células de escoamento na área de estudo foi realizado de acordo com as suas características topográficas e urbanas, com base no Sistema de Informação Geográfica do Município de Paraty e em outras bases de dados disponíveis, tais como cartas topográficas, fotografias aéreas, imagens de satélite e visitas de campo. Os dados de precipitação foram obtidos da estação pluviométrica de Paraty. Para calcular marés astronômicas, os regimes de maré foram inseridos no software SisBaHia (Rosman, 2011). Os coeficientes de run-off (vazão ou escoamento superficial, relacionado com a capacidade de absorção do solo) e Manning (relacionado com a rugosidade do solo), são baseados em Wilken (1978) e ASCE (1969), de acordo com as características de cobertura do solo das bacias hidrográficas em estudo. A modelagem da situação atual tem como objetivo realizar um diagnóstico do funcionamento das bacias dos rios Perequê-Açu e Mateus Nunes, com a identificação, quantificação e mapeamento das áreas sujeitas a diferentes níves de alagamento. A subdivisão das bacias hidrográficas compreende 569 células representando áreas de planície, 120 células de canal representando os rios que compõem as bacias e 72 células representando as áreas de encosta.

Após inserir todos os dados relevantes, o modelo é capaz de reproduzir a situação atual representando a realidade das bacias Perequê-Açu e Mateus Nunes. A calibração de um modelo matemático é um passo importante, de modo a reduzir as incertezas na representação simplificada do sistema real, e garantindo níveis aceitáveis de confiança no modelo. Essa calibração é feita através do ajustamento dos parâmetros hidrológicos, fazendo coincidir as descargas de água simuladas pelo modelo às observadas num evento real. No caso em questão, a partir de estatísticas disponíveis para um posto fluviométrico do Rio Perequê-Açu, foi definida a vazão de pico para o tempo de recorrência de 25 anos e esta foi utilizada, juntamente com uma estimativa do tempo de concentração da bacia, para a calibração deste rio. Para o Mateus Nunes, considerando sua semelhança e proximidade com a bacia do rio Perequê-Açu, foi ajustada uma vazão de pico proporcional à vazão de TR 25 anos do Perequê-Açu, considerando a relação entre as respectivas áreas de drenagem. Adicionalmente, marcas de inundação mapeadas através de relatos de moradores foram consideradas no processo de calibração, de modo a fazer o modelo inundar estas áreas. Este exercício seguiu o procedimento de "tentativa-erro", no qual os parâmetros são ajustados manualmente através de sucessivas simulações e comparações entre valores observados e calculados, permitindo a calibração do modelo (Bonganha et al, 2007). Assim, os desvios entre os valores calculados pelo modelo e aqueles de referência foram ajustados.

Depois de calibrar o modelo baseado na representação correta da situação atual foram simulados eventos evento de precipitação para tempos de recorrência (TR) de 10 anos, 25 anos e 50 anos. O TR de 25 anos é a referência do Ministério das Cidades para projetos de macrodrenagem e, portanto, é o tempo usado para fazer avaliações de projeto. Assim adotei como critério apresentar os cenários mais relevantes para TR 25 neste resumo expandido em português, no capítulo que se segue. O TR 10 é o tempo de projeto para a microdrenagem (que é básico para projetos de loteamento e tem uma escala mais local) e o TR 50 é muito usado em estudos de hidrologia como verificação superior, para testar o limite de falha do projeto. Os mapas e hidrogramas dos resultados mais relevantes são apresentados para estes tempos de recorrência na parte 4, capítulo 12.3. Como condição adicional, são considerados cenários de mudança climática, considerando um aumento de 10% na precipitação e um aumento do nível médio do mar de 15 cm para o ano de 2035. Os critérios para a adoção destas alterações no regime de chuvas e condições de contorno da bacia estão fundamentados no relatório regional do Projeto COPPETEC: PPE 18954 (Rosman 2015) para o ano 2100, considerando a estimativa do IPCC de elevação de 18 a 79 cm do nível do mar. Segundo este relatório, estudos mostram que nas últimas décadas o nível médio do mar tem elevado de 4 a 6 mm por ano. Este relatório considera cenários de mudanças climáticas para 2040 com elevações do nível do mar de 10 cm relativa a um cenário provável em 2040, supondo uma elevação do nível médio do mar de 4 mm/ano (cenário NNM1) e de 15 cm relativa a um cenário pessimista supondo uma elevação do nível médio do mar de 6 mm/ano (cenário NNM2). No presente estudo, é considerado um horizonte temporal até 2035, (considerado um limite razoável de planejamento de aproximadamente 20 anos) e é assumido o cenário NNM2 previsto no relatório em referência.

Desenvolvimento de cenários de urbanização

Os cenários de urbanização consideram os componentes físicos da bacia, tais como topografia, ocupação urbana e infraestrutura física, entre outros. Este passo metodológico, apesar de aparentemente ser mais propositivo do que analítico, resulta da consideração de todas as análises antecedentes e envolve a quantificação de um número de parâmetros qualitativos e quantitativos que resultam nos vários cenários definidos adiante nesta fase. Os parâmetros quantitativos incluem densidade de população, dimensão de lotes, taxas de impermeabilização do solo, cobertura do solo (com valores correspondentes de run-off e Manning), e infraestrutura básica e serviços. Os parâmetros qualitativos incluem características da paisagem, serviços ecossistêmicos e desenho urbano, entre outros. A análise física e histórica da evolução do comportamento hidrológico das bacias dos Rios Perequê-Açu e Mateus Nunes demanda a consideração dos seguintes aspetos:

- as bacias do Perequê-Açu e do Mateus Nunes se comunicavam por uma rede de canais nas suas áreas mais baixas, compartilhando a planície aluvial no trecho final da bacia. As planícies no entorno do rio Perequê-Açu apresenta cotas ligeiramente mais altas que as do rio Mateus Nunes;

- o rio Mateus Nunes foi retificado e esta configuração fez aumentar as velocidades de escoamento, aumentando a capacidade erosiva do rio, que incidiu, escavando o fundo e gerando profundidades do leito que hoje dificultam a comunicação deste com a sua planície de inundação, carregando mais rapidamente e de forma significativa as vazões de cheia para as áreas urbanas.

- a perda de parte significativa da vegetação original da na planície entre os rios Perequê Açu e Mateus Nunes agravou as inundações a jusante. O uso dos terrenos agrícolas (onde a floresta ambrófila original foi praticamente suprimida) para o pasto de gado tem contribuído para a compactação do solo e consequente diminuição da capacidade de infiltração pluvial.

- as planícies aluviais do Perequê-Açu tem sofrido ações antrópicas mais intensas que as do Mateus Nunes, com a construção desordenada de habitações, comércios e condomínios, e há indícios que a ocupação urbana se irá intensificar nestas planícies.

A elaboração de cenários alternativos foi desenvolvido em interação com a análise hidrológica, permitindo verificar a eficácia das soluções e refinar as várias hipóteses de acordo com as respostas obtidas pelo exercício de modelagem. As propostas de projeto desenvolvidas buscam compatibilizar o crescimento urbano com a recuperação de funções hidrológicas e propriedades ambientais do sistema fluvial. Os diferentes cenários consistem na simulação da atual tendência de expansão urbana, e cenários alternativos, de onde decorrem um conjunto de variações, totalizando 44 cenários de urbanização.

Os cenários para B2, C2, D2, E2, F2 e G2 são apresentados neste sumário executivo, acompanhados de uma descrição detalhada. O adiantamento destes resultados justifica-se para facilitar uma primeira leitura e complementar o capítulo 12.3.

CENÁRIO A1 (Modelo de calibração) TR25

➢ este cenário representa a situação física modelada e permite garantir que o modelo está apto a responder às propostas que serão testadas em cada um dos cenários hipotéticos de desenvolvimento urbano. A vazão de referência utilizada para a calibração foi a máxima instantânea calculada para tempo de recorrência de 25 anos a partir de dados de 2007 da Estação Fluviométrica de Paraty, igual a 151,5 m³/s.

CENÁRIO B1 a B3 (Modelo da situação atual) TR10, TR25, TR50

Para a modelagem do Cenário 2, foi atualizado o desenho do rio Perequê-Açu a montante da BR-101, bem como de suas margens nesse trecho. Assim, o modelo foi atualizado em função das condições físicas atuais da bacia, de modo a permitir inserir os projetos definidos para cada cenário de urbanização. Este cenário avalia a situação atual, a partir da revisão do cenário de calibração, que foi definido para 2007.

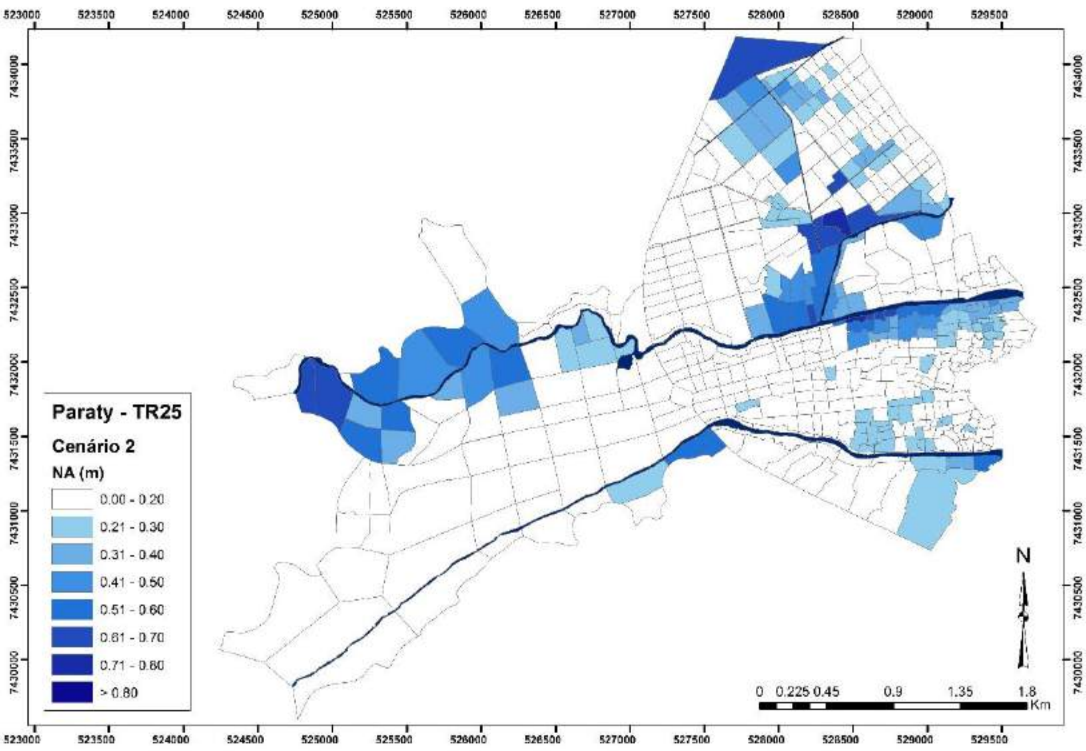


Fig. 10. Cenário B2 (TR25) - modelo atual em 2016.

CENÁRIO C1 a C8 (Modelo tendencial) TR10, TR25 e TR50 com e sem mudanças climáticas + alternância TR10 e TR50 nas duas bacias

➢ Este cenário prevê a continuação da atual tendência de urbanização na planície a montante da rodovia Rio-Santos (BR-101), como é preconizado pelo Plano Diretor de 2010 (Prefeitura de Paraty, 2011). Este cenário assume a expansão urbana de toda a área proposta pelo Plano Diretor com a finalidade de mostrar os impactos da atual tendencia de expansão urbana, se a ocupação não for controlada e nenhuma ação sistêmica for definida. Para a modelagem do Cenário 3 foram adotadas as seguintes modificações ao Cenário B:

- Aterro de 1m em toda a planície a montante da BR-101, inclusive na margem esquerda do Perequê-Açu;
- Aumento do runoff para 0,75;
- Diminuição do Manning nas ligações: de 0,15 foi para 0,06;
- Diminuição da largura das ligações (a ligação entre as células passa a ser feita através do sistema viário).

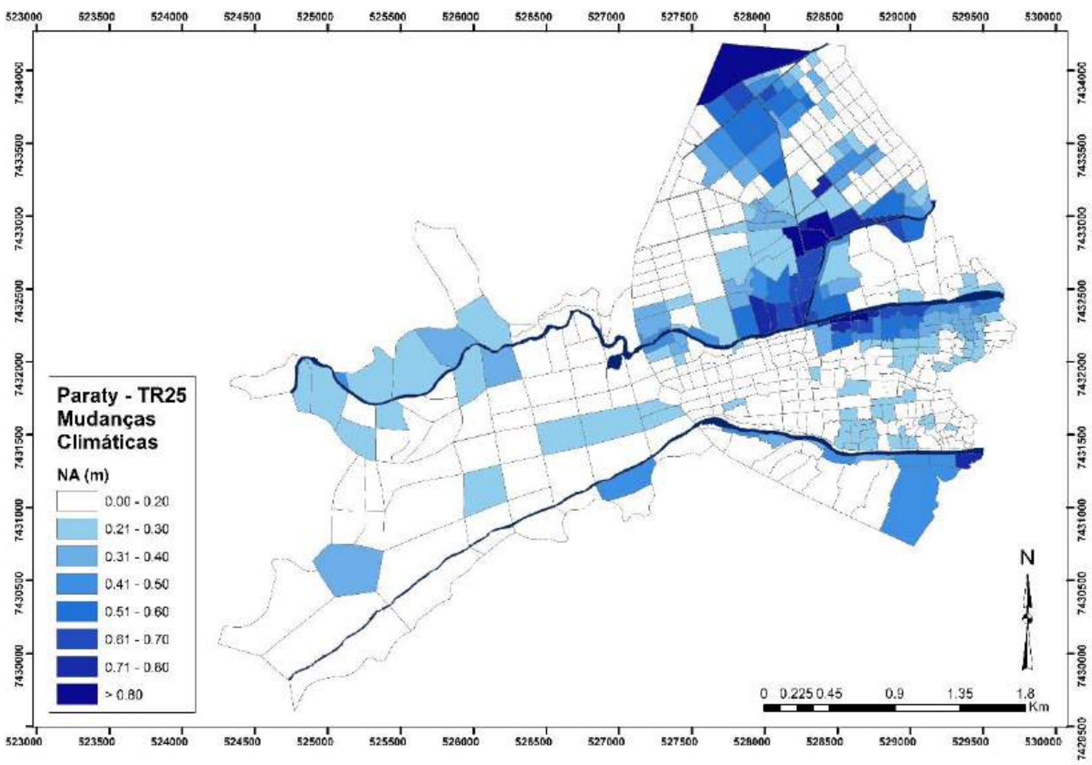


Fig. 11. Cenário C5 (modelo tendencial) TR25 com mudanças climáticas para 2035.

CENÁRIO D1 a D8 (Modelo cumulativo) Cenário C + Alterações no Jabaquara (sem parque Jabaquara) + dragagem (TR10, TR25 e TR50 com e sem mudanças climáticas + alternância TR10 e TR50 nas duas bacias)

- Este cenário configura uma situação de máxima ação antrópica, considerando as restrições impostas no cenário C de ocupação da planície sem a adoção de medidas de adaptação do uso do solo, acumulando todas as medidas propostas no cenário E. Pretende-se mostrar que a ocupação indiscriminada de montante impede o desenvolvimento de uma solução que minimize os alagamentos na cidade, com impactos irreversíveis no funcionamento da bacia, mesmo com novos investimentos em infraestrutura.

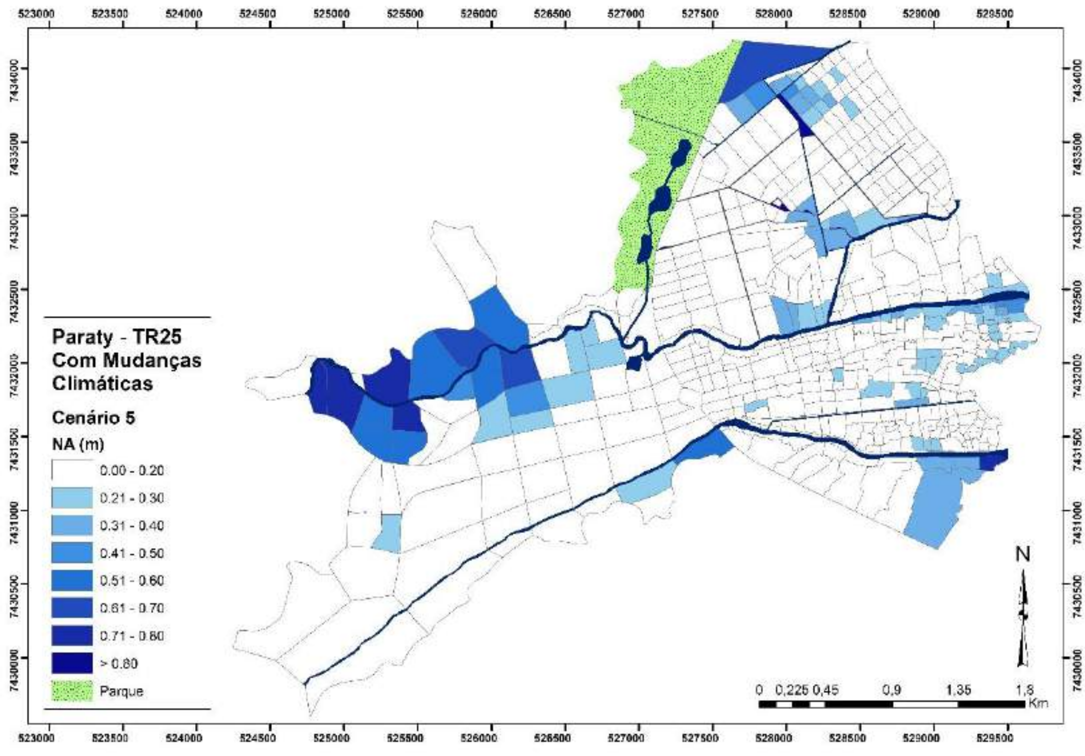


Fig. 12. Cenário E5 (modelo compacto) TR 25 com mudanças climáticas para 2035.

CENÁRIO E1 a E8 (Modelo compacto) Cenário B + parque Jabaquara + alterações no Jabaquara + dragagem (TR10, TR25 e TR50 com e sem mudanças climáticas + alternância TR10 e TR50 nas duas bacias)

Este cenário direciona o crescimento urbano para os espaços abertos a jusante da BR-101, com maior incidência no Bairro de Jabaquara, mas também considerando a ocupação de outros espaços abertos remanescentes (e.g. área do aeroporto). Este cenário define taxas de ocupação mais elevadas na área de Jabaquara e outros espaços remanescentes junto à área urbana consolidada, que têm a drenagem para o mar facilitada, sem incorrer em acréscimos de vazões para o centro histórico. A preservação das àreas de planície a montante da BR-101 é a medida de adaptação do uso do solo mais relevante, definindo os espaços abertos remanescentes da planície aluvial como área de infiltração fluvial e amortecimento de cheias, transferindo o seu potencial construtivo para a área de Jabaquara.

A introdução de novos canais complementares da rede hídrica existente visa reconectar o sistema hídrico, e recuperar propriedades naturais de flexibilidade da bacia, aumentando a capacidade de drenagem através do direcionamento de parte do fluxo do rio Perequê-Açu para Jabaquara. É importante notar que a implementação destes canais, embora sejam artificiais, recuperam a distribuição natural de fluxos na foz, que originalmente drenavam grandes volumes para a zona localizada a Norte do Morro do Forte, hoje denominado de Bairro de Jabaquara. A nova rede de canais propostas é assumida também como elemento definidor do desenho urbano proposto para este cenário, valorizando a presença destes elementos na paisagem local, que se adequam particularmente ao espírito do lugar.

A dragagem do Canal do Jabaquara, do Rio Perequê-Açu e do rio Mateus Nunes, nos trechos a jusante da rodovia BR101, para a remoção dos sedimentos em excesso observados na situação atual, visando recuperar as condições de escoamento e características de seção transversal anteriores aos processos de assoreamento por desmatamento a montante ou pela retificação de cursos d’água.

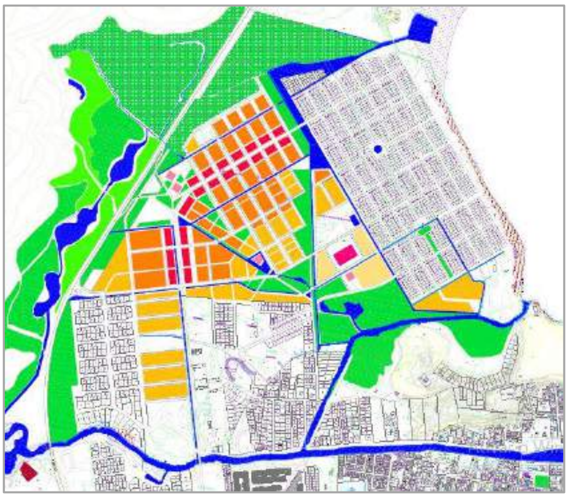


Fig. 13 (à esquerda): Área de intervenção proposta no cenário E- modelo compacto.

Fig. 14 (à direita): Desenvolvimento urbano proposto para a àrea de intervenção.

Para a modelagem do Cenário E, utilizando-se o Cenário B como base para a modelagem, sobre o qual foram feitas as seguintes modificações:

- Desvio do Perequê-Açu para o parque feito através de canais de 12m de largura com declividade de fundo semelhante à declividade do rio;
- Inclusão de três lagos com amortecimento da vazão desviada que servem para alimentar dois dos canais propostos (através de um orifício circular de 1m de diâmetro cada) e o canal já existente na região (através de dois orifícios celulares de 1,20m de lado cada).
- Aterro nas células com cota menor que 1,50m na região do Jabaquara;
- Aumento do runoff na área, calculado de forma ponderada de acordo com a ocupação proposta. Para o cálculo, foram utilizados os seguintes valores: 0,75 para Alta Densidade; 0,6 para Média Densidade; 0,4 para Baixa Densidade;
- Diminuição do Manning na ligação: de 0,15 foi para 0,06;
- Diminuição da largura das ligações (a ligação entre as células é restringida ao sistema viário e à rede de canais proposta);
- Transformação de algumas células de planície em células de canal para representar a inclusão da rede de canais proposta, com consequente alteração do tipo de ligação dessas células (passam a ligar com suas margens por vertedouro).

- Diminuição da cota de fundo das células do Canal do Jabaquara e dos rios Mateus Nunes e Perequê-Açu desde a BR-101 até sua foz, além dos canais existentes na região do Jabaquara;
- Diminuição do Manning de ligação em algumas seções dos rios devido à dragagem;
- Aumento da largura de saída do canal do Jabaquara para o mar;
- Aumento da largura dos canais existentes na região do Jabaquara;
- Inclusão do canal do aeroporto com transformação das células de planície em reservatório.

CENÁRIO F1 a F8 (Modelo resiliente) Cenário 2 + parque Jabaquara + Alterações no Jabaquara + dragagem + Ocupação controlada a montante da BR + Parque Mateus Nunes + ligação das bacias + soleiras (TR10, TR25 e TR50 com e sem mudanças climáticas + alternância TR10 e TR50 nas duas bacias)

- Este cenário procura uma solução de compromisso com as dinâmicas de mudança de uso do solo registadas na bacia. São propostas medidas de conservação ambiental das áreas a montante da BR-101, permitindo, porém, a ocupação de parte da bacia. A ocupação seletiva e controlada de áreas a montante da BR, procura direccionar o crescimento urbano para as áreas onde já se encontram vetores de expansão, de forma a conciliar o desenvolvimento urbano com a necessária conservação e otimização dos serviços ecosistémicos prestados pela planície de inundação. Este cenário enfatiza as medidas de restauração fluvial e ações de reflorestamento, bem como restrições à ocupação de áreas a montante do BR-101. Evitando ocupação plena de montante, não se preveem aterros generalizados nessa área (embora sejam permitidas regularizações e ajustes nas áreas de loteamentos controlados), configurando um cenário que respeita a lógica de requalificação fluvial e procura otimizar o uso dos recursos existentes.

A requalificação fluvial do Rio Mateus Nunes propõe a reconexão de meandros e recomposição da mata ciliar original. Nessa configuração, as áreas de planície da antiga propriedade localizada entre o rio Mateus Nunes e a estrada Paraty Cunha são convertidas em parque urbano, seguindo o conceito de paisagem multifuncional.

Propõe-se a classificação desta área como zona de infiltração pluvial e amortecimento de cheias, explorando um conjunto de benefícios da preservação desta unidade paisagística, através do incremento dos serviços ecosistémicos prestados por esta área, tais como enriquecimento da biodiversidade e qualidade do ambiente urbano, proporcionando neste espaço um conjunto de atividades culturais e recreativas, atividades desportivas e educação ambiental.

O desenho deste cenário inclui o desenvolvimento de uma proposta de utilização da margem direita do Mateus Nunes para a prática de golfe. De modo a desenvolver uma solução realista para o desenho destas lagoas, esta solução foi desenhada pela equipa especialista em campos de Golfe internacionais do Arquiteto Jorge Santana da Silva, que desenvolveu um ante-projeto para um percurso de golfe de 18 buracos especialmente desenhado para a margem esquerda do Mateus Nunes, tomando em consideração as características bio-físicas do terreno e sua adequação a esta prática desportiva. Pretende-se assim avançar uma possibilidade de uso compatível com a preservação desta área.

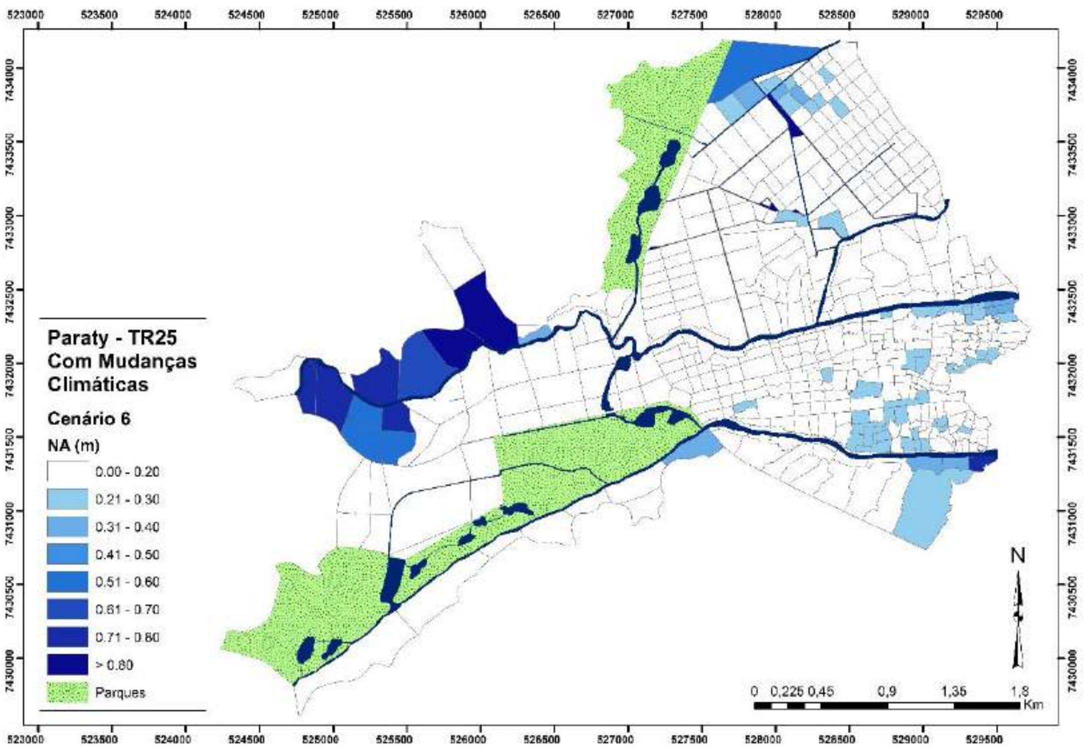


Fig. 15 Cenario F5 (modelo resiliente) TR 25 com mudanças climáticas para 2035.

Neste cenário, propõe-se recuperar a relação do rio Mateus Nunes com suas planícies de inundação, de forma a garantir um amortecimento para suas vazões e permitir que as vazões do Perequê-Açu que aportarão ao seu leito não gerem extravasamentos de calha. Verificando-se que o leito do rio Mateus Nunes sofreu um processo de erosão que destanciou da cota de vertimento pelas suas margens, não seria razoável pensar em uma dragagem das áreas marginais, pois isto levaria à remoção de grandes volumes de terra. Dessa forma, é proposto como alternativa, a introdução de soleiras submersas no curso do rio Mateus Nunes, para forçar a subida do fundo por assoreamento nestes locais, recuperando em parte a declividade mais suave que existia antes do processo de erosão, facilitando assim o extravasamento para as planícies de inundação. Através desta solução técnica, os parques são inundados pelo extravasamento do rio Mateus Nunes. Ao longo da lagoa proposta junto à BR-101, propõe-se a construção de um dique, impedindo que as águas armazenadas temporariamente usem a BR como dique (o que poderia interferir estruturalmente com seu aterro). O dique também permite que as águas do Perequê-Açu usem a calha do Mateus Nunes, enquanto o parque, a montante, amortece a inundação do Mateus Nunes, para que os volumes de água do seu pico de cheia passem após os volumes de pivo de cheia do Perequê-Açu - ou seja, os picos são desacoplados, o que faz aumentar a capacidade da calha existente. Apesar disso, em caso de cheias maiores no Mateus Nunes, este ainda pode compartilhar a àrea das lagoas que compõem o caminho dessa ligação com Pereque-Açu.

A abertura de novos canais ligando as duas bacias hidrográficas permite reconectar os rios Perequê-Açu e Mateus Nunes, de forma a que estes voltem a compartilhar parte da planície de inundação, aliviando os riscos de inundação quando esta incide sobre uma das bacias separadamente (no Mathes Nunes ou no Perequê-Açu), como tem sido verificado em eventos de cheia registados anteriormente. A criação de áreas de armazenamento de água temporário a montante da BR, pela margem esquerda do Perequê-Açu, aproveitando a própria oportunidade gerada pelo aterro da estrada, que oferece condições de retenção da água desviada por um novo braço do rio Perequê-Açu para a área de Jabaquara.

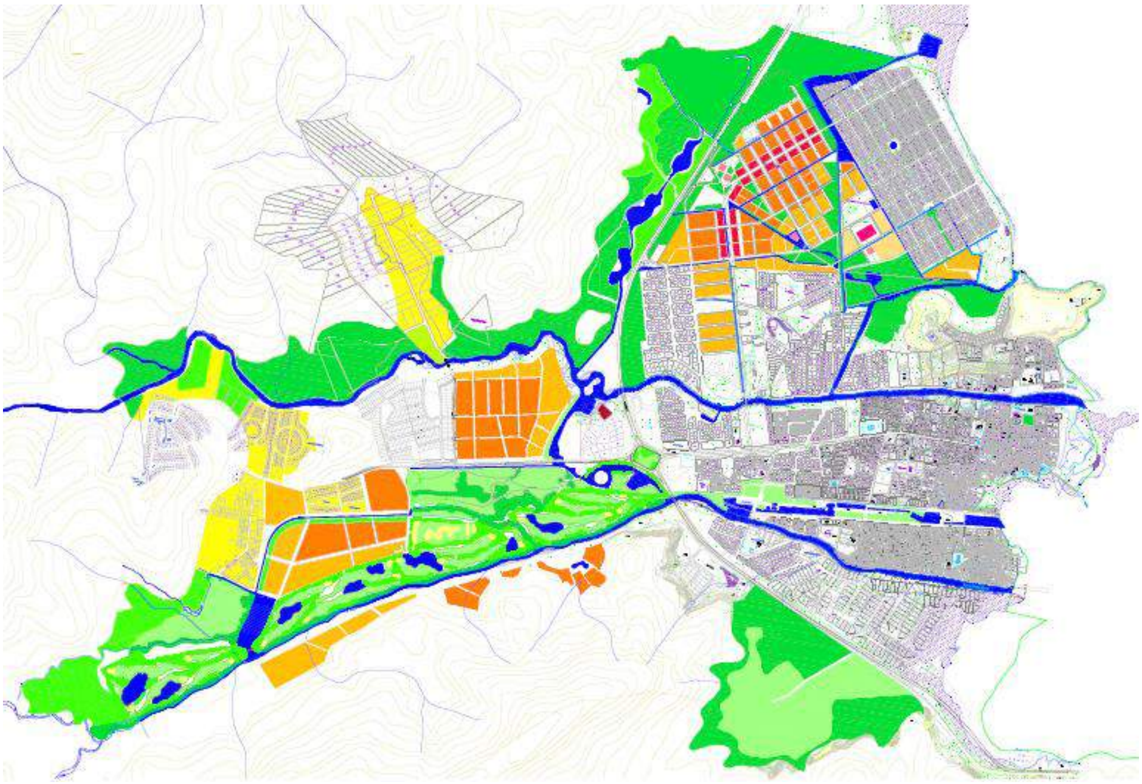
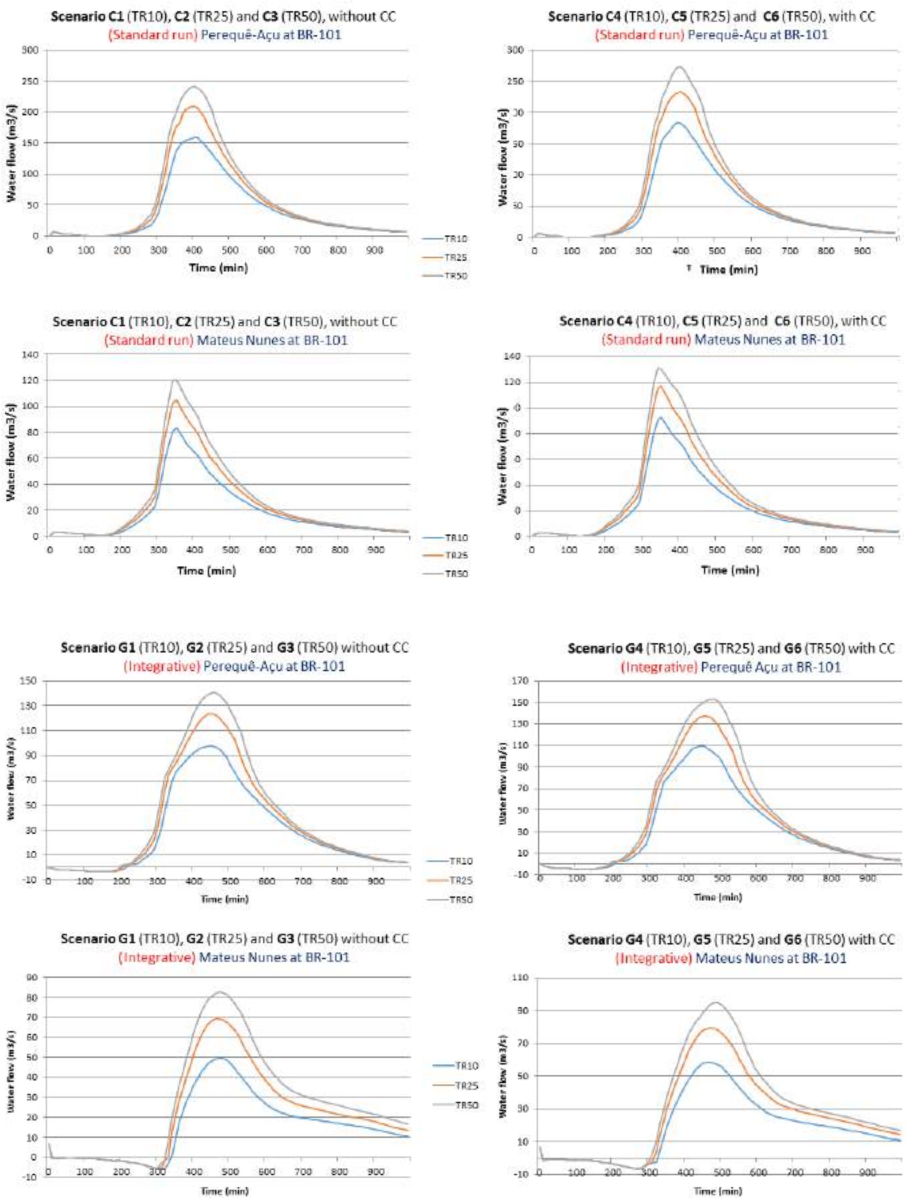


Fig. 16 Mapa de uso do solo proposto para o cenario F (modelo resiliente)

A modelagem do Cenário 6 considerou, além de todas as modificações realizadas ao Cenário 2 para o Cenário 5, as seguintes alterações:

- Considerou-se aterro de 1,0m na área de ocupação proposta;
- Considerou-se aumento do runoff na área, calculado de forma ponderada de acordo com a ocupação proposta para as áreas a ontante da BR101. Para o cálculo, foram utilizados os seguintes valores: 0,75 para Alta Densidade; 0,6 para Média Densidade; 0,4 para Baixa Densidade;
- Diminuição do Manning na ligação: de 0,15 foi para 0,06;
- Diminuição da largura das ligações (a ligação entre as células passa a ser feita por ruas).
- Foram criadas células para representar o canal de ligação entre as bacias;
- A ligação do canal com o Perequê-Açu e com o Mateus Nunes é do tipo vertedouro. O Perequê-Açu passa a alimentar o canal a partir do momento em que atinge a cota 1,0m;

- Também foi representado um dique ao longo do canal de ligação em sua margem direita na área do Parque proposto com cota igual a 4,50m.
- Foram propostas duas soleiras, uma com cota de vertimento de 2,50m (mais a jusante) e outra com cota de vertimento de 3,50m (mais a montante).
- Foi representado um dique associado a soleira mais a montante em uma área do parque, com cota igual a 4,80m.
- Foram criadas células para representar os novos lagos e canais do parque proposto.



Hidrogramas comparativos do cenário C (tendencial) e cenário G (integrativo)

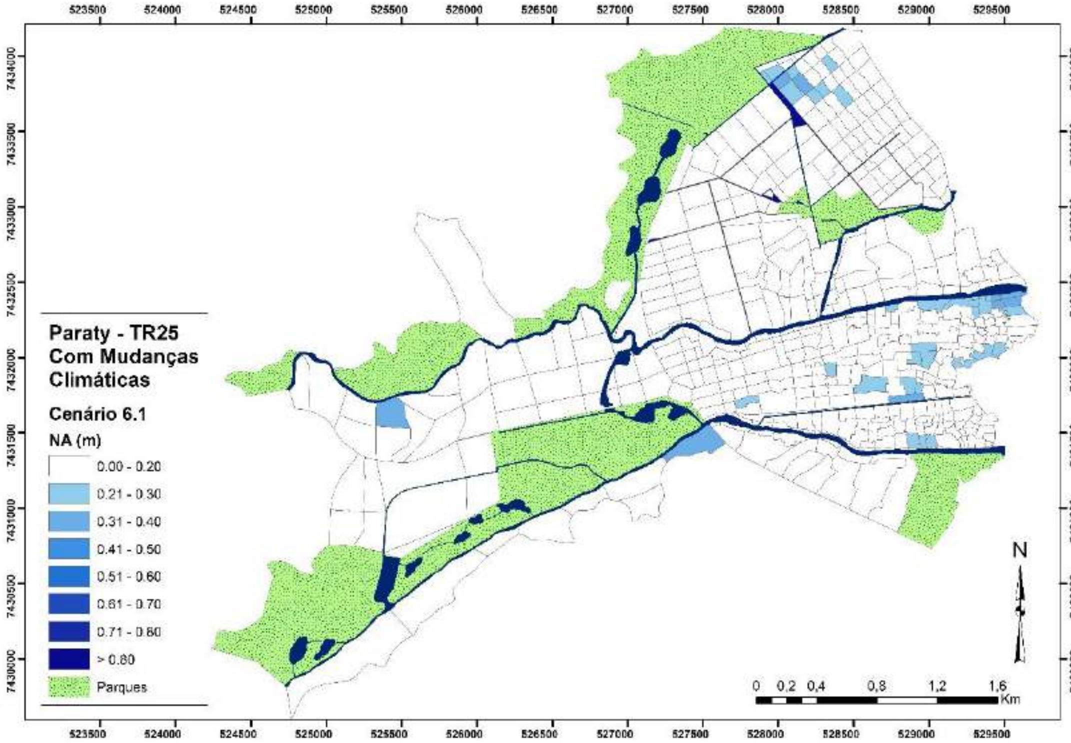


Fig. 17 Cenário G5 (modelo resiliente) parque urbano na planície a montante

CENÁRIO G1 a G8 (Modelo integrativo) Cenário 2 + parque Jabaquara +Alterações no canal do Jabaquara e dragagem + Parque Mateus Nunes + ligação das bacias + soleiras + dique + cota de segurança no Condado + novo canal Aeroporto (TR10, TR25 e TR50 com e sem mudanças climáticas + alternância TR10 e TR50 nas duas bacias)

- Nesta variação possibilita-se a avaliação separada das contribuições das intervenções adicionais para otimização dos impactos positivos do cenário 6. Um novo canal é proposto na área do aeroporto, prevendo a deslocalização deste equipamento do centro da cidade e criação de um espaço publico ao longo do novo canal. São também definidas cotas de segurança de inundação no bairro do Condado (5.7 m), onde novos loteamentos já implantados se encontram em situação de risco elevado. Esta solução é justificada pelo fato desta área não permitir a construção de diques, uma vez que a drenagem interna não teria saída, a não ser por comportas tipo *flap* ou por bombeamento. Como complementação ao Cenário 6, é também proposto um dique de 1,50m no trecho mais a montante do rio Perequê Açu.

Os resultados que são adiantados neste sumário serão apresentados com maior desenvolvimento no capítulo 11, pag. 224. Neste momento importa salientar, com base nos mapas apresentados nos cenários C e D, como a ocupação de áreas periurbanas a partir de um núcleo urbano que já sofre com inundações a jusante, pode gerar dois efeitos deletérios importantes. O primeiro é o agravamento das inudações no núcleo urbano consolidado, pela impermeabilização de solos a montante, remoção de áreas naturais de retenção e eventual canalização de trechos de rio. O segundo efeito negativo é a eliminação do espaço disponível e necessário para a implantação de medidas sistêmicas de adaptação do uso do solo e recuperação de funções hidrológicas perdidas ou reduzidas ao longo do tempo (por desmatamento, retificações, aterros, atividades agrícolas, etc). A ausência de uma visão sistêmica sobre estes problemas traz uma outra ordem de problemas igualmente importantes, que podem ser melhor avaliados nos cenários E, F e G: a consideração de uma ampla gama de serviços ecossistêmicos (inclusive de amortecimento de cheias), podem potencialmente contribuir não só para o bem estar e a segurança da população, como o desenvolvimento sustentável da economia local através da otimização dos recursos naturais, valorização do ambiente construído e enriquecimento do patrimônio cultural.

X – Posicionamento do autor e contribuições da pesquisa

A pesquisa interdisciplinar é hoje reconhecida como uma necessidade fundamental para a compreensão de problemas do ambiente urbano. No entanto, os desafios que se colocam a um estudante de pesquisa que se propõe a um projeto deste tipo, são mais complexos e multifacetados do que é geralmente reconhecido. Talvez a maior das dificuldades de integrar diversos campos de conhecimento na observação de um determinado fenómeno do mundo real, é a de integrar esses elementos no espaço cognitivo ampliado resultante do próprio processo de descoberta. No caminho que percorri ao longo dos anos que me dediquei a este trabalho, pude testemunhar uma evolução do meu pensamento que me levou a fazer ajustes táticos nas sucessivas investidas ao objeto e sujeito desta pesquisa. Muitas vezes, este projeto se revelou demasiado arriscado, sem garantias de arribar a bom porto. Talvez não por acaso, um Porto Paraty, foi o mote contínuo que escutava no nevoeiro desses dias. Se foi finalmente possível alcançar algum sucesso nesta empresa, deve-se à existência de um fio condutor fundamental, verdadeiramente resiliente, capaz de assimilar e acomodar um processo de aprendizagem dinâmico e nem sempre previsível. Esta tese não é mais do que um exercício de descodificação e discernimento desse fio condutor, traduzida numa linha de pensamento que irei expor nas seguintes páginas, obtido através do trabalho de elaboração científica e integração de um longo processo de aprendizagem.

As minhas experiências profissionais no Brasil, na Índia, em África e na Europa foram particularmente importantes para formar a perspetiva que busco neste estudo, partindo do reconhecimento da inseparibilidade de problemas sociais e ambientais, e da consequente necessidade de formar quadros explicativos multidimensionais destes problemas. Na minha tese de Mestrado apresentada na Faculdade de Engenharia da Universidade do Porto (Barbedo, 2007), baseada na minha experiência profissional em Angola enquanto Técnico de Planejamento Municipal no Programa de Desenvolvimento das Nações Unidas, estabeleci um conjunto de relações entre àreas de concentração de pobreza urbana e vulnerabilidade a desastres hidrológicos. A experiência recente em estudos interdisciplinares no Reino Unido levou-me a procurar fundamentos teóricos para o desenvolvimento de uma abordagem integrada destes problemas. Em 2008, ingressei na Universidade de Birmingham na qualidade de part-time student, completando o curso de Pobreza Urbana e Desenvolvimento ministrado pelo Doutor Philip Amis, que aceitou orientar os primeiros ensaios que deram origem a esta pesquisa, juntamente com o Doutor Dan Van der Horst. No mesmo ano, fui contratado pela WSP International Sweden para trabalhar na qualidade de Urbanista em Tripoli, Líbia, o que me obrigou a suspender temporariamente minhas pesquisas académicas, entretanto retomadas em 2010. Em 2011 fui aceite como candidato a PhD pela Universidade de Birmingham, e foi-me oferecida uma *Visiting Fellowship*, o que me permitiu consolidar os fundamentos teóricos desta pesquisa. Muitos dos conceitos que foram adotados posteriormente e que configuram o engajamento teórico da presente tese, devem muito aos dias, semanas e meses passados na biblioteca da Universidade de Birmingham, e das discussões com colegas e professores durante este período.

Foi em Março de 2012, com a atribuição de uma bolsa de pesquisa pela Fundação da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPPES) que este projeto adquiriu a sua forma definitiva, permitindo sediar a pesquisa no Instituto Luiz Coimbra de Pós-Graduação e Pesquisa em Engenharia da Universidade Federal do Rio de Janeiro (COPPE/UFRJ). Esta decisão foi estratégica para tornar este projeto exequível, e veio confirmar uma intenção antiga de desenvolver estudos de pós-graduação nesta respeitabilíssima instituição. Já em 1997, quando acompanhei Paulo Mendes da Rocha ao Rio de Janeiro num memorável encontro com Oscar Niemeyer, aproveitei a viagem para visitar as instalações da COPPE e a Reitoria da UFRJ na Ilha do Fundão. Em 2010 visitei novamente a COPPE com o inuito de procurar o Doutor Paulo Carneiro, e desde então tenho beneficiado do seu valioso aconselhamento e apoio. Com a orientação de Marcelo Miguez e Paulo Carneiro desde 2012, pude beneficiar das valências técnicas e conhecimento altamente especializado em modelagem hidrológica no Laboratório de Hidráulica Computacional da COPPE, bem como observar mais de perto os processos de decisão política no caso de estudo escolhido. Todos estes aspetos faziam parte da minha proposta de trabalho original, obrigando simultaneamente, ao envolvimento de um conjunto alargado de pesquisadores em diversas vertentes, e a uma imersão profunda na realidade concreta de Paraty. Em 2014, graças a novo financiamento obtido pela Fundação de Amparo à Pesquisa do Rio de Janeiro com a atribuição de uma Bolsa Nota 10, pude finalmente estabelecer uma base física em Paraty para aprofundar o meu trabalho de campo.

O investimento no trabalho de campo neste caso, induziu a conclusões distintas das que seriam possíveis obter numa análise mais limitada ao ambiente do laboratório combinado com a elaboração teórica sobre o tema. O conhecimento empírico permitiu confrontar os resultados dos experimentos realizados no laboratório com uma realidade mais ampla, que ultrapassa os limites do recorte do caso de estudo. A percepção de novos níveis de complexidade, revelou a insuficiência dos processos analíticos remotos, bem como o perigo de generalizações conceituais e insuficiente análise crítica de correntes de pensamento distanciadas da realidade prática. Por outro lado, a observação e acompanhamento dos processos de deliberação política em Paraty, permitiu construir um conhecimento “a partir de dentro” dos processos geradores de dinâmicas de uso do solo na àrea de estudo. O contato direto com os diferentes atores sociais, bem como acompanhamento dos processos de discussão pública relativos ao desenvolvimento urbano da cidade e do município, permitiu identificar diferentes lógicas de disputa de agentes públicos e privados na apropriação e transformação do território.

No âmbito do grupo temático criado pela Prefeitura de Paraty para discussão das propostas do Plano Diretor de 2010, apresentei contributos para a revisão das propostas de uso do solo propostas por este plano. Foi-me concedida a oportunidade de fazer uma apresentação formal no IPHAN, entre outras apresentações públicas sobre o impacto das mudanças do uso do solo nas inundações, bem como discussões em círculos mais restritos com a participação de atores-chave. Estas discussões permitiram debater os resultados preliminares da modelação hidrológica com estes atores contribuindo assim para uma mudança positiva da percepção destes atores sobre os impactos esperados pela atual tendência de expansão urbana no município. O desenvolvimento de cenários hipotéticos de desenvolvimento urbano visando a redução das inundações urbanas no Município, permitiram avaliar potenciais custos e benefícios hidrológicos de diferentes opções de uso do solo. A introdução destes elementos no ambiente sócio-político local (ao confrontar os atores com resultados preliminares e observar seus efeitos na percepção e atuação de cada um) constitui uma inovação metodológica neste tipo de estudos. As recomendações ao Plano Diretor apresentadas neste trabalho foram incorporadas ao conjunto de contribuições a serem enviadas à equipa responsável para a elaboração do futuro Plano Diretor de Paraty. Estes desenvolvimentos recentes apontam para um quadro de fortalecimento da esfera pública na tomada de decisões, preconizados por pesquisas anteriores desenvolvidas sobre o caso de Paraty. No entanto, o processo de democratização e transparência dos processos de decisão política tem sofrido avanços e recuos, revelando ainda notórias fragilidades para a consolidação da capacidade técnica e competência institucional do poder público para uma efetiva regulação das dinâmicas de mudança do uso do solo, bem como um claro deficit de articulação entre a atuação dos agentes económicos e as necessidades reais da sociedade.

Existe um longo caminho a percorrer entre tornar uma questão socioambiental específica num objeto legítimo de debate político, e a adopção de medidas efetivas por parte das autoridades políticas responsáveis, dependendo em grande medida da capacidade de mobilização de agentes económicos e sociais na construção de um novo paradigma de produção do espaço urbano. O que se identifica como necessário para avançar nesta construção coletiva, é descrever, com a máxima precisão possível, as lógicas de cada um dos atores; que estão instituídas, implícita ou explicitamente nos modos de produção e reprodução do espaço urbano; e que se encontram sedimentadas num determinado conjunto de práticas de governânca, a que eu irei chamar de governamentalidade da terra urbana. Longe de querer entrar aqui numa discussão etimológica do conceito originalmente enunciado por Foucault, o que sustenta o uso deste conceito ao longo deste trabalho é a possibilidade de apontar com mais rigor e clareza as causas que estão na raiz do problema focado neste estudo, aumentando as possibilidades de confirmar ou não, a validade das teses que irei apresentar.

Reconhecem-se à partida, limitações inerentes ao presente trabalho para esgotar esta discussão, bem como do seu potencial contributo para a academia, onde aqui se abrem mais avenidas de pesquisa do que soluções para os desafios que se colocam às cidades Brasileiras contemporâneas, face aos enormes conflitos socioambientais e políticos que o país enfrenta. No que concerne à sua aplicabilidade prática, será necessário um maior distanciamento para uma análise crítica das contribuições desta pesquisa para a afirmação de uma política de adaptação do uso do solo que assume o sua necessária dimensão transformativa, no que respeita ao equilíbrio entre interesses público e privados através do cumprimento da função socioecológica da propriedade. Mesmo que algumas pistas possam ser oferecidas por este estudo, muitas questões permanecem em aberto. Do ponto de vista académico, a abordagem proposta neste estudo acrescenta valor aos métodos convencionais focados na análise mais restrita à avaliação de riscos de cheias urbanas, identificando um campo mais amplo de ferramentas de análise para situar o problema dentro de um determinado contexto sócio-politico. A utilização concertada destas ferramentas em pesquisas futuras congéneres poderá contribuir para uma melhor integração entre conhecimentos técnico-instrumentais e questões políticas de difícil tratamento no âmbito da governança urbana. Os elementos teóricos e metodológicos reunidos neste estudo, oferecem um arcabouço conceptual poderoso, passível de ser desenvolvido em estudos posteriores, para observar os problemas em tela sobre diversos ângulos, permitindo identificar um conjunto de articulações e relações entre os diferentes aspetos a ser analisados. Espera-se assim contribuir para uma dinâmica de pesquisa que excede os limites necessariamente impostos a este trabalho, um largo espectro de possibilidades de desenvolvimento para investigação futura.

PART ONE: PROPOSITIONS OF THE STUDY

1. Introduction

In taking the title *Urban flood mitigation through land-use adaptation*, this thesis proposes to explore an original concept for the effective operationalization of mitigation and adaptation theories in concrete practices of public policy. Such a proposition departs from two fundamental ideas: the first is to redefine urban flood mitigation as a set of socioecological functions within a given urban structure, and the second is to narrow down the concept of adaptation to an urban policy directed toward the adjustment of land-use change dynamics to these functions. The central hypothesis of this study is that the interconnection of these concepts may inform an urban policy for broadly changing the current patterns of unsustainable depredation of natural resources in the process of producing the urban space, with emphasis on the mitigation of its effects on flooding and related social vulnerabilities. In the context of the present study, this hypothesis links mitigation and adaptation theories to a fundamental principle contained in Brazilian law: the Social Function of the Property and the City, which establishes external limits to the exercise of property rights. Defining flood mitigation as a socioecological function is not only a matter of theoretical rigor, but is also a powerful conceptual tool for a more concrete definition of the public interest related to the use of urban land. Thus, this thesis is aligned with a conceptualization of environmental and urban problems that seeks a sustainable path in the "adaptive reproduction of urban structures that have a focus on the readjustment of the legitimacy bases of urban policies" (ACSELRAD, 1999a), thereby emphasizing the need for further politicization of urban issues, while also taking into account a spatialized view of these issues.

While this study focuses on the role of land use in urban flooding, as a physical problem of natural sciences, it also clearly consubstantiates a problem of social theory and political sciences. These multiple dimensions make it particularly challenging to circumscribe the object of analysis and to choose the issues to be explored since doing so immediately raises a number of dilemmas: how can such a broad theoretical field be covered without incurring the risk of ignoring the depth that each of the issues involved demands? If land-use adaptation is not yet an established field of knowledge in the literature, what essential aspects should be put in the foreground for justifying this investigation? And how can these aspects be presented within the limits of the present work, in order to sustain a dynamic of research directed for furthering our understanding of its theoretical relevance?

In order to answer these questions, an intense effort has been made to review and map related discussions within quite diverse subjects. One of these discussions is the political debate on climate change, that global dimension of geopolitics where the problems of urban environment transition seem to be paradoxically acknowledged and overwhelmed by an ecological crisis at a planetary scale. There is the problem too of some ambiguities regarding the notion of adaptation when applied to social systems, and the epistemological alternatives set forward by the notion of "transformative adaptation." There is the socioecological debate on ecosystem services and what has been defined as ecosystems-based adaptation. And there is the conceptual evolution of the different modes of "dealing with floods" that I have attempted to understand as an emergent field of knowledge, provisionally called here *integrative flood science*. This evolving scientific field necessarily involves all the other subjects, and therefore it will be discussed later as to what extent it may be worthy to approach its redefinition from a more integrative perspective. In the same vein, land-use adaptation may be seen as a first approach of bringing these discussions together within the political realm, departing from an interdisciplinary dialogue between them.

An obvious problem that arises from this problematization is the practical impossibility of covering all the aspects that deserve a careful examination here. What is possible within the modest dimensions of this work is to show how some fundamental problems are interconnected, and how its implications for urban policy may be better grasped through the approach it proposes. There are also limits on any attempt to reconstruct the abovementioned diffuse theoretical context into a relatively autonomous scientific field[5], since, in this case, Bourdieu's (1975) notion of "relative autonomy" may

[5] As referred in the previous note, the notion of field has been developed by Pierre Bourdieu, initially for analyzing an intellectual field (BOURDIEU, 1966). The field is considered relatively autonomous in the sense that its participants follow its own distinctive rule or logic (Ji, 2014). In the words of BOURDIEU

have limited application. More than a field of analysis, land-use adaptation emerges as an *urban question* in the sense given by Castells (1977). But the comments that will be soon introduced here regarding this question should be read as an attempt to move beyond a mere ideological discussion[6] toward the development of new methodological tools for analyzing problems of public policy concerning urban land. This brings a second order of challenges related to the choice of the theories which may be used to interpret the sociopolitical context where land-use change processes and related decisions take place, as well as the logics of the various participants which are behind these processes and decisions. These choices will be presented in the next section, after describing the core problem of this research and the theoretical approach for tackling this problem.

1.1. Problem statement

Today, the technical-scientific means available for objectively investigating the hydrological functioning of urban watersheds makes it possible to ascertain, to a fairly detailed level, the impacts of territorial changes on flooding, as well as the possibilities of adapting land-use change processes according to hydrological functions. But existent studies on urban hydrology still need to develop a more complete treatment of political problems concerning the adoption of preventive and mitigative measures, requiring also a more integrated consideration of social and economic aspects for successful implementation. This is because the focus of flood management on institutional and socio-political aspects, rather than solely on technical ones, is a relatively recent field of research. In most studies on flood risk management, risks and impacts are thoroughly outlined, but few consider the governance problems that ultimately lead to the success or

(2004), "the system of forces that are constitutive of the structure of the field … is relatively independent of the [external] forces exerted on the field (pressure)."

[6] Castells (1977) emphasizes that "the urban question (…) is an ideologic question." But Foucault (1994) believed that reasoned explanations to social problems have to be sought "not in an ideology but in the existence of this political technology which we have formed in our own societies."

failure of flood management plans. Moreover, the due consideration of the long-term benefits resulting from the adaptation of peri-urban floodplains aimed at the preservation of water-flow regulation services is even more unlikely in the Brazilian context where the battle for conservation of nature is largely focused on pristine natural areas.

Addressing the challenges posed by urban growth in areas particularly sensitive to flooding requires not only the use of a larger set of tools to view the ecosystem services associated with a particular river basin, but also the consideration of political and economic factors that influence land-use change processes. The focus of environmental management on political aspects understood in a broader sense - involving institutional, social and economic aspects - is a relatively recent field of research. Here lies a methodological challenge of finding an appropriate balance between the analysis of physical processes (in the field of natural sciences) and social-political processes (in the field social sciences), a challenge not yet sufficiently addressed in the literature. From a practical point of view, this gap is reflected in the difficulty of reconciling the formal instruments of land-use planning with processes that influence the actual occupation and transformation of the territory. In particular, current land-use planning and urban water management instruments have revealed their shortcomings in the face of dynamic expansion in peri-urban floodplains, which, when located upstream of consolidated urban agglomerations, result in the worsening of floods in downstream areas. In order to determine the root causes of these problems, this study is focused on the tensions between the understanding of the nature of the problem of urban flooding, the socio-economic factors that influence the phenomenon of suburbanization, and the institutional factors that affect land-use change dynamics.

One of the most problematic issues in the discussion about urban flooding is the difficulty of the actors involved in understanding systemic relations in the territory (PEARCE 1998 BOYER AND POLASKY 2004). Considering these limitations, flood mapping in urban areas is an important element for informing the actors involved in land-use decisions. It is particularly important to consider that the regulatory services of the hydrological cycle are non-transferable ecosystem services that produce benefits for a given urban community as a whole, but through an uneven geographical distribution. This means that the strategic resources for flood mitigation are local and need to be specifically identified. However, the implementation of land-use adaptation measures for the prevention and mitigation of floods faces a number of obstacles due to the lack of integration between scientific knowledge of risks and political, economic, and social rationalities regarding the ways of alleviating these risks. The difficulty of reconciling different visions and establishing meaningful cooperation among a wide range of actors with conflicting interests constitutes major challenges for urban governance. In this regard, Wojciechowski, 2009 pointed out the difficulty of integrating different sectoral perspectives in face of the specific complexities in every public policy area.

According to Beck (1992), what becomes clear in risk discussions are the fissures and gaps between scientific and social rationality in dealing with the potential of danger. In the same vein, it may be said that there is a disconnect between the technical analysis of urban flood risks, and the logics of the various agents who participate in the decision-making processes that determine the degree of exposure to these risks. At a time where the separation between social sciences and natural sciences is becoming less and less possible, the debate on the adaptive capacity of cities remains paradoxically divided among specialists and expert views. Acselrad (1999b) finds this dividing line in "sustainability speeches" between the technical representation of urban structures (in this instance, the analytical study of hydrological functions associated with the process of urban growth) and the politicized critique of the mismatch between the modes of production of the urban space and (their incapacity to respond to) the rhythm of growing social demands. While there is a growing body of literature attempting to bridge physical and socio-political dimensions of urban problems, the difficulty of integrating these views often results in competing claims to rationality. If research on public policy follows with some embarrassment on the footsteps of "technophobia" (BECK, 1992), authoritative studies on urban flood risks rarely bring significant change in land-use policy. Instead, hydraulic engineering expertise studies often contribute to the technical legitimacy of depredatory practices, where each project searches for autonomous solutions analyzed case by case, justifying the piece-meal decisions promoted by the construction business, real estate developers, and private investors.

Peri-urban floodplains are subject to severe socioeconomic pressures for further development, posing a big challenge to sustaining critical water-flow regulation services. Since private net benefits of conversion often exceed those of preservation (VUUREN and ROY 1993), the appraisal of structural measures for flood alleviation is often conducted much more thoroughly than nonstructural measures. In this regard, Corkindale (2007) notes that until nonstructural and structural measures are appraised on equal terms, and in as much detail as traditional hard engineering solutions, it is overwhelmingly probable that the latter will be preferred to the former. Schuyt (2005) argues in an overview paper that policy makers do not understand the full economic value of floodplains. Underestimating the range of ecosystem services that an area can provide is likely to result in inappropriate use and this, in turn, may bring even lower economic benefits (HALLER 2010). This is even more challenging in the Global South, where the need for development is hard to challenge and the battle for conservation is largely focused on pristine natural areas.

Although the role of land-use on the mitigation of flood risks may be measured and spatialized by technical experts, the actual integration of this knowledge in planning and management practices is not a straightforward, purely technical exercise. To date, there is little theory about the pathways for mainstreaming urban flood mitigation, and it remains unclear how local authorities can best integrate adaptation into their development plans and policies (IPCC 2014). Furthermore, it may be questioned as to what extent these measures have failed to be implemented through existing urban planning practices, and what the institutional barriers are for its implementation within the various sectors involved. Discussions on governance such as the ones explored by OECD, 2010; Bulkeley et al. 2011; or Garschagen and Kraas 2011, explore important areas for understanding how socioecological conflicts, such as the ones provoked by the increasing exposure of people and assets to flooding, reflect wider institutional conditions and changing sociopolitical and economic conditions.

Within this larger context, government institutions with specific mandates on land-use planning and management are supposed to make land-use decisions based on reliable information, awareness of socioenvironmental risks, and technical competence. This process also involves negotiating with the private sector and civil society about which urban governments occupy a central role in harmonizing private and public interests. This harmonization is problematic since deliberation on land-use can threaten vested interests of the *status quo* or prioritize the interests of some over the well-being of others (see MEADOWCROFT, 2009; SMITH and

STIRLING, 2010). Adger et al (2009) note that the constraints on implementing adaptation measures are socially constructed by human agency in that economic interests, laws, and regulations, or broader social and cultural considerations, can limit adaptation. In the face of these challenges, the allocation of land-use is never a neutral process and adapting land-uses to socioecological functions requires taking into account these conflicting interests.

1.2. Approach of the research

This thesis addresses these multiple problems from a socioecological perspective, developing a two-pronged methodological path which seeks a balance between spatial and political dimensions of the object and subject of analysis. While the components of the spatial analysis will be described further ahead, something must be said at this stage about the theoretical approach adopted for the analysis and discussion of political dimensions. These are understood in a broad sense, departing from the assumption that the successful allocation of appropriate land-uses fundamentally depends on good urban government (i.e. what government institutions do to safeguard the public interest on land-use decisions) and good governance (i.e. how these institutions work with other stakeholders). Recent discussions in Latin American politics argue that such conflicts configure a governability dilemma (BRUERA, 2013) normally associated in mainstream politics with parliamentary support to maintain the rule of government. The present thesis enlarges the scope of this discussion from a quite different perspective, by introducing the notion of governmentality[7].

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[7] Governmentality has been firstly introduced by Michel Foucault as part of a course on “Security, Territory, and Population between 1977-78 in the College de France. Latelly the concept has been developed in anglophone sociology for studying complex techniques used to manage populations and regulate social conduct,. Some Anglophone governmentality scholars have given a specific neoliberal meaning - see Barry et al 1996 and Dean 1999, 2007) for Foucault’s views on neoliberalism see Foucault (2008) and for a critique of its positions on neoliberal politics, see Zamora and Behrent (2016)

[8] For an introduction to the concept of climate-resilient pathways, see Chapter 20, sections 20.2.3. and 20.6. of the II Working Group of the Fifth IPCC Report (2014).

As it is commonly used in the literature, the distinctive use of the words "government" and "governance" makes it possible to discern the role of the State and the interaction of government institutions with other organizations and socio-economic agents influencing political decisions, as in the case for example, of land-use decisions. In turn, the notion of governability is useful for understanding the political compromises made within related decision-making processes to maintain the stability of elected governments. As pointed out by Bruera (2013), authors like Baiochi and Checa (2007), Leite (2008), Couto (2009), Feres (2010), and Hunter (2011), have generally distinguished economic, political, and societal dimensions of governability. Such a distinction is useful for interpreting these dimensions separately, making it possible to understand how land-use change dynamics are shaped by the balance of forces between the various interests at play. However, the notion of governability does not provide satisfactory conceptual tools for envisioning political change, contributing to a general sense of powerlessness and frustration. Moreover, it does not explain its oxymoron, where the need for establishing political compromises among the various forces contributes itself to the political gridlocks that are meant to be avoided through political negotiation.

There is also a third reason for introducing the concept of governmentality in the literature on urban land policy and risk research: in countries of the Global South, and in other regions strongly marked by a colonial property regime, the political gridlocks for land-use adaptation are heavily influenced by patterns of resource exploitation which cannot be fully grasped by the notion of governability; even worse, the notion of governability can serve to legitimize political decisions that are not merely the product of a national political circumstance, but are also influenced by the hegemonic logics of exploitation, appropriation and commoditization of natural resources. This hypothesis, although it inevitably incurs the risk of overgeneralization, may deserve some further investigation, to which the present work may only give some hints. Meanwhile, by exploring this theoretical approach in the analysis of land-use change processes, the present study will also question to what extent the concept of governmentality may be useful for broadening the understanding of critical problems of urban policy that have been chronically left aside.

The techniques and rationalities developed by the State have been described by Foucault as a political technology formed in a given society. Foucault's notion of political rationality and the concept of governmentality seem particularly useful for explaining how the governability dilemma is solved by combining the narrower interests of the elites with the broader social demands of the population at large, regardless of its environmental costs in the long run. While governability focuses on the conditions for maintaining the power of government within the status quo and existent social demands, governmentality, according to Foucault (2007), focuses on the procedures, tools, and techniques by which the power relations take place. For Jessop, the concept of governmentality allows us to see how the state combines, arranges, and fixes existing micro relations of power, which are then codified, consolidated, and institutionalized (JESSOP, 2007), allowing to highlight certain rationalities of government institutions (WALTERS and HAARH, 2005), but also its interactions with the logics of economic agents and social actors in the configuration of a political technology on which dominant interests are conjugated.

As such, this study is not merely focused on analyzing the impacts of land-use change processes on flooding conditions, but is also concerned with analyzing power relationships between the political actors who are more or less directly involved in these processes. However, it is understood as an essential analytical step to establish an in-depth technical knowledge of the physical problems in question (i.e. assessing flood impacts of land-use change in a specific geographical context) in order to construct a rationale capable of informing a clear articulation of the main environmental conflicts at play. In order to enable this understanding, there is a need to measure and localize water-flow regulation services within a certain context of decision making and within the local landscape where the conflict between development and conservation plays out. It should also be noted that the analysis of these political dimensions of land-use change do not intend to be merely descriptive, selecting particular aspects that the analysis intends to highlight. In this perspective, the impediments for the adoption of mitigating urban flood risks through land-use adaptation measures are identified by considering this two-pronged analytical approach, taking into account the local geographical context of a concrete socio-political reality. The adjustment of land-use change processes aiming to increase the adaptive capacity of urban structures is seen as a continuous problem-solving process, conceived as an evolving relationship between political and technical knowledge, within the warp of a complex interplay of economic interests and social demands.

The increasing exposure of urban communities to flooding is therefore hereby understood as a problem involving multiple dimensions, best understood through the analysis of physical and socio-political dimensions in an interactive research process:

- Regarding socio-political dimensions, I will analyze the factors that contribute to a certain dynamic of territorial transformation where individuals, social groups, and institutions act, influence, and condition each other through a set of formal and informal rules that shape the actions of the various agents involved in land-use change processes;

- Regarding physical dimensions, I will assess, quantify, and map the impacts of different scenarios of land-use change in the aggravation or alleviation of flooding conditions, establishing a causal link between land-use changes and the positive or negative impacts on floods.

This combination of methodological approaches adds value to conventional methods solely focused on flood risk analysis, where these dimensions can be analyzed from: i) surveying political decisions, institutional representatives, and other stakeholders that influence the processes of land-use change; ii) mapping the impacts of different scenarios of urbanization with the help of a hydrodynamic model; iii) communicating the results of the hydrodynamic modeling exercise, making available new information for deliberation processes; and iv) observing the positions and discourse of key-actors on land-use decisions.

This interactive process aims to confront the technical knowledge acquired from the hydrodynamic modeling with the reality of the decision-making process, communicating the results of the modeling exercise within the local context of decision making and within the local landscape where the conflict between development and conservation plays out. In earlier works, it has been argued that knowledge about ecosystem services and landscape values should be clearly communicated and made easily accessible to policy makers, (other) stakeholders, and members of the public (DE GROOT et al, 2010). Such a confrontation allows for identifying the conflicts between divergent interests of various social groups, as well as observing the tension between the rules imposed by institutions and the real choices and decisions of people in response to these constraints.

From this approach, the conversion of peri-urban floodplains is explained as the sum result of individual decisions, but also by social and economic interactions where one can recognize a rationality upon which we can reflect. This requires the observation of the decision making process within a concrete socio-political reality and the drawing of conclusions about the impediments and conditions for its possible transformation. Monitoring the dynamics of different actors involved in land-use decision making throughout this process will help to demonstrate how flood risk is perceived by individuals and institutions and to what extent this is taken into account in collective deliberation processes. Finally, the relationship between the constraints imposed by the physical characteristics of the territory, the rules laid down by the institutions, and the possible answers from a certain socio-economic reality will compose the explanatory framework of the problems under examination.

1.3. Research questions and objectives of the research

Departing from the above theoretical considerations of power asymmetries that have an imprint on environmental change, this research seeks answers to a central question: What are the root causes contributing to the current trend of increasing exposure of people and assets to flooding? In order to answer this main question, two sets of questions will guide the research through the empirical study. I call the first set the factual questions of the research: Who are the main players governing land use change processes and how do they influence land use change dynamics? And, which instruments and mechanisms can be used for regulating these processes and dynamics? Answers to these questions will be confronted with a second set of interrogations, which I call the speculative questions of the research: How do these different sectors interact with each other, contributing to certain outcomes regarding land use change decisions? And, what role do government institutions play at their various levels and sectors in the reproduction of socioecological conflicts related to the production of the urban space? Such questions touch upon difficult problems of urban governance, and answering these are essential steps toward embedding flood mitigation measures into land use planning and management practices.

The aim of this study is therefore to identify the impediments to the adoption of land use adaptation measures for flood mitigation in current land use planning and management practices. The research also has the following specific objectives:

- To develop a hydrodynamic model of the Perequê-Açu and Mateus Nunes river basins with the aid of Modcel;
- To estimate the hydrological costs of urban expansion in Paraty, taking into account the proposals contained in the master plan of 2010;
- To diagnose the main socio-economic factors and institutional factors that influence the current trend of urban expansion in Paraty;
- To develop an alternative urban development scenario designed to mitigate urban flooding and measure its hydrological benefits;
- To document and analyze the processes of deliberation and decision making regarding land use in Paraty between 2010 and 2015;
- To review the relevant institutional framework regarding land use and urban water management in the specific context of the case study.

These objectives will structure the various methodological steps of the research which will be related to each other by critically discussing: i) the impact of conflicting interests and market forces that influence land use decisions; ii) the consequences of action or inaction of the State for the satisfaction of social demands; and iii) the ways by which regulatory institutions contribute (or not) to the legitimization of trends or allow for the pursuit of alternatives for curbing the current trend of increasing flood vulnerabilities.

1.4. Justification of the case study

The particular combination of ecological, geographical, historical and cultural characteristics of Paraty make the choice of this case study particularly appropriate. The leading Brazilian urban planner Lucio Costa described Paraty as "the city where the ways of the sea and the paths of the earth meet and interlock" (my translation).

According to Cury (2002), "Paraty distinguishes from other historical settlements by its interconnection between the forest, the sea and the city (…) in different and constant interactions which characterize this human settlement" (my translation). This study is, to a great extent, about how to make effective use of the understanding of this two-way relationship between water and land, which characterizes the unique landscape of Paraty. The recognized cultural importance of its built heritage and its close relationship with the river and the sea, makes the problem of urban flooding an important threat, reflecting the tensions between conservation and development within a territory of high environmental value. In fact, a significant part of the municipality is considered environmental protection area (83% of the Municipality area), for conservation of the remnants of the Atlantic Forest and its rich biodiversity. So, in addition to historical heritage, the municipality also holds important environmental value, and its relatively long history of attempts to protect the city and its immediate surroundings furnishes the advantages of historical perspective.

Along the last fifty years, many government actions have been taken in various attempts to preserve not only the built heritage of the city, but also its surrounding environment. The cultural landscape around Paraty was crucial for its recognition in 1966 as a National Cultural Heritage site, which are categorized by aspects of environmental diversity and concerns about the preservation of the existing natural resources, as well as the role of local communities in the use of these resources. Recognized as a unique historic gem in 21st century Brazil, Paraty is also a candidate for the designation of UNESCO's World Heritage site. Notably, the latest response of UNESCO to this candidacy stressed the need for a more thorough consideration of the environmental setting in which the city is located. The candidacy process by the National Institute of Historic and Artistic Heritage Brazilian Institute for the Historical and Architectural Heritage (IPHAN) identified many natural and cultural values of the areas surrounding the city which overlay with the water-flow regulation services of the floodplain.

1.5. Structure of the manuscript

This study is organized in five parts, with fifteen chapters in total. Part one includes the first chapter, being this introduction, and the second chapter, which is a description of the methodology adopted by this study. Part two, entitled “Theoretical Foundations of the Research,” is comprised of a literature review of the broad topics referred in the introduction. The empirical parts of the research are broadly divided into two parts: Part three, “Policy Analysis,” and Part four, “Spatial Analysis.” Finally, Part five presents the discussion, recommendations, and conclusions.

2. Methodology

In this section I describe the methods employed in this research. As discussed in the introductory chapter, this research proposes to situate the problem of urban flooding within its specific sociopolitical context, considering the way public institutions condition land use change dynamics as well as the social and economic factors that influence such processes. Incorporating these multiple dimensions require an examination of the object of analysis from multiple dimensions, which seeks an appropriate analytical balance between spatio-physical aspects (natural science research) and sociopolitical aspects (social science research). In the next section, I present the analytical framework developed for this research, followed by a more detailed description of each analytical step.

2.1 Analytical framework

The analytical framework of this research is organized in a six-fold structure which has been specifically designed to clarify the main analytical steps of the research without losing sight of the unity of the object of analysis. The six analytical steps are equally divided between the policy analysis and the spatial analysis. The policy analysis considers the institutional setting, legal framework, and stakeholders. The spatial analysis considers land use change dynamics, scenario development, and hydrological study.

Concerning the policy analysis, the research focuses on identifying the institutional relationships understood in a broad sense, including legal, political institutional, and societal aspects.

- The legal framework consists of the broad policies on urban and environmental governance at the federal and state level, understood as formal *external rules* conditioning land use change processes. This includes fundamental constitutional principles and policy guidelines on urban governance, as well as the legal framework related to the land use planning and water management. This analysis helps define the legal instruments that may serve for adapting land use change dynamics.

- The institutional setting is concerned with the structural side of environmental governance, composed of the government agencies with specific duties and responsibilities on land use planning and water management, and the corresponding institutional arrangements in place. This analytical step helps define the *roles* of government organizations with specific responsibilities on land use planning and water management.

- The stakeholder assessment is concerned with *internal stakes* (i.e. the interests of the actors) that influence and condition land use change dynamics at the micro-level of decision making. This analysis will take into account the priorities and rationalities of driving socio-economic forces involved in land use decisions and helps identify *conflicts of interest* on land use decisions.

Concerning the spatial analysis, the analysis focuses on the ecosystemic relationships between land and water—more specifically, between land use change dynamics, urbanization processes, and hydrological functions—and aims to understand the way land use change dynamics interfere with flooding conditions.

- The analysis of land use change dynamics includes a thorough description of the main geographical features of the territory under study. Particular attention is paid to existing socioecological conflicts. This analysis helps identify *trends* of urbanization in the study territory.

- The development of hypothetical scenarios of urban development for the study area helps to develop *alternatives* to the identified trends.

• The hydrological study includes the characterization and hydrodynamic modeling of the river basins, detailed flood mapping of the study area, estimation of hydrological costs, and benefits of the hypothetical scenarios.

These analytical components form a multi-dimensional datacube, which may be represented schematically in the following diagram:

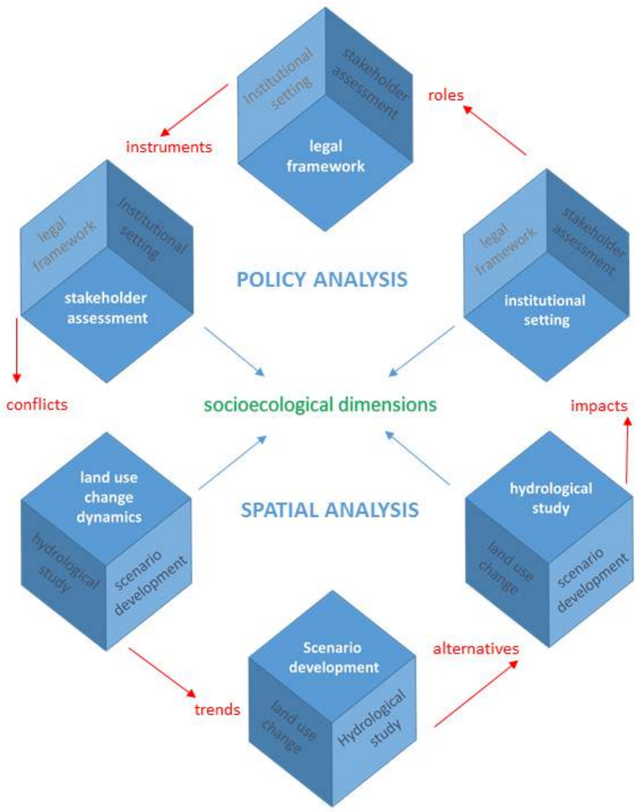

Fig. 18. Analytical framework representing the interactions between the six analytical steps

The above analytical framework condenses the main components of analysis and attempts to show how these are inter-related. The results of these various aspects will be extracted both directly from each of the analytical component, as well as from establishing relations between spatial and political aspects of the analysis along each methodological step. This integrated approach allows for the comparison of the results of the various analyses undertaken, examining the intersections, interactions, and interdependencies of socioecological dimensions of the analytical object. It is through this reconstructive effort that the unity of this object will be rebuilt in the discussion, considering economical, governmental, and societal logics that shape land use change dynamics in the study area.

2.2. Analysis of the legal framework

The analysis of the legal instruments considers legislation affecting the planning, management and use of land and water, as well as constitutional principles and policy guidelines of urban policy contained in the City Statute. This analysis also considers political and legal aspects of particular relevance to the theme of flood mitigation and land use adaptation. The central focus of the analysis is on the relationships between the process of policy making and the existent juridical setting in Brazil, highlighting the mismatches between normative and practical realities and the fact that recent advances in the legal framework at the national level of governance have not yet been internalized at the local and regional levels. On the other hand, the set of approved laws are considered the result of political struggles for the recognition of rights, duties, and powers within a continuous historical process, which is not successful since these are not effective in practice. Hence, this section is an attempt to link adaptation policies to land use planning and water management and to connect these with socioecological principles solidly established in the Brazilian Constitution and the City Statute, among other important legal provisions.

Direct research has been collected from the Brazilian legislation, together with indirect information yielded from a desk-based study of national reports, ministerial boards, forums, and debates promoted by governmental agencies. An examination has been made of the norms, legal instruments, and mechanisms that effect the regulation of land use change processes in the urban context, paying particular attention to its interconnections with water resources. The principle of the Social Function of Property is emphasized as a central normative guideline for embedding flood mitigation in land use decisions, based on the argument that it comprises both social and ecological dimensions within its overarching constitutional principle. Considering that a coherent body of policies on flood risk management is not yet fully developed in Brazil, this analysis outlines a body of relevant legislation which may be used for the mitigation of land use impacts on flooding and highlights recent innovations in the Brazilian law concerning land use and water management as well as other institutionalized norms affecting land policy.

2.3. Institutional analysis

The institutional analysis will present a critical analysis of the responsibilities of key public institutions and relevant legal instruments, focusing on the interactions among intersections of the local, state, and federal levels of government. This assessment is based on a desk-based study of national reports, ministerial boards, forums, and debates promoted by governmental agencies on land use planning and urban water management. This analytical component focuses on the institutional conditions of decision making and the structural aspects (i.e. institutions, norms, and procedural settings) that directly or indirectly affect land use and water management policies. Institutional conditions are hereby understood as the setup of organizations with a rule-like status underpinned by normative systems to regulate land use and water management. A revision of a body of policy-related literature about recent innovations in the Brazilian law concerning land use and water management is also included, considering the legal framework as institutionalized norms.

The institutional analysis is based on a desk-based study of official documents that guide national policies on land use and water management. A survey of the main programs and government sectors involved with the theme of the research was performed by examining policy documents of the following ministries and agencies: Ministry of Cities (Ministério das Cidades (MC)); Ministry of Science and Technology (Ministério da Ciência e Tecnologia (MCT)); Ministry of Environment (Ministério do Meio Ambiente (MMA)); Secretary of Strategic Affairs (Secretaria de Assuntos Estratégicos (SAE)); and the National Water Agency (Agência Nacional de Águas (ANA)). Policy documents and legislation proposals (e.g. amendments to existing laws) have also been surveyed by accessing information available online on the websites of the following National Councils: Council of Cities (Conselho das Cidades, usually named ConCidades); the National Environmental Council (Conselho Nacional de Meio Ambiente (CONAMA)); the National Water Resources Council (Conselho Nacional de Recursos Hídricos (CNRH)); the Council for Economic and Social Development

(Conselho de Desenvolvimento Económico e Social (CDES)); and the Brazilian Forum on Climate Change (Fórum Brasileiro de Mudanças Climáticas (FBMC)).

2.4. Stakeholder analysis

The focus of the stakeholder analysis is related to how the various actors operate, whether they are property owners, real-estate agents, or construction business or government officials. This analysis is conducted in order to understand how stakeholders influence land use decisions and how government actors manage or fail to manage the reconciliation of public and private interests (in this instance, interests regarding the adoption of flood mitigation and land use adaptation measures). Particular attention is paid to the identification of conflicting interests concerning land use and the actual process side of politics where individual and collective actors with diverging views and interests interact. A characterization of the interests at play in the decision making process is presented and two major dynamics of land use change are described based on the dominate discourses of the various stakeholders. Empirical data was obtained through a combination of secondary data analysis, semi-structured interviews, focus groups, and direct observation of deliberation processes. This was complemented by a desk study of the legal and political context concerning land use planning and water management. I have participated in a workgroup for discussing the Master Plan of Paraty, organized by the Municipality between February 2013 and July 2014, which yielded an important inside perspective on related decision making processes and highlighted the relevance of the various issues under analysis here. This also helped to establish rapport and trust with local actors, which resulted in a high level of confidence in the findings.

Key actors have been interviewed following a snowball approach, starting at public hearings where they were represented. This made it possible to identify stakeholders in the early stages of the research and subsequently to identify a broader range of actors. A desk-based study of official reports provided input for the preparation of the interview questions and broadened the scope of the data collection exercise. A guideline with a set of interview questions addressed the different ways parties perceive how land should be used, grasping causal relationships on dysfunctions and conflicts regarding land use. Interviews were semi- structured in order to allow for exploration of other topics that emerged during the course of the questioning. The data collected from interviews were triangulated through focus groups with representatives of the main sectors involved (housing market and construction businesses, tourism industry entities, and environmental associations and technical experts). Different topics were grouped in a newly developed typology based on the number of times each type of interest was mentioned in the interviews.

In total, 29 semi-structured interviews were held involving a wide range of actors and anonymity was guaranteed to all participants. These actors included three officeholders at the State level, three municipal officers, one former secretary of the environment, two representatives of NGOs, five residents affected by flooding, four real estate developers, two large land owners, four medium-size land owners, three local politicians, and two leaders of local associations. Besides this, many informal conversations were carried out with people interested in urban development, local economy, and politics. These people range from professionals of the construction sector to engineers, architects, low grade officers in government offices, petty property brokers, shop owners and traders, labor contractors, workers, members and volunteers of political parties, municipality staff, lower rank police officers, former agricultural landowners, etc. The stories narrated by these people were haphazard and anecdotal. However, there was a distinct structure to these stories that, when placed in macro regulatory context, made sense and helped in binding the loose threads together. Insights from these narratives helped formulate relevant and pin-pointed questions for subsequent interviews of government officials and private investors who are prime agents in land development. With the help of these interviews, I have attempted to understand the regulation of this particular sector by exploring the experience of real estate firms. Examining their interaction with the various decision making and regulatory bodies and the instruments used by such firms to conduct business with the state's regulatory bodies proved particularly useful for unpacking the relationships between formal and informal processes of land use change.

To validate the information obtained from interviews and focus groups, analyzed according to the framework mentioned, I also conducted public presentations and open debates about land use change and urban flooding with key actors. These took place in Paraty between November 2013 and February 2014, allowing me to engage in discussion with the different sectors about the expected flood impacts of further urban expansion into upstream reaches of the floodplain, as well as potential hydrological benefits of alternative scenarios of urban development. Finally, a second round of interviews allowed me to specifically investigate the changing, or resistant, perceptions and positioning of each actor regarding urban flooding and the ability and potential willingness of key stakeholders, as expressed in the interviews and focus groups, to become over time more committed to and involved in a collaborative approach to the development of land use policies for urban flood prevention. Inquiring about stakeholders' perceptions is justified because perceptions are the best forms of assessment available when factual measurement is not possible (Bressers 2011). This last phase of the research allowed me to rank manifestly the level of each actor's interest on urban flooding (low, medium, or high). Interest was defined as the level of importance urban flooding-related problems represent to each stakeholder before and after the discussion. High interest means that the actor is fully committed to considering flood related concerns on land use decisions; medium interest means that the actor attributes reasonable importance to flood-related problems—that is, s/he considers these concerns but does not prioritize them; and low interest means the actor manifestly neglects flood-related problems.

2.5. Spatial Analysis

The spatial analysis focuses on land use change dynamics within the territory under study. This constitutes the first analytical step, mainly featuring quantitative information about urban growth and land use change within the study territory. The main features of the territory under study are described, characterizing the overall context of Paraty. This characterization is examined at multiple levels of analysis. At the watershed level are considered the two river basins on which the city of Paraty is located. On a more detailed level, the study focuses on the lower region of the basins, namely the urban and peri-urban floodplain of the city of Paraty, comprising an area of approximately 1000 hectares. This area will be described in more detail, focusing on flood-related risks and possible ways to mitigate these through land use adaptation. Finally, I make a critical analysis of the land use proposals of the Master Plan of Paraty. The conversion of rural and forest land into residential and commercial areas has been mapped and quantified by overlapping cartographic and satellite imagery in a geographic information system. The maps and aerial photographs have been georeferenced using ArcView GIS. The coordinates are based in Universal Trans Mercator (UTM) projection.

2.6. Scenario Development

Hypothetical scenarios of alternative land uses considers the physical components of the basin, such as topography, urban occupation, and physical infrastructure, among others. These scenarios result from equating all of the previous steps of analysis and involves the quantification of a number of quantitative and qualitative parameters, which result in the various scenarios set forward at this stage. Quantitative parameters include population density, dimension of plots, soil sealing, land cover (with correspondent values of run-off and manning), and basic infrastructure and services. Qualitative parameters include landscape features, ecosystem services and urban design, among others. The elaboration of scenarios has been developed in interaction with the hydrological analysis, making it possible to refine the various hypothesis according to the responses obtained by the hydrological modeling exercise.

2.7. Hydrological Analysis

The hydrological analysis assesses the current exposure to floods within the study territory through a hydrodynamic model of the Perequê-Açu and Mateus Nunes river basins. There is a wide range of available modeling tools for assessing the effects of hypothetical land use changes on flooding (unidimensional and multi-dimensional models, using conservative or non-conservative equations, each with its advantages and limitations (see Sousa 2010)). The level of complexity and the resolution of the analysis do not have to be as high as possible; rather, they need to be “fit for purpose” according to the level of detail provided by the available input data in the modeling process development. The mathematical model MODCEL, developed at the Laboratory of Computational Hydraulics of the Federal University of Rio de Janeiro (Mascarenhas and Miguez, 2002; Miguez et al, 2011) is an “off the shelf” model that is a suitable choice for this experiment.

MODCEL has the characteristics of a Quasi-2D (see Cunge et al., 1980) hydrodynamic model and is based on the concept of flow cells, whereby the territory is represented by a set of interconnected compartments along the entire watershed.

The US Army Corps of Engineers (1993) and Barnard et al (2007) recommend the use of hydrodynamic models where rivers present low slope and in complex systems where drainage networks are divided and then reconnected again along the drainage network, as is the case in the lower regions of the Mateus Nunes and Perequê-Açu river basins. MODCEL is able to reproduce a great variety of hydraulic patterns in an urban landscape and to consider a set of distributed measures in order to test the behavior of the urban drainage network. An important feature related to MODCEL is that flows may occur in different parts of the basin(s) independently and at the same time; eventually, as the flood increases, these areas may act jointly. This hydrodynamic model, although it works through unidimensional hydraulic relations, is capable of representing water flows in two dimensions. In fact, in the case of urban basins, the model is able to represent the flow exchange between surface cells and subterranean cells, usually representing drainage galleries, which enables the representation of the water flow in three dimensions. The cells work as the storage elements of the model, representing land shapes and land use characteristics, while the discharge links, on the other side, give life to the different flow possibilities. To consider peri-urban floodplains upstream of the urban area, Quasi-2D models are more adequate than unidimensional models because they allow a more systemic view of how the river system functions. In the context of this study, MODCEL allows for the testing of different possible land uses, enabling a better understanding of their effect on water flow regulation services. This is especially important when severe flood problems occur with large inundation areas and superficial flows and topography play major roles.

In order to calculate future changes in astronomical tides, tide regimes were inserted in the free software SisBaHia (Rosman, 2011). The water flow coefficients—runoff (related to the absorption capacity of the soil) and manning (related to the roughness of the soil)—are based on Wilken (1978) and ASCE (1969), according to the characteristics of soil coverage of the river basins under study. After inserting all relevant data, the model is able to reproduce the current situation representing the reality of the Perequê-Açu and Mateus Nunes river basins, which constitutes the benchmark for comparing future scenarios. At this stage, calibration is an important step as it aims to reduce the uncertainties in the simplified representation of a real system and ensures acceptable levels of confidence in the model.

The calibration of the mathematical model has been made by adjusting its parameters so that the water discharges simulated by the model are approximate to those observed in real events. This calibration was made following a "trial and error" procedure, in which the parameters were adjusted manually through successive simulations and comparisons between the observed and calculated flows, enabling the validation of the model (Bonganha et al, 2007). Calibration of the model was completed by calculating the deviation between the peak flows calculated by MODCEL and the flow rates recorded in situ. These deviations ranged from -10.2% to 2.4%. In addition to the peak flows, the times of concentration obtained for the two watersheds were also used for model calibration. After calibrating the model, future scenarios of urban expansion into the remnant areas of the floodplain was tested in order to measure its impact on urban flooding.

PART TWO:

THEORETICAL FOUNDATIONS OF THE RESEARCH

3. Overview of the literature

Increasing awareness of the impact of land-use change on ecosystems is motivating the scientific community to search for adaptation pathways[8] to reduce socioecological vulnerabilities of climate-related risks. As far back as the early 1990s, the Intergovernmental Panel on Climate Change (IPCC) has played a major role in advocating the conceptual pairing of mitigation and adaptation, which affects the mutual relations between national governments and their geographic spaces by promoting international agreements toward this global agenda. Since the early 2000s[9], many countries have been committed to developing specific adaptation policies and programs in the most varied sectors, yet it is not clear how to integrate these into existent planning and management practices. In the case of Brazil, the government recently joined the coalition of countries seeking highly ambitious goals at the Paris Climate Conference (COP 21), but the crucial question of how to operationalize adaptation in concrete urban policies remains largely unanswered. Particularly, there remains a gap between the possibilities underpinned by the theoretical frameworks of mitigation and adaptation and the actual possibilities of putting these concepts into practice according to specific national institutional contexts. This results in a disconnect between theory and practice, the duplication of policy agendas, and a general failure to clearly materialize effective urban policies at the local level of governance. As a primary step to addressing these problems, this review presents the most relevant theoretical concepts affecting this discussion and is organized by a number of themes in three chapters.

The first chapter sets the backdrop of the broader discussion on climate change against the challenges posed by the global context of urban environment transition. The second chapter discusses the main concepts of adaptation, land-use adaptation, and

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[8] For an introduction to the concept of climate-resilient pathways, see Chapter 20, sections 20.2.3. and 20.6. of the II Working Group of the Fifth IPCC Report (2014).

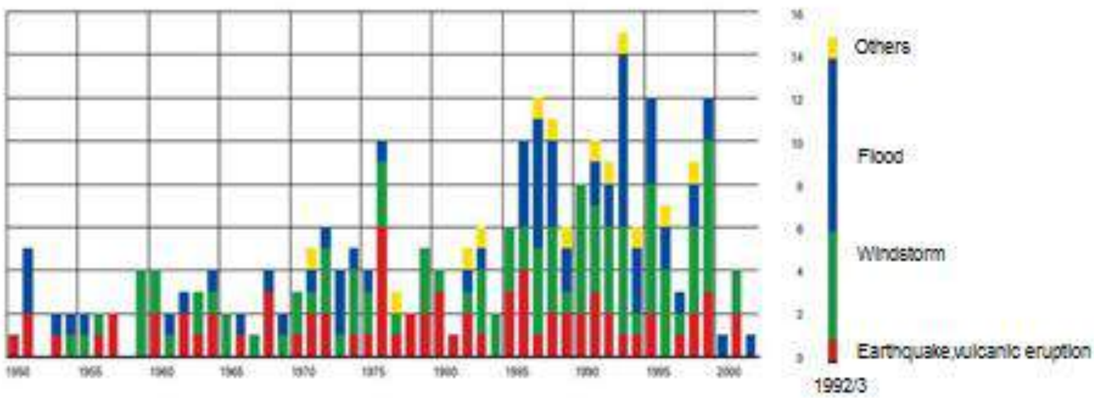
[9] Three specific funds were created at COP7 to support the implementation of various measures that facilitate vulnerability assessment and adaptation. Since then, adaptation has become an increasingly important component of the international climate change dialogue.

ecosystems-based adaptation, characterizing the theoretical approach that entails such concepts. Here, the emergence of an ecosystem approach is contextualized within foundational theories on socioecological systems, which are characterized by the interdependent and interconnected nature of social and ecological systems. This section concludes with the characterization of water-flow regulation and related ecosystem services, broadly divided into regulating, provisioning, cultural, and supporting services. The third chapter explores a range of theoretical, empirical, and exploratory literature within the broad interdisciplinary field of what I call here "integrative flood science." The present review does not seek to deal with all the many implications of this growing body of literature and is intentionally focused on the most relevant discussions that may theoretically ground the concept of land use adaptation as a feasible political practice for the prevention of urban flood risks.

3.1. Making sense of the global ecological crisis

The acceleration of changes in the planet's environment is stimulating novel discussions at the intersection of the most diverse fields of social and natural sciences. Stemming from such debates, Crutzen and Stoermer (2000) suggested that the planet has entered a new geological period, the Anthropocene, in which the Earth is fundamentally influenced by humans on an unprecedented scale. According to Crutzen (2006), human activities have become significant geological forces, for instance through land-use changes, deforestation, and fossil fuel burning. Through these transformation processes, these activities have acquired the status of a geophysical force capable of destabilizing the limit-conditions of human existence. Among other environmental problems of political concern, the scientific observation of global warming and sea level rise are contributing to a growing awareness of the magnitude of humans' influence on climate conditions and the consequent shared threats to our life conditions on Earth. The acceleration of these transformation processes are defining, in the words of Palsson et al. (2013), a geological force actively conscious of its geological role. Despite the controversy among the scientific community regarding the adequacy of these terms, the meaning of the Anthropocene for human thinking is that it points to a definite epochal shift in history, through which we are invited to revise our philosophical understanding of Nature and our place within it.

Whether researchers engage with such theoretical formulations or not, there is a consensus that the expected increases in the atmosphere's temperatures are anticipated to have important consequences on flooding conditions. In light of what is today a widely accepted view regarding human influence on the climate, the increasing vulnerability of urban communities to flooding can no longer be discussed in isolation from the broader context of global environmental change. Between 1996 and 2005, disasters classified as floods and windstorms were the two most frequent of all disasters (UN-Habitat 2007). The fourth assessment report notes that urban flooding is the main effect of climate change on urban settlements (IPCC, 2007), not only because of sea level rise but also because of induced changes on the frequency and intensity of rainfall patterns. The fifth assessment report concluded that it was very likely that heavy precipitation events (i.e. the proportion of heavy rainfall to total precipitation), would increase over most areas of the globe, especially in the case of wet tropical regions. However, the same report made it clear that there is no unequivocal evidence of an increase in extreme rainfall events during the last century. What is consensual in the literature is a growing occurrence of extreme flood disasters during the last decades, as shown in Figure 19[10].



[10] The database compiled by the Centre for Research on Epidemiology Disasters confirms this trend, according to which floods are the type of natural disasters that affected the highest number of people betwee 1900-2009 worldwide (see www.em-dat.net). For other assessments of observed flood disasters see Berz, 2000 and IFRC 2010.

Fig. 19: Number of natural catastrophes between 1950- 2000 (Munich Report, 2002).

According to the fifth assessment report (IPCC, 2013), warming of the climate system is indisputable (there has been an increase of 0.65 to 1.06° C over the period 1880 to 2012), and since the 1950s, many of the observed changes were unprecedented over decades to millennia (IPCC, 2013). In the most optimistic scenario, the IPCC projects that the global mean temperature is likely to increase 1.4ºC by 2100 (IPCC, 2007).

Such an increase in flooding conditions may be aggravated in low-lying coastal zones by sea-level rise. It is almost certain that global mean sea levels will continue to increase beyond 2100 due to thermal expansion continuing for many centuries (IPCC, 2013). These increases will not be homogeneous, varying according to local conditions (see Nicholls 2011), but it is very likely that more than 95% of the ocean area will be affected by the end of 2100 (IPCC, 2013). Tidal regimes have significant variations, and the impact of sea level on inundations is particularly felt when high discharges of storm water flowing into low-lying coastal areas coincide with high syzygy tides. The loss of mass from glaciers and ice sheets, together with increased temperatures of the oceans, contribute to sea-level rise. Between 1901 and 2010, sea levels increased at an average global rate of 1.7 mm/year, almost doubling to 3.2 mm/year between 1993 and 2010. According to the fourth assessment report, estimates for future sea-level rise vary from 18 cm to 59 cm during the 21st century (IPCC, 2007). During the last fifty years, the extent of ice in the Arctic is decreasing at an average rate of 3.5 to 4.1% per decade (IPCC, 2013; NSIDC, 2015). It is also important to note that climate change is not just affecting the risk of extreme disasters, but it is also expected to alter the hydrological cycle in many ways, leading to other smaller-scale occurrences that do not appear in most statistical studies, such as saltwater intrusion, small-scale flashflood events, and increasing prevalence of water-borne diseases. When combined with overpopulation and poverty, these occurrences are likely to have a silent impact on many human settlements.

While most scientific studies leave little room for questioning human influence on climate, there remains in the popular debate on climate change, contestation regarding the anthropogenic origin of global warming. Since early discussions on the matter, climatologists have argued that most of the warming since at least the mid-twentieth century is very likely due to human activities (STERN, 2006; COP15, 2009;

WORLDWATCH INSTITUTE, 2009; IPCC, 2013), and in 1995 the IPCC stated that "the balance of evidence suggests that there is a discernible human influence on the climate." This has been the main argument for persuading governments to set targets for offsetting carbon emissions[11]. While it seems to be too early for climatologists to make exact pronouncements on the future impacts of carbon emissions on the atmosphere (see QUIGGIN 2008, STUART et al. 2009), it is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas emissions and other human-induced factors (IPCC, 2013). Yet, the most skeptical argue that it is difficult to ascertain what determines the planet's temperature, the impact of greenhouse gas emissions being only one of many factors to consider in a non-linear system like the earth's climate. In fact, there are countless factors to consider for understanding climatic variations, such as changes in the sun's energy, land-use changes (responsible for the high concentrations of methane in the atmosphere), the warming or cooling effects of pollutant aerosols, and the impacts of changing humidity and cloud cover. In the face of such complexity, the anthropogenic nature of global warming is still contested[12]. Moreover, the large majority of nations is loath to diminish carbon emissions at the speed that is needed[13], offering great resistance for shifting investments toward renewable energy sources. As Latour wittily noted at the closing of his first Gifford Lecture, it is the first time in history that a

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[11] According to the evidence presented by the IPCC (2013), carbon dioxide concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land-use change emissions. During the same period, concentrations of methane increased 150% and nitrous oxide increased 20%.

[12] For a contestation of the influence of greenhouse gas emissions on global warming, see for example Freitas. 2002; Essex and Mckitrick. 2003; Kininmonth. 2003; Leroux. 2005; Lindzen. 2006; Frank, 2008; Watts 2011.

[13] Considering the current concentrations of greenhouse gases in the atmosphere, it is unlikely that a future reduction of carbon emissions will be sufficient to prevent global warming. In fact, the real goal of the emission reduction targets of the Kyoto Protocol is not to reduce total emissions, but to delay the doubling of the historic averages by twenty years in order to prevent 'dangerous anthropogenic interference' with the climate system. Thus, beside the possibility of serious aggravation of the current trend if the current carbon emissions are not substancially reduced, there is a high probability that global mean temperatures will continue to increase for many centuries to come.

group of scientists is being accused by other scientists of being a lobby (LATOUR, 2013). It may be worthy to note here that scientists and experts are not only producing different technical rationalities while trying to explain the current observed trend of global warming, but are also contributing to social perceptions of risks, establishing acceptable thresholds of risk, producing different claims of knowledge concerning the technical manageability of ecological breakdowns, and opening a whole new exploration of the opportunities for profit as a result of climate change.

After all, it was the scientific knowledge of the steam engine, the enormous advances of the chemical industry, and the immense technological capacities for extracting resources, among many other commemorated "progresses of human civilization" ranging from the mass destruction of forests to the drilling into the depths of the Earth, that caused the current global ecological crisis. As far back as 1986, Beck already advocated for "a political sociology and theory of the risk society, as an essentially *cognitive sociology*: not simply the sociology of science, but in fact the sociology of all the admixtures, amalgams, and agents of knowledge in their combination and opposition, their foundations, their claims, their mistakes, their irrationalities, their truth, and in the impossibility of their knowing the knowledge they lay claim to" (BECK, 1992). By acknowledging this complexity, researchers are called to leave their comfort zone of expertise and to have the courage to open up the debate about the different worldviews, institutions, and economic interests that sustain the industries of knowledge to which all of the scientific and academic community, in one way or another, is a part of.

The current political impasses regarding national and international environmental policies evince the presence of these tensions and conflicts, reflecting a highly disputed arena between economic interests, social demands, and ethical values difficult to reconcile. The contradictions and ambiguities of Brazilian environmental policies demonstrate these difficulties: in fact, Brazil was one of the first countries to sign the Convention on Climate Change during the Earth Summit held in Rio de Janeiro in 1992 and has recently made ambitious political compromises at COP 21 concerning the reduction of carbon emissions and other targets for adaptation to and mitigation of climate change. However, it was also Brazil that raised the issue of "equity" between developed and developing countries, based on the argument that the bulk of the climate change problem was created by the former group. Other emerging economies like China and India have followed the same political claims, demanding for a "common but differentiated responsibility" in pursuit of their own trajectories toward industrialization. While such a debate tends to get lost in the spurious identification of who is culpable for or victimized by climate change (see PROCTOR and SCHIEBINGER 2009; HOGAN, 2009), the so-called BRICs[14] are now championing the yearly growth of carbon emissions in the world. Today, China is the most responsible for carbon emissions in absolute terms (emitting double the US's emissions per year (30% of total) and surpassing the EU's emissions per capita)[15].

Concerning the Brazilian political commitments during the last decade, there are indications that these would not be assumed by the government if these would not satisfy the interests of the agro-business sector (e.g. reinforcing extensive sugar cane monocultures) and the energy sector (i.e. favoring hydroelectrical, thermoelectrical, and nuclear power plants) (see ACSELRAD, 2009). The survey of greenhouse gas emissions of the Brazilian Climate Observatory (SEEG, 2015) registered two main trends on greenhouse gas emissions. While land-use change (mainly due to deforestation) presents large fluctuations over time, in the case of energy, agriculture, industrial processes, and waste, emissions have consistently grown since the 1970s as shown in figure 15.

[14] The BRICS: Brazil, Russia, India, China, and South Africa.

[15] According to the World Resources Institute, land-use change by deforestation is the largest contributor to carbon emissions in Brazil, causing nearly 45% of total emissions.

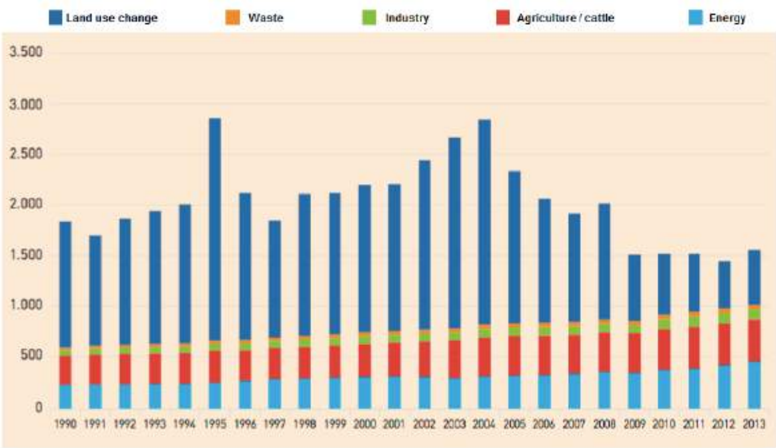

Fig. 20 - GEE emissions growth in Brazil by sectors between 1990-2013 (SEEG, 2015)

When considered separately, land-use change fell 56% between 1990 and 2013. As a result, greenhouse gas emissions due to land-use change (which, during the 1990s, reached 70% of Brazil's emissions) dropped to 35% in 2013, but have risen again since then. In turn, the other sectors showed a continuous (and very pronounced) increase. The energy sector presented the highest rates with an increase of 103%, followed by industrial activities (93%), and waste dumping (68%), and agriculture (46%) in the period between 1990 and 2013.

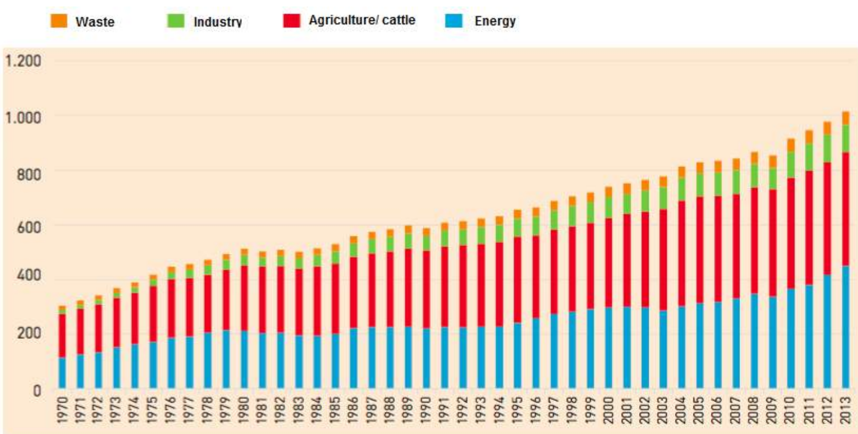

Fig. 21 - GEE emissions growth in Brazil by sectors between 1990 and 2013, excluding land-use change (SEEG, 2015)

Overall, between 1970 and 2013, there was an increase of almost 300% in energy emissions. Energy emissions exceeded agricultural emissions for the first time in 2012 and the difference increased further in 2013. When considering net emissions, energy is already the main source of greenhouse gases in Brazil at 39% of emissions, followed by agriculture at 36%. Meanwhile, little progress has been achieved in repowering the existent infrastructure and investing in renewable sources of energy, such as the untapped Brazilian potential for solar energy or mini-hydric stations. However, these would require a change to the energetic model of Brazil, and this is neither a venture of interest for the abovementioned sectors, nor for the extractivist economy, nor for other powerful industries playing a hegemonic role at this level of decision making. These examples illustrate how dominant economic powers tend to legitimate the pursuit of vested interests sustained by fallacious ideological arguments of economic development and growth. In the words of Beck (1992), "such attempts to gain at least political meaning that these newly arising commonalities of danger (…) collide with national-state egoisms and the prevailing (…) interest organizations of industrialized societies. The commonality of dangers confronts the pluralistic structure of interest groups with almost insoluble problems". Such difficulties are contributing to a "political vacuum" of institutional competence for dealing with growing environmental risks, while it is unclear what sort of politics or political institutions are actually necessary in order to face this challenges. What is clear, however, in light of what is already known about the impacts of human activities, is that there is a new legitimacy for new forms of regulation of economic systems of production, including the current expansive forms of reproduction of the urban space.

3.2. Land-use change in urban environment transition

The macroperception of local problems by remote influences such as global warming may be misleading, making less clear the role of land-use change around urban areas and generating further problems from unintended consequences of urban expansion and fragmentation. But land-use change and territorial transformations provoked by migration processes and ongoing social changes are at the root of the most vulnerable situations faced by large contingents of the population. The effects of the distortions on the perception of depredatory dynamics through macro-analysis is particularly visible in Brazil. In a country with continental proportions, the big picture of mass deforestation turns the focus of environmental agencies on (rather insufficiently) surveying the preservation of large pristine forest areas. Meanwhile, the micro-level of small-scale land-use changes happening around small towns and villages across the Brazilian territory is less monitored, both in terms of deforestation and in terms of qualitative information on biodiversity losses.

The impressive concentration of land resources in large holdings is well-known throughout the vast Brazilian territory, but the effects of this historical characteristic inherited from colonialism and patrimonialism[16] in the contemporary production of the urban space is less understood. This is also a typical situation of many peri-urban floodplains of South America and many other countries in the Global South, where wetlands that have been previously converted for agricultural use are currently undergoing subsequent and more dramatic processes of land-use change. Now, it is important to acknowledge the socio-political implications of these territorial transformations. As noted by Ribeiro and Cardoso (2003), the urban land may be defined as a social good on which urban populations fundamentally depend. This social good is not restricted to a mere piece of land, but to a set of infrastructures, services, job opportunities, and other important social goods which are physically and socially related to a certain territory. The right of access to this "social wealth" (RIBEIRO AND CARDOSO, 2003) is restricted by various modalities of appropriation and transformation of these “resources,” upon which, in many cases, the most profitable economic activities depend. The urban land and the different modes of appropriation are foundational to any man's course in the historical process (BALDEZ, 2003), and there is no way to think about the adaptive capacity of urban communities without this foundation.

In Brazil, as in many other countries with a colonial past, the poor never had access to land for housing in adequate locations (BALDEZ, 2003). The resulting realities are in fact so different and divided that they often seem to belong to different worlds

[16] The concept of patrimonialism was originally developed by Max Weber to explain the concentration of different powers and the way private interests “colonize” the centers of decision within the State apparatus. The thesis developed by Raymundo Faoro (1958) exposes the origins of Brazilian patrimonialism, which is characterized by the relationship between the concentration of property, economic power, and political power. Faoro emphasizes the colonial origins of the concentration of land property in Brazil, explaining how the instrumentalization of the State generates an overwhelming bureaucracy designed for self-serving purposes.

(SANTOS, 2012) where the simultaneous existence of land scarcity and land abundance in the same geographical space may be observed (RIBEIRO andCARDOSO, 2003). Central to this debate is the concept of "urban environment transition" (McGRANAHAN et al 2001), referring to the underpinning problems that arise from rapid urban growth. Uncontrolled urban development, especially in developing countries, led to a very fast process of urban growth into natural floodplains. Such rapid changes in the urban environment reflect socio-political disputes over a space marked by conflicts. These conflicts are characterized by a highly politicized landscape and the imprint of strong economic interests encouraging speculation processes over land resources. They also involve a deeper consideration of the socioeconomic conditions and housing demands of the groups living or working in the urban periphery and the associated daily struggles for political recognition. The urban floodplain is, therefore, a highly contested terrain, which is the result of local socio-natural relationships that encapsulate past legacies and arrangements, as well as interactions occurring at other scales, such as anthropogenic climate change.

While considering climate related geo-hazards, it is important to take into account how flood hazards turn into disasters. The expansion of urban communities into fragile ecosystems heightens flood risk due to the increasing exposure of people and economic assets, but also because the process of urbanization itself alters local hydrologic characteristics. As such, it cannot be ignored that uncontrolled urban expansion and the consequent exposure of people and economic assets are the major causes of increased flood disasters. In fact, land-use change had much greater effects on ecological variables than climate change in recent centuries (DALE, 1997). In the last fifty years alone, anthropogenic environmental impacts are thought to be the most severe in human history (GRAU and AIDE 2008). The Millennium Ecosystem Assessment (CONVENTION FOR BIODIVERSITY, 2005) presented ample evidence of a dramatic environmental degradation during the last century, namely on specific types of freshwater, wetland, and floodplain ecosystems. According to the report, this degradation has been occurring more rapidly than ever since the 1950s, accounting for more than 50% of wetland losses in parts of America, Europe, and Australia (CONVENTION FOR BIODIVERSITY 2005). Such conditions increase the likelihood of potentially abrupt changes in the affected ecosystems, which can be difficult or even impossible to reverse.

The current trends of uncontrolled urban expansion may be partially explained by the domination of production and reproduction systems within dominating economic systems marked by sharp inequalities in the distribution of resources[17]. Ilife (1987) explained the consequences of such inequities and characterized determining factors of "structural poverty" within land-rich and land-scarce societies. The exceptional concentration of all forms of capital—economic, political, military, cultural, scientific, and technological—among the agents and mechanisms that dominate the economic and social world has been described by Bourdieu (1998) as the foundation of a symbolic domination without precedent. In the Global South, such concentration of resources is particularly evident in relation to land property around urban areas. This property is characteristically organized in large land holdings, which, in many cases, have been previously used for agricultural activities and, more recently, await their conversion for urban development. Considering the underlying importance that changes in land use have on flooding conditions, the problem of adapting land uses to increasing social needs for urban land becomes of growing importance.

The IPCC's fourth assessment report (IPCC, 2007) notes that the complex relations between urbanization processes and climate change impacts are twofold. On one hand, urbanization is one of the causes of global warming ("Non-climatic drivers, such as land use, land degradation, urbanization and pollution, affect systems directly and indirectly through their effects on climate" (IPCC, 2007); "complex feedbacks and interactions occur on all scales from local to global") (IPCC, 2007); on the other hand, climate change is also increasing vulnerabilities in cities ("Climate change is likely to exacerbate other stresses on infrastructure, and human health and safety in urban centers.") But what needs to be understood by policy-makers, is that the antidote must be sought in the poison that led to the present circumstances: the urban land, transformed into a high-value commodity in the process of urbanization. By understanding the links between local and global scales of environmental problems, urban flood mitigation

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[17] In Brazil, Pochmann (2004) accounted in the year of 2003 that 10% of the Brazilian population detained 75% of the total wealth (POCHMANN, 2004).

through land-use adaptation acquires full relevance, not only because it may significantly contribute to the reduction of depredatory practices on deforestation affecting global conditions, but also because of its local benefits on social ecosystems.

The new emphasis on adaptation is particularly relevant to the specific needs of urban populations located in tropical coastal regions of the global South. In these areas, significant numbers of people are exposed to environmental risks exacerbated by both climate change and uncontrolled development, resulting in an "adaptation deficit" (BURTON, 2004; BURTON and MAY, 2004; QUAN and DYER 2008; PARRY et al., 2009). Adaptation deficit is defined here as the degree of inadequacy of a social system to address its environmental conditions, which leads to a higher or lower exposure to natural hazards. While the climate change mitigation theory defends the need to lessen human impacts on the atmosphere through carbon emission reductions, climate change adaptation focuses on finding sustainability strategies to live with the current trend in global warming. In this regard, the Ministry for the Environment of New Zealand (2004) noted that the need for adaptation does not come out of the views concerning the causes of climate change, but out of the need to adapt our societies and urban systems to a changing environment. It is important to consider that there are large variations in the relative importance of climate change-related risks compared to other pressing environmental burdens. Moser and Satterthwaite (2008) observed that when a large proportion of the population lacks infrastructure such as water, sanitation, and drainage, it is difficult to claim that the problem is primarily one of climate change. Therefore, it is important to consider that climate change impacts will compound existing deficits in the provision of public services and infrastructure and will affect disproportionately poor and marginalized communities. "Added to other stresses such as poverty, inequality, and diseases, the effects of climate change will make (…) livelihood security (…) more difficult to achieve for many locations, systems, and affected populations." (IPCC, 2013). Based on this rationale, Quan and Dyer (2008) note that filling the adaptation deficit is often the best defense against climate change.

Poverty and persistent inequality[18] may be the most salient of the conditions that shape vulnerability to climatic factors. The understanding of these correlations and those between urban flood vulnerability and urban poverty is increasing with the use of geoprocessing tools. For example, Barbedo (2007) identified a number of relationships between pockets of poverty and environmental vulnerability along riverbanks in the Angolan capital of Luanda; and Alves et al. (2010) shows how low-income populations live in more vulnerable conditions exposed to floods and diseases in the largest Brazilian metropolis of São Paulo. As such, climate change is expected to have a relatively greater impact on the poor as a consequence of their lack of financial resources, poor quality of shelter, exposure to geohazards, and limited provision of basic services. In an urban study on pro-poor adaptation to climate change, Moser and Satterthwaite (2008) observe that although the concept of vulnerability has focused mainly on its social and economic components, its focus on physical hazards, when applying it to climate change, becomes more important. This is because urban poor populations generally have to live with multiple risks and are subject to overlapping hazards from a range of environmental sources, while also facing a number of other hazards, stresses, and constraints.

3.3. The need for a new paradigm of socioecological governance

From the above discussion, it is clear that global warming cannot be understood in isolation from anthropogenic land-use change. The growing acknowledgement of the synergetic relationships between these drivers of change is contributing for furthering our

[18] For the sake of analytical rigour, it is important to distinguish the concepts of poverty and inequality, but it is equally important to think through the concepts that explain their interdependent relationships. As noted by Beck (1992), the social meaning of inequality has changed, and more attention needs to be ascribed to socio-spacial dimensions of inequality. A concept in urban poverty studies is “poverty trap” (Jalan and Ravallion, 1997), which explains how the negative effects of the environment on vulnerable areas persistently constrain the development of these urban communities. Another relevant concept is the one of “chronic poverty” (Hulme, Moore and, Shepherd, 2001; Amis, 2002), which refers to the permanence and extended duration of poverty within certain socio-spacial conditions. More recently, there has been a group of studies explaining the indirect impacts of environmental conditions on public health (see McGanahan, 2007). Focussing on the burdens caused by the degradation of ecosystems, a scoping study of IIED (2007) emphasizes that these burdens hit the poor disproportionately, illustrating that poor people are more vulnerable to ecosystem change.

understanding about the interconnected nature of social and environmental problems. It is precisely because global warming needs to be understood with due consideration to other drivers of change – not only climatic, but with many other dimensions—that increasing urban flood vulnerabilities cannot be dissociated from the socio-spatial contradictions that characterize the vast majority of urban settlements worldwide, particularly in the Global South. Considering the changing socio-economic conditions in countries undergoing recent processes of "urban environment transition" (MCGRANAHAN, 2001), it is reasonable to expect that flood risks may become more dramatic as a consequence of abrupt social changes, with the resulting aggravation of socio-spacial divides and inequities that are already deeply embedded in the urban space. Considering the observations of Quan and Dyer (2008), who argue that "filling the adaptation deficit is often the best defense against climate change", the deep-rooted inequality in the access to affordable land, in fact constitutes the great adaptation deficit to be filled. In other words, it is the maladaptation of land-use change dynamics to the very process of social change that needs to be addressed, requiring important changes in current urban policies and economic practices affecting decisions about land use.

In light of the conflicts arising from the need to radically transform existent economic systems of production, it is important to consider how the acknowledgement of socioecological interdependencies brings new sources of social conflicts. And while such conflicts tend to deepen the levels of vulnerability of the most disadvantaged social groups, negative environmental outcomes affects the society at large. The current ecological crisis shows that changing established modes of economic production (including the modes of reproduction of urban structures) is not merely a question of whether to opt either for the interests of the poor or the established status-quo, but rather is a matter of common interest for the society as a whole. As pointed out by Chakrabarty (2009) in his daunting paper "The Climate of History," "there are no lifeboats here for the rich and the privileged." This may be interpreted as a response to Hardin (1972), who envisioned an overpopulated planet where the wealthier social groups would be able to survive from a collapsing disaster. In an eventually more lucid vision, Beck (1992) wrote that the Earth is becoming an ejector seat that no longer recognizes any distinctions between rich and poor, black and white, north and south, or east and west. The threatening possibility of a general collapse at a planetary scale is motivating some intelectuals to hesitate between the prospects of an eminent global disaster (Zizek, 2010) and ecological discourses of hope inspired by Bloch's (1995) "horizon of possibilities (…) as the way in which the future is inscribed in the present" (SANTOS, 2000). In fact, the unprecedented degradation of life-support systems is also affecting the very interests of dominant classes (whether conscious of the fact or not). The eventual acknowledgement that the more direct interests of the rich are also affected by the global ecological crisis may motivate their engagement in promoting societal and economic transformations that envisage a shift in the current trends of unsustainable patterns of urban expansion. However, in human history, scarcity has been more often the *leit motif* for greed rather than fuel for solidarity. While Chakrabarty's end of history is yet to come, it is more likely that life boats will continue to be built for the rich and the priviliged, especially in cities marked by stark social differences. In respect to this debate, Acselrad (2009) wrote that the reluctancy of the elites in adopting measures compatible with the principle of precaution as it relates to climate matters seems to suggest that the logic of the life boat is in operation today. And even if some reduction in the huge differential between the poorest and the richest members of society can eventually be attained, self-destructive practices will persist unless the society as a whole develops new institutionalized practices of cooperation for actively protecting socionatural values of vital importance for present and future generations.

The dilemma remains between the need to change the course of human history and the difficulty to put into question the very foundations of the worldviews that contributed to the current systemic crisis. The narrower ideals of human progress, the hegemonic dogmas of economic growth, and the dominant forms of natural resource exploitation, have squandered their supposed universal acceptance, in as much human's self-destructive potential is revealed in what Beck (1999) as called the "world risk society". In fact, these have never been consensual among the large numbers of oppressed civilizations that have been systematically exterminated throughout the last five hundred years. The current trend of natural resource reflects a contingency of powerlessness, or a political void where private interests dominate over the public good to such an extent that the multiple forms of domination became "naturalized," legitimized, turned into a culture, an hegemonic mentality of global proportions. As noted by Ioris (2014), the environmental agenda of the modern state, with its sophisticated green discourse and complex regulatory apparatus, has become the champion of widespread environmental degradation and socionatural impacts.

Once again, as warned by Arendt (1970) nearly half a century ago, we do not know where these developments will lead us, but we do know, or should know, that every decrease in power is an open invitation to violence. It is not surprising that it was the author of the "Human Condition" who dedicated an important part of her philosophical and political writings to the study of totalitarian regimes, who conceptualized power as "the human ability not just to act but to act in concert" (ARENDT 1970). Arendt's ontological conception of power is of fundamental importance to understanding why the increasing vulnerability of human societies is evincing the need for a paradigmatic shift in existent institutions and human relationships. Such a shift requires a whole new culture of cooperation within broad and inclusive ethical commitments around shared values, which are beyond classes, nations, cultures, or life forms. In order to apply Arendt's definition of power into the more specific subject of this research, it is important to distinguish between political power and the many forms of domination[19] that are exerted according to different logics of appropriation and transformation of nature. "Acting in concert" refers to a more explicit sense of political action, through which these various logics need to be translated into an organization in space that puts the common interest above personal interests. Thinking through these conceptualizations offers useful prospects for the construction of a new paradigm of socioecological governance, one necessarily charged with a sense of self-transformation and the implicit conditions of cooperation and joint action.

[19] In critically analyzing the differences between transitive and intransitive power, Goehler (2000) explains that while transitive power refers to Weberian conceptions in terms of domination relationships, intransitive power has a self-referential character based on the recognition of common values and collective action.

4. The sociological debate on adaptation

If mitigation and adaptation are meant to be the navigational instruments for guiding geopolitics in the XXI century, clarity of meaning in the use of these concepts is paramount. And even if these concepts may not eventually last as the hegemonic theoretical backdrop of geopolitics as long as expected by their advocates, we have arrived at the need for effective theoretical tools for their effective operationalization. This constitutes the basic point of departure of this research, grounded in the fact that mitigation and adaptation are recognized and supported by the large majority of national governments and international organizations, while appearing in the literature with very different meanings.

Flood mitigation is hereby used in the precise sense of reduction of human impacts on flooding conditions by territorial transformations at the watershed level. This definition leaves less room for theoretical interpretation and is plain enough to distinguish it from many other uses of the term in environmental sciences, including the mitigation of anthropogenic impacts on the climate through emission of greenhouse gases. This delimitation does not mean that the complex interactions and trade-offs between land-use change processes from local to global levels are ignored. On the contrary, this study emphasizes the importance of urban land policy on adapting to climate variability and change. It must be clear however that the evaluation of such interactions and trade-offs goes beyond the scope of the present work, which is more concerned with the interdependencies between land and water systems at the more tangible level of the interactions within each river basin.

The concept of adaptation, in turn, while it has been thoroughly defined *strictu-sensu* in biology, remains controversial when applied to socioecological systems. This may be partially explained by the fact that the concept of adaptation in social and political science is much less mature than the concept of mitigation and hence it has not been the subject of rigorous policy analysis[20]. It is not a goal of this work to engage in a broader analysis of adaptation theories, nor in an in-depth conceptual discussion regarding the fluidity of its evolving definitions and their possible modes of ideological appropriation. Instead, a more precise definition of land-use adaptation will be given in the following section, providing both conceptual autonomy from hegemonic theories and analytical clarity to the possibility of engaging with this concept using a very concrete and distinctive approach for engineering more sustainable patterns of urbanity. But before exploring this theme, it is necessary to address at the outset a broader level of discussion, concerning the appropriateness of the idea of adaptation when applied to a social context.

The most common critique to the concept of adaptation is related to the diffuseness of the concept. Giddens (1984), for example, questions how far this concept can be vacuous, “so wide and vague in its meaning as to be more confusing than illuminating.” Regarding this critical stance, both the United Nations Framework Convention on Climate Change (UNFCCC) and the IPCC sustain that the robustness of the concept of adaptation lies precisely in its flexibility, allowing for the development of diverse approaches for promoting adaptation policies and programs according to different social, political, and cultural realities. This position is reflected in the recent international agreements dealt at COP 21, where countries were allowed to develop different mitigation and adaptation strategies in a flexible way. If this flexibility may be regarded as a virtue by policy makers, there is an evident risk of misappropriation of these notions which may lend support to Giddens’ concerns. Indeed, an overview report from the OECD (2006) observed that interpretations of some of key adaptation terms by scientific groups or policy makers can be quite different, which may lead to varied or false expectations and responses once adaptation enters wider circles of policy. According to this source, the use of such concepts may need to be handled with more care and accuracy. Here it is perhaps important to consider that Giddens’ strong criticism of the notion of adaptation has been

[20] A list of key concepts and terms regarding the concept of adaptation may be found in OECD (2006). This overview report illustrates the wide range of existing definitions, demonstrating that the use of the concept varies across institutions and different groups of stakeholders.

made in the context of his strong opposition to Parsonian theories of social evolution (see MAYHEW, 1983) in which adaptation was a key requirement for a social system to survive. According to Giddens (1984), such theories lead to deterministic explanations belonging to evolutionist theories, which in his view did not account for the fact that social agents possess what he calls a "transformative capacity" by which human beings are capable of altering their social circumstances. In the same vein, the Brazilian philosopher and educator Paulo Freire (1970) rejected the idea of adaptation as a mere process of accepting and accommodating environmental conditions. He believed that humans are beings of transformation of the world, emphasizing their capacity to transform the places where they live. According to Freire (1997), the dialectic between world and conscience characterizes human agency through acts of decision, rupture, and option, making history a narrative of possibilities. Such an understanding of history and the assumption of a non-determinist vision of the world, is, in the thought of this author, a sine qua non to talk about ethics.

This debate reflects the conceptual tension between structural conditions and individual agency, and the need for a point of balance between adaptation and transformation as conditions for change and survival to change. For adaptation to meaningful in socionatural systems, it is necessary to discern two fundamentally distinct (although complementary) uses of the term adaptation: on one hand, human collectives (like all other animals) need to adapt themselves to environmental conditions, such as climate variability and the peculiarities of a certain territory; on the other hand, awareness of actual and expected conditions allows humans to interfere with socioecological systems, integrating themselves into each context as agents of transformation of the world. It is clear then that human adaptation is distinct from the biological relationship of adaptation between other living organisms and their habitat, in the sense that the process of integration of human communities with their life-support systems is permanently inducing changes in these supports, hence always containing an important component of transformation. Here is the idea of transformative power of human societies by collective action. But this has never been ignored by Parsons (1967) who defined power as "the capacity of a social system to mobilize resources to realize collective goals."

To sum up, the concept of adaptation, as it is usually defined in the climate change literature, is first and foremost concerned with the fact that global warming poses additional risks for human and natural systems, acknowledging the need to adapt these systems to these risks. But the point which I would like to make is that human societies are in a constant process of transforming their own habitats. Therefore, internalizing the need to adapt to global environmental change, human societies are called to adapt their economic processes and social institutions of territorial transformation. Recent discussions on adaptation recognize the importance of considering transformation within adaptation processes[21], which would successfully integrate transformative dimensions of change within adaptation theories. Such an integration is important in order to avoid a negative (and equivocal) understanding of adaptation as a process of accommodation to unfavorable and/or precarious circumstances. Assuming this perspective as a point of departure, the mainstay of this work is to bind the concept of adaptation with the Social Function of Property in the only way this theoretical exercise may prove to be useful: by understanding its consequences in political practice.

4.1. What is land-use adaptation?

Land-use adaptation is not currently used as an academic term[22] but there is a growing body of literature on *ecosystem-based adaptation,* which may provide relevant guiding theoretical frameworks for grounding the concept[23]. Ecosystem-based adaptation is defined as the "use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt" (CBD 2009). Based on this theoretical background, land-use adaptation is hereby defined as the set of adjustments on land-use

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[21] Transformational change was an important theme of the recent IPCC Fifth Assessment Report (IPCC, 2014), which deserves particular attention for Chapters 8, 16, and 20 of the report on Impacts, Adaptation, and Vulnerability.

[22] A search of the key words "land use adaptation" found no entries for this term in a Google search of academic texts online made on 4 March 2016. However, there is a growing body of literature making use of these words separately. In a similar search of academic texts in the same webseach platform, these words appear sepparatedly in 2 610 000 results.

[23] See for example Daily and Matson (2008), Daily et al. (2007), Moser and Ekstrom (2010), and Clar et al. (2013). This literature will be further discussed in chapter 2.3.

decisions designed to help urban communities mitigate anthropogenic impacts and aimed at reducing socioecological vulnerability.

The concrete application of this concept may be examined in more detail by specifying the hazard that is supposed to be mitigated (in this instance, urban flooding), what is meant to be adapted (land use), and to what ends (the social and ecological function of the city). This more specific use of concepts makes it possible to characterize land-use adaptation as an identifiable overarching urban policy and to lay the foundation upon which it may be used operationally within the broader range of actions that are needed to mitigate urban flooding. The specific application of this definition to a socioecological function such as flood mitigation enables a clearer focus on the conceptual dimensions of an ecosystem-based approach to adaptation, which highlights the essential role of land use in the process of adjustment to and transformation of human habitats. It also represents a paradigmatic shift and a radical change in perspective in handling floods, moving beyond a solely negative perspective based on risk to a new focus on socioecological values and benefits.

Adapting land use's socioecological functions may be defined as a pro-active perspective of constructive intervention (SEN, 2014), since it is precisely by altering the use of natural resources that the synergy between mitigation and adaptation measures can better contribute to sustainainable socioecological systems. As Sen notes, "the environment is not only a matter of passive preservation, but also one of active pursuit. Even though many human activities that accompany the process of development may have destructive consequences (and this is very important to understand and to address), it is also within human power to enhance and improve the environment in which we live" (SEN, 2014). Indeed, directing human interventions for incrementally adapt urban structures to a set of socioecological functions (such as flood mitigation) can substantially enhance environmental conditions and potentiate existing ecosystem services. Incremental adaptation can be considered the extension of actions and behaviors already in place in order to reduce losses or enhance benefits associated with climate change, often where the goal is to maintain the essence and integrity of an existing system or process at a given scale (KATES et al., 2012; PARK et al., 2012). Transformational adaptation, in contrast, includes actions that change the fundamental attributes of natural and human systems (IPCC, 2014). Transformational changes can be considered as means of reducing vulnerability, not only to environmental risks, but also by challenging the economic systems and social structures that contribute to certain patterns of production and reproduction of socioecological conflicts.

4.2. The origins of the ecosystem approach

The development and progressive acceptance of the ecosystem approach can be described as a narrative of bridging different disciplinary fields through a large number of contributions, particularly those of natural and social sciences. Earlier studies on ecosystems rooted in the 1960s contributed to a growing acknowledgement of the inter-connectedness of ecological processes. These studies broke new grounds of science by combining different sets of information and analysis and exploring the possible relations among them. One of the first applications of the ecosystem concept to watershed management appears to be in the Hubbard Brook Watershed Ecosystem study (BORMANN and LIKENS, 1967, 1974), which investigated the interactions between ecology, hydrology, and meteorology within a catchment. This study showed important properties of ecological and hydrological processes, illustrating the role of water in linking various ecosystems. The multitude of inter-linkages among natural phenomena along the hydrologic process is a clear example of the complex trade-offs and synergies that occur among a wide range of different processes. O'Sullivan (1979) observed that such processes are explained by the property of indivisibility, through which an ecosystem transmits information from one part of the system to another by means of the hydrologic cycle. One of the main findings of these studies was that when fragmentation of ecosystems occurs, the system enters into a process of entropy. This process of entropy is typically characterized by the progressive degradation of natural processes, diminishment of patterns of biological productivity, and disruption of ecological functions.

The property of indivisibility, as observed by O'Sullivan, is present in all ecosystems and may be extended to all living and non-living organisms. This idea finds perhaps its best expression in the hypothesis of Gaia (LOVELOCK, 1972), describing the Earth as a set of contingent feedbacks and loops, where the reactions of the planet to human actions can be taken as a self- regulating response. Yet, its theorization does not suppose the existence of a superorganism or a global entity endowed with any sort of unified agency. As Latour (2012) emphasizes, the policy relevance of Lovelock's Gaia lies in the image of a complex ensemble of interconnected bio-physical processes which react in continuous feedbacks and loops (which may eventually eliminate humans' existence), without constituting an ontologically unified entity. This paradoxical lack of unity within an inextricable set of processes, actions, and reactions can be observed from global to local scales in social and natural systems, evincing the impossibility to separate these if one wishes to address "real world" problems.

In the 1980s, the renewed interest in environmental concerns was built on considering sustainability issues in the development agenda. During this time, the influential Brundtland report (WCED, 1987) stimulated a renewed interest in environmental concerns, emphasizing the importance of considering sustainability issues in the international policy agenda. The recognition of the need to address sustainability issues was also triggered by economic and social studies that generated an intense debate about the human capacity to destroy the so-called "natural resources" on which they depend. An outstanding contribution within this debate was Hardin's groundbreaking article "The tragedy of the commons" (HARDIN, 1968). The essential argument of Hardin was that any natural resource, when shared by a community, tends to be overexploited, that the self-interests of each member within a given community coincide with the progressive diminishment of the corresponding resource. Hardin´s arguments generated a controversial debate on what has been conventionally defined as common-pool resources[24] and opened a rich discussion about the ways human communities compete or cooperate within certain rules of use. The contributions of Elinor Ostrom opened up new perspectives regarding this discussion by showing many practical

[24] Gibson et al (2000) observes that ecosystems such as forests or wetlands yield some products that are subtractive (e.g. wood, animal species, fibre etc) and other that are nonsubtractive (e.g. flood regulation). This distinction is important for understanding which aspects of a particular ecosystem are common-pool resources and which are public goods. Ostrom et al (2002) highlighted, however, that subtractive and non-subtractive products (or services) are related, explaining that cutting timber, for example, can reduce a forest's ability to provide flood mitigation services.

examples where common-pool resources are used in a sustainable manner through culturally-sedimented, commonly-accepted rules of use. The findings and theories on common-pool resources developed by Ostrom and her colleagues[25] have carved out an important transdisciplinary research domain, enabling the development of new prospects about the relationship between property rights, public goods, and public choices. This is an important body of literature that deserves further attention in land-use adaptation studies because it allows for a comprehensive approach to influencing factors in decision making by considering a wide range of institutional factors.

In the early 1990s, researchers concerned with biodiversity issues started discussing the need to develop an Ecosystem Approach (EsA) for studying natural and human systems from a holistic perspective. The recent interest in the EsA was very much influenced by the Convention for Biological Diversity (CBD), first held in 1995. This convention adopted the EsA as its primary framework for action[26], considering all the goods and services provided to people by biodiversity and ecosystems (Convention for Biological Diversity, 2000). At the time it was suggested that an Ecosystems Approach would deliver more integrated policy and management toward the needs of people (DEFRA, 2011). In 2005, the Millennium Ecosystem Assessment (MEA) Report, presented the most extensive collaborative and scientific initiative ever undertaken to assess the planet's ecosystems. Daily et al (2009) observed that the adoption of the approach developed by the MEA would lead to the recognition that natural systems are

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[25] Accepting that ecosystem services entail both common-pool resources and public goods makes it useful to draw on previous frameworks of the analysis of the commons in its essentials. In this regard, see, for example, Wilson, 1977, Kiser and Ostrom, 1982, Bromley et al 1992, and Ostrom et al 2002.

[26] The ecosystem approach adopted by the Convention for Biodiversity (MEA, 2005) is consistent with the current thinking of Integrated Flood Management in that it includes human and natural factors in a systemic and holistic perspective and the entire watershed as an indivisible unit. As it has been described in more detail in chapter 2, Integrated Flood Management, as defined by the World Meteorological Organization (2009), is based on the recognition of the interconnectedness of bio-physical and socio-economic processes, which promotes the integrated management of land, water, and living resources.

vital assets and an understanding of how these assets play central roles in supporting human well-being, which would lead individuals and institutions to routinely incorporate their material and intangible values into decision making. The MEA introduced a new framework for analyzing socioecological systems that had wide influence in academia. Since then, various governmental organizations are starting to give due attention to ecosystem services and have set out to adopt the EsA (e.g. EU Water Framework Directive, EU Soils Directive, UK Soils Strategy, Action Plan for Embedding an Ecosystem Approach, and the UK National Assessment of Ecosystem Services (2011), etc.). Despite the considerable progress in encouraging government institutions and other governance sectors to adopt the principles of the EsA, decision making is still failing to consider the main concerning factors.

Several authors refer to ES as an integrating concept that explicitly brings together the different environmental processes which are interlinked. There are many definitions of ES found in the literature, and all definitions are very broad in scope. But whatever differences might exist on defining ES, the EsA considers the environment according to the range of goods and services it provides to people and how these benefits might be altered by human influence on ecosystems[27]. In this regard, Müller et al (2006) argued for the need to revise and clarify ES principles in order to make them more useful operationally, while others (MALTBY, 2000; HARTJE et al., 2003, DEFRA 2011) emphasize that the fluidity of such definitions is a virtue, allowing a more flexible use of ES principles according to different circumstances. Being that the EsA is an evolving concept in a very early stage of development, it is natural that many unanswered questions and avenues for further research still remain. Most of the problems about how to integrate a more complete set of information in the ecosystem services provided by strategic areas for urban flood mitigation are not yet resolved. However, the adoption of such an

[27] Daily (1997) has defined ecosystem services as the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. The Millennium Ecosystem Assessment (MEA) defined ecosystem services as the benefits people obtain from ecosystems (MEA, 2003). According to DEFRA (2011), the term ecosystem service can be used broadly as "what nature gives us."

approach, together with the recognition of the diversity and heterogeneous nature of ecosystems, is significantly contributing to the development of a wide range of research approaches used for their characterization. While an extensive assessment of the methodologies developed for this characterization goes beyond the scope of the present work, the next section presents a brief summary of the ecosystem services that may be associated to flood mitigation and land-use adaptation measures.

4.3. Water-flow regulation and related ecosystem services

Perhaps the most attractive prospect of the ecosystem approach is the opportunity to consider bundles of ecosystem services along with flood mitigation, enabling the exploration of trade-offs and synergies among a number of potential benefits. Integrating ecosystem services with flood management makes it possible to generate positive synergies among multiple goals that incorporate ecological and social values. Understanding flood mitigation as a socioecological function within the whole ecosystem has the potential not only to prevent losses and damages from flood related risks, but can also potentially bring co-benefits through the enhancement of related ecosystem services. Hence, a more holistic understanding of ecosystem services can give a richer set of information to decision makers and can help attract new sources of investment.

Framing flood mitigation as a socioecological function requires the discernment between functions and services and the understanding of the difference between flood mitigation and water flow regulation[28]. In order to unfold these different aspects of water and its relations to ecosystems, it is important to note that water is both a system and a primal element of several ecosystems in which the hydrologic cycle occurs. Rivers constitute an important part of this cycle, and it may be said that one of the functions of the river is to let the water flow. Accordingly, floodplains can be seen as a fundamental

[28] Some examples of specific research on water-flow regulation services for flood mitigation in the literature on ecosystem services can be found in Acharya (2000), Emerton (2005) and Shrier (2010), among others.

element of this cycle, accommodating the waters when these overflow the river channel (this is a typical example of a water-flow regulation service). On the other hand, to say that a floodplain has a socioecological function is to say something about what it does within a certain social and natural system. It also says something about its history: how natural processes dynamically form a given landscape unit and how that space has come about to be transformed and appropriated by human actions. In this case, the socioecological functional aspects of a river and its floodplains, are strictly connected with transformative adaptation dynamics within a certain cultural landscape.

It is also important to note that flooding, while it is a natural process that fundamentally occurs in wetland ecosystems, is very much influenced by remote ecosystems, such as forests located in upper levels of the floodplain[29]. Forests within and around watersheds play a prominent role in retaining water in periods of flooding, by absorbing and slowing down the run-off from heavy rains. Moreover, forests regulate water quality through filtering and purification during which water is released to surface water bodies and underground aquifers. As such, there are many ecosystem services provided by various interrelated ecosystems, which can have important roles on flood regulation and other related services. Flood mitigation requires, therefore, a thorough consideration of a wide range of natural and cultural processes occurring throughout the entire watershed.

Wetland ecosystems encompass a wide range of hydrological, ecological, geomorphological, and economic characteristics and are present in a variety of natural and man-made environments. The designation of wetland ecosystems was established in 1971 by the Ramsar Convention Bureau by grouping together a wide variety of landscape units whose fundamental characteristic was being strongly influenced by water. This

[29] The interactions between these processes have been thoroughly studied (see e.g. MALTBY, 1986; DUGAN, 1990; BARBIER et al., 1997), but still their importance is mostly underestimated. In regard to the role of forest ecosystems, the EU Water Directive recognizes that forests play a key role in soil protection and water regulation by preventing soil erosion and desertification as well as by reducing the risks of floods.

convention considered wetlands to be “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.” Dugan (1990) suggests that water ecosystems can be grouped and simplified according to seven common landscape units, indicative of specific geomorphologies: (i) estuaries; (ii) open coasts; (iii) floodplains; (iv) freshwater marshes; (v) lakes and ponds; (vi) bogs and peatlands; and (vii) swamp forests. According to Vandewalley et al (2010), man-made wetlands, such as paddy systems, irrigation tanks, and waterlogged areas, could be added to these groups. Despite the wealth of literature[30], classifications of the functions and services provided by wetlands are rarely consistent. Naturally, not all wetlands provide the same services, and, in many cases, it is difficult to identify precisely the extent of the service and its concerning functions.

Due to the wide variety of relevant ecosystem services to be taken into account, this study hereby adopts the four broad types of ecosystem services defined by the UK Environmental Agency (DEFRA 2011): i) regulating services; ii) provisioning services; iii) cultural services; and iv) supporting services. These four types will be described in the following pages.

Regulating services

Watersheds vary according to geomorphologic, hydrologic, biotic, and other characteristics and can have the most different configurations: from almost flat and desert environments to forested mountains or tundra wetlands, a wide variety of combinations of ecosystems can exist. Wetlands act as a sponge, and when they are subject to inundation by floodwaters, their soils become saturated. Bullock and Acreman (2003)

[30] Many authors have extensively discussed the ecosystem services provided by wetlands. For more information on the specific roles wetlands play and how these interact with the local environment, see Adamus and Stockwell (1983); Maltby (1986); Dugan (1990), Barbier (1993), and Finlayson et al (2005).

show that floodplain wetlands can reduce flood magnitude downstream, with examples from all regions of the world.

Both wetlands and forests play an important role in climate regulation at a local scale and may also contribute to climate regulation on a global scale. Although this service has not been adequately quantified, Bolund and Hunhammar (2007) note that the potential cooling effect of forests and wetlands is of particular interest in urban areas where urban heat island effects may raise the temperature by as much as 5°F (3˚C). Vandewalle et al (2010) observe that wetlands are also one of the biggest carbon sequestration ecosystems in the world's climate regulation system. Bolin and Sukamar (2000) estimate that wetlands account for approximately 37% of the terrestrial carbon pool. Pant et al (2003) and Euliss et al (2006) noted that wetlands have an important role in regulating carbon dioxide (CO2) and methane (CH4), with great potential to help mitigate climate change. Mitsch and Gosselink (2007) observed that processes of carbon accumulation in wetlands result in massive soil carbon stores, representing the largest component of the earth's terrestrial biological carbon pool.

Provisioning services

Wetlands, floodplains and forests are often rich in biodiversity and high in biomass. These ecosystems provide habitat for a wide variety of plant and animal species, including fish, birds, amphibians, and aquatic invertebrates. The Millennium Ecosystem Assessment (MEA, 2005) describes a wide range of provisioning services provided by wetlands such as food, fiber, and fuel; biochemical (extraction of materials from biota); and genetic material and biodiversity (species and gene pool). Vandewalle et al (2010) noted that wetlands provide habitat to a diverse group of plants and animals, including migratory birds. According to Mitsch and Gosselink (2000), nearly all freshwater fish depend on wetlands for some part of their life cycle, often laying their eggs in a wetland's slower moving waters during spring flooding cycles. Many of the plants and animals present in wetland ecosystems can potentially provide beneficial consumptive uses to people, such as food, and raw materials such as fibers and wood. Emerton et al (1998) notes that wetland crop cultivation provides a significant supplement of food for local communities and yields a source of cash income from the natural resources provided by wetlands for household use.

Cultural services

Wetlands have important functions in many cultures around the world. How these cultural services are valued depends on the exchange relationships between each community and a certain landscape unit. Cultural services may vary from agriculture to tourism activities, involving such different values as spiritual or aesthetic, among many other possible attributes. Everard (2004) makes an overview of the potential of sport and leisure activities in wetlands, concluding that economic benefits can be very significant. Recreational and educational services improve the local environment by providing landscape that can be potentially used to learn about ecology and biodiversity, as well as amenity spaces for the community. Spiritual and aesthetic values can also be very important to a specific region's culture, economy, and quality of life for local communities. Particularly in urban regions, river, and/or floodplain systems help to raise public awareness about flooding phenomena and provide knowledge on the direct and indirect benefits of wetland conservation.

Supporting services

Water treatment services comprise perhaps the most widely recognized service provided during the hydrologic cycle. Vandewalle et al (2010) note that water purification and the maintenance of water quality is both manageable and economically exploitable. Water quality-related services include waste treatment, nutrient cycling, and erosion control via sediment and storm water retention, as well as detoxification[31]. Hunt and Doll (2000) explain these processes of water purification and transformation of pollutants by describing a combination of physical, chemical, and biological processes. In many urban regions, the wetlands that surround the city provide invaluable supporting services by filtering the runoff from adjacent areas and related water bodies through riparian vegetation buffers. Maltby and Acreman (2011) note that the maintenance of naturally

[31] According to Vandewalle et al (2010), detoxification services may be divided into three phases: retention, recovery, and removal of pollutants.

flooded conditions may also be an essential requirement to avoid severe environmental degradation.

5. Integrative flood science as an emerging field of knowledge

In this chapter I critically analyze the concepts of what I have called *integrative flood science*, contextualizing them in historical terms[32]. The first section will clarify the main concepts that have emerged for dealing with floods over time. Main stages of conceptual development are characterized, showing how the use and the diffusion of related concepts evolved according to different modes of economic production and technology, which also reflects different perspectives regarding the relationships of human transformation and adaptation to land and water. An exploration of the concepts of resilience, vulnerability, and risk is also presented at the end of this section. The second section analyzes how state-of-the-art concepts are being appropriated in the policy domain, using the case of the European experience. This choice is justified by the fact that the European Union offers an example of a common effort to translate state of the art concepts in a shared policy framework among various nations within diverse circumstances and backgrounds at the national level. The broad policy framework on flood risk management is described, inquiring into the recent efforts to embed flood risk management in specific policies and with a particular focus on how these are being articulated in planning and management practices. As it will be discussed ahead, the definition of “Flood Risk Management” is associated with a more narrow focus on “risk” and an emphasis on managerial aspects rather than on planning and governance aspects. The third section addresses the main shortcomings of these conceptual approaches, analyzing the gap between theoretical concepts and practical realities. Two are highlighted: i) traditional concepts of land drainage remain dominant practices, while prevention measures are rarely implemented; ii) governance practices have not been

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[32] This contextualization is theoretically based on the contemporary critique of the unhistorical and depoliticizing use of concepts, developed by Reinhart Kosseleck in his influential work on conceptual history (Koselleck, 1999), and relations with social history and hermeneutics (Koselleck, 1997). A good review in Portuguese of the Koselleckian formulations can be found in Jasmin 2005.

sufficiently adapted. These main shortcomings are explained by the difficulties to embed land-use adaptation measures in flood management strategies, which are fundamentally rooted in economic and institutional constraints.

5.1. Conceptual evolution in the state-of-the-art

The concepts for dealing with floods in urban environments have evolved in approach and perspective, widening their scope and complexity by incorporating new dimensions. Tunstall et al (2004) described this evolution in four main stages, describing conceptual approaches from land drainage, flood defense, flood control, and, more recently, flood risk management. Adding to these main stages, a more recent concept of Integrated Flood Management has emerged, showing that this conceptual discussion is still evolving.

The drainage of wetlands for human occupation has occurred since ancient times, being the most extensive man-made transformation of riverine areas and floodplains throughout the world for millennia. In Brazil, the extensive use of land by monocultures contributed to the conversion of enormous areas with the development of large-scale drainage schemes. In fact, land drainage has left an undeletable mark of human presence throughout the world, from the ancient drainage schemes of the Hindus Valley to the backwaters of Kerala, and perhaps the most poignant example of human nature, the vast rice fields of China. Since the XX century, the conversion of wetlands has dramatically increased due to the mechanization of agricultural production and urban development. In cities, urban drainage solutions have been mostly designed to take water away as fast as possible, conditioning waterways and changing their course, which are usually associated with landfilling operations. Mostly these operations have been made without regard for environmental impacts such as changes in sediment flows, erosion, and other consequences of landfilling, in particular the aggravation of flooding conditions in downstream areas.

The technological possibilities opened up by the development of concrete infrastructures allowed a whole new capacity for transforming human environments. Where floods have been seen as a serious threat, a flood defense approach was adopted by using dykes, embankments, and levees. This type of infrastructure has been widely used in order to protect people and property assets and is based on the notion of resistance to floods, which is defined as the ability of a system to show no reaction if disturbed. With few exceptions, these engineering schemes have been designed often on a case-by-case, fragmentary fashion rather than in a strategic way, which often reveals counterproductive results in the long run. In this respect, Miguez et al (2015) observe that when a lowland area is protected by a levee against a pre-defined flood design event of a fixed return period (as is usually considered in design procedures), the feeling of safety brought by these works tends to attract more people to the protected areas near the river. Furthermore, as noted by these authors, several times the planning process loses track of the original hazard mapping. Another characteristic of this type of intervention is that it has been traditionally made from a bottom-up approach, one determined by technocrats and with little engagement of other relevant stakeholders.

From the beginning of the 1970s, a shifting tendency toward urban drainage has driven the design efforts to source control measures, focusing on the flood causes, that is, on minimizing and reorganizing superficial flows (MIGUEZ et al, 2015). Flood control emerged as an approach that makes use of the previous technical concepts but with a more sophisticated understanding of water systems and claims the possibility of controlling natural processes according to acceptable levels of risk. Flood control strategies aim to minimize the consequences of a flood by collecting and dispersing water and combining structural solutions and non-structural measures (land-use planning and management). There is considerable confusion in the literature regarding these terms. Vis et al (2003) observes that structural measures are not only composed of “hard” engineering (such as the construction of structural defenses, embankments, and drainage schemes), but also of “soft” engineering measures (such as river restoration measures and multifunctional landscapes for water storage). In turn, non-structural measures include land zoning for reducing the impacts of urbanization, the preservation of natural buffers for enhancing infiltration, and the regulation of construction standards. Chang (2007, 2008) notes that “soft” engineering and non-structural solutions offer more opportunities for nature and landscape development and are often considered to be more in line with sustainability. The following table schematizes structural and non-structural measures, illustrating related effects and externalities.

	Structural measures	Non-structural measures
	Hard Engineering	Soft Engineering
Example	Drainage infrastructures, embankments, reservoir dams, dykes, and weirs	Creation of retention basins, managed realignment of retention basins, dyke relocation, and retention
Effect	Immediate and effective flood mitigation	More sustainable flood mitigation
Externality	Adverse externality (decreasing capacity of infiltration or drain affects flood risk locally and downstream adversely)	Beneficial externality (increasing capacity of infiltration or drain affects flood risk locally and downstream beneficially)

Table 1. Structural and non-structural measures for flood mitigation

The concept of Urban Flood Control brought significant advances to Integrative Flood Science. The understanding of hydrological processes has significantly increased through the development of mathematical and computational capabilities, making possible more accurate forecasts of flooding conditions according to local characteristics. At this stage, the functioning of water systems across river basins is fully understood on a scientific basis, which makes it possible to quantify flows, water volumes, and inundation levels across the watershed. In order to deal with urbanization processes, innovative drainage-related concepts have been developed such as the North American concept of Low Impact Development (USDoD, 2004; KLOSS and CALARUSSE, 2006), the Water Sensitive Urban Design concept developed in Australia (BMT WBM, 2009), and the British concept of Sustainable Urban Drainage Systems (ANDOH and IWUGO, 2002). Despite the advances that such approaches represent, Miguez et al (2015) recognize (by presenting various cases in the Brazilian context[33]) that urban flood control is an issue that is hard to solve, especially in dense cities occupying lowlands. In the face of these shortcomings, the belief in a possibility to control floods to acceptable levels of risk according to certain thresholds of acceptable risk is questioned today by many

[33] The cases presented in the study "Urban Floods in Lowlands—Levee Systems, Unplanned Urban Growth and River Restoration Alternative: A Case Study in Brazil" show various problem in the use of levees in a case study in Baixada Fluminense, in the Metropolitan Area of Rio de Janeiro (see Miguez et al 2015).

scholars who argue that when imponderable factors are considered, the idea of control is misleading and may also have counterproductive effects[34].

Since the 1990s, there has been a gradual transition toward a more strategic, multi-dimensional, and integrated concept of flood risk management. This concept moves away from the traditional focus on defending against floods via control of the flood hazard toward a focus on managing the flood risks in terms of both probabilities and consequences. Under this approach, managing flood risks is characterized by the repetition of a number of activities: analysis of risks and benefits, consideration of structural and non-structural measures, the making of policy decisions, the implementation of measures, and the directing of public investment to strategic interventions. Throughout this cycle of activities, decision-makers must account for changes and trends in both the short and long terms. This integrated approach to flood risk management has had a significant impact on the evolution of perspectives about the topic during the last decade, and it is becoming common for governments to invest in a range of actions directed toward planning, land management, flood warning, community involvement, and structures to reduce flood risk.

Flood risk management is described by Tunstall et al (2004) as the decision-making process that seeks to manage the reaction of the hydrologic system to external perturbations, recognizing in particular that not all floods can be prevented. The emphasis is placed on the need to consider the entire watershed, not only in terms of its physical aspects but also the institutional conditions in place, such as administrative boundaries and stakeholders. Flood mitigation strategies designed in order to slow the flow of floodwaters and give space to the water are often described in the literature as ways of "living with the flood" instead of "fighting floods" (VIS et al. 2003). Similar strategic interventions include "making space for water" through the provision of "green infrastructure," thereby creating areas that can be used to accommodate the flood waters during and after an event. These interventions aim to enhance resilience to changes in the hydrological cycle, such as landscape conservation for infiltration and upstream storage, which increase the response of watercourses and retention basins, among others. The role of adapting land use to areas of increased flood risk is discussed in the literature on Flood Risk Management[35]; floodplain functions for regulating the water cycle are also well documented[36], showing that floodplain wetlands can reduce flood magnitude downstream, and using examples from all regions of the world. Floodplains not only are important for their storage capacity (RICHARD and HUGHES, 2008), but also for their favoring of infiltration into the floodplain soils, which convey large amounts of water during wet periods (KEDDY, 2000).

The consolidation of theoretical concepts of Flood Risk Management, together with recent interdisciplinary research in a wide variety of fields of knowledge, is directing the state-of-the-art of this interdisciplinary field toward a more holistic conception of Integrated Flood Management. This concept was proposed by the World Meteorological Organization (2009), based on the recognition of the interconnectedness of bio-physical and socio-economic processes. The concept moves beyond the focus on flood risk toward a more integrative perspective of the management of land, water, and living species. The ecosystem approach adopted by the Convention for Biodiversity (MEA, 2005) aligns with the current thinking of Integrated Flood Management by emphasizing the integration of human and bio-physical factors, considering the interdependencies through complex interactions among these factors, and accounting for the effects of individual actions within watersheds, ecosystems, and biomes. From a socioecological perspective, this conceptual approach is particularly relevant in that it justifies an effort to unfold such a

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[35] Specific discussion of the role of land use on reducing flood risks may be found in Kousky et al. (2011), Liao (2012), and GFDRR (2012).

[36] See Acharya (2000), Emerton (2005), Shrier (2010), Offermans et al. (2011), Haasnoot et al (2012), Liao (2012, 2015). Bullock and Acreman (2003).

conceptual approach in order to systematize its various dimensions into a discernible framework.

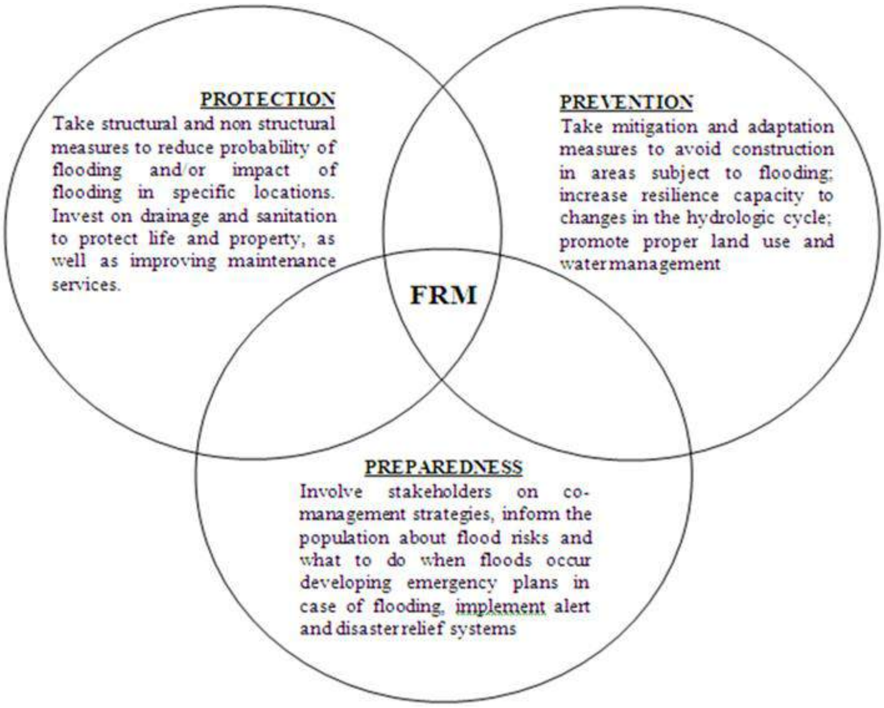

Fig. 22: The multi-dimensional nature of flood risk management (by the author)

Integrated Flood Management can be framed out in three main dimensions, combining protection, prevention, and preparedness measures in which the planning, management, and governance of natural resources are entirely integrated. As the diagram suggests, integrated flood management needs to be understood as a continuous process in which the planning cycle is an essential part of the management process itself. Within this cycle, aspects of governance involving the participation of a wide range of stakeholders are crucial aspects to consider. While protection and prevention measures involve structural and non-structural measures, more emphasis is given to non-structural measures within preparedness measures. These measures may be unfolded with a combination of environmental education (to elicit local knowledge about existing risks and coping strategies), early warning systems (e.g. text messages on mobile phones, local radio messages, sirens), mapping of community needs (e.g. directing people who are sick or wheelchair-dependent to flee by themselves when flood events occur), emergency training for fire services and council workers (e.g. with pumps, sand bags), and emergency back-up facilities (e.g. flood-proof evacuation centers). Many of these measures may seem less technical, but they do depend very heavily on good ICT and on good weather-prediction models.

5.2. The theoretical tripod of resilience, vulnerability, and risk

At the center of integrative flood science is the concept of resilience. In an overview of recent experiences on developing strategies for dealing with floods in urban environments, Hooijer et al (2004) identified a trend in enhancing resilience to flood events. The notion of resilience takes into account how systems, communities, or sectors deal with disturbance, uncertainty, and unexpected changes over time, and it is characterized by both adaptation and transformation (WALKER and SALT, 2006; FOLKE et al., 2010; WESTLEY et al.,2011). While traditional engineering solutions frequently show the trend of transferring problems to downstream reaches (e.g., channel enlargement measures), Zedler and Kercher (2005) observe that the areas that best abate flooding are those occurring upstream of places where flooding is a problem. Mitsch and Gosselink (2000) review a number of experiences in preserving and restoring wetlands in the upper reaches of a watershed, recognizing the critical role of wetlands in mitigating flood damage since they store large quantities of water, thereby effectively reducing the height of flood peaks and the associated risk of flooding downstream. River restoration and the adaptation of peri-urban floodplains through improving infiltration and storage measures and for the purpose of reducing hydrological impacts (see MITCHELL et al 2006) show the potential of adapting land uses to flood mitigation functions in order to accommodate the stormwater during and after flood events.

The concept of resilience is a much more comprehensive approach than traditional concepts of resistance and may include many different dimensions, including social and psychological aspects among many others. Resilience to change can be achieved by better adapting to the evolution of nature and landscape, by reducing the magnitude of flood peaks, and by reducing the impact of change on social systems through the development of better emergency response and flood-recovery strategies. Ecological resilience is a measure of the disturbance of dynamic systems where changing phenomena (i.e. climate variability) and external factors (e.g. unintended urbanization dynamics) result in high uncertainty[37]. In this case resilience is measured by the magnitude of disturbance that can be absorbed before the system changes its structure. Hydrological resilience fits within this definition, constituting a very specific aspect of the resilience of a socioecological system. It can be characterized by three aspects:

• The magnitude of the reaction;

• The graduality of the reaction with increasingly severe disturbances; and

• The recovery rate.

According to Klijn et al (2008), in resilient systems no sudden catastrophes will occur but damage will increase gradually with disturbance. The resilience of a hydrological system depends on its adaptive capacity to change according to the rate of increase in impacts with more severe events and to the rate of recovery after flood events. Recent research is exploring the possibilities of statistically analyzing these aspects from an integrated perspective, using a resilience scale (see VERÓL, 2013) to study urban resilience for distinguishing and defining different "abilities" of socioecological systems in adverse conditions.

Vulnerability is dynamic and multi-faceted, with social, economic, and environmental dimensions (RAHMAN et al, 2007). The term is generally used in relation to an inability to cope with external changes, including avoiding harm when exposed to a hazard. This includes people's inability to avoid the hazard (exposure), anticipate it, take

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[37] Holling (1996) explains that the resilience of a system has been defined in two different ways in the literature, what he called *engineering resilience* and *ecological resilience*. The first definition focuses on efficiency, constancy, and predictability, and corresponds to the more traditional use of the word as a physical property in engineering, normally used to calculate how long a system takes to return to equilibrium once its equilibrium has been disturbed. Such a definition is appropriate for systems where uncertainty is low, but it can be counterproductive for dynamic, evolving systems. The second definition, *ecological resilience*, focuses on persistence, change, and unpredictability (HOLLING, 1996). In this case, resilience is measured by the magnitude of disturbance that can be absorbed before the system changes its structure. According to these authors, this second definition of ecological resilience is the most adequate for evaluating, understanding, and managing complexity and change in ecosystems. For further discussion of the topic see also O'Neill et al, 1986, Tilman and Downing, 1994, and Holling and Gunderson, 2002.

measures to avoid it or limit its impact, cope with it, and recover from it (HARDOY and PANDIELLA, 2009). Moser (1998) defines vulnerability as insecurity in the well-being of individuals, households, and communities, including sensitivity to change (op. Cit., our emphasis). Vulnerability can be understood in terms of a lack of resilience to changes that threaten welfare, which can be environmental, economic, social, and political, and can take the form of sudden shocks, long-term trends, or seasonal cycles. Such changes usually bring increasing risk and uncertainty, requiring greater efforts to build social capital of vulnerable communities so that these may increase resilience by better coping and recovering after flood events. However, if the level of exposure to flood hazards increases, a human system may face greater risk despite reduction in social vulnerability achieved through the implementation of adaptation strategies (BROOKS, 2003).

When certain thresholds of a certain geomorphological process are surpassed, it becomes a geomorphological hazard. However, a geomorphological hazard is only a problem when it interferes with the socio-economic environment, causing loss of life or damage to property. Risk, in turn, is the probability of a flood event and of the potential adverse consequences for the socio-economic environment (ALKEMA, 2007). The US-EPA (1995) characterizes risk as being dually composed of hazard and exposure. Exposure, sensitivity, and adaptive capacity together determine vulnerability.

According to Varnes (1984), risk (R) depends on the magnitude of the hazard (H), on the vulnerability (Vu) of the exposed element to that particular hazard, and the value (Va) of the element:

$$R = H \times Vu \times Va$$

According to Moser's (1998) definition of vulnerability, this concept is closely linked to a lack of assets. The more assets people have, the less vulnerable they generally are; the greater the erosion of people's assets, the greater their insecurity. Generally, an asset is identified as a "stock of financial, human, natural or social resources that can be acquired, developed, improved and transferred across generations. It generates flows or consumption, as well as additional stock" (FORD FOUNDATION, 2004). By determining the level of risk, it is possible to define the limit of water level that is considered acceptable for the community. This limit is the threshold that indicates the critical point of abrupt change of efficiency in aggregating decisions within a catchment.

5.3. The European policy framework in flood risk management

The evolution of concepts toward a more integrated approach to flood risk management emerged in a common and very large context, both in terms of different disciplinary fields and different country experiences. National governments have varied greatly in the attention they have paid to the issue of flood risk, and experiences in the Global North and the Global South are markedly distinct, reflecting national circumstances that need to be considered. Even among countries with a longer history of planning and management, different political cultures and physical characteristics gave rise to very different national experiences. Considering such contextual factors, the European Union serves as an example of a particularly rich experience in developing specific urban policies around flood risk management that deserves to be examined.

The commitments assumed by the European Union in international treaties on climate policy resulted in the official acknowledgement by all Member States of the European Union (EU) that the current levels of exposure to flood risk demand consistent policies and concrete actions. Severe flood events in the recent past and awareness of the possible worsening conditions due to climate change motivated some European National Governments who are now at the forefront of research and policy guidance in a number of related fields of knowledge[38]. At the policy level, some countries have primarily focused on precautionary measures, while others have put more effort into managing flood disasters[39].The EU Water Framework Directive, published in 2000, gave an

[38] The flood disasters of 1993 and 1995 in the Netherlands are usually considered as alarms that later triggered the "Room for the River" approach, which changed Dutch flood risk management strategies. Making room for rivers is an alternative that puts the territory in safer conditions and is often related with the premises of the river restoration approach, which aims to adapt the territory to a better environmental arrangement (MIGUEZ et al, 2015).

[39] In the UK, for example, these principles have been consistently developed and implemented throughout the last decade. Triggered by the climate change debate and the frequent flood disasters occurring

important impulse to this theme (MIGUEZ, 2015), and in 2007, with the EU Flood Directive[40], the European Union defined a common framework of action for the integrated management of flood risks. Since then, the increasing number of technical and academic studies in Europe indicates that the international debate on flood risk management is increasingly influential in policymaking.

Based on various country experiences in the EU, Klijn et al (2004) conclude that there is a growing recognition that "Besides climate change with its potential effects on flood probability, demographic and economic developments urge us to reconsider the current flood risk management strategies as vulnerability mounts" (KLIJN et al., 2003). Genovese (2006) refers to the report of the European Environmental Agency (EEA, 2004) as a landmark for recognizing consensus within the European research community about an increasing occurrence of flood events. In response to the growing number of natural disasters, the European Commission (EC) is encouraging its country members to develop approaches to flood risk management that seek to "work with nature rather than against it" (EU DIRECTORATE GENERAL ENVIRONMENT, 2011). The EU Flood Directive states in its Article 1: "(…) to establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the

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throughout the country, the UK government launched a consultation exercise aiming to seek a common vision for a future of coexistence with water. The UK national strategy called "Making Space for Water" is a particularly interesting document that emphasizes the role of land-use-based strategies and makes recommendations for strategic thinking about various aspects of flood risk management. The current planning policies for managing flood risk through land-use planning in the UK have been inserted in the Policy Guideline 25 of the PPG: Development and Flood Risk (DTLR, 2010). This policy document places special emphasis on the need to integrate knowledge about "how the risk of flooding should be considered at all stages of planning and settlement process in order to reduce future damage to property and loss of life "(DTLR, 2010). Following these efforts, the UK government has recommended to all Local Planning Authorities to "give due attention to the subject without taking into regard if their areas have experienced significant flooding events in recent years" (Department of Transport, Regions and Local Governments, 2001). The UK Government has been monitoring the implementation of the Policy Guideline 25 by Local Planning Authorities through plans and decisions about the control of occupations through the reports of "Target 12" (the guiding document on flood risk).

[40] In October 2007, the European Parliament and Council passed the EU Flood Directive (2007/60/EC) on the assessment and management of flood events. The Directive defines requirements for European Member States for assessing and managing flood risks.

environment, cultural heritage and economic activity associated with floods in the Community."

Among other measures, the directive requires to all Member States to implement

- Preliminary flood-risk assessment,
- Flood-hazard mapping and flood-risk mapping, and
- Flood-risk management plans.

The directive demands that all EU members shall develop such planning and management instruments until the end of 2013. In order to put this into practice, some national governments are reinforcing the capacity for risk reduction through the creation of structures for coordination between neighboring municipalities and different levels of governance. The focus on spatial planning is central to the directive and was emphasized by the IRMA-SPONGE research program in one of its four main conclusions ("The most effective flood risk management strategy is damage prevention by spatial planning" (HOOIJER et al., 2004)). The priority given to spatial planning in Europe is a clear indication that state-of-the-art flood-risk management is moving beyond a single-focus on infrastructure investment, toward becoming a process of continuous planning, management and governance, expressed on three fundamental guidelines contained in the EU Flood Directive:

- Setting up appropriate governance and institutional arrangements,
- Planning and implementing physical and non-structural measures, and
- Maintaining and optimizing the performance of these measures

According to the EU Flood Directive (2007, cited by KELLY et al., 2007), the development of sustainable policies and strategies for flood-risk reduction should attempt to meet the following guidelines:

• Appropriate action must be taken to create legal frameworks as well as administrative and economic conditions that are stable and technically informed. These structures should also allow public and private sectors to contribute to flood prevention, safety of dams, and reduction of flood effects on health, safety, property, land, and water;

• Priority should be given to integrated water management across the catchment basins rather than the management of floods in specific locations;

• All human activities that have the potential to affect human health or the environment shall be subject to environmental impact assessment. This assessment should not be limited to the restricted area in question and any potential effect on surrounding areas (including edge effects) should be considered;

• Physical planning, construction, and urban and rural development should consider the requirements for reduction and prevention of floods, including provision of retention areas;

• Development and land-use change must be analyzed through monitoring of urban sprawl in areas susceptible to flooding;

• The responsible institutions should consider the nature of the problems, local needs, and knowledge. The mechanisms of decision-making and local policies should also be considered;

• Communication policy should be developed to inform the public about the risks of flooding and should also facilitate public participation in the decision-making process.

The EU Flood Directive sets out a framework for the first time to cover all sources of flooding, highlighting the importance of spatial planning guidance and sustainable development, which requires the development of Flood Management Plans for all urban catchments in all European rivers. Summing up the planning and management measures recommended by reports and policy documents in the EU, I have gathered these actions in the table below:

	Planning	Management
Prevention	know risks, map natural hazards, and undertake vulnerability analysis; undertake inventories of land occupation by informal settlements; survey vacant land to identify safe and appropriate sites for relocation; elaborate comprehensive land-use plans, linking them to national adaptation plans; constrain urban sprawl by limiting urbanization into rural and natural surroundings;	simplify planning arrangements and strengthen building codes and land-use zoning; revise land tenure arrangements and laws, securing property rights to the poor; support good agricultural practices as well as forest and wetland conservation; protect ecological buffers, restricting urbanization in environmentally sensitive areas; plan for evacuation when in-situ upgrading is not possible;
Protection	plan investments in sanitation and drainage infrastructures; undertake 'soft defense works' such as beach nourishment and re-vegetation of cliffs; assess bottlenecks on existing systems and assure maintenance services;	facilitate settlement and provision for low-cost housing in areas less exposed to risk; take precautions by considering environmental risks while locating new infrastructures; improve pollution control, waste management, and maintenance of natural drainage systems;
Preparedness	elaborate disaster-preparedness mechanisms, including warnings and emergency plans; inform the population about flood risks and what to do when floods occur.	implement disaster-preparedness mechanisms, including warnings and emergency plans; improve public awareness and build resilience through environmental education; involve stakeholders in co-management strategies.

Table 2: The planning and management cycle of flood risk management (by the author)

5.4. The gap between theory and practice

Although Flood Risk Management already reflects a mature state of conceptual development, potential shortcomings of its application in practice are frequently pointed out in the literature. Two generic challenges should be highlighted:

- Despite the recent advances in the modes of dealing with floods, traditional concepts of land drainage remain dominant practices, while land-use adaptation measures are rarely implemented.

- Urban floods have been conceptualized in a different way without an accompanying change of governance and organizational practices, hindering a systematic integration of the planning and management of land and water.

While the first order of problems is mainly related to the insufficient appraisal of land-use options for reducing flood exposure, the second order of problems is remarkably complex due to the difficulties of mobilizing stakeholders in cooperative arrangements, which involve individuals, groups of interest, and institutions within a catchment and beyond. As Chang (2005) explains, the problems of successful flood management depend in a large extent on getting people to cooperate. This raises the issue of how to take stock of the strategic interactions among these individuals, which change institutional arrangements, modify policies, and improve coordination between organizations. Therefore, the influence of socio-economic systems are essential factors to consider on any flood management strategy.

One generic problem regarding the lack of implementation of land-use based measures for flood mitigation is that there is little attention paid to the valuation of the relative cost-effectiveness of non-structural measures. It is important to note that the evaluation of the costs and benefits of land-use adaptation measures is an essential element for embedding these in the decision-making process, which largely depends on decisions from local governments that are subject to a number of pressures and conflicting interests. In this regard, Corkindale (2010) notes that "until non-structural and structural measures are appraised in the same way, and in as much detail as traditional hard engineering solutions, it is overwhelmingly probable that the second are preferred to the first." In fact, if the benefits of structural and non-structural measures are not compared in equal terms, then it will be difficult for decision-makers to understand the potential advantages of the adoption of coherent and long-term flood management strategies that are based on a systemic action over the hydrographical basin.

In general, the economic appraisal of conventional structural measures for flood-risk management is conducted much more thoroughly than it is in the case of non-structural measures. Since the application of valuation methods are only applied to conventional infrastructures, land-use adaptation measures are not appraised equally with these. Ideally, the economic costs associated with the degradation of ecosystems must be offset by any gains arising from land-use modification for urban development. If only built structures are considered to be flood protection assets, then the flood mitigation value of natural systems may be overlooked and lost, necessitating even greater investment in built structures. Miguez et al (2007) observe that even in the case of the provision of new recreational areas with flood mitigation functions, it is not always easy to convince local communities and stakeholders of the importance of these measures. Furthermore, hard infrastructure solutions are usually more attractive to local authorities because they involve minimum disturbance to landowners (Boardman, 1995).

Adverse externalities are mostly generated by upstream or neighbouring development and hard mitigation (e. g. embankments and drainage), while beneficial externalities are mostly generated by upstream or neighboring soft mitigation (e.g. wetlands and natural land cover) (Chang, 2005). While the adverse externality generated by hard mitigation often results in an embankments race, the beneficial externality generated by soft mitigation is often compromised due to free-riding. Even though each decision-maker is aware of the problem, insufficient resources will be committed to soft mitigation. Policy instruments to internalize externalities include quantity controls, price controls, and a mixture of both. Adverse externalities are mostly generated by upstream or neighboring development and hard mitigation (e.g. embankments and drainage infrastructure) while beneficial externalities are mostly generated by upstream or neighboring soft mitigation (Chang, 2005, page 29).

As was seen in this chapter, the most traditional approaches based on the concept of resistance and a sole focus on hard engineering solutions appear to be outdated and a growing emphasis on the importance of adapting to the hydrologic cycle seems to be gathering a broad consensus in the literature. Therefore, when making decisions about flood-risk management, it is crucial to give the due weight in decision-making to non-structural measures, along with the most traditional structural measures. This requires not only knowledge of the risks involved but also the integration of other information from a wide range of sectors, including inherent costs and values of potential synergies and trade-offs among ecosystems within each catchment. It is also important to recognize that integrated flood management is as much a problem of governance involving multiple organizations as it is a question of science and designing effective policies for managing flood risks. As noted by the GFDRR (2012), situating flood-risk management objectives in land-use policy requires integrated governance and operational frameworks to be in place.

Mainstreaming flood mitigation through land-use adaptation requires the proper consideration of the necessary arrangements for coordinating the collective work involved in the implementation of these measures. It is noted in the literature on environmental mainstreaming that due attention must be given to organizational arrangements for integrating environmental concerns in decision-making processes (DALAL-CLAYTON and BASS, 2009, NUNAN et al, 2012). The systematic integration of flood prevention into land-use planning and management practices requires to first embed such matters at the policy level. The integration of prevention, protection, and preparedness measures for sound flood management involves the necessary coordination of different sectors' demands and at various levels of action. Bringing all these elements together is a complex endeavor, and the respective implications for governance are not yet clear. A salient factor is that the practical implementation of Integrated Flood Management faces significant difficulties to overcome the divisions between different sectors. Such difficulties are partially explained by the fact that the various sectors of public administration have had traditionally little dealings with each other, over time developing bureaucratic settings that prevent their working closely together.

The neo-institutionalist concepts of path dependence may help to explain the difficulties of incorporating land-use measures for the prevention and mitigation of flood risks. Particularly, it is interesting to see how the historical paths of institutions block possibilities of sectoral integration and inter-institutional cooperation. In the Brazilian context, Abrucio (2005, 2006) studied the challenges of inter-institutional cooperation, emphasizing the need for horizontal coordination among various sectors and levels of governance. The question of how to coordinate decisions also involves specific technical knowledge needed to address complex issues, which requires proper institutional mechanisms for the integration of sectoral policies. These necessary conditions constitute important organizational challenges, which depend heavily on legislative, political, administrative, technical, and financial factors. As noted by Ioris (2014), the application of detailed science, parliamentary law-making, and systematic public consultation may give the impression that the state is effectively moving toward higher levels of sustainability and ecological citizenship. However, technical innovations in organizational and managerial aspects are not sufficient for overcoming long-established path-dependencies related to dominant economic interests impeding the state apparatus, thereby requiring more radical transformations of state-society relationships, stronger political commitments, and a more interventional role from the state.

PART THREE – POLICY ANALYSIS

6. The macro level of land and water policy

This analysis considers political and legal aspects of particular relevance to the theme of flood mitigation and land-use adaptation. The central axis of analysis is placed on the relationships between the process of policy making and the existent juridical setting in Brazil, thereby focusing on the mismatches between normative and practical realities, which further highlights the fact that recent advances in the legal framework at the national level have not yet been internalized at the local and regional levels of governance. On the other hand, the set of approved laws are considered as the result of political struggles for the recognition of rights, duties, and powers within a continuous historical process that does not actually succeed when these are not implemented in practice. Hence, this section is an attempt to link adaptation policies to land-use planning and water management, and to connect these policies with socioecological principles solidly established in the Brazilian Constitution and the City Statute, among other important legal provisions.

The analysis is based on a desk-based study of national reports, ministerial boards, forums, and debates promoted by governmental agencies for the construction of a national adaptation policy, and includes an examination of the norms, legal instruments, and mechanisms affecting the regulation of land-use change processes in the urban context, considering also its interconnections with water resources. The principle of the Social Function of Property is emphasized as a central normative guideline for embedding flood mitigation in land-use decisions, based on the argument that this overarching constitutional principle comprises both social and ecological dimensions. Considering that a coherent body of policies on flood-risk management is not yet fully developed in Brazil, this analysis outlines a body of relevant legislation that may be used for the mitigation of land-use impacts on flooding, highlighting recent innovations in the Brazilian law concerning land-use and water management, as well as other institutionalized norms that affect land policy.

6.1. The construction of a National Adaptation Policy in Brazil

Concerns about the need to adapt human systems to increasing flood risks in Brazil have been strongly influenced by commitments assumed by the Brazilian Government in climate change international forums. The 1992 United Nations Conference on Environment and Development (UNCED), also known as Earth Summit, has contributed to a renovated interest in urban and environmental questions. At the time, the Brazilian Urban Reform Forum signed the Treaty titled "Towards Just Democratic and Sustainable Cities, Towns and Villages," and Brazil was the first country to sign the Convention on Climate Change in 1992. But it was only in June 2000 that the Brazilian Forum on Climate Change (Fórum Brasileiro de Mudanças Climáticas, hereafter FBMC) was instituted by the Federal Law 3515/2000. This Forum was created with the goal of mobilizing Brazilian society about the problems arising from climate change, as well as assisting the government in incorporating these concerns into public policies (FBMC, 2008). Since then, the establishment of public policies that promote adaptation to negative environmental and socioeconomic vulnerabilities have become part of the political agenda.

The Ministry of the Environment has a specific Secretary on Climate Change and Environmental Quality, who is responsible for defining strategies and proposing mitigation and adaptation policies to climate change. This Secretary coordinates the Executive Group of the Interministerial Committee on Climate Change, which is in charge of the National Plan on Climate Change. The National Environmental Council (Conselho Nacional do Meio Ambiente, hereafter CONAMA) also created a Climate Working Group. Another collegiate organization chaired by the Ministry of the Environment is the National Water Resources Council (Conselho Nacional de Recursos Hidricos, hereafter CNRH). CNRH is responsible for coordinating and mediating agents involved in the management of water resources. This Council suggests principles and guidelines to enable the integration of water policy with forests, biodiversity, land-use, human settlements, and climate, as well as the development of research and the dissemination of technology for water resources.

In 2007, the National Plan on Climate Change (Plano Nacional de Mudanças Climáticas, hereafter PNCC) was instituted. While the large majority of PNCC is dedicated to “mitigation opportunities,” the need to implement adaptation measures and adaptation capacity building was also established at the policy level. The National Fund on Climate Change (Fundo Nacional de Mudanças Climáticas, hereafter FNMC[41]) was created in 2009, enabling financing instruments for the creation of funds, programs, and credit lines involving the National Development Bank (Banco Nacional de Desenvolvimento, hereafter BNDES) and Caixa Econômica Federal. To date, these instruments are mainly related to the elaboration of studies for the mitigation of greenhouse gas emissions studies and the implementation of Clean Development Mechanism projects. According to CGEE (2007), there is significant delay in defining strategies and actions for the two most fundamental aspects (i.e. vulnerability and adaptation) due to the specificities of the country and the implications for development.

The National Policy on Climate Change (Política Nacional de Mudanças Climáticas, hereafter NPCC), was created in 2009 for the elaboration of relevant policies at the national level as well as the state plans and other programs and projects, directly or indirectly, related to climate change. The Multi-Year Plan (PPA) 2012-2015[42] incorporated the NPCC adaptation policies, setting the goal for the development of a National Plan for Adaptation (Plano Nacional de Adaptação, hereafter NPA). The NPA (not yet completed) is supposed to establish a set of government measures to adapt to climate change in the areas of transport, biodiversity, coastal areas, food security, industry, health, and water resources. However, there are contradictory signs concerning the commitment of the government to establish adaptation measures as a strategic priority.

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[41] Financial resources of the Brazilian Forum on Climate Change include contributions from pollutant industries, such as oil exploration and energy-intensive production activities.

[42] The Multi-Year Plan (PPA) establishes guidelines, goals, and targets for government projects and long-term programs for a period of four years.

A sign of such contradictions is that the policy areas of natural disasters and cities have been excluded from the NPA. Another example of the lack of commitment is the recent discontinuation by the Secretariat of Strategic Affairs of a major study on the expected impacts of climate change on Brazil, called "Brazil 2040"; the study aimed to assess possible impacts of climate change on water resources, power generation, agriculture, health, and infrastructure. After the first commitments assumed by the Brazilian Government over two decades ago to promote sustainable patterns of urban growth, these fundamental policy goals have not yet been solidly linked to national adaptation policies.

The city and state of Rio de Janeiro have also pledged to reduce emissions through sub-national climate change laws. In 2010, the state of Rio passed its Policy on Global Climate Change and Sustainable Development (LAW 5690 of April, 2010), setting emissions reduction targets and adaptation goals through 2030. This policy identifies waste, transportation, energy, and industry as the crucial sectors for carbon emission reductions, and it sets a carbon intensity target requiring that the carbon intensity of the State return to below 2005 levels by 2030. In this context, the Governor of the State of Rio de Janeiro signed the Decree 43216 (30^{th} September, 2011), promising an 8% reduction relative to 2005 levels by 2012, 16% by 2016, and 20% by 2020. But the available data on the levels of carbon emissions in the State reveal a very different reality, reflecting the mismatch between the pretensions of the city to be an “environmental champion” (an expression used in some reports of the Municipality of Rio de Janeiro in the process of candidacy for the 2016 Olympics) and the actual state of affairs concerning environmental matters in the State.

At a National level, according to the Greenhouse Gas Emission Estimate System of the Climate Observatory (2014), carbon emissions in Brazil are not decreasing. On the contrary, they increased 7.8% between 2012 and 2013, based on the levels registered in 2005. During the same period, deforestation rates climbed 16.4% (mainly in the Amazonian region, but still growing in the Atlantic Forest Biome where 93% of its original area has been devastated during the last 500 years). Concerning National outputs of CO2 from the energy sector, according to the same source, there has been as increase of 7.3% in the year 2013 alone.

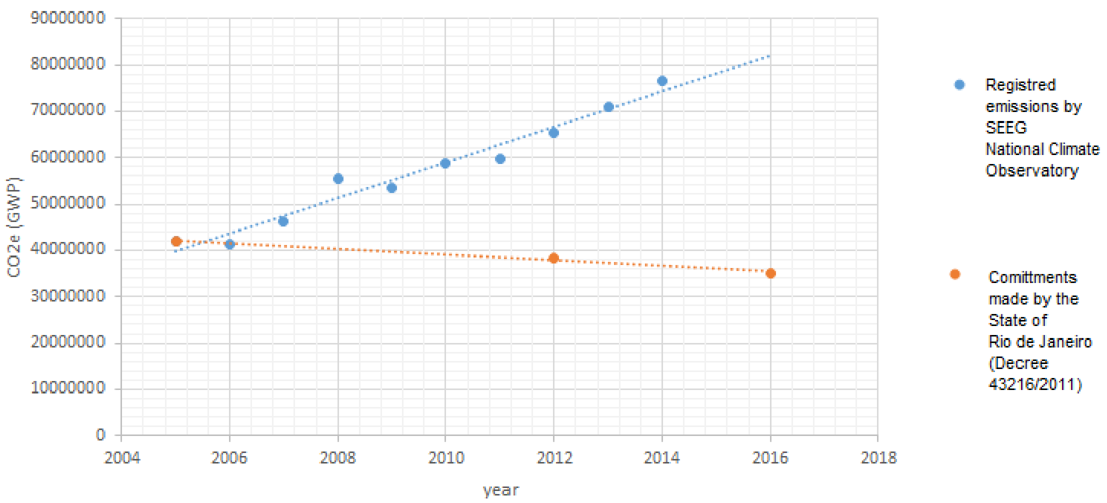

Fig. 23: Registered CO2 emissions for the State of Rio de Janeiro (in blue) and political commitments made by the State government (orange). Data compiled by the author from the Greenhouse Gas Emission Estimate System of the Climate Observatory. Raw data collected online on 21/02/2016 at http://plataforma.seeg.eco.br/

6.2. Property rights in Brazil and the Social Function of Property

While analyzing the Brazilian property right regime, it is important to avoid inadequate extrapolations from other national contexts, which often happens in comparative studies between North and South, and particularly between Anglo-Saxon and Lusophone Countries (what has been called by Sarkar (2011) as a recently added subliminal dimension of the "globalization of law"[43]). In Brazil (as more generally in Latin America), the root of the legal system is usually referred to as civil law[44], while in

[43] According to the critical re-examination of legal systems made by Sarkar (2011), the works of La Porta et al. (1997, 1998, 1999, 2000, 2006) and their followers advocated for the superiority of common law, influencing the legal reform policies of the World Bank and other institutional organizations toward Anglo-Saxon legal system. Sarkar denounces these attempts of legal reform as attempts of "globalization of law."

[44] Civil law systems were derived mainly from Roman Justinian's Institutes of the sixth century AD, whereas common law was not. According to Cecilia Siac (1999), and contrary to popular belief, both systems of law borrowed much of their substantive law from Roman law, but from different periods. While Civil Law systems accepted, in whole or in part, Justinian's Corpus Iuris Civiles of the sixth century AD, the Common Law has more similarities to Roman law of the first two centuries AD. The civil law systems

Anglo-Saxon Countries, national laws and regulations have distinct foundations, known as common law[45]. A fundamental difference for adapting land uses according to socioecological functions is that in civil law systems, there is a marked distinction between public and private rights, while in common law, these are treated jointly. Another underlying difference is that in common law, the granting of construction rights to private property owners is an exclusive prerogative of the government. As such, construction rights cannot be tradable among property owners, since the law does not allow property owners to purchase development rights from other properties. However, as will be further explored in the analysis of the instruments foreseen in the City Statute, property rights may be transferred, provided that the government decides such operations via the Municipal Master Plan. By contrast, in some common law States, urban development rights became a separate marketable property[46], enabling a landowner to acquire development rights from another private landowner in the form of a market transaction. It must be clear then that in countries such as Brazil, this is not possible in light of its fundamental legal principles. As in other countries rooted in the French legal system, development rights may only be obtained through an act of the State, provided that common and diffuse rights supersede the rights of landowners. This is what Justice Benjamin (2009) has called "the role of environmental law in restricting individual property rights":

... [Contemporary] judicial regimes require that real properties—rural or urban—serve multiple ends (private and public, including ecological), which means that their economic utility is not exhausted on one single use or the best use, let alone the most lucrative use.

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were further sub-divided into those of German, Scandinavian, and French origin, the latter being followed by Latin American countries.

45 Common law systems are found in England, Ireland, U.S.A (with the exception of Louisiana), Canada (with the exception of Quebec), Australia, and most present and former members of the British Commonwealth. Civil law systems are found in continental Western European countries and in most of their ex-colonies, in most of Latin America, Russia, and the CIS Republics (in STEIN, 1992).

46 Tradable development rights were first implemented in New York, and have been adopted not only in other North American Cities, but in very differnet contexts such as Mumbai.

In truth, the Brazilian constitutional-legal order does not guarantee property and business owners the maximum possible financial return on private goods and on activities undertaken [...]. Requiring individuals to comply with certain environmental precautions in the use of their property is not discriminatory, nor does it interfere with the principle of equal protection under the law, principally because nothing can be confiscated from a person if she does not properly own or hold title to it. If landowners and occupiers are subject to the social and ecological functions of property, it makes no sense to claim as unjust the loss of something that, under the constitutional and legal regime in effect, they never had, that is, the possibility of complete, absolute use, in scorched-earth style, of the land and its natural resources. Rather, making such claim would be an illegal takeover [...] of the public attributes of private property (essential ecological processes and services), which are assets of common use in the terms of the heading to Article 225 of the Constitution of 1988[47] .

This response of the Supreme Court is an eloquent example of the juridical Brazilian system, requiring the formal recognition of social functions that are above private property rights[48]. The social function is the notion that the right of private ownership includes an obligation to use property in ways that contribute to the collective or common good (see VAN BANNING, 2001; FOSTER AND BONILLA, 2011). This recognition imposes a duty of solidarity upon landowners, providing “a new concept of property, based upon the constitutional principle that the function of property must be social” (CUNHA, 2011), i.e. private property is not an exclusive function of the interests of individuals, owners, or possessors, but rather the specific allocation of uses which satisfy a social interest (DE GRAZIA, 2003). As highlighted by Ondetti (2015), it

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[47] Response of the Supreme Court of Justice No. 1.109.778/SC written by Justice Antonio Herman Benjamin (in BRYNER, 2012).

[48] Article 225 of the Brazilian Constitution provides that: “everyone has the right to an ecologically balanced environment, which is an asset of common use and essential to a healthy quality of life, and both the Government and the community shall have the duty to defend and preserve it for present and future generations” (adapted from the translation of the Georgetown University Political Database of the Americas, 1996).

empowers authorities to take punitive action against owners of urban land that has not been built upon or is un- or underutilized, turning available three policy instruments which may be used for this purpose: compulsory subdivision or construction, increased property taxation, and expropriation with compensation in government bonds.

Although the notion of social function as constraint to private property is not new, its recent internalization in legal instruments of urban policy is groundbreaking in Latin America, and more generally, in the Global South. Conceptually, it constitutes a new paradigm for dealing with property rights (see ALFONSIM, 2003) by linking the exercise of urban property rights to economic, social, and environmental ends.

The Social Function of Property has been set forward in the political agenda of South American countries by social movements claiming the redistribution of underutilized farmland, originating a rich discussion documented in many scholarly works on rural land reform[49]. A strong social movement of urban reform arose in the 1970s, bringing together social leaders, trade unionists, NGOs, members of the Catholic Church, parliamentarians, and professionals. The first steps of this movement were given in narrow spaces of participation, still in the presence of the military regime. In the 1980s this movement grew, following the widespread demand in society for political freedoms (MARICATO, 2006). Since then, progressive demands for using the social function of property as a guiding principle for urban policy became increasingly vocal. These demands faced strong opposition from conservative sectors, giving voice to long disputes that finally culminated in the Urban Reform Amendment (Emenda Popular da Reforma Urbana) inserted in article 182 of the 1988 Brazilian Constitution[50]. This article contains an explicit discussion of the social function of property, with a specific description of

[49] For the objectives of the present work, the principle of the Social Function of Property is hereby focused on in its application to the urban context. For a wider discussion of the arguments in favor of and against the application of this principle considering rural and urban contexts see Bryner, 2012; Ondetti, 2016.

what it entails in the urban context. Although attempts to extend the social function principle to the urban sector are not unprecedented, Brazil's efforts to create a legal framework that specifically outlines how this principle should be enforced in the urban context are rather exceptional (ANKERSEN AND RUPPERT, 2006, pp. 112). According to the Brazilian Constitution, the social function of property has three main elements:

- Economic (rational and adequate use of urban land);
- Environmental (adequate use of resources and preservation of the environment);
- Social (compliance with the provisions that regulate urban land tenure and the guarantee of the right to affordable urban land).

The 1988 constitution clarifies the links between the exercise of property rights and the social functions of the city, relegating more detailed definition to supplementary legislation and Municipal Master Plans. In this regard, many authors criticize the conservative positioning of the Brazilian law, according to which the effective enforcement of the social function of property is delegated to municipal master plans. According to Ondetti (2015), this ambivalence of the law makes the effective enforcement of the social function of property highly dependent on local conditions. Fernandes (2007) goes further with this criticism, sustaining that such conservative strategies "make this principle merely rhetorical." In the same vein, Ondetti (2015) observes that the fact that such tools are included in the master plans does not necessarily mean that authorities are actually utilizing them. According to this last author, one of the reasons for the general lack of consistent use of such tools is that there is no centralized source of information on actions reflecting enforcement of the social function. Since the Ministry of the Cities (Ministério das Cidades)[51] was tasked with aiding municipalities in the elaboration and

[51] The Ministry of Cities was created in 2003, in the first year of mandate of President Lula da Silva, when the Labor Party (Partido dos Trabalhadores) took over the government. Although this Party has a long history of advocating land reform, according to Ondetti (2016) "only incremental gains have been made" in rural land redistribution during the last three last mandates. In regards to urban land, according to an

implementation of municipal plans, as well as to compensate for the existing deficits in these areas, this federal agency should be more proactive in following up on the effective conditions for actual enforcement of this fundamental principle of urban policy.

The remarkable low level of embeddedness of the Social Function of Property in ordinary decision making does not mean this and other principles foreseen in the Brazilian Constitution are themselves inadequate or unnecessary. On the contrary, it is the institutions and the society, at the various levels of decision that need to focus on enforcement and compliance in order to incorporate these important normative guidelines into their routines. As the present analysis shows, the Constitution of 1988, read together with sectoral laws, is unequivocal in placing the environment and the common good at the core of public policy, allowing for collective and other diffuse interests to be prioritized over private property rights.

7. Legislation on urban planning and environmental management

In Brazil, a comprehensive policy for flood management is not yet solidly established in national legislation. However, there is a wide range of legal instruments that may well be used for promoting urban flood mitigation measures into land-use planning and management routines. In order to have a comprehensive understanding of the opportunities opened up by these instruments, this section presents a number of federal laws linked to the planning, management, and use of land and water, as well as cross-sectoral laws that are relevant to environmental planning. This list does not intend to be comprehensive, but to highlight some of the most relevant pieces of legislation that need to be taken into account for the development of a Land Use Adaptation Policy. These are listed in the following tables 3, 4, and 5.

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analytical overview of master plans in Brazil made by Oliveira and Biasotto (2011), the constitutionally-mandated master plans "have advanced little or not at all in promoting access to urban land."

1988 Constitution	Institutes the Social Function of Property (see pages 145-150). Attributes responsibilities to three levels of government for assuring the right to an "ecologically balanced environment." Enforces the elaboration of Master Plans for all cities above 20,000 inhabitants. Defines the right to housing as a basic right to all Brazilian citizens.
Federal Law nº 6766/79	Legislates Land Parceling norms and attributes the responsibilities of Brazilian municipalities in defining urban and rural land uses, as well as land parceling and definition of functional uses. Despite repeated efforts to amend the Land Parceling over the last two decades, it remains today as the main piece of legislation governing land subdivision and parceling. In practice, the law establishes a “double standard” by imposing a minimum plot size of 125 m2 with minimum front of 5 m (a standard that is non-economical and exclusive). Establishes that 35% of the property to be used for public use (Federal Law 9785/99 modifies this parameter by transferring responsibility to the municipal authorities to determine the percentage for compulsory assignment of public areas).
Complementary law 140/2011	Attribute competencies for the three levels of government for environmental licensing. Determines that Municipalities should decide on territorial transformations for impacts within Municipal boundaries.
Statute of the City (Federal Law nº 10 257/ 2001	Designates the Municipal Master Plan as the basic instrument for regulation of land resources, including peri-urban rural areas. Among other dispositions, it separates property rights from the potential right of construction, foresees the transmission of surface rights, allows consortiated urban operations, and includes right to preemption (these instruments are described in pages 157-168).
Federal Law nº 11107/2005	The public consortia law is a regulatory instrument for horizontal and vertical cooperation among the three spheres of governance, opening the possibility to strengthen the intervention of public authorities and to optimize and rationalize the application of public resources in the execution of responsibilities that are shared among the three levels of government.
Federal Law 11428/06 and Federal Law 11426/08	Regulates the conservation of the Atlantic Forest. After the Federal Law 11428/06, new allotments must preserve 50% of the existent vegetation. After the Federal Law 11426/08, the supression of secondary vegetation in advanced states is forbiden in urban areas.

Table 3 Legal instruments on land-use planning

Federal Law n. 9985/2000 National System of Conservation Units	Defines Environmental Protection Areas (APAs). APAs can have different characteristics according to their functions, such as APAs for Integral Protection and APAs for Sustainable Use.
Amendment No. 19 of 1998 and with the recent approval of Federal Law No. 11107 of 2005	Regulates the creation of consortia for horizontal and vertical cooperation among the three spheres of governance, opening the possibility to strengthen the intervention of public power and to optimize and rationalize the application of public resources in the execution of responsibilities that are shared among the three levels of government.
State Law 5101/2007	Defines the competencies of INEA as the executive organism of the environment policies at the state level on water resources and forests.
Environmental Policy Act Law 6938/1981 SISNAMA(regulated by Federal Law 7.804 (1989)	Is the main framework for environmental management in Brazil, defining the responsibilities of related institutions. It also determines the procedures, criteria, and control instruments for the integration of the activities of the various organs within the environmental policy system. The Federal Law 6938/1981 creates a system of environmental permits (see CONAMA's Resolution No. 1). It also includes procedures for environmental impact assessments and reports, and institutes strict liability for environmental harms.
Federal Law 7.661/1988	Establishes the elaboration of Coastal Management Plans (PNGC).
Decret nº 5.300/2004	Defines the rules and criteria to be followed in allocating land use and occupation in the Coastal Zone, establishing special criteria for the planning and management of coastal regions.
Federal Law 12.651/2012 (Forest Code)	The two instruments of greatest relevance under the Forest Code are: i) the legal reserve and the permanent preservation areas, defining a proportion of each rural property where vegetation must not be removed, and ii) the permanent preservation areas (APPs), which legislate the protection of water sources and margins of water bodies, prohibiting any productive activity in riparian areas. Reduces environmental protection areas along river courses by defining the center of river courses, and not from its margins as it was previously established by the law 4771/65. *53 articles are being questioned by the Public Ministry, alleging inconstitutionality of this law.
Provisional measure 2.220/01	Establishes the basis for application of Special Use for Residential Areas

Table 4 - Cross-sectoral laws affecting land and water planning and management

Fed. Law 9.433/97 (National regulatory framework concerning water management and sanitation)	Establishes the watershed constituencies as as the basic unit for implementation of the activities of the agencies involved in Water Management under the following principles: i) the systematic management of water resources; ii) the adequacy of water resources management to the physical, biotic, demographic, economic, social, and cultural rights; iii) integrated management of water resources and environmental management; iv) the coordination of water resources planning with other planning sectors and with state, regional, and national levels; v) the integrated management of water resources and land-use; vi) the integration of watershed management with estuarine systems and coastal areas. The Law does not include a specific treatment of urban flooding. In a generic statement, Article 31 recognizes the need of the Federal District and municipalities to promote the integration of local policies and both the federal and State institutions with responsibilities in sanitation, land use, and other related environmental matters.
State Law 3239/1999 (Water Policy in the State of Rio de Janeiro)	Institutes the following as main objectives (article 42): i) Coordinate the integrated managemtent of water ii) Mediate conflicts related to hydric resources iii) Implement the policy of hydric resources iv) Plan, regulate, and control the use, preservation, and recovery of hydric resources v) Promote water pricing and charge for the use of water (State Decree 32862/2003, modified by the 41039/2009, defines the responsibilities of the State Council of Hydric Resources.)
Federal Law No. 11445/2007	Regulates the basic sanitation sector and recommends that sanitation plans should be compatible with the plans of river basins where they are inserted.
Federal Law 5 639/2010	Regulates water management competencies of INEA (the State decree 43921/2012 establishes the new organizational structure, namely with the creation of a Warning Flood System).
State Law 1.060/07	Attributes responsibilities to the State Government to develop diagnosis of flood risks, develop projects for flood control, and assist municipalities in improving drainage schemes. The law emphasizes the importance of the sharing of stream management by more than one municipality (such as the cases of streams along administrative borders, as well as the need to assist small municipalities with limited technical capacity. The law establishes principles for improving coherency between municipal plans and actions at the local level, focusing on medium-term goals.)

Table 5 Legal instruments on water management

The above-mentioned legal instrument provides an important juridical base for the development of a land-use adaptation policy for the mitigation of flood risks in urban environments. However, responsible authorities still need to develop a more proactive role in defining concrete actions at the local level of land and water governance, with a specific focus on the mitigation of urban flooding. While there is certainly room for improving the existent legal framework, the main challenge is in implementation and institutional development. While this is one of the water policy objectives, the management system for hydric resources has little or no governance over the flooding problem and floods (FORMIGA, 2014). Below the Ministry of the Environment, the National Water Agency[52] (ANA) is responsible for the prevention and mitigation of natural disasters, including the prevention and minimization of the effects of droughts and floods. In conjunction with the National Civil Defense, ANA is responsible for monitoring these events and undertaking studies on natural disasters. But ANA is focused on water management at the National level (deciding on water conflicts among states, emergency plans for droughts such as the ones occurring in 2014, etc.), and urban flood-related problems are not a priority of this organization. Nevertheless, ANA developed a national program for Water Management and Flood Control in Urban Environments entailing two fundamental objectives: i) induce municipalities to adopt an integrated view of urban drainage and flood control; and ii) encourage "best practices" by improving public services such as garbage collection. However, the adoption of preventive measures was beyong the scope of this program.

The delineation of water basins as the basic unit of water resource management has the potential to better integrate land-use planning and water management, providing the “locus” both for the identification of risks and the identification of adaptation responses and strategies, and to better identify systemic relations of interdependency. The

[52]ANA is responsible for the management of water resources, including the assurance of regular access to water and the promotion of its sustainable use. ANA's activities include the elaboration of planning instruments, such as the Plan of National Water Resources Plan, setting the general framework and guidelines for integrated water management.

adoption of the water basin as planning unit enables municipalities to address these issues across sectors and beyond conventional administrative boundaries, including collaboration arrangements among municipalities. According to the Federal Law 9433/1997, each hydrographical region is supposed to have a deliberative Water Basin Committee in operation for the integration of sectoral policies. The main responsibilities of the Water Committees are listed below:

- Approve and send to the State Water Management Council the proposal for the Water Basin Plan;
- Propose the classification of water bodies of the Watershed concerning use and conservation criteria, to be submitted for technical evaluation;
- Propose water price rates and approve water-charging criteria, to be submitted for homologation by the State;
- Elaborate proposals for exemption of rights of use concerning water resources, namely on water retention, derivation, and discharges of smaller dimension;
- Propose the constitution of the respective Water Agency and approve the annual budget and accounting plan for the respective Water Agency;
- Approve annual and multiannual investment plans in services and infrastructure related to hydric resources, taking into account the Watershed Plan;
- Implement actions in collaboration with the executive organ, with the goal of defining criteria for the preservation and use of protection margins for bodies of water;
- Mediate and resolve, when possible to resort in first instance, eventual conflicts related to water use.

In the State of Rio de Janeiro, there have been nine committees created since 2002, one of which was the Water Basin Committee for the Ilha Grande Bay, which was created in 2011 and finally became operational in 2014. Meanwhile, the competencies legally attributed to the Water Basin Councils will only be meaningful with the necessary capacity building of its members for using, interpreting, and integrating existent plans and available databases, which are, in most cases, not used as guidelines for the elaboration of projects and proposals by these organs. Without this integration, it will be difficult for the Water Basin Committees to have a relevant role in urban flood-related problems under their jurisdiction.

As noted in a study of water management in São Paulo (see Johnsson and Kemper, 2005), the most important role of the water basin committees should be to make the protection of water resources and urban expansion compatible through the implementation of the State Headwaters Protection Law of 1997 (a state law of São Paulo). As observed by these authors, this role includes conceptualizing a broad policy for water source protection and restoration through the elaboration of specific laws for each sub-basin (…) with an environmental focus and work in tandem with protection efforts. However, this state law has not been replicated in Rio de Janeiro or other Brazilian Statesand the protection of headwaters largely depends on the capacity and will of municipal authorities to improve their urban regulations so as to guarantee the control and monitoring of land use in the sub-basins. As such, what is considered that should be the most important role of the Water Basin Committees is well beyond the capacity of the river basin bodies and the water resources management system as a whole, since it will necessarily involve sectoral policies in the areas of housing, transportation, and employment (JOHNSSON and KEMPER, 2005).

The first regulatory effort of water and sanitation in Brazil was made in 1971 through the PLANASA (Plano Nacional de Saneamento), created in 1971 and abolished in 1986. The centralized management model promoted by PLANASA has proven, in many cases, to suffer from chronic problems related to inadequate performance and low productivity of public sanitation companies, leaving many consumers with unreliable (and often nonexistent) basic sanitation services. PLANASA aimed to improve water supply and sanitation services, requiring each State in Brazil to create its own state-owned company, from which the municipalities were able to contract services for water and sanitation. The Federal National Bank of Housing (Banco Nacional de Habitação) under the Ministry of Internal Affairs (Ministério do Interior) was assigned to finance water and sanitation works for the municipalities that had joined PLANASA. In 1986, the Federal National Bank of Housing and PLANASA were abolished.

7.1. The City Statute and its instruments

The most important regulatory mark created by the Ministry of Cities is the City Statute (Federal Law 10 257/2001). The City Statute[53] greatly expanded the ability of municipal and state governments to regulate and guide urban development. The City Statute establishes general guidelines and presents a set of key innovative instruments for the execution of integrated urban policies. This law also establishes the links between the exercise of property rights and the social functions of the city, moving toward a higher definition, but relegating more detailed definitions to supplementary legislation and master plans.

According to Ribeiro and Cardoso (2003), the City Statute contains two models of public policy: distributive/redistributive and regulatory. The distributive/ redistributive model is related to the provision of both social housing and urban services directly by the government (i.e. land tenure regularization and other related arrangements (e.g. *usocapião*), urbanization of slums (i.e. favelas), and redistributive practices aiming to capture part of the financial gains generated by urban expansion to finance public investments. The regulatory model is related to the prioritization of collective interests above private interests within urban development and land-use change dynamics. This model is supported by a set of instruments of particular importance for adapting land use to the social function of property, such as the institution of conservation units within urban areas[54], among other tools available to municipal governments to enforce the social function (FERNANDES, 2007).

These general principles express an understanding of the social function of property as incorporating both concerns of social justice and environmental sustainability. They establish the supremacy of collective or diffuse interests in the right to property by

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[53] For a critical analysis of the City Statute see Barros and Carvalho, 2010.

[54] Article 4, chapter V and VI of the City Statute.

limiting this right to the imperatives of environmental preservation and proper use of natural resources in order to ensure the welfare and safety of urban land users and neighbors (Cardoso, 2003).

Noteworthy, the first paragraph of article 1228 of the 2002 Civil Code determines a number of limitations to property rights within the same spirit, which are useful in defining the social function of property:

O direito de propriedade deve ser exercido em consonância com as suas finalidades econômicas e sociais e de modo que sejam preservados, de conformidade com o estabelecido em lei especial, a flora, a fauna, as belezas naturais, o equilíbrio ecológico e o patrimônio histórico e artístico, bem como evitada a poluição do ar e das águas.

The right of property must be exercised in accordance with its economic, social, and environmental ends, so that the flora, fauna, and natural beauties are preserved, as well as the ecological balance and the historical and artistic patrimonies, and so that air and water pollution are averted, in obedience of the rules established by specific legislation.

Article 1228 of the 2002 Civil Code

The implementation of the constitutional provisions reaffirmed in the above-mentioned Civil Code are reinforced by the City Statute, which also defines duties to private and public agents (…) and establishes penalties for transgressors of the law, as well as requires the production of complementary norms at the municipal level to ensure its full applicability (MACIEL, 2012). However, the operationalization of the instruments and principles foreseen in the City Statute requires technical capacity and political commitment for its application in practice. This requires that municipal authorities understand the possibilities opened up by the instruments and mechanisms foreseen in the City Statute. Due to their particular relevance for the purposes of the present research, some of these instruments are described below.

Transferable development rights

Transferable Development Rights (TDR) allow the possibility of a landowner to exercise the constructive potential of a certain property in an alternate location. These instruments may be used for the promotion of protection measures of areas with high environmental value, allowing land owners to exercise their development rights in other adequate sites. According to the City Statute, areas subject to TDR must be included in the Master Plan defining the areas in which the owners can transfer the building potential into areas able to receive this potential. TDR constitute a practical solution for protecting areas where there is public interest in maintaining essential socioecological functions, transferring the constructive potential to those in which the densification is desirable or at least tolerable. Article 35 of the City Statute states that this instrument can be used in situations where (among others) specific areas should be preserved, whether for their historic, environmental, scenic, social, or cultural interest. This means that TDR can be applicable for protecting areas of environmental value, namely where important water-flow regulation services are provided. There is little experience in using these instruments for the mitigation of flood risks, but pioneering examples of their application in Brazil are encouraging. For example, in the Master Plan of S. José, which in the Southern State of Santa Catarina, flood prone areas, in addition to areas of cultural preservation, were defined as subject to TDR. The practical implications for using this instrument for flood mitigation are not yet sufficiently tested in practice, justifying an examination of international experience and research on this particular subject. The concept of using Transferable Development Rights has been used more extensively in the USA and recent research has been conducted in the UK for the creation of variants of Transferable Development Rights for flood mitigation. Chang (2007, 2008) proposes an innovative set of mechanisms, which, according to the author, may help gather external or alternative resources or even reduce public expenditure in order to compensate for insufficient public funds. Among other propositions of Chang, two types of transactions seem to offer interesting possibilities: one is what she calls Transferable Flood Reduction Permits, through which downstream areas can purchase remote land-use adaptation measures in order to mitigate impacts of new development; and the other is called Tradable Risk Neutral Permits, through which hard engineering measures, when deployed, need to be followed by soft engineering measures to generate flood storage upstream to offset incremental downstream risks involved. In these cases, the transactions to which this author refers are theoretically possible to apply in the South American context, since what is meant to be traded are compensation measures for the externalities of new developments.

Surface rights

Surface rights (*direito de superfície*) give a component of flexibility to urban land use. This instrument allows for the separation of property rights to the potential right of construction and foresees the transmission of surface rights without transferring property ownership. An interesting possibility pointed by Cardoso (2003) is that this instrument could be articulated with compulsory land parceling, through which the use of the land would be enabled by transferring the surface rights. This instrument has already been used in some Brazilian Municipalities, constituting a low-cost solution for the public administration to unlock land resources for the provision of social housing.

Pre-emption right

This instrument confers to the municipal government's preference for acquiring urban properties subject to onerous alienation between individuals. The use of pre-emption rights by the municipality enables the creation of land reserves of public domain for the construction of public equipment or social housing (CARDOSO, 2003). However, due to the limited timeframe imposed for operationalizing this instrument, its effective implementation depends on previous assessment of land tenure in the targeted areas by the Municipality and swift responses from the property registry.

Onerous concession of construction rights

The City Statute provides for the "onerous concession of construction rights" (*outorga onerosa do direito de construir*), a mechanism by which the municipality can force an individual to pay for any construction that exceeds the surface area of his or her own land (*solo criado*). However, the adoption of this instrument by municipalities may have counterproductive results, discouraging investment in areas where densification is allowed.

Progressive taxation of underutilized urban property

The progressive taxation of underutilized property (*IPTU progressivo*) is an extra-fiscal instrument that may be used by municipalities to exert pressure over property owners for the effective use and land parceling of specific territories when such areas have been recognized through the Land Use Master Plan as liable for land parceling and urbanization. In such cases, the Municipality may create specific laws[55] establishing the conditions and deadlines for the fulfillment of these obligations. In case the property owner does not proceed with the required urban operations, the Municipality may impose sanctions for payment of a specific tax, whose value increases annually at a maximum rate of 15% over the period of 5 years.

Disappropriation of private property

The administrative procedure of expropriation is seen in Article 182, paragraph 4, III of the Federal Constitution and in Article 8 of the City Statute. According to Maciel (2012), this is an extreme measure to be mainly used as an intimidating instrument to force the landowner to make use of his or her property according to previous declaration of public necessity, public utility, or social interest of the property in question. For the disappropriation to happen, the Federal Senate has to approve entitlements of public debt according to the fair indemnity of the property owner.

Consorciated Urban Operations

The City Statute foresees the creation of social and economic assistance programs for urban communities affected by consorciated urban operations. In its Article 33, the creation of consortia is considered as an instrument that may be used to facilitate large urban operations, especially when these operations include: i) the extension of public spaces and implantation of infrastructure; ii) implementation of housing programs and environmental valorization; iii) modification of indexes and characteristics of land parceling, use, and occupation, as well as altering construction norms, considering their environmental impact and neighborhood impact.

[55] See Article 5, 6 and 7 of the Federal Law 10.257/2001.

“Considera-se Operação Urbana Consorciada o conjunto de intervenções e medidas coordenadas pelo Poder Público municipal, (...) com o objetivo de alcançar (...) transformações urbanísticas estruturais, melhorias sociais e a valorização ambiental” (Estatuto da Cidade, Seção X, Art. 32, § 1º).

“Urban consortia operations are considered the set of urbanistic interventions of large dimension coordinated by the Municipality (…) with the objective of reaching (…) structural urban transformations, social betterments, and environmental valorization”

The new legitimacy given by the principles contained in the City Statute provide a rare opportunity to modify a secularly built management pattern that has been unable to secure neither the constitutional human right to adequate housing nor the right to an ecologically balanced environment (ALFONSIM, 2003). The potential use of the instruments disposed by this Federal Law—in particular the ones related to surface rights, transferable development rights, and pre-emption rights—enable innovative solutions and arrangements for adapting land use to the social function of property. This principle may be mainstreamed by disentangling property rights and the right of use in situations where the benefit of the overall community needs to be preserved, and the aforementioned instruments enable arrangements for the protection of the interests of property owners. However, without effective collaboration and adaptation to the new conditions laid down by law, instruments such as surface rights and transferable development rights remain innocuous (CARDOSO, 2003). The creation of incentive policies for the implementation of the instruments foreseen in the City Statute, as well as the avoidance of excessive bureaucratic procedures, may encourage local administrations to adopt these instruments.

Despite the important progress that the Statute of the City represents, there is still a clear deficit of incentives for Municipalities to use these instruments and mechanisms of articulation. In particular, the allocation of adequate urban density patterns according to environmental parameters may be more effectively implemented by making use of transferable development rights and surface rights, assuring the harmonization of public and private interests, and finding an appropriate balance between the availability of land resources and housing demands within the municipality. The use of taxation mechanisms in conjunction with these instruments may also prove to be useful in regulating the land market, controlling speculation processes, and promoting the economic use of land and water resources. In this regard, Correia (2005) and Porto and Lobato (2004) noted that an adequate articulation of command and control instruments, social participation processes, and more flexible negotiation and regulation mechanisms are crucial. In the face of the complexity of the decision-making processes concerning land use, none of these can produce efficient results in isolation: they need to complement each other.

7.2. Shortcomings of market-based mechanisms for flood mitigation

In recent years, an increasing emphasis is noticeable in the adoption of market-based mechanisms for environmental protection in Brazil[56], revealing a growing trend in policy of transferring government responsibilities to the private sector. These mechanisms may be broadly divided into Payments for Ecosystem Services (PES), incentives for the creation of Private Reserves of Natural Heritage Reserve (RPPN)[57], and Compensatory measures for environmental damages. Concerning the first mechanism, most PES schemes are financed by national and international programs and, increasingly, private companies. The second mechanism, the creation of RPPN, is promoted by State regulation, through which land owners are exempted from taxes on the protected area, among other subsidies and incentivescompensation measures are regulated by the Federal law 9.985/2000 (SNUC). The evaluation of these initiatives to date is not yet documented, making it difficult to assert the usefulness and adequacy of market-based mechanisms on each specific context. In any case, there are a number of aspects that require careful examination, and there are reasons to believe that such instruments may have limited application for the mitigation of urban flooding. In the case of PES and Compensation measures, it is even possible that these may have counterproductive results in the Brazilian context. In this respect, a few points may be worth mentioning in order to show that there is an excessive expectation in relation to the use of market-based mechanisms when it comes to the mitigation of flood risks.

While the development of market-based mechanisms for carbon sequestration may prove to be effective at a larger scale, by creating incentives for forest restoration, it is

[56] For more information on recent experiences on PES in Brazil, see von Glehn and Taffarello, 2013.

[57] To date, more than 1,000 private reserves have been established, covering nearly 700,000 hectares (CNRPPN, 2012).

important to note that water-flow regulation services constitute non-transferable ecosystem services across watersheds (LIU *et al*., 2010), and within each watershed, any existing urban area in a downstream location will be negatively affected by new developments upstream. As such, there is no unequivocal support for the proposition that giving the option of compensating externalities on a different parcel, or by transferring that obligation to another landowner, will compensate for the externalities produced by any given new development. This is because the benefits of flood mitigation are locally specific and have limited transferability within the given conditions of each particular watershed, requiring proper evaluation through the use of hydrological modeling tools. Another aspect that must be noted is that PES are based on the beneficiary-pays principle––in the case of flood mitigation, this means that vulnerable areas can be seen as potential buyers of flood mitigation functions, which may have pervasive social effects. Summing up, the idea of creating a trading market for reforestation, which adds monetary value to native vegetation, has limited application to flood mitigation, and even if beneficiaries and providers of water-flow regulation services are properly identified, beneficiaries should not be liable for ensuring the protection of socioecological functions that are supposedly granted by the Brazilian Constitution and other legislation.

The most polemic issues of attributing monetary values to to ecosystem services arise from the potentially perverse effects that over-reliance on the market as a solution to environmental problems can represent. There are authoritative sources who argue that “conservation needs should be price-determining, not price determined (DAILY, 1997, 2007). This author warns that the effective management of ecosystem services and functions involves resolving fundamental philosophical issues, requiring important institutional changes that can only be achieved by the transformation of existing structures of governance and collaborative decision making. Daily goes even further in stating that there is need for an entirely new order of values in which natural and social capital are above the market and cannot be tradable.

Other authors point out a number of strong critical points regarding the monetary valuation of ecosystem services, questioning if turning our life-support systems into commodities is the way to go for sustainability (see GHAZOUL, 2007). While confirming the usefulness of valuation methods, Pascual et al (2009) recognized that monetary valuation techniques have their limitations. Gaps in knowledge about ecosystem dynamics, technical issues, and/or human preference make predictions uncertain (PASCUAL et al 2009). Goulder and Kennedy (2009) highlight the difficulties of measuring ecosystem values in the complex and diffuse network composed of different ecosystems. Bullock and Acreman (2003) argue that there is a shortage of understanding of eco-hydrological relationships. Goulder et al (1998) criticized the generalized, simplified, reductionist views in which the linkages between social and ecological systems are not properly considered. Kumar and Kumar (2008) observed that Ecosystem Services frameworks are yet to evolve in a way that engages local communities in the identification and valuation of natural capital assets. Carpenter et al (2009) noted that some evaluation practices intended to improve ecosystem services and human well-being are based on untested assumptions and sparse information.

A common feature of these shortcomings is that they all rest, in a way or another, on the difficulty to define and characterize incommensurable goods and services (see PEARCE, 1998). In the face of these problems, the idea of "making the market work for the environment"[58] needs further scrutiny and existent studies are not conclusive in regards to its efficiency. It should also be noted that the application of market-based mechanisms in contexts where the institutional framework presents significant shortcomings may simply not be applicable. Even in situations where sound instruments and mechanisms of planning and management are in place, the many entangled political and legal instruments that condition land-use decisions may jeopardize the systematic use of PES schemes. Moreover, there may be ethical issues of equity and social justice between beneficiaries and providers, which need to be contextualized and taken into account. Corkindale (2010) sums up these shortcomings quite well, highlighting three main issues that require further research:

[58] In 1993, a policy document of the UK Department of the Environment (DOE, 1993) set a number of policy prescriptions suggesting the idea of "Making markets work for the environment" (DOE, 1993), arguing that this would be more cost-effective than "blue print" land-use regulation. This agency identified a number of advantages of the application of market-based principles: i) cost-effective realization of environmental objectives; ii) financial incentives for innovative solutions; iii) more flexibility for producers and consumers in weighing the advantages and drawbacks of reducing environmental impacts; and iv) additional public revenues.

- “suppliers” and “beneficiaries” need to be properly identified, defining those who generate positive externalities and those who generate negative externalities;

- the costs and benefits of proposed investments for flood mitigation need to be properly appraised, explicitly stated and quantified as far as possible;

- environmental impacts need to be considered, as well as eventual corresponding compensations.

As long as these complexities are not properly assessed and resolved and their effectiveness is only tested in a local specific context, it is unlikely that market-based mechanisms can be effectively used for the mitigation of urban flooding. Since little happened to use market-based mechanisms for this purpose in practice, there is a shortage of evidence on the success of its application in the Brazilian context.

8. The role of state institutions on land-use decisions

In this chapter, I present a detailed analysis of the formal institutions conditioning land-use change processes in the Brazilian context. The analysis of public institutions is based on the previous analysis of the legal framework and complemented by interviews with government officials and other State actors who have an active role in land-use decisions. Particular attention is paid to understanding how public institutions are subject to multiple and contradictory influences from micro to macro levels of governance, which renders an ambivalent role in government agencies. The interest in the ambivalence of state institutions is based on previous discussions of reflexive governance, claiming that certain governance patterns undermine themselves by inducing changes that affect their own working (VOß *et al*. 2006, RIP 2006, VOß and KEMP, unpublished manuscript). These observations will have their meaning more specifically directed to the focus of this study by elucidating how private interests are co-opted by State institutions, highlighting the endogenous nature of steering political actors.

8.1. Cultural heritage and environmental conservation agencies in Paraty

The National Institute for the Artistic and Historic Heritage (IPHAN), which is responsible for the cultural heritage, is strongly represented at the local level in Paraty[59]. IPHAN is linked to the Brazilian Ministry of Culture, with a wide range of responsibilities, from activities related to the identification, protection, restoration, preservation, and monitoring of physical, scenic, and archaeological properties, to those related to the administration of libraries, archives, and museums. Through IPHAN, the Brazilian Government is also responsible for the preservation of 11 properties registered by UNESCO as World Cultural Heritage sites—a designation for which Paraty has been waiting as a candidate for the last 12 years. IPHAN acts in Paraty through its 6th Regional Supervision Agency, the seat of which is located in the city of Rio de Janeiro. It is represented in Paraty by its 8th Sub-regional Supervision.

Many government actions have been taken in various attempts to preserve not only the built heritage of the city, but also its surrounding environment, through both federal laws and state policies that create various categories of protected areas in the municipality. Concerned with the protection of the Atlantic Forest remains, which cover approximately 70% of the municipality, a number of laws, decrees, and administrative rules have been created to institute forest parks, environmental protection areas, and ecological reserves within the Municipality of Paraty.

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59 IPHAN was created on January 13, 1937, through Law number 378, and was instituted as a Federal Public Agency in 1990, linked to the Brazilian Ministry of Culture (MinC). IPHAN was responsible for the first measure of legal protection of Paraty, through the State Decree-Law number 1.450 of September 18, 1945, which considered Paraty as a State Historical Monument. In 1958, IPHAN registered the "Conjunto Arquitetônico e Paisagístico da Cidade de Paraty especialmente o edifício da Santa Casa" (Paraty City's Architectonic and Landscape Ensemble, especially the building of the Santa Casa Hospital) in the Book of Registration of the Fine Arts and the Archaeological, Ethnographic and Landscape Book. In 1966, the Federal Government, through Decree Law number 58,077 of March 24th, registered the "*Landscape Setting of the Municipality of Paraty*, and especially the architectonic ensemble of the village" (my graph), as a National Monument. The entire Municipality was registered in the Book of Registration of the Fine Arts and the Archaeological, Ethnographic and Landscape Book of the National Artistic and Historical Heritage Institute on March 1st, 1974.

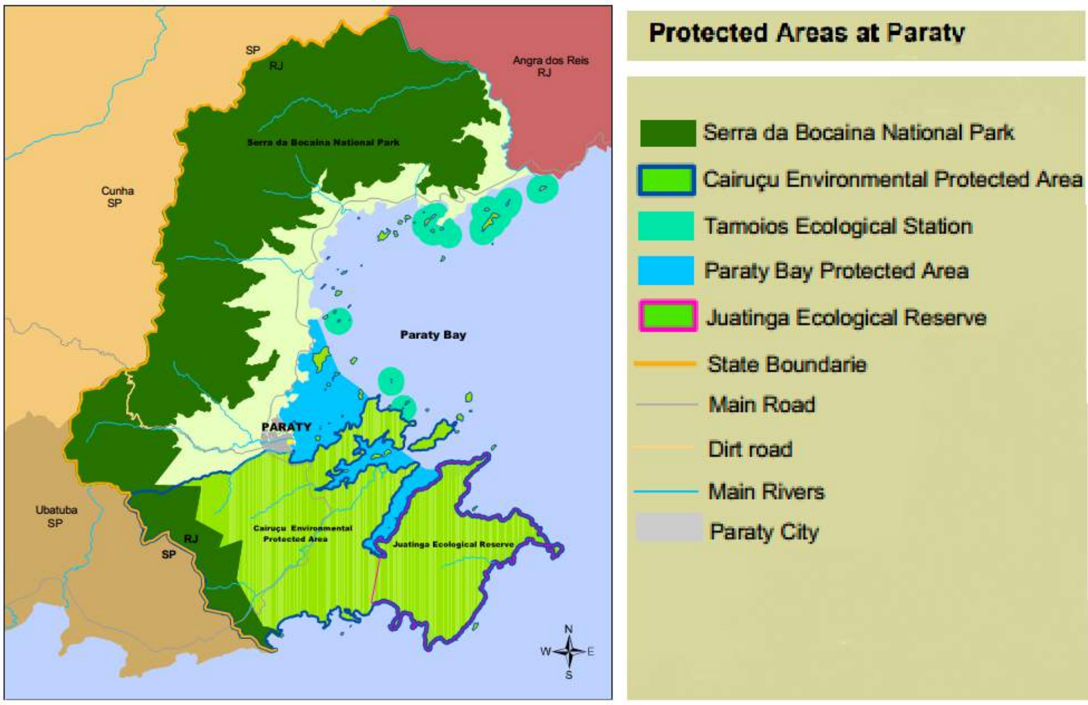

Fig. 24 Protected areas at Paraty (APAs) *in* PRO-UNESCO 2011 (modified)

The municipality of Paraty has been considered an integral part of the Atlantic Rainforest Biosphere Reserve by UNESCO since 1992. Wildlife and natural Protection areas include Cairuçu Environmental Protection Area (APA Cairuçu, which occupies almost 1/3 of the municipality of Paraty) and Juatinga Ecologic Reserve[60], Paraty Bay, and Saco do Mamanguá Municipal Environmental Protection Area (Municipal Environmental Protection Area in 1984), the Tamoios Ecological Area and the Bocaina National Park. The Bocaina National Park is overlapped by the State Park of Serra do Mar, in São Paulo, and by the Environmental Preservation Area of Cairuçú. Since 2006, the Ministry of Environment created the Bocaina Mosaic, aiming to enhance and improve the protection of 10 conservation units managed by the three different levels of government within the municipalities of Paraty and Angra dos Reis in Rio de Janeiro State, but also including areas in São Paulo State. Environmental agencies directly

[60] Juatinga Ecological Reserve is a public property within APA Cairuçu, managed by the State Institute of Forestry, created by the law nº 1.071, November 18, 1986, and is subject to the Environment State Secretariat of Rio de Janeiro.

bound to the Ministry of the Environment, such as the Chico Mendes Institute for Biodiversity(ICMBio), have a strong representation in Paraty. ICMBio is directly connected to the Environmental and Natural Resources Agency[61] (IBAMA) and is mainly mandated for the management of biodiversity conservation and forestry in Natural Conservation Areas[62].

The analysis of the discourse of federal agencies such as IPHAN, ICMBio and IBAMA evinces that both agree on the need to preserve the remnants of Atlantic forest along the hills that surround the city of Paraty, but urban expansion into upstream reaches of the floodplain is not seen as a concern to these agencies. After the revision of the Master Plan in 2007, IPHAN took prompt action against a municipal proposal of doubling the urban expansion area, and succeeded in bringing this issue to the public ministry, which in turn embargoed the proposal. But IPHAN's main concern is the conservation of the built heritage and protecting the old town from visual impacts whereas ICMBio and IBAMA's issues are related to biodiversity conservation and protecting the remnants of the Atlantic Forest from negative human impacts. Both agencies have access to resources and have developed strategies according to their mandates, but do not possess the skills and political will to address issues related to urban flooding. As an example, during the public consultation sessions of the new master plan of Paraty, both representatives of IPHAN and IBAMA advocated a "gradient of occupation" in which the low-lying areas that make the transition between the city and the mountains would preferably be occupied in favor of the protection of the hillsides. I have directly asked representatives of IPHAN if they would incorporate into their guidelines regarding land-use regulations specific recommendations regarding urban flooding. The answer has been that flood prevention is not within the mandated responsibilities of these agencies. Interviews conducted with technical staff of both agencies have shown that even though flood prevention may be recognized as a co-benefit to environmental and cultural heritage conservation and biodiversity, IPHAN and IBAMA have priorities other than flood prevention. The

[61] IBAMA (Brazilian Institute for the Environment and Renewable Natural Resources) is a Federal Agency, created in 1989 through Law number 7,735, of February 22, altered by laws number 7,804 of July 18, 1989, number 7,957, of December 20, 1989, and number 8,028, of April 12, 1990, and is linked to the Brazilian Ministry of the Environment.

[62] There are also a number of smaller agencies with similar responsibilities, which are limited to specific roles and areas under their responsibility, such as non-governmental agencies (e.g. S.O.S Mata Atlântica) and various Natural Conservation Unit Councils with specific mandates at the local level.

contributions of IPHAN held in public audiences about the revision of the Master Plan, as well as legislation issued by these organs, is centered on limiting urban density and the maximum height of buildings, while the consequences of converting agricultural lands located in upstream regions of the existent urban area is apparently ignored.

The strong influence of IPHAN and IBAMA is an exception to the generally low influence of national agencies at the local level. This is so because Paraty has been classified as National Heritage and large areas of the municipality are classified as Natural Protection Areas. These areas are regulated by the National System of Conservation Units (SNUC) through the Federal Law n. 9985/2000. The protected areas of the Municipality of Paraty aim to protect the remnants of Atlantic Forest, without, however, having the concern to protect the floodplain from further occupation. During the interviews and public consultation sessions, it was remarkable to hear the general lack of understanding of the social groups involved in the discussions about the conceptual differences between categories of protected areas, such as the difference between an Environmental Protection Area (APA) and a National Park (PARNA), and even less between APAs of Integral Protection and those of Sustainable Use, which were recognized more recently by the National System of Conservation Units (Federal Law n. 9985/2000 SNUC).

According to interviewees, both IBAMA and IPHAN would allegedly like to reduce the risks of flooding, but none of them is assigned to adopt these goals as central to their activities. Both agencies have shown low levels of interest in urban flooding-related problems. In the second round of interviews after the public hearings, these agencies did not present substantial changes regarding their interest in urban flooding. Each agency is mainly concerned with its specific agenda, each one conditioning land-use decisions in different ways, which, in turn, are also constrained by limited access to land resources and housing needs. Conservationists such as IPHAN sustain their concerns with avoiding further development close to the existent built heritage while environmentalists such as IBAMA continue giving top priority to biodiversity concerns. As a result, some of the rules imposed by these institutions are contributing, paradoxically, to further urban expansion into the floodplain. The lack of articulation between the rules imposed by these institutions, together with weak integration of other pressing needs (such as housing for the poor and flood prevention), are contributing to further urban expansion into upstream reaches of the floodplain and encroachment into river banks, thereby putting the historic and environmental heritage under a greater risk.

8.2. The roles of the State Institute of the Environment

The State Institute of Environment (INEA) has remarkable responsibilities in the Municipality of Paraty. These responsibilities are due to the presence of large portions of the Municipal territory, which are subject to various categories of environmental protection, regulated by SNUC[63] and other laws and policies at the State level. INEA is the result of the fusion of three different environmental organs: the State Foundation of Environmental Engineering (FEEMA), the State Superintendence of Rivers and Lagoons (SERLA), and the Forest State Institute (IEF). This fusion represents an effort to integrate water resources and the management of the territory and forests, and is a deliberate attempt to overcome the traditional lack of collaboration between these organs. The Directory of the Territory and Water Management (DIGAT) is the coordination body of INEA, although some of its responsibilities are shared with other directories of INEA. One of INEA's important roles is the licensing of projects that require environmental permits for construction, and all municipalities are required to submimt these projects for appraisal by the Directory of Environmental Licensing (DILAM). INEA is also in charge of the National System of Conservation Units (SNUC), having the power to establish Environmental Protection Areas. Nonetheless, the action of INEA on environmental protection is notoriously contained by stronger government agencies involved in the promotion of natural resource exploitation, such as the oil industry, mineral extraction, and infrastructure expansion.

Since the fusion of the institutions that gave place to INEA was precisely justified by the need to better articulate the management of land and water resources, this state-

[63] In accordance with the SNUC – Federal Law number 9,985/2000, Article 15: "The Environmental Protection Area is usually a large area, with a certain level of human occupation, presenting abiotic, biotic, esthetic or cultural characteristics that are specially important for the quality of life and the well-being of human populations, and its basic objectives are to protect the biological diversity, to discipline the occupation process and to ensure the sustainability of the use of natural resources."

level organ should be more proactive in promoting the integration of different sectoral views and concerns. This agency is also in better position to promote proactive measures of land-use adaptation for flood prevention. For this purpose, flood zoning at the state level could be a powerful tool to curb conversion of agricultural peri-urban lands into residential areas. Mainstreaming such sorts of analytical procedures into local and regional planning may provide a stronger basis for the state environment agency INEA and other public bodies to reach a common understanding of the impacts of land-use decisions on urban flooding. Projects at a regional scale may enable cooperation and combine multiple sources of data to create a better understanding of the system, aside from the potential for complementary funding (Pinkerton 2009). At the state level, INEA, the State Institute of Environment, is the most influential organ in far-reaching land-use decisions. The high influence of the state-level agency INEA is due to the fact that up to the present date, urban operations requiring environmental permits (such as land subdivision) require approval by this organ, since the Municipality of Paraty still does not have an operating environmental council within the municipal apparatus.

A senior staff member of the state agency INEA reported that their potential steering role is often undermined by the difficulty in articulating with the local level, contributing to a degree of mistrust among government institutions, which often see one another as adversaries instead of partners.

"O que havia (no governo passado) era um enfrentamento com o INEA o tempo todo, com os órgãos ambientais o tempo todo…embate, embate, embate, e a coisa não andava, só andava para trás."

"What happened (in the past Government) was a confrontation with INEA all the time, butting heads with the environmental agencies all the time, and things didn't go forward, only backwards."

According to a former municipal officer, one of the reasons for the lack of cooperation between INEA and local administrations is the enormous difficulties of the Municipality to obtain the required licenses for its projects, supposedly issued by INEA. The fact that this state organ has significant responsibility in adjudicating issues of environmental impact assessment is partially responsible for INEA's caseload.

"Eu fiquei dois anos lá, a gente querendo a licença dos postos de saúde e escolas, cara a gente não conseguiu! Até hoje não saíu (…) dois anos cara, que a gente tá lá em cima, sabe, respondendo. E eles não conseguem emitir as licenças, cara. Não tem operacional para dar resposta à demanda que eles criaram…"

"I stayed two years there, asking permits for the health care centers and schools, we didn't make it! It has not been issued yet (…) two years, that we are there you know, answering. And they are not able to issue the permits. They do not have operational staff for answering to the demand that they created…"

A high staff member of INEA, when asked about why INEA does not have a stronger role in promoting preventive measures through land-use control, justified that much of what INEA is supposed to do is overwhelmed by the pressing needs of high-risk areas, which require increasing needs in hard-engineering infrastructure. As a consequence of the rigidity of stringent licensing procedures, this state agency shows difficulty in fulfilling its role of licensing Municipal projects in due time:

"O INEA hoje é um problema porque as leis são muito rígidas. Exigem conferências muito aprimoradas, para você fazer licenciamentos, você tem que apresentar coisas muito esmiuçadas, e eles depois não tem capacidade para avaliar tudo isso em tempo hábil, e te licenciar e te dar o caminho para você chegar à licença. Então você fica com o negócio parado, um tempo, aquele movimento que você fez a princípio para fazer o negócio dentro da legalidade, você depois não consegue a licença (…) E aí acaba que empurram mais ainda (para a ilegalidade) porque quem vai tentar fazer certo, não consegue fazer. E depois não pode, porque, como apresentou, não tem licença, não vai fazer. Fica com medo porque se o INEA pegar (…) E aí o cara faz como ? Não apresenta porra nenhuma e faz escondido. Em geral é o que acontece."

"Today, INEA is a problem because the laws are very rigid. There are very stringent demands for getting permits, you have to present many details, and then they don't have the capacity to evaluate all that in due time for licensing and to give you the path for you to get your permit. So you get stuck, some time, and that move you made at the beginning to make a legal business, then you don't get your permit (…) so then it ends up that they even push you more (toward illegality) because who attempts to make it right, is not able to do it. And then he can't do it, because as he presented and he does not have a permit, he won't do it. He fears getting caught by INEA (…) and then how does he do it? He doesn't present anything and does it anyway. In general that's what happens."

The actual enforcement of federal and state environmental laws is often problematic, being commonly criticized at the local level as external constraints to "local development" and "economic growth"—as it will be seen in more detail in the stakeholder assessment section, these criticisms have been registered not only in the talks of those with vested interests in the construction business, but also by public administrators with attributed roles in the enforcement of these laws. It is however, possible to develop a different perspective on the heavy Federal and State regulation affecting the municipality of Paraty. The presence of conservation units regulated by SNUC offers a rare opportunity to develop sound planning and management at the local level, if these are carefully articulated with the main environmental planning instruments. These instruments are the Ecological-Economic Zoning (ZEE), the Municipal Master Plan, the Water Basin Plan, the Municipal Environmental Plan, and the Integrated Coastal Management Plan. Sectoral plans such as sanitation, housing, transportation, and mobility, which, according to the Brazilian law should be developed by the Municipality, also offer untapped opportunities for the interface between federal, state, and local planning and management instruments.

The SNUC and the adoption of water basins and sub-water basins as planning units provide an important juridical base for the integrated management of water resources and land use. It is important to note that according to the Federal Law n. 9985/2000, the regulation of Environmental Protection Areas is not only applicable for bio-diversity conservation purposes, but can also be created to assure sustainable uses in strategic locations. The idea of applying these instruments to flood prevention is nonetheless a very new initiative regarding peri-urban catchments in the Brazilian context, but it is also very topical since a recent innovative experience in this regard is being developed in "Baixada Fluminense" in the Metropolitan Area of Rio de Janeiro (see CARNEIRO et al. 2012).

Another particularity that makes a stronger case for the participation of INEA in far-reaching land decisions in Paraty is the "Integrated Management of the Ilha Grande Bay Ecosystem" (GEF, 2011)[64]. This project has been recently launched by the Global Environment Facility and INEA is responsible for its management in partnership with the Brazilian Office of the United Nations Food and Agriculture Organization (FAO). The main objective of this project is to achieve long-term conservation and sustainable use of the Ilha Grande Bay ecosystem considering the mainland, the sea, and the islands that

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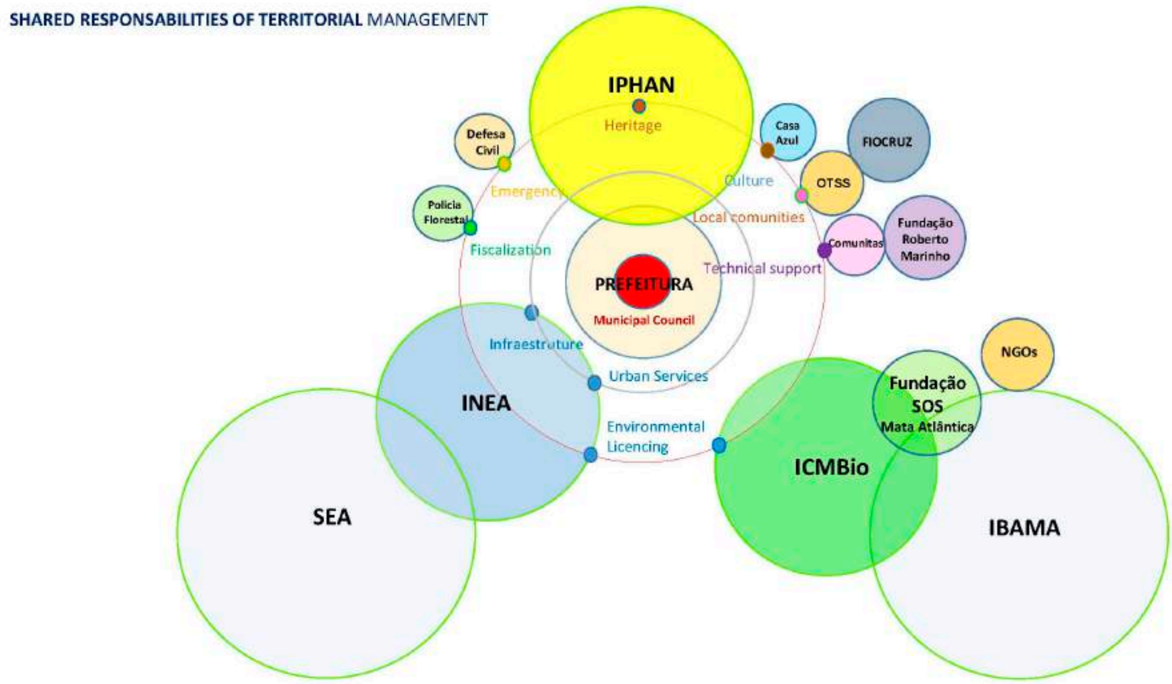
[64] More information on the Integrated Management of the Ilha Grande Bay Ecosystem project is available at http://www.inea.rj.gov.br/Portal/Agendas/GESTAODEAGUAS/Gerenciamentocosteiro/PROJ_GESTAOINTEGRADABAIAILHAGD&lang=PT-BR

comprise this ecosystem. This project could be seen as an opportunity to promote coordinated and integrated action strategies involving INEA and the Secretary of the Environment of Rio de Janeiro State, which is co-funding the project together with the Global Environment Facility[65]. It is worth noting that one of the goals established by this project is the "mitigation of selected threats affecting the 'health' of the Ilha Grande Bay Ecosystem and its ability to provide critical 'environmental goods and services." Such an ambitious project may constitute an opportunity for a more complete assessment of the many ecosystem services provided by peri-urban floodplains within the broader set of environmental assets of the region. This assessment would certainly help decision makers to broaden their understanding of the importance of preserving and enhancing strategic ecosystem services in these areas, especially when these provide important socioecological functions such as flood mitigation. A more comprehensive understanding of the interconnection between social and ecological benefits of adopting land-use adaptation measures would also potentiate the access to ecosystem services funds. Since the continuation of this project is not assured after the period 2011-2016, INEA will need to assure the incorporation of the goals and strategies developed under the Ilha Grande Bay project within the ongoing development of planning and management instruments such as the Ecologic and Economic Zoning (ZEEC).

The following table schematically represents the main spheres of influence on land use decisions in Paraty, as well as the agencies with shared responsabilities on territorial management and other related activities. On the image on the top right, the third sector organizations are included, although these have little influence on planning activities, while on the image on the bottom left the influence of the private sector on land use decisions is particularly pronounced, overlapping with the area of flows of public investment in infrastructures.

[65] According to informations available at INEA's website, the project has a duration of 5 years (from 2011 to 2016), with funding of $2.7 million from the Global Environmental Facility (GEF) and $6.4 million from the consideration of the State of Rio de Janeiro.



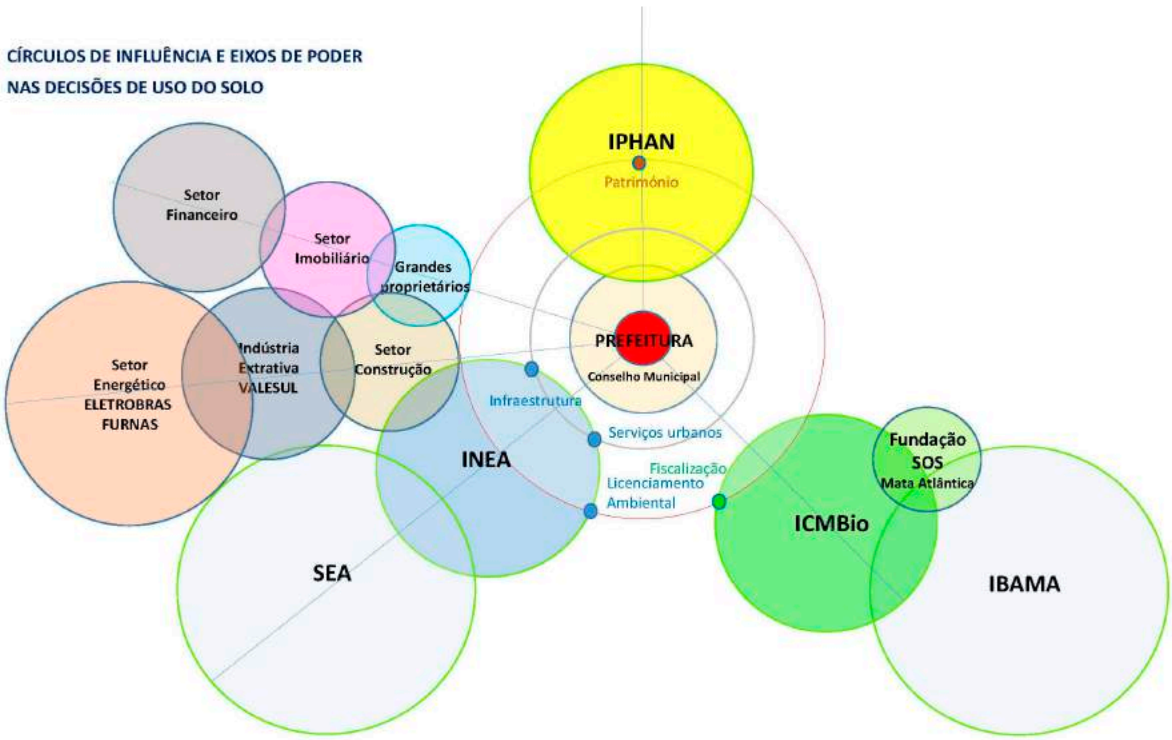


Table 6: Institutions and organizations with influence on land use decisions

8.3. Responsibilities and constraints of local governments

Although there are limitations on the municipality regarding the control and regulation of land-use change processes, the analysis of the legal framework leaves no doubt about the responsibility of local governments to ensure the common good and environmental sustainability. Since the beginning of the political reform initiated by the authoritarian military regime, decentralization has become a hegemonic principle in the democratization of the public sector, increasing the role of local governments. The scope of the Master Plan was significantly enlarged after the 1988 Constitution, including not only the mere zoning (i.e. definition of occupation rates, areas of urban expansion and environmental protection, standards for opening allotments or land subdivisions) but also the role of Municipalities in promoting social welfare in the city and the use of new instruments for urban and environmental management. The City Statute reinforces these responsibilities, detailing municipal competencies in planning, managing, and controlling land use, as well as in implementing public policies and participation in national public resources. The Complementary Law 140/2011 reinforces the administrative autonomy and responsibility in environmental licensing within Municipal boundaries.

As it has been noted in the analysis of the legal framework, municipal authorities have at their disposal the necessary instruments for safeguarding socioecological function in urban areas within their administrative boundaries (e.g. by assigning compatible land uses to flood mitigation services), as well as for compelling landowners to subdivide or build on underutilized properties (i.e. through punitive property tax rates) when the public interest is at stake. Oliveira and Biasotto (2011) argue that, in the vast majority of cases, the master plans outline the policy tools for enforcing the social function of property far too vaguely to allow for effective implementation, at least without complementary legislation, whose approval is often delayed. Goulart et al (2013) noted that municipal authorities had either not incorporated these tools into their master plans or, more commonly, had failed to pass the regular legislation needed to implement them. Referring to the core policy instruments outlined in the constitution for enforcing the social function of urban land, these authors argue that “[although] the instruments have been incorporated in almost all of the plans analyzed, they were rarely regulated in a way that would make them immediately applicable following the approval of the master plan. In addition, it is not unusual that the regulation of the instruments empties them of their power to induce urban development or to democratize access to well- located urban land" (OLIVEIRA AND BIASOTTO, 2011, *in* ONDETTI, 2015).

The devolution of responsibilities to Brazilian municipalities has not been followed by the necessary reforms at the local level, and therefore local governments' shortcomings have not been sufficiently addressed. Municipal governments generally lack the political will and human resources needed to put into practice the policy tools that are legally at their disposal. Generally, there remains a lack of leadership in the formulation and implementation of urban policies for directing growth to adequate areas, whether through direct interventions or by means of regulatory actions. Municipal administrators rarely assume their mandated political powers for assuring the harmonization of collective needs and private interests, and land-use decisions at the local level are generally seen as highly fragmented rather than holistically. This may be partially explained by the inherent structure of local governments, where the existing institutional setting is very rigid and highly hierarchical, and sectoral projects and plans are scattered and uncoordinated. The perpetuation of political posts within the bureaucratic apparatus and the lack of monitoring and controlling mechanisms have been pointed out as persistent problems of stagnation and inefficiency of the local government. The low level of effective commitment of the Municipality in coping with urban flood problems is reflected in existing regulations at the local level: the Municipal law 609 of 1981 (PREFEITURA DE PARATY, 1981) regulates land-use operations in the Municipality, in which article 15 states that land subdivision in flooded areas or areas subject to flooding is not allowed before action is taken to assure the drainage of waters. This short reference is a transcription of the federal law 6766/89 and does not bring any further specification: the "flooded areas" are not formally mapped by the municipality, which is generally the case in Brazilian municipalities.

Insolvency of Municipalities is a grave and common problem in Brazil. In December 2014, the National Confederation of Municipalities (Conselho Nacional de Municípios) pointed out that 5,368 municipalities—96.4 % of the total number of Brazilian Municipalities— listed in the Agreements Record of the National Treasury (commonly known as CAUC) would end the year with financial irregularities. Municipalities listed in CAUC are prevented from receiving voluntary transfers from the Union. Voluntary transfers are those for specific investments in public infrastructure and services and do not include mandatory transfers as FUNDEB and the Municipalities Participation Fund.

The creation of the Secretary of the Environment, together with the regularization of the Municipal debts, which occurred in 2014 after many years of insolvency by Municipal finance defaults, provided the financial and juridical basis for establishing a Municipal environmental policy in Paraty. However this is far from being a reality in Paraty, characterized by inconsequential implementation of proper land-use planning, lack of rule enforcement, weak coordination across sectors, bureaucratic inertia, and insufficient technical capacity.

9. The micropolitics of land-use change

This analysis is based on direct information collected in the course of the field study, with the aim of better understanding the factors influencing land-use change processes at the local level. Interviewing stakeholders and observing deliberation processes enabled the deconstruction of, to some extent, how individuals, social groups, and political forces exert their influence over land-use decisions. The identification of key constitutive relationships between each group of agents allows for the unfolding of the actual process side of politics where individual and collective actors interact. Excerpts of the talks of the respondents highlight the unruly and hidden factors shaping formal and informal processes of land-use change. Reconstructing the symbiotic relations between these two patterns of land-use change, and unfolding the fluxes of influence within decision-making processes, suggest that segregation and suburbanization dynamics, although reflecting divergent interests at play, are not necessarily antagonistic, but rather complement each other in a continuous cycle.

9.1. The dual economy of speculation of land markets

For analytical purposes, it was possible to distinguish two inter-related dynamics of land-use change, which I have termed the segregation dynamic and the suburbanization dynamic and which will be described in the following subsections. The dynamic of urban segregation is shaped by the actors concentrated at the top of the social pyramid, holding the bulk of land resources. This group is configured by the relationships between large land property owners, the corporative circuits of the real construction and the real estate business, and capital investors and developers involved in land speculation markets.

Today, the landscape of Paraty along the national road is still marked by the presence of large open spaces along the coast. These floodplain areas are in the hands of five large property owners, who inherited, bought, or transferred to private companies the property of these agricultural lands, destined for prime real estate property. These key players constitute a powerful political block who not only have a massive presence in the region of the study area, but who also hold large properties in other Brazilian states. It is worthy to recall the key importance that peri-urban floodplains represent for this first group of agents, reflected in the social conflicts arising from the process of appropriation of these lands after the construction of the national road connecting the cities of Rio de Janeiro and Santos in the early 1970s.

The information yielded throughout the field work helped to unfold the mechanisms through which the formal market of urban land is, to a large extent, regulated by the agents operating inside the circuits of transaction between developers, construction companies, and extraction industries. As in many sectors of the Brazilian economy, the construction sector constitutes an oligopoly within a pyramidal structure topped by extractive industries, which in turn have a relationship of dependency with the energy sector (i.e. electrical energy supply and oil industry). The presence of these powerful industries is remarkable in the area of influence of the Municipalities of Paraty. In this case, the regional monopoly of asphalt provision is detained by the politically powerful multinational giant Vale Sul (the second biggest mineral extraction company in the world). The formal market of urban land is therefore self-regulated by a powerful lobby where the extraction and energy industry sector play a determinant role in the viability of new urban allotments. The regional monopoly of an indispensable raw material for this type of urban operation makes it possible to set the price of this commodity and related installment services for each land allotment, assuring a non-explicit but very effective regulating power for this private player.

It is useful to understand how the pace of territorial changes is connected with the self-regulating mechanisms of this segment, through which the logics of transformation of land resources are determined by the imperatives of maximization of capital gains. The supply of formal urban land finds here a determinant bottleneck, since the optimal margins of profit depend on the scarcity of available urban land for development. The economic model usually adopted by these agents is the gradual construction of low-density residential areas, exclusively serving the interests of the prevailing elite in the forms of gated communities and allotments for the upper-classes, or simply properties kept away from development for speculative reasons. Following this logic of the maximization of profit margins, the oligarchic circuits of real estate-construction businesses can set the price of each plot of land, where each residential unit is turned into a luxury product of outstanding value. In some cases, the first allotments are sold at much lower prices in order to pay for the necessary infrastructure works such as road paving and landfilling. However, this opportunity is only given to investors with privileged information, and the remaining lots establish the market price and stimulate a progressive escalation of land costs over time.

Real estate sector respondents explained that the land price increases in the remaining areas available for development close by the city are fueling speculation of the land market and inducing urban expansion. According to the respondents, the price per square meter within the physical boundary established by the national road IC101 increased more than 1000% during the last fifteen years. This has been confirmed by various reports of investors about the impressive margins of profit obtained during this period—plots of 360 m^2 in the year 2000 ranged between R$30 and R$60 per square meter, while in 2015, an equivalent plot in the same location was evaluated between R$350 and R$500 per square meter (R$1.00 is approximately US$0.25, considering values from February, 2016). A real estate agent reported that after buying a property in 2002, he sold this plot after two years for the double of the price and used the surplus of this transaction in a similar investment in more distant locations. He explained that the increasing price per square meter of the remaining areas available for development close by the city encourages speculation of the land market and urban expansion in upstream areas of the floodplain, constituting interesting business opportunities for investors, especially in a context of tourism expansion such as is seen in Paraty.

9.2. Suburbanization as the flip side of the coin of segregation

Like other Brazilian municipalities, Paraty finds the most critical indicators of the lack of effective planning and management in the vast areas of illegal land parceling and irregular occupation of inappropriate areas, namely along river banks and areas subject to landslides where most casualties are registered after flood events. This is also the most expressive sign of a divided society within a complex socio-economic fabric where two distinct logics of appropriation coexist in a symbiotic relationship: if there is a market-based logic of profit maximization by private investors targeting high-income groups, there is a response emerging from the necessity of the sectors of society that are excluded from this process of wealth accumulation, which in turn creates new logics of appropriation of the urban space that tend to generate a self-destructing synergetic cycle.

This second dynamic of suburbanization is configured by a wide range of social groups, resulting from the pressures and demands irradiating from the base of the society. These social groups are composed of a considerable portion of the population taking part in the production of territorial changes that vividly reflect the daily struggles of the people living and moving toward the periphery. This evolving social fabric is composed not only of the poor, the landless, or the migrant population, but also by an emerging middle-class with growing acquisitive power. Within this group, former small property owners whose land has been acquired by private players purchase new properties in the new residential sites. The land-use changes resulting from the activities promoted by these agents are predominantly manifested through the sprouting of informal housing in peripheral areas, characterized by ad-hoc processes of land subdivision and illegal constructions, which are radically transforming the physical and cultural landscape of previously rural and forested areas.

Individuals operating land-use changes in upstream reaches of the floodplain (such as landfilling and embankments) have shown reluctance in recognizing the impacts on flooding produced by these territorial transformations. Short-term economic goals have been the most common justification for expanding the city toward these areas, varying from job creation to less specific notions of economic growth. In the interviews conducted with this segment of the population, the most common complaint referred to the scarcity of affordable land for urban development. The majority of the representatives of this group of agents, when asked about their interests, were also very prominently concerned with short-term economic goals, such as being close to job opportunities or opening small businesses. The tourism sector is also creating substantial incentives for expanding into new areas, generating jobs and commercial gains with many ramifications within the local economy. Along the river banks in upstream regions of the basins, settlements, hotels, lodges, and restaurants flourish and end up competing for land with the local population.

The piece-meal actions of the informal market exert strong influence on land-use change processes. However, it is problematic to determine the degree of influence of medium-size and small property owners since most respondents reported a variety of outcomes regarding their intentions to develop their land. Informal sections of the housing market compete through various speculation processes and act directly in the territory, contributing to increasing fragmentation of land ownership. Land subdivisions are normally obtained by breaching the formal institutions through illegal or informal means. Cases of physical intimidation and violence have been reported involving land disputes, becoming one of the main causes of murder within the municipality. The real estate developers explained the various informal institutional means needed to proceed with the illegal parceling of agricultural land. Two types of illegal operation and one type of informal land parceling are described below:

- "Grilagem" operations: "Grilagem" consists of the unlawful taking of a property with the intent to permanently appropriate the area. If the legitimate owner does not claim the land and the new occupant remains for the period of five years, the new occupant is entitled to claim it his/her property. This kind of operation is normally made by locally influential people, often with connections to the local registry or other bureaucratic offices who have access to privileged information about the status of the lands to be appropriated;

- "Laranja" operations: the "laranja" is an intermediate agent hired by the landowner for proceeding with the necessary actions to sell the land in piece-meal operations; if the illegal operation is denounced, the landowner may be formally accused of a criminal act. In such a case, the landowner may present a complaint claiming that his/her land was invaded without his/her acknowledgement. As long as there is no evidence of direct contact with the "liana," the landowner is not liable for any charge; meanwhile, the agent is no longer in operation, so there is no one to blame for the illegal act;

- "Fração ideal" operations, followed by informal parceling: "Fração ideal" is a legal land tenure operation in which the landowner (who normally have large and medium agricultural landholds) sells a portion of his/her agricultural lands without proceeding with the subdivision of the land; when various investors buy a property, each of the investors acquire a percentage of the total area. In a subsequent phase, each of these new property owners proceed with illegal subdivisions of plots without passing through the long bureaucratic procedures and the various regulatory authorities. In some cases, the selling operations of this second phase are made through an intermediary agent, or "laranja."

9.3. Informal networks and organized structures of influence

During the course of field work, many cases of dishonorableness were reported between private and public actors involved in land-use decisions. Based on the information collected from the interviews, quasi-legal and illegal practices predominate both formal and informal processes of land-use change. The encroachment of economic instances on governance instances is not a novel finding, referring to a rich body of literature in social science that analyzes at great length the complementarity between clientelism[66] (GALJART 1965) and corporativism (KAUFMAN, 1977), and the compromises between elites and the bureaucratic apparatus (URICOECHEA 1978; DINIZ, 1986). All of these concerning factors have been found to varying degrees in the context of this case, helping to explain how private interests are represented through formal and informal relationships between the State and private sectors. The modest dimensions of the present work do not aim to make a comprehensive treatment of these themes, on which there is already a rich body of literature. But the above discussion brings new elements to this broader discussion, allowing for a better understanding of how clientelistic practices affect political outcomes regarding land-use decisions. While the

[66] Clientelistic networks manifest themselves in high levels of corruption, nepotism, and intra-elite accommodation in which top political leaders offer rent-seeking opportunities to other political elites and important political supporters. These types of informal relationships are also characteristic of the contemporary processes of capitalist economic development, unfolding to varying degrees and in different forms in the most diverse national contexts. On clientelism in Brazil see also SCHWARTZMAN, 1977 and FERNANDES, 1976.

information yielded during the interviewing process cannot be conclusively proven, it is useful to account the reported episodes from an analytical perspective, which makes it possible to typify the various modes of influence within a discernible logical structure. These are hereby broadly divided in two main categories:

- *Informal networks* are composed by technical professionals who have access to the corridors of politics, as well as to bureaucrats who facilitate the political outcome of piece-meal projects or other immediate interests of individuals and economic groups.

- *Organized structures* consist of various forms of representation of private interests encroached in the state apparatus. These structures of influence have been usually found between the corporate circuits of infrastructure and service provision and between government position holders within the public administration.

An example of the presence of organized structures of influence in this case is the registered episode of an attempt to alter the urban expansion area by the Municipal Council. The proposal approved by the elected aldermen at the time consisted of extending the urban expansion area from the maximum altitude of 100 m to the maximum altitude of 200 m above sea level (Article 208 of the referenced proposal). If such a proposal would be actually put into practice, large areas lying between 100 and 200 meters above sea level would be open for new developments. Against this attempt, IPHAN moved a prompt action by presenting a formal charge at the Public Ministry Judicial Court. The Public Ministry agreed with IPHAN's position, embargoing the decision of the corresponding Municipal law. This episode has been explained by various respondents as a result of the pressure exerted by powerful groups of influence, indicating the possibility of loyalty of some local officers to specific private interests. The permanency of political seats for various terms through consecutive re-election has been pointed to as a major cause of corruption cases. In particular, the supposed role of the aldermen (vereadores) in defending the public interest seems to be more vulnerable to the domination of vested interests, which become enablers of speculation processes. According to a former municipal officer presently retired, the Municipal Council is subject to numerous pressures for satisfying a variety of private interests .

O papel dos vereadores seria fiscalizar para que isso não acontecesse né? Só que eles em vez de fiscalizar para impedir que aconteça, eles fiscalizam para descobrir as maracotaias e aí pedir uma percentagem. Olha aí você me dá aí uns 20, 30% senão isso aí não vai acontecer, que eu não vou deixar. (…)Um dia eu cheguei na câmara dos vereadores…desliga aí esse negócio aí…deixa eu te contar uma coisa (…)"

"The role of the aldermen should be to follow up so that does not happen. But instead of checking in order to stop that from happening, they check to get to know about the scams in order to ask for a percentage: 'Look, you give me some 20, 30%, otherwise that won't happen because I will not allow it.' Or sometimes are not scams, just legal things (...) One day I arrived at the Council...turn that thing off, let me tell you something (...)."

The dominating influential goups were described by an interviewee as a small number of well-established economic groups that are able to exert pressure over land-use decisions at various levels of government. This has been confirmed by various interviewees with inside knowledge of the influence exerted by vested interests on land-use decisions. One of the mechanisms through which economic groups exert influence on land-use decisions is through the finanicing of political campaigns within each electoral cycle. Subsidies and donations for political parties and candidates are given in exchange for previously-attained political agreements. A typical form of returns obtained by economic groups in financing political campaigns is public biddings of municipal services and infrastructure. In such cases, the bidders of a tender previously determine who is supposed to "win" the tender, arranging their bids in such a way as to ensure that the designated bidder is selected by the purportedly competitive process.

"é um grupo de pessoas, cara, de 15, 20 pessoas que mandam na cidade. A gente não sabe, não vê. Mas tem. Que cada hora pende para um lado dependendo de quem manda no governo (...) É isso, cartéis (…) e só chega no poder quem faz o jogo que tá aí. E depois, o jogo que tá aí tem que ser jogado com quem ele jogou para chegar no poder (...) os políticos mudam, as empresas estão aí…então isso prova que o hábito cíclico que se criou é que tá botando todo mundo nessa batedeira aí. Todo mundo tá virando corruptor e corrupto. E o Brasileiro já pensa assim, ah, como é que eu vou fazer para me dar bem? Virou uma cultura né?"

"It's a group of people, man, of 15, 20 people... Who run the town. The people do not know, do not see. But it happens. At any given moment they lean toward one side depending on who runs the Government." "It's like that, cartels (...) and can only attain power by playing the game that is out there. And then, the game that is out there needs to be played with the ones who helped him to attain that power." "Politicians change, the companies remain...the cyclical habit created is putting everybody in a mixer, where everybody is turning corruptor and corrupted. And the Brazilian already thinks like that...ah, how can I make it work for me? It turned into a culture, you know?”

Examples of cases of clientelistic practices have been reported by former municipal officers, who described various irregularities in public procurement processes in which public officials and contractors look for personal gains, for example, by accepting a bribe in exchange for a vote to approve an urban expansion area. According to an interviewee with inside knowledge on the pressures exerted over the designation of the urban expansion area proposed in the Master Plan of Paraty, there is a productive chain with high stakes on the approval of the new urban perimeter:

“ …é muita grana cara. Uma lei que você muda na Câmara, um terreno que não podia (construir nada) passa a poder ser vendido. E um monte de gente se beneficia com isso. E junto vai o pessoal que vende material de construção e…todo mundo né…é uma cadeia (…) Uma cadeia forte que gera emprego, que gera riqueza no município, que faz as coisas rodarem, só que a um custo de prostituição da cidade.”

“It's huge money. A law that you change in the town hall, a piece of land turns into something with high value. And a bunch of people benefit from that. And with that goes the people that sell construction materials and...everyone you know...it's a chain. A strong chain that generates jobs, generates wealth in the municipality, that makes the wheel move around, but at the cost of the prostitution of the city.”

The lack of clear criteria and transparency in land-use deliberation processes provide an ideal environment for the continuity of clientelistic practices, enabling flows of privileged information within informal networks of influence, while special standing privileges are given to organized structures representing the interests of private economic groups. The general idea expressed by the majority of interviewees is that there is no political will for challenging the establishment, which is deeply encroached in the bureaucratic apparatus. This has been also reported by some of the interviewees:

“Não há vontade de ordenar porque (…) tem muita gente ganhando grana hoje que vai ter prejuízo, entendeu? (...) Eles não querem fazer direitinho, eles querem ganhar (…) isso não dá voto! Dá grana é vender as coisas do jeito que eles tão vendendo. Fazendo as coisas do jeito que eles estão fazendo o negócio.”

“There is no will to order that because (...) there is a lot of people earning money today that will have prejudice, understand? (…) They don't want to make it right, they want to win (...) that doesn't get any votes! They profit doing things their way. Making things the way they are doing business.”

These statements are illustrative of the difficulties of implementing coherent and long-term land-use planning at the local level. Following City Council public meetings and integrating a working group for the analysis of the Master Plan of Paraty allowed for an inside perspective into land-use deliberation processes and provided clear indications that confirm the general opinion expressed by the interviewees. The participation in public hearing sessions promoted by the Municipality, as well as public debates promoted by other organizations (e.g. IPHAN, ICMBio, other NGOs), made it possible to account for the presence or absence of key stakeholders in public debates. It is remarkable how large landowners have shown little interest in participating in open discussions, even when the land-use decisions are supposedly highly relevant to their interests. In his theory of communicative action, Habermas considers whether a person avoids open confrontation by simply refusing to make public his or her interests and intentions, endangering the possibility of developing clear and fair deliberation processes. Such problems will be further discussed in the section dedicated to the logics of societal systems of participation, which also reflects on the shortcomings of existent participatory practices for reaching a common understanding of common problems related to urban flooding, as well as on the difficulties for defining and defending collective interests in land-use deliberation processes.

PART FOUR – SPATIAL ANALYSIS

10. Urban growth and land-use change in Paraty

In this chapter, I outline the main features of the territory under study, and characterize the overall context of Paraty. This characterization is examined at multiple scales of analysis. The broader scale of analysis considers the whole Municipality of Paraty, focusing on the existing urbanized areas and its evolution during the last 15 years. At the watershed level, the hydrological analysis considers the two river basins on which the city of Paraty is located. On a more detailed level, the study focuses on the lower region of the basins, namely the urban and peri-urban floodplain of the city of Paraty, comprising an area of approximately 1000 hectares. This area will be studied in more detail on the subsequent chapters concerning the scenario development and the hydrological analysis.

10.1. Location of the study area

The municipality of Paraty is located in the Southwestern region of the State of Rio de Janeiro, at an approximate distance of 400/450 Km from the Metropolitan Regions of Rio de Janeiro and São Paulo. The municipal territory is borderd by the Atlantic Sea in an inlet, the Ilha Grande Bay ecosystem, located at the 250 07' 30" South latitude and 440 41' 15" West longitude, at the southwest end of the State of Rio de Janeiro. It occupies a total area of 917km². Its limits are: north, the municipality of Angra dos Reis in the same State; south and west, the municipalities of Ubatuba and Cunha, both in the State of São Paulo; and east, the bay of Paraty, on the Atlantic Ocean. Surrounded by islands and a succession of mountains, covered by the exuberant vegetation of the Atlantic Forest, the city of Paraty is recognized not only for its outstanding cultural value but also for its rare environmental value[67].

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[67] The Municipality of Paraty is within what has been defined as a biodiversity hotspot, being the habitat of many endemic species of the Atlantic Forest threatened with extinction. A biodiversity hotspot is defined by Wikipedia as a biogeographic region with significant reservoirs of biodiversity that is under threat from humans. According to the study conducted by Mittermeier, Myers, and Mittermeier (1999) "Hotspots: Earth's biologically richest and most endangered terrestrial ecoregions," the Atlantic Forest is one of the 25 richest reservoirs of plant and animal life on Earth, and is one of the most threatened biomes in the world. These biodiversity hotspots cover only 1.4% of the planet yet contain 60% of terrestrial species diversity. Today only 7.3% of its estimated original area exists, while 93% has been devastated.

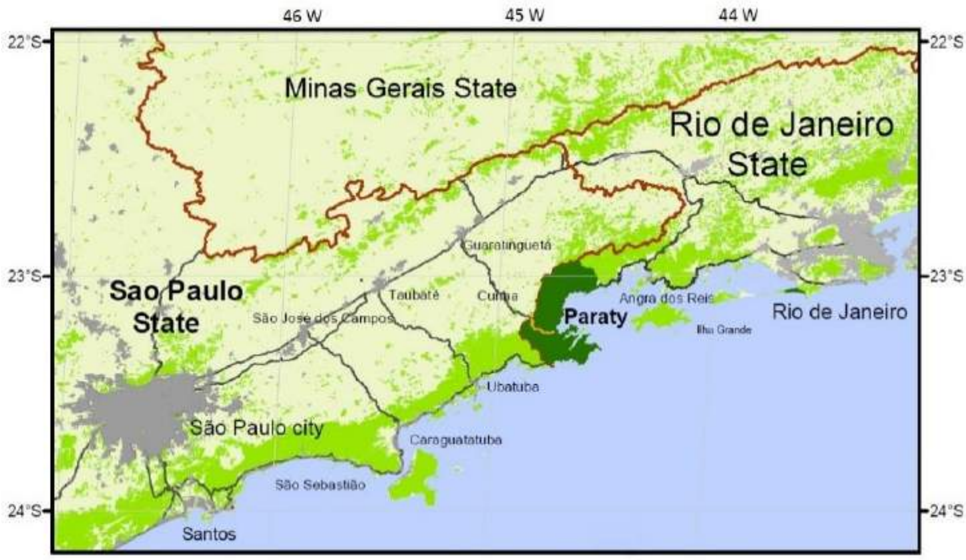

Fig. 25: Geographical location of Paraty (*in* MINISTÉRIO DA CULTURA, 2011, modified by the author)

The architecture and urban form of the old town is a lasting materialization of colonialism, which resulted from migratory waves related to the cycles of resource extraction in Brazil. Its strategic location was due to the ancient indigenous path across the mountains into the hinterland, used by the colonizers. Since its foundation by the Portuguese in the XVII century, the wetlands that make the transition between the forest and the sea have been progressively drained for agricultural activity and the construction of the colonial town, boosted by the gold coming from Minas Gerais in the XVIII century. In the XIX century, Paraty became an important regional center, serving as a strategic port for the coffee monocultures of the Paraíba Valley, officially gaining the status of City in 1844. After the construction of the railway that bypassed Paraty at the end of the XIX century, its economy went through a long period of stagnation and isolation. Since the 1970s, agricultural land ownership in Paraty has maintained ancient characteristics rooted in colonial land property regimes, while local fisherman communities have slowly been established in spontaneous settlements along the coast. This has contributed to the maintenance of the architectural characteristics of the old town, officially recognized by multiple categories of special conservation as a historical site in 1945 (*Monumento Histórico do Estado, do Rio de Janeiro*), in 1958 (*Tombamento nos Livros de Tombo de Belas Artes, Etnografia, Arqueologia e Paisagismo*), in 1966 (*Monumento Nacional*), and in 1974 (*Tombamento do Município de Paraty*).

The particular characteristics of Paraty make this territory uniquely marked by tensions and contradictions between, on one side, the need to preserve the old town and its environmental setting, and on the other, the intention to promote its attractive features for tourist exploration and related economic activities. This ambivalence of objectives has been present since the early plans for the city (see TURIS EMBRATUR, 67), which were based on the contradictory goals of "conservation, development and tourism." Since the 1970s, the valorization of the cultural heritage of Paraty has been stimulated by linking the symbolic power of this particular setting to forms of consumption promoted by the tourism industry and the leisure market, which in turn have putt in motion a process of appropriation and speculation of land. From this perspective, it is possible to establish a parallelism between the current commodification of urban land and other cycles of resource extraction in Brazil, constituting today one of the most (if not the most) profitable activities today in Paraty.

These tensions started to gain expression with the construction of the National Road (hereafter called BR-101), which connects the cities of Rio de Janeiro and Santos along the coast. The construction of the new road triggered various economic interests in the region, particularly connected with real estate and the speculation of land markets. Large properties along the road and the seashore have been claimed by the supposed title holders, giving place to harsh disputes between the claims of the newcomers and the local population. In many cases, settlers have been expelled or forced to sell their houses. The neighborhood "Ilha das Cobras," in the city of Paraty, has been a direct consequence of this process. Landless local communities rapidly invaded the area after being expelled from their previous settlements, giving origin to the most populated neighborhood within the Municipal territory. In some cases such as in the village of Trindade, the local community succeeded in resisting the pressure of powerful groups[68] that were attempting to take their lands for tourism development projects.

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[68] The story of resistance of the community of Trindade, defended by the famous lawyer Sobral Pinto, has been recorded in the movie *Vento Contra* directed by Adriana Mattoso (see http://cinemateca.gov.br/cgi-bin/wxis.exe/iah/?IsisScript=iah/iah.xis&base=FILMOGRAFIA&lang=P&nextAction=search&exprSearch=ID=009272&format=detailed.pft).

The abovementioned tensions have created conditions of restricted land supply of urban land for large segments of the population, giving rise to many socioecological conflicts in a rapidly evolving social context. According to IBGE (2010), the Municipality of Paraty had in 2010 a population of 37,575 inhabitants, an increase of 27% in the 10 years preceding (IBGE, 2010). The urban population of the city of Paraty does not exceed 20,000 inhabitants, but there is an important inflow of tourists throughout the year, increasing the total population by up to three times as much as its fixed urban population. In order to understand the demographic trends of Paraty, it is important to consider that the sharp transition from rural to urban environments in Brazil did not occur uniformly in the Brazilian territory[69]. The fact that Paraty is located between the two largest metropolitan areas of Brazil, namely Rio de Janeiro and São Paulo, makes this municipality subject to a number of socio-economic pressures that develop from subsequent demographic transition trends.

10.2. The Perequê Açu and Mateus Nunes River Basins

These watersheds within the study area have two main rivers, the Perequê-Açu and Mateus Nunes, and their basins comprise an area of approximately 16,500 hectares (see location on Figure 1). The geomorphology of the Perequê-Açu and Mateus Nunes river basins is mainly characterized by two landscape units: the Coast Range, with its highest point at 1,600 m, and the low lands stretching along the coast into the Ilha Grande Bay.

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[69] Brazil presents the highest proportions of population living in urban areas, surpassing the average of Latin American countries. 94% of the urban population is concentrated in large metropolises and megacities. The waves of migration from rural to urban environments intensified during the 1940s, and in 1970 the Brazilian population was predominantly urban, reflecting a reversal of social and territorial characteristics in less than three decades. Thereafter, the rates of urbanization continued upward while moderating their intensity, going from 55.9% in 1970 to 75.6% in 1991. The 2010 Census confirmed the trend, registering 84.4% of Brazilians living in cities (IBGE, 2010). The population estimates of IBGE for the Brazilian states, with reference data of 1st of July, 2014, is of 16,461,173 in the State of Rio de Janeiro, and 44,035,304 in the State of São Paulo. The demographic changes in these states have been the largest in Latin America, and have not been followed by adequate provision of public services such as sewage, sanitation and solid waste collection.

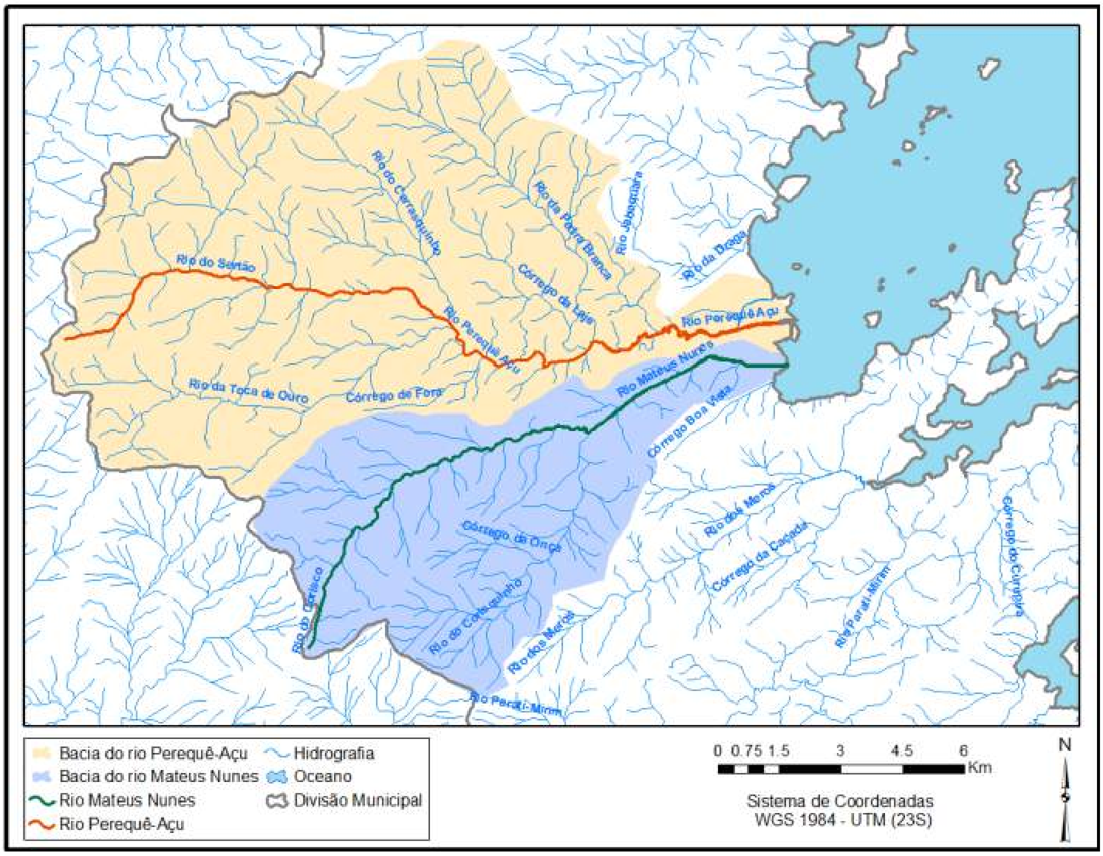
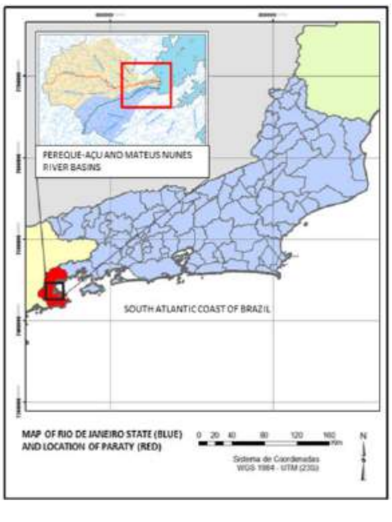


Fig. 26: The Perequê-Açu and Mateus Nunes river basins and their affluents



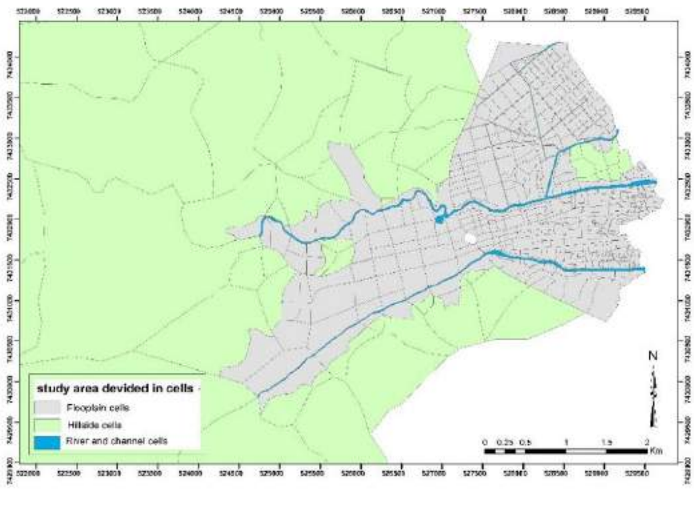


Fig. 27: Regional location of Paraty

Fig. 28: Study area devided in flow-cells

The Perequê-Açu and Mateus Nunes river basins, along which the city of Paraty is built, belong to the Ilha Grande Bay Ecosystem, designated in the State of Rio de Janeiro as superintendence SR1. The rivers that descend from the escarpment of the Atlantic Forest have a torrential regime, with strong erosive power and the potential to hit the plains when precipitation levels are high. The transition to the lowland is phased by a narrow intermediate level between the slope and the plain. The two river systems flowing into the urban area of Paraty have steep gradients, bringing rapid discharges of large volumes of storm water into floodplain areas when heavy rains occur. In general, these heavy rains have smaller volumes of stormwater than in the neighboring municipality of Ubatuba, because Paraty is protected by the mountains from the cold fronts coming from the South. Despite this advantageous situation, floods happen frequently, forming vast wetlands that have been progressively converted for urban uses.

The rivers Perequê-Açu and Mateus Nunes, where the city of Paraty has developed, suffered numerous interventions over time, such as corrections, deviations, and changes in the geometry of its sections. These human interventions have intensified floods with significant impacts in rural and urban populations when extreme hydrological events occur. Other anthropogenic influences in the basin are contributing to the worsening of floods, such as deforestation in some parts of the Serra da Bocaina, which contributes to the increase in flow rate, erosion, sediment transport, and silting of rivers in the lower part; the highest flood risks are associated with the occurrence of extreme rainfall events in tandem with high tides. In recent years, floods have become of greater magnitude and frequency, affecting several locations in the city of Paraty. The last biggest flood occurred on the 10th of January, 2009, when intense rainfall hit the mountainous region of Paraty, raising the water level in upstream areas of the Perequê-Açu river up to 8 meters, leaving destroyed homes and displaced people in 12 (twelve) districts. The rain began to fall from 21:00 on the 9th of January, and the event resulted from the collision of a cold front coming from the South Atlantic with a warm front coming from the Inland territory. The peak-flow discharge occurred between 2:00 and 3:00 on the 10th of January. The Navy Tide table indicated that the peak of the high tide of the full moon happened at 3:00, reaching a tide height of 1.3 m. The water-flow capacity of the Perequê-Açu river was surpassed, flooding surrounding areas in the plain up to 1.60 meters; trees, rocks, and cars were dragged, contributing to the damming of the river. The most affected districts were Condado, Portão de Ferro, Chácara da Saudade, Jabaquara, Trevo, Portal das Artes, Ponte Branca, Caborê, Princesa Izabel, Ponte Nova, and Portão Vermelho.

During the rapid process of urbanization during the last two decades, conflicts have occurred between urban pressures and the need to protect this fragile ecosystem. The basin has a clear territorial subdivision, with some areas of remaining forest situated on steep hills that surround the watershed, which provide important functions to climate regulation and the hydrological cycle. In turn, the northern areas of the basin that are not incorporated into the urban fabric play an important role in urban flood control. These areas also function as a buffer zone for other protected areas located on the upper course of the Perequê-Açu and Mateus Nunes river basins. The natural conditions and geomorphologic characteristics of the plains, together with processes of uncontrolled urban occupation and lack of basic infrastructure, make the urbanized areas along the river courses particularly prone to flood-related risks. The process of occupation of the lowlands, characterized by successive deforestation, intensive use of inadequate agro-pastoral practices, uncontrolled urban expansion, and the cutting of hills for roads and embankments resulted in accelerated soil erosion, causing bottlenecks in the river beds and channels with a direct effect on flooding.

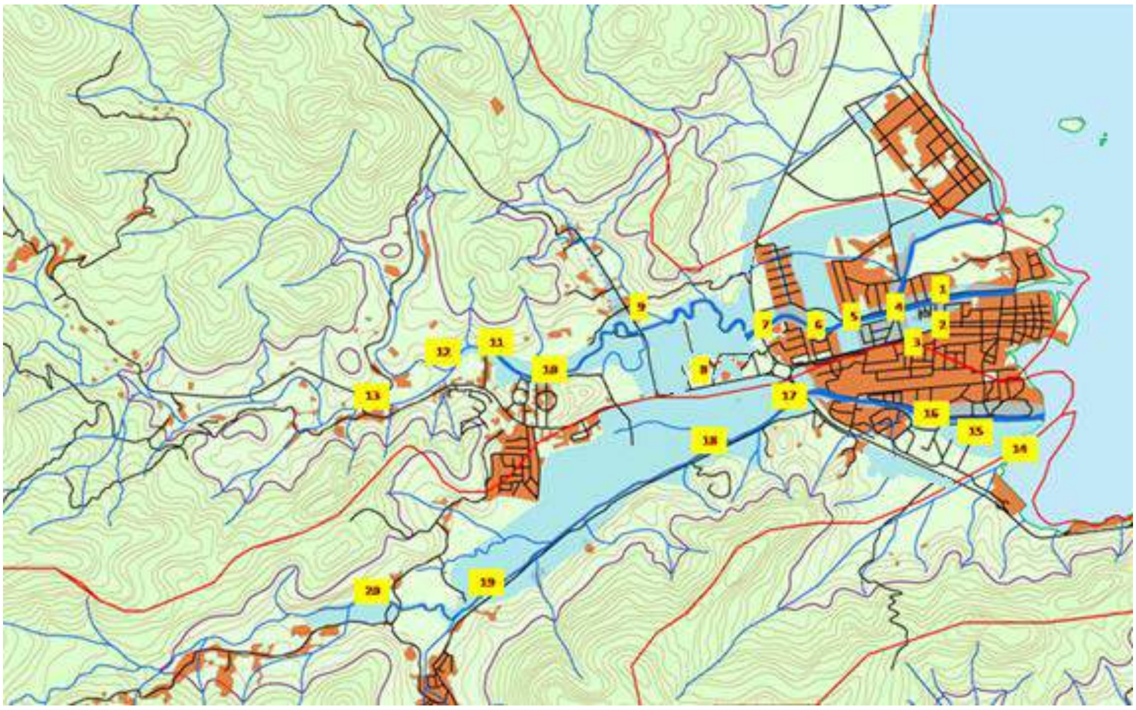


Fig. 29: GPS points of photograph survey of affected sample areas

Fig. 30 (left): Present mean level of the river Perequê-Açu (my photo) point GPS 4

Fig. 31 (right): The same area looking upstream in the recent floods of March 2011 (from the civil defense archive) – point GPS 4

Fig.31 (left): In Bairro Chácara, streets flooded to the height of 1.5 m (my photo, with the civil defense staff at Rua Ozeias Martinho de Almeida) - point GPS 2

Fig. 32 (right): A new condominium is being built in an area where flood marks are still visible (my photo) - point GPS 2

Fig. 33 (left): Flood in Paraty 2009/12/04 (from the municipality archive) - point GPS 3

Fig. 34 (right): Flood in Bairro Chacara 2009/12/04 - point GPS 5

Fig. 35 (left): Flood in Paraty 2010/1/1 (from the civil defense archive) - point GPS 6

Fig. 36 (right): Flood in Paraty 2010/1/1 (from the civil defense archive) - point GPS 7

Fig. 37 (left): Av. António Gama 2010/1/1 (from the civil defense archive) - point GPS 8

Fig. 38 (right): Bairro Patitiba – point GPS 3

Fig. 39 (left): Signs of damages in the margins of Perequê-Açu (my photo) - point GPS 4

Fig. 40 (right): Floods in April 2011 (from the municipality archive) - point GPS 8

Fig. 41 (left): Mateus Nunes from the bridge BR 101, Km570 (my photo) - point GPS 17

Fig. 42 (right): Ilha das Cobras at the margin of Mateus Nunes - point GPS 16 (my photo)

Fig. 43 (left): Jardim Riviera 1 2009/1/10 (from the municipality archive) - point GPS 8

Fig. 44 (right): Flood at Perequê Açu at the junction with Jabaquara chanel

Fig. 45 (left): Bairro Condado was massively destroyed in January 2009 but new houses have been built in the same area (my photo) - point GPS 10

Fig. 46 (right): Rua das Flores in January 2009 (municipality archive) - point GPS 11

Fig. 47: (left) Precarious constructions in steep gradient areas of Bairro Condado

Fig. 48 (right): Remaining signs of destruction in Bairro Ponte Branca - point GPS 12

Fig. 49 (left): Destruction of infrastructures at Penha - point GPS 13

Fig. 50 (right): Road interrupted at Penha - point GPS 12

Fig. 51 (left): The city is prone to flooding both by stormwater run-off and sea level rise (my photo) - point GPS 14

Fig. 52 (right): The fisherman's neighborhood in the banks of Mateus Nunes is extremely vulnerable to floods (my photo)

Fig. 53 (left): floods in Paraty 2009/12/04 (from the municipality archive) - point GPS 16

Fig. 54 (right): the Perequê-Açu floodplains are intensely occupied in vulnerable sites

Fig. 55 (left): Floods in March 2011 in river Mateus Nunes (from the civil defense archive) - point GPS 18

Fig. 56 (right): Floods in Perequê-Açu (from the civil defense archive) - point GPS 9

Fig. 57 (left): Embankment in the Mateus Nunes river (my photo)

Fig. 58 (right): Accumulation of sediments and erosion in Mateus Nunes river (my photo)

10.3. Socioecological conflicts in the Municipality of Paraty

Throughout the last decades, informal settlements have emerged around the consolidated urban area of the city of Paraty, which is marked by high spatial inequalities created in a relatively short period of time. As it can be seen in Figure 59, in 1965 the urban core was concentrated close to the sea, with slow expansion occurring to upstream areas. The fluvial system of the river Perequê-Açu (to the north) still presents its main channel flowing to the northern area of Jabaquara and its secondary meanders flow freely along the floodplain, while Mateus Nunes (to the south) has already suffered an artificial rectification of its section's geometry. In 1990, the city developed in all directions and but its urban area still presented a generally compact urban form. The river Perequê-Açu's last segment has been channeled and its meanders have been suppressed.

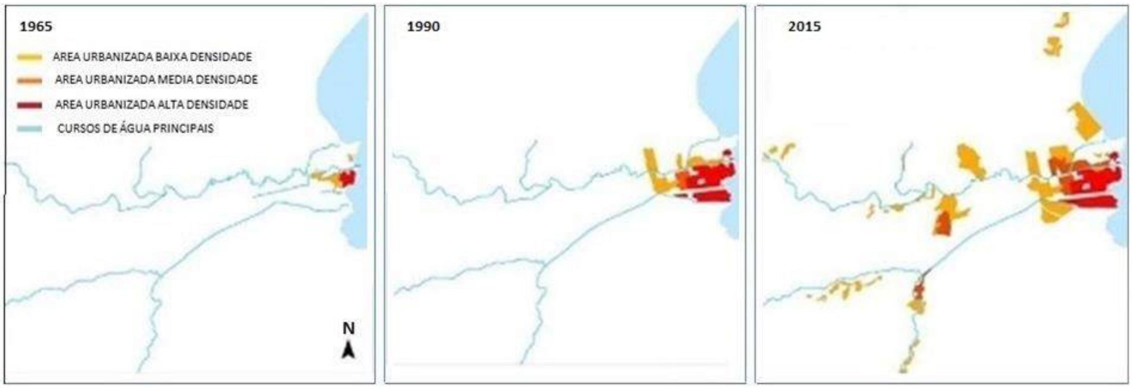


Fig. 59: Evolution of urban expansion in Paraty during the last 50 years, also representing the configuration of its main rivers.

Along the rivers Perequê-Açu and Corisco (a tributary of the Mateus Nunes river), urban development is already occurring at a fast pace. In the immediate upstream surroundings of the large properties described earlier, various neighborhoods have rapidly developed in the last 25 years, many of them driven by informal occupation and uncontrolled land-use change processes. From 1990 onwards, pressures over land resources have been more intensely manifested through the emergence of new residential areas on (previously) rural land, the multiplication of formal and informal settlements in flood risk areas, and illegal occupation and deployment of urban subdivisions, in some cases sponsored by the municipality. Structural problems in such areas include the lack of housing for the most disadvantaged social groups and poor sanitation services in the flood prone areas where they live. These problems result in serious consequences for the well-being of local communities, contributing to socially inequality and environmentally unsustainable patterns of urban growth. In rural areas of the municipality, areas affected by floods or steep-sided hillsides prone to landslides have also been progressively occupied. Generally, urban areas are provided with better infrastructure fading out into the administrative boundaries, whereas peripheral areas are poorly served by sanitation systems. The same pattern can be seen in relation to a lack of garbage collection: in peri-urban areas, a significant amount of waste is discarded in the drainage network and vacant lots due to inefficient collection system and misinformation of the resident population on the consequences of these practices.

Uncontrolled urban expansion into flood prone areas is one of the principal drivers in the contamination of the soil and water. The indirect impacts of floods on health by the contamination of soils and water by urine, fecal matter, and hazardous waste is affecting poor communities in Paraty, contributing to the spread of infections. The study conducted by MCGRANAHAN (2007) shows that infiltration of polluted water into low-pressure water-distribution systems contaminated drinking water supplies causing outbreaks of diarrhea and other diseases. Pollution of water bodies in Paraty are contributing to accelerated environmental degradation and threatening public health[70]. The untreated sewage of peripheral communities is discharged into surrounding water bodies and the resulting waste is discharged out into the seawaters of Paraty Bay. According to the water quality tests conducted by YOU (2003), Jabaquara Beach was found to be unsafe for swimming due to high fecal contamination. According to the same study, Mateus Nunes and Perequê-Açu River were considered unsafe for all aquatic sports. The pollution of surface water bodies, such as rivers and beaches, due to untreated sewage, results in increased health risks, loss of amenities, and ecological degradation. As a consequence of deficient sewerage, drainage, and rubbish collection services, there is significant exposure to water and sanitation-related diseases. Diarrhea, for example, is a widely

[70] According to IBGE Census data from 2010, sanitation indexes are quite critic for the large majority of municipalities of Rio de Janeiro State, including problems related to the frequency of irregular supply, lack of network pressure, poor water quality and irregularity of supply. These compounded risks are creating a growing deficit of infrastructure and services provision, which are constrained by technical and budgetary limitations of local and state governments.According to the National Sanitation Institute (Sistema Nacional de Informação sobre Saneamento, 2008), the worst deficits are observed in peri-urban areas, where urban infrastructure and service provision are lacking.

studied indicator in the municipality, shown to be prevalent in both the urban and the rural areas of Paraty (see BARRETO, 2002). The most severely affected areas—Mangueira and Ilha das Cobras—are also the more densely populated, low-income areas within the municipality.

Inadequate land-use planning and unregulated land tenure increase flood vulnerabilities and related risks, especially within low-income social groups. Due to the lack of affordable alternatives, the poor cannot afford to buy, build, or rent secure housing in safe areas, while lands of higher value are occupied by better-off urban residents. Below are listed some of the main problems that contribute to increased flood-related risks in Paraty:

- Lack of housing alternatives for the poor
- Lack of public infrastructure, such as water supply, sanitation, and drainage
- Inadequate basic services such as health care and waste collection
- Risk from natural disasters, namely floods and landslides
- Poor land and water management
- Lack of alternative solutions for land acquisition in safe areas

Several factors shape other specific problems, such as the fast expansion of privately-owned developments, destruction of important ecosystems, and uncontrolled urbanization. These trends, coupled with inadequate policies and enforcement of those in effect, result in the destruction of critical ecological assets and increase the vulnerability of infrastructure and land uses. The relevance of these factors increases where the ecological underpinnings of urban development are more fragile—in such areas, any significant additional stress can potentially lead to serious disruptive events and impacts.

10.4. Urban growth within the Municipality of Paraty 2001-2012

This section presents the results of the analysis of land-use change dynamics concerning urbanization in the Municipality of Paraty. The image below show the areas where this study has been focused, following the delimitation of Macrozones proposed by the 2010 Master Plan. Population data and population growth values are presented on the next page, followed by the analysis of each settlement, and compare the observed changes between 2001 and 2012.

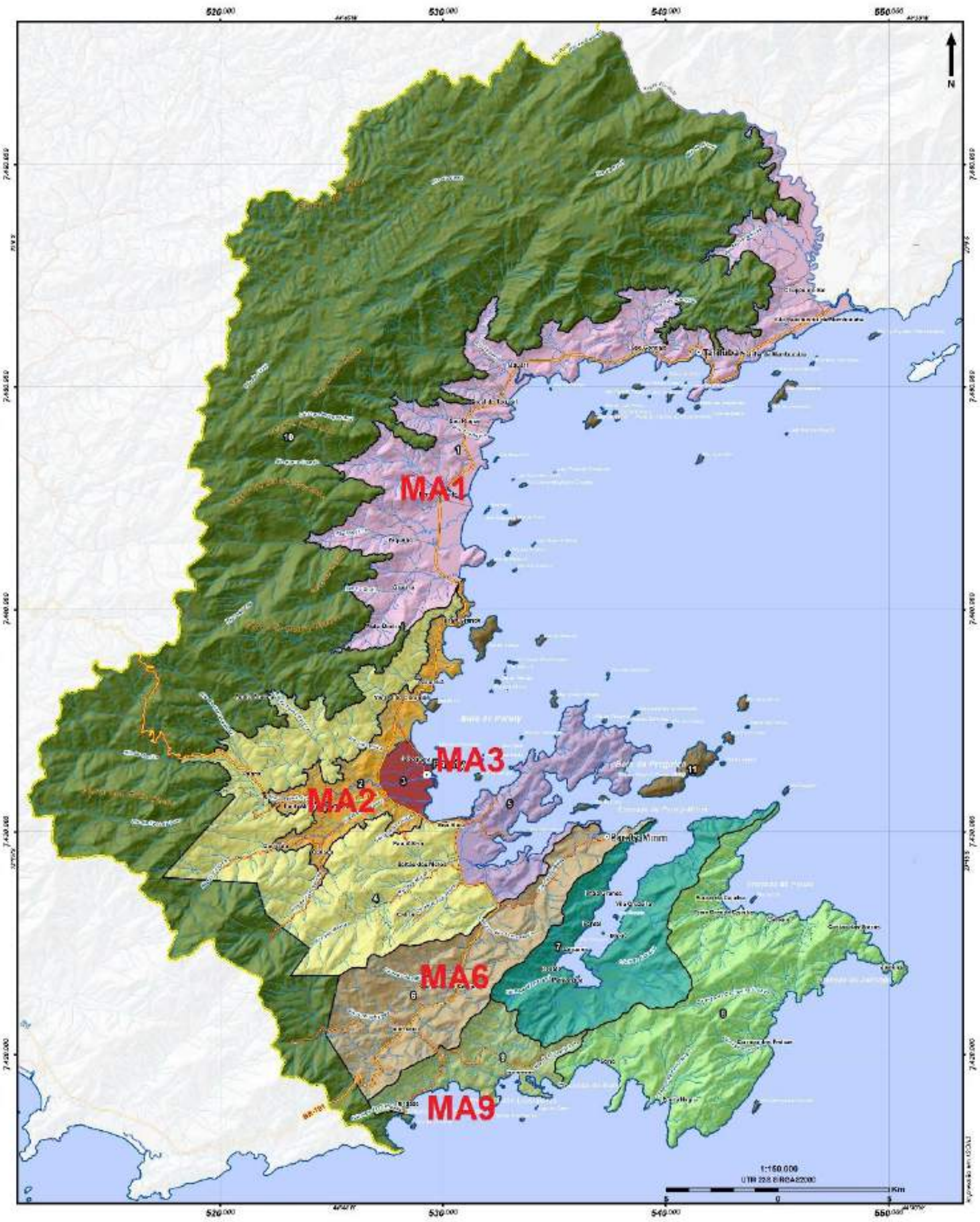


Fig. 60: Most populated areas of the Municipality of Paraty. Source: Paraty 2011.

According to Census data from IBGE from 2000 and 2010, the population in the Municipality of Paraty had an increase of 2.44%/year. The Master Plan of Paraty of 2010 estimated population values based on population data from 2007 for each Macrozone, as is shown in the table below. This information has been used as reference for simulating a hypothetical scenario of the continuity of the growth rates observed during the period 2000-2010, extending this trend until the year 2035.

	ha	MA	2000	2010	2015	2020	2025	2030	2035	%/year
Trindade										
Laranjeiras	1971	**MA9**	1065	1600	1925	2316	2787	3354	4035	3.77
Património										
Quilombo/Campinho										
Paraty Mirim	5132	**MA6**	1610	1242	1350	1448	1576	1685	1789	1.20
Coriscão/Corisquinho										
Ponte Branca										
Pantanal/Condado	2412	**MA2**	3979	7324	9665	12754	16830	22209	29306	5.70
Corumbê										
Paraty	594	**MA3**	**13957**	**16426**	17688	19048	20511	22088	23785	1.49
Graúna										
Barra Grande	4088									
Praia Grande/Araújo										
São Roque	2140	**MA1**	5497	6636	7229	7875	8579	9345	10181	1.73
Taquari										
Tarituba	1.551									
São Gonçalo										
		MUN.	26108	33228	37486	42290	47709	53823	60720	2.44

Table 7: Population data for the period 2000-2010 and estimated population until 2035 (by the author, information from IBGE, Census 2000 and 2010).

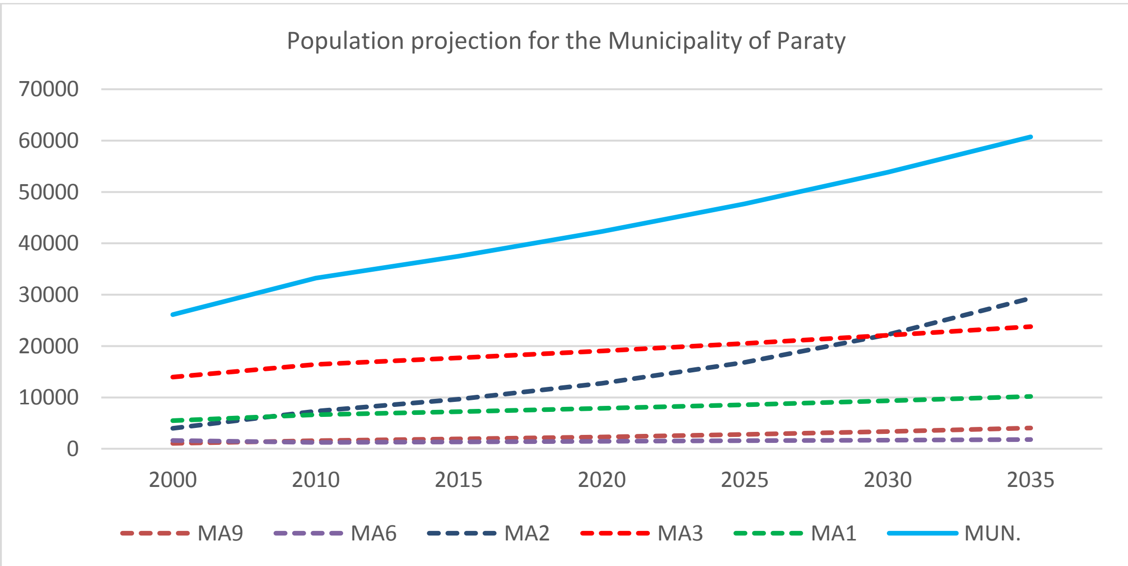


Fig. 61: Population projections for the Municipality of Paraty and for each Macrozone.

In order to make an analysis of the land-use change dynamics in the Municipality of Paraty, 18 sample areas have been selected, capturing the most significant territorial transformations occurring between 2001 and 2012. The analysis of satellite images collected from the platform Google Earth Pro made it possible to quantify the number of urban operations, the increase of converted areas for commercial and residential use, and the increase in the number of urban clusters On the following pages, the images obtained through this analysis are presented, followed by a comparative analysis of this data.

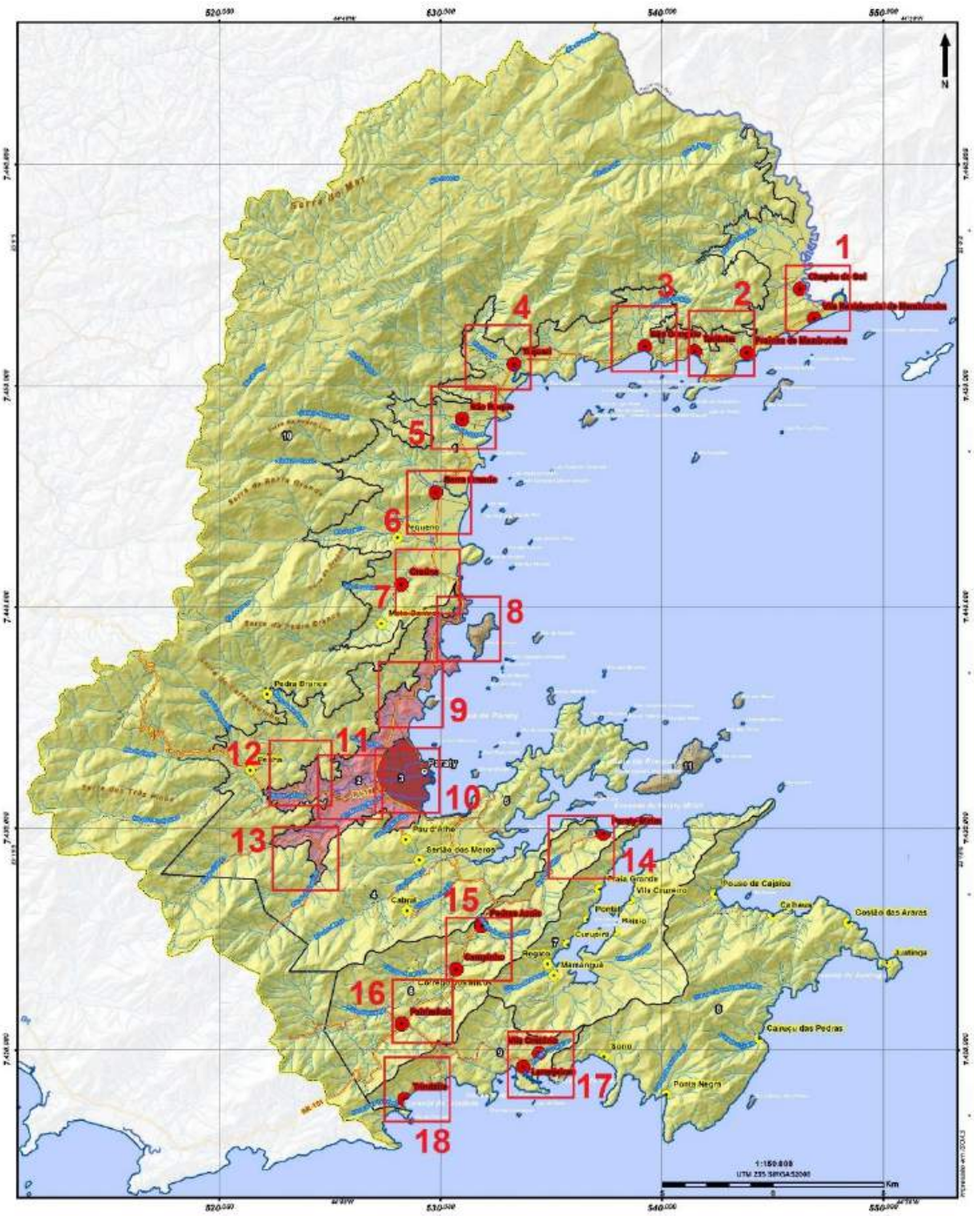
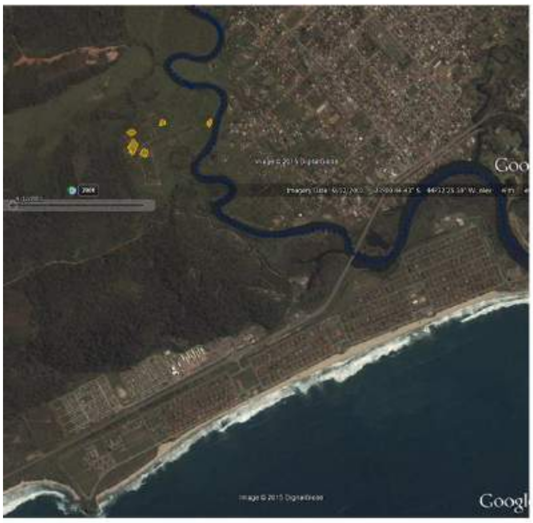
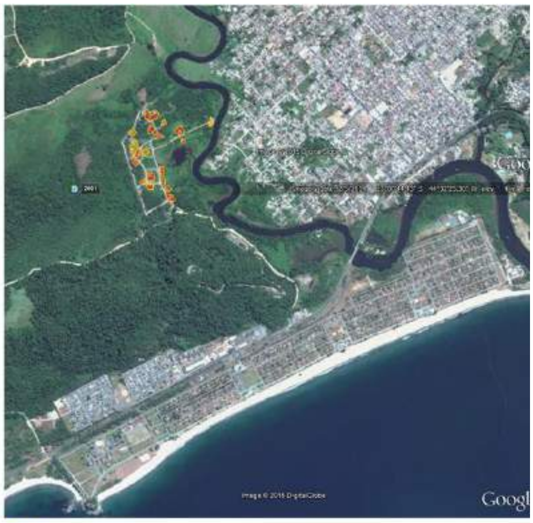


Fig. 62: Map of the Municipality of Paraty with the sample areas marked from 1 to 18.





N 1 CHAPÉU DO SOL/ MAMBUCABA

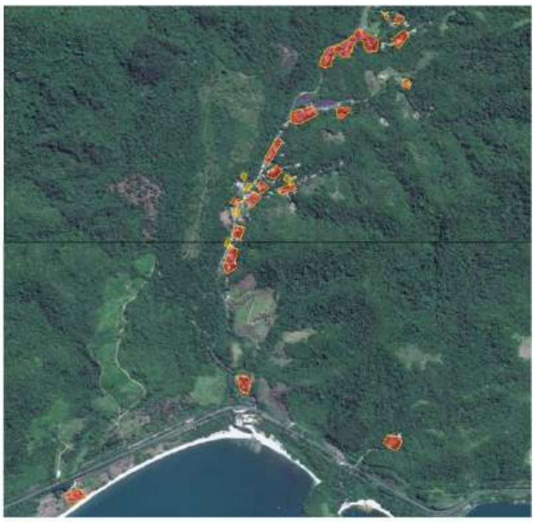
2001
2012

0 0,5 1 1,5 2 Km

N 2 TARITUBA/ PRAINHA DE MAMBUCABA

2001
2012

0 0,5 1 1,5 2 Km



N 3 SÃO GONÇALO

2001
2012

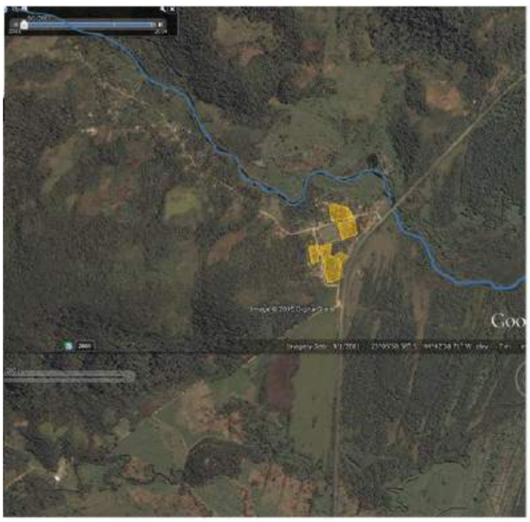
0 0,5 1 1,5 2 Km

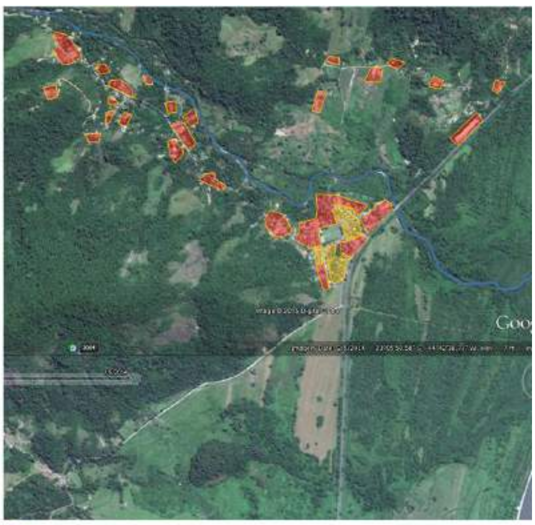
N

4 TAQUARI

N

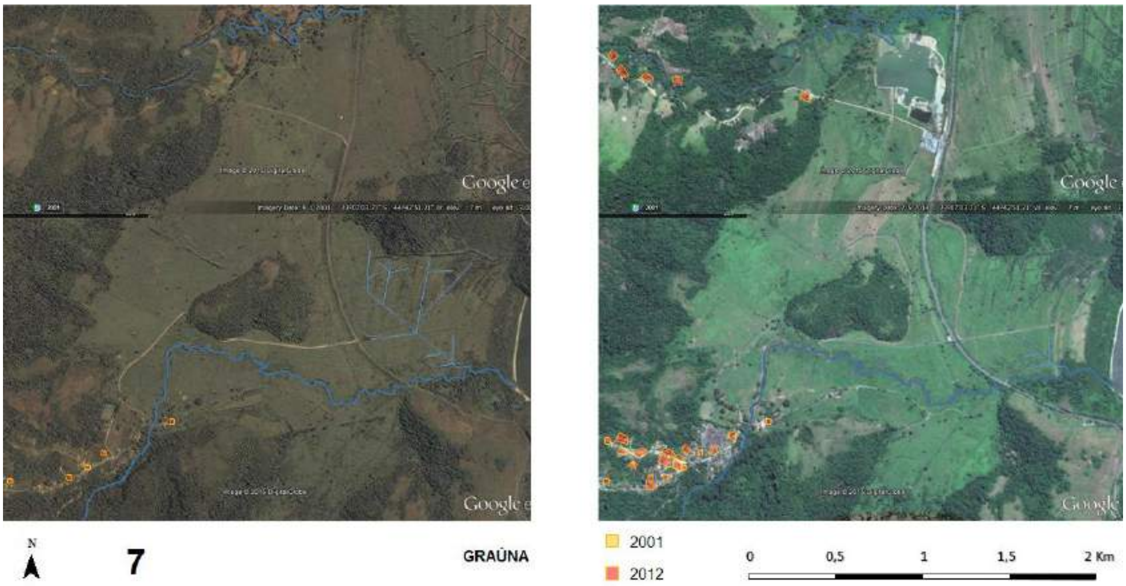
5 SÃO ROQUE



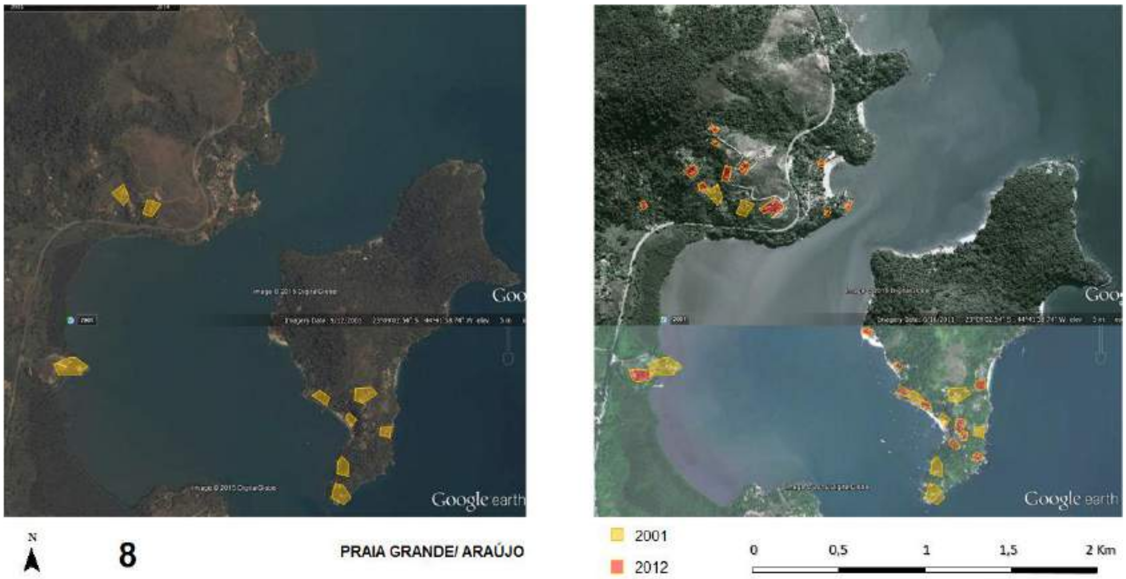


N

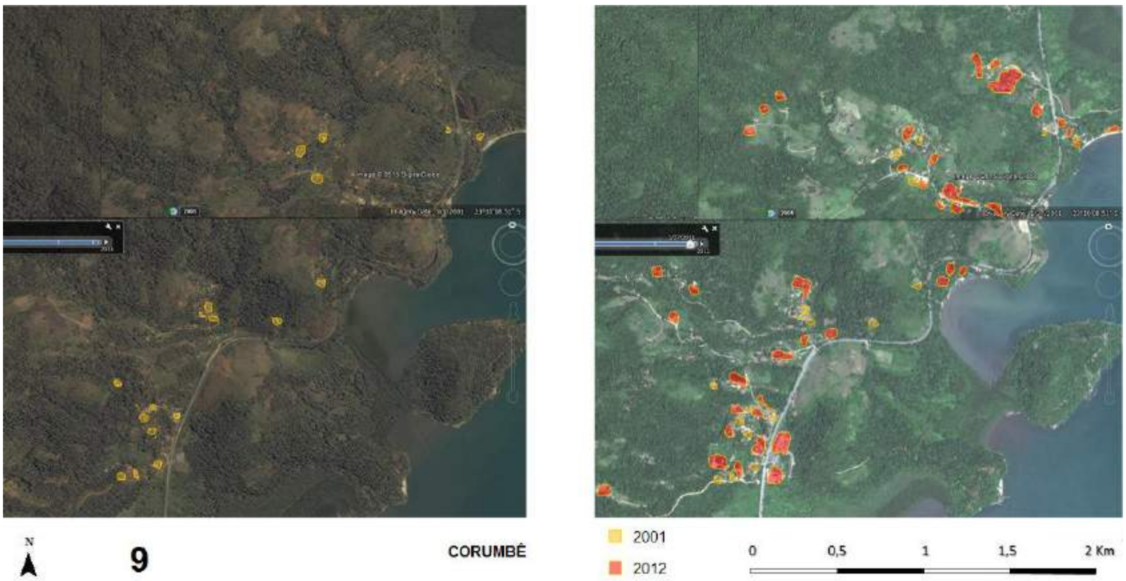
6 BARRA GRANDE



7 GRAÚNA



8 PRAIA GRANDE/ ARAÚJO



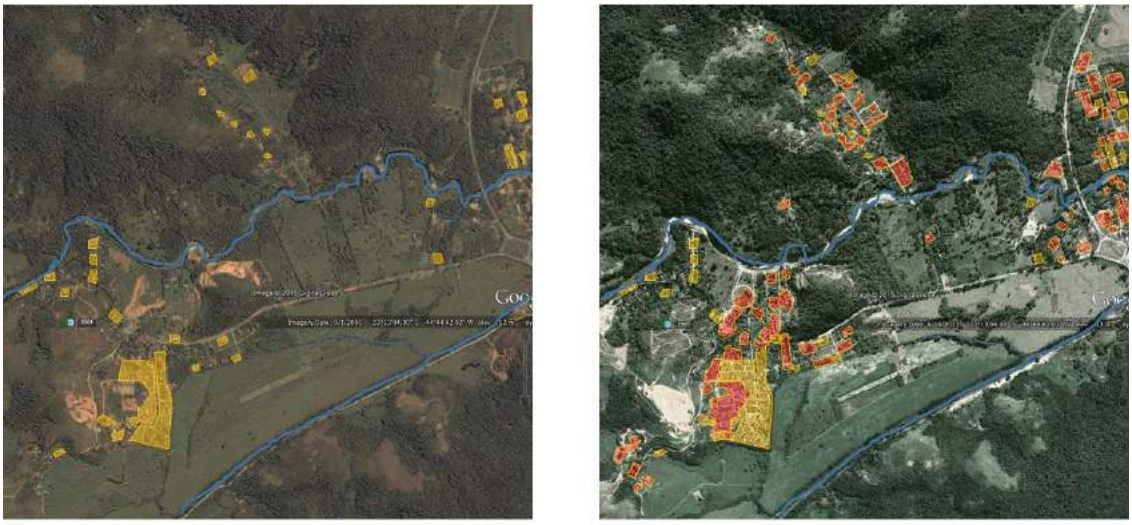
9 CORUMBÊ

N

10 PARATY

2001
2012

0 0,5 1 1,5 2 Km

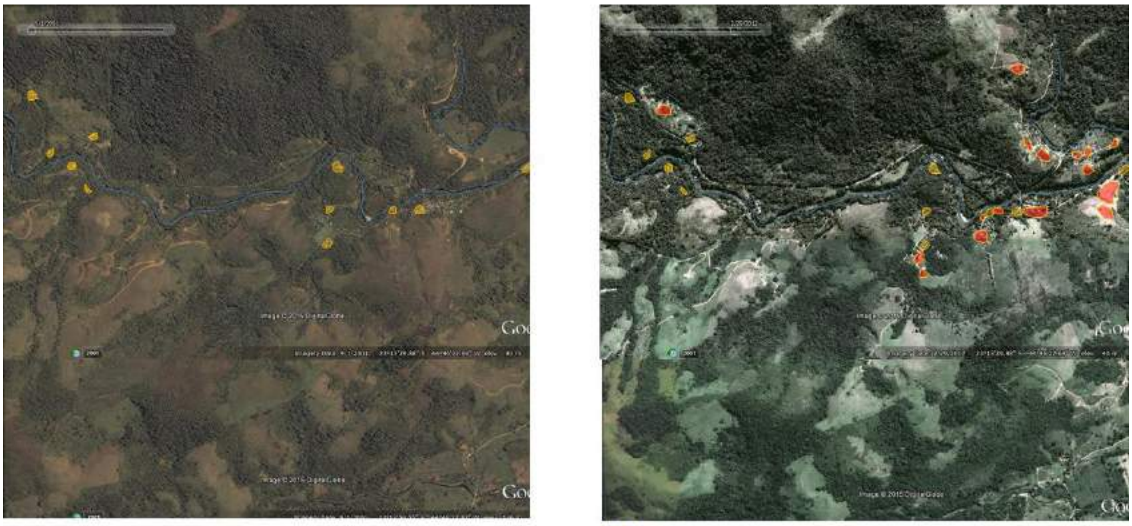


N

11 PANTANAL / CONDADO

2001
2012

0 0,5 1 1,5 2 Km

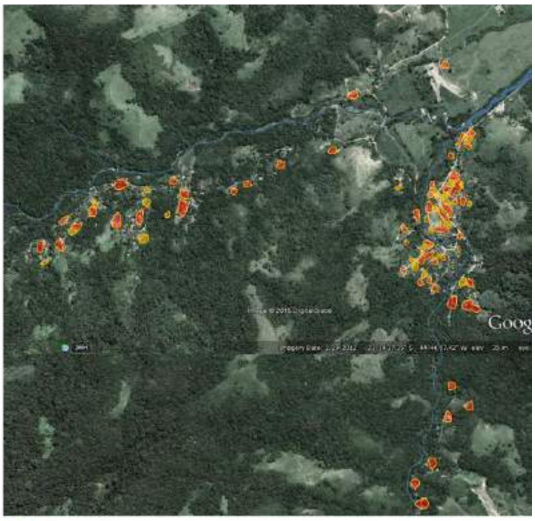


N

12 PONTE BRANCA

2001
2012

0 0,5 1 1,5 2 Km



N

13 CORISCÃO/ CORISQUINHO

2001
2012

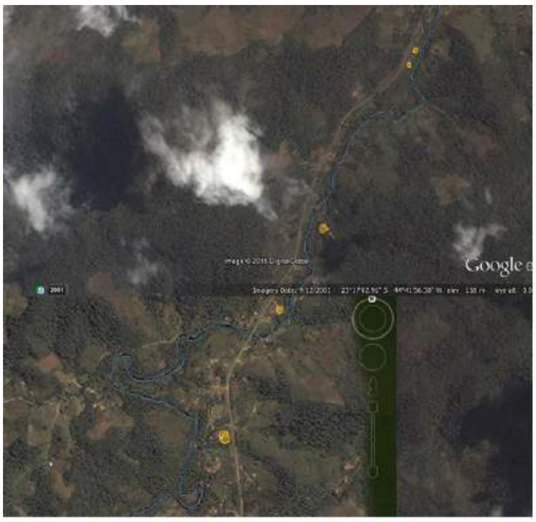
0 0,5 1 1,5 2 Km

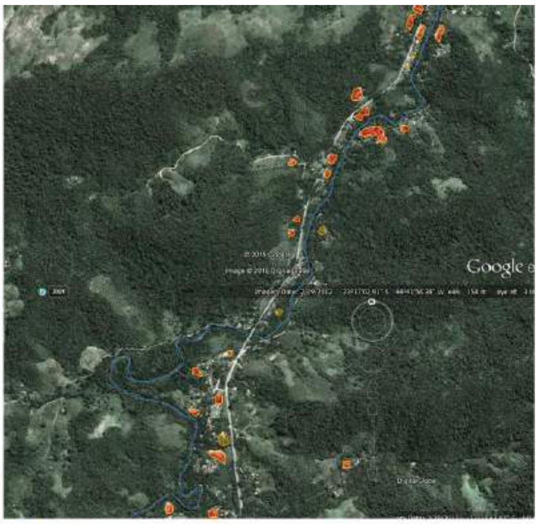
N

14 PARATY-MIRIM

2001
2012

0 0,5 1 1,5 2 Km



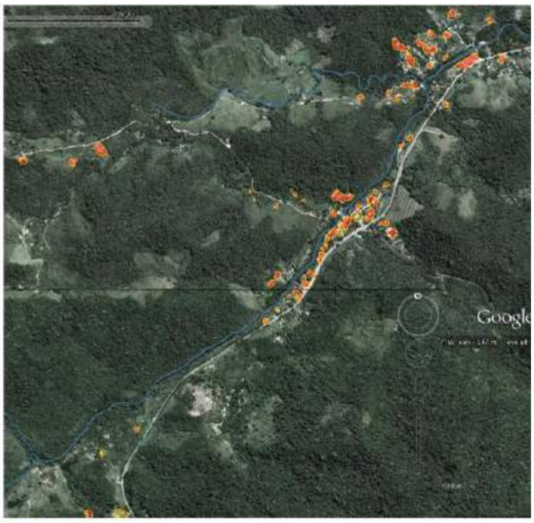


N

15 QUILOMBO DO CAMPINHO

2001
2012

0 0,5 1 1,5 2 Km



N

16 PATRIMÓNIO

2001

2012

0 0,5 1 1,5 2 Km

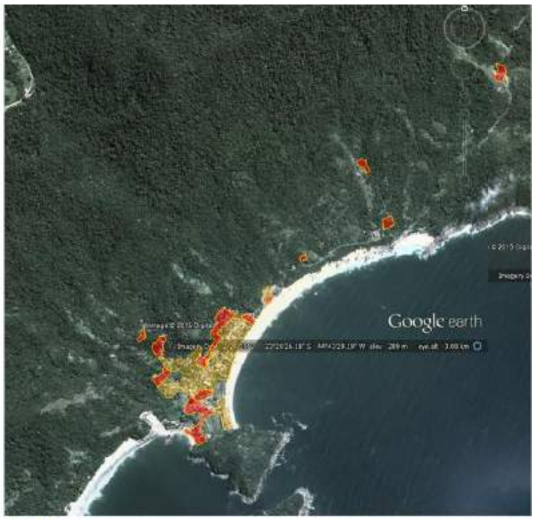
N

17 LARANJEIRAS/ VILA ORATÓRIO

2001

2012

0 0,5 1 1,5 2 Km



N

18 TRINDADE

2001

2012

0 0,5 1 1,5 2 Km

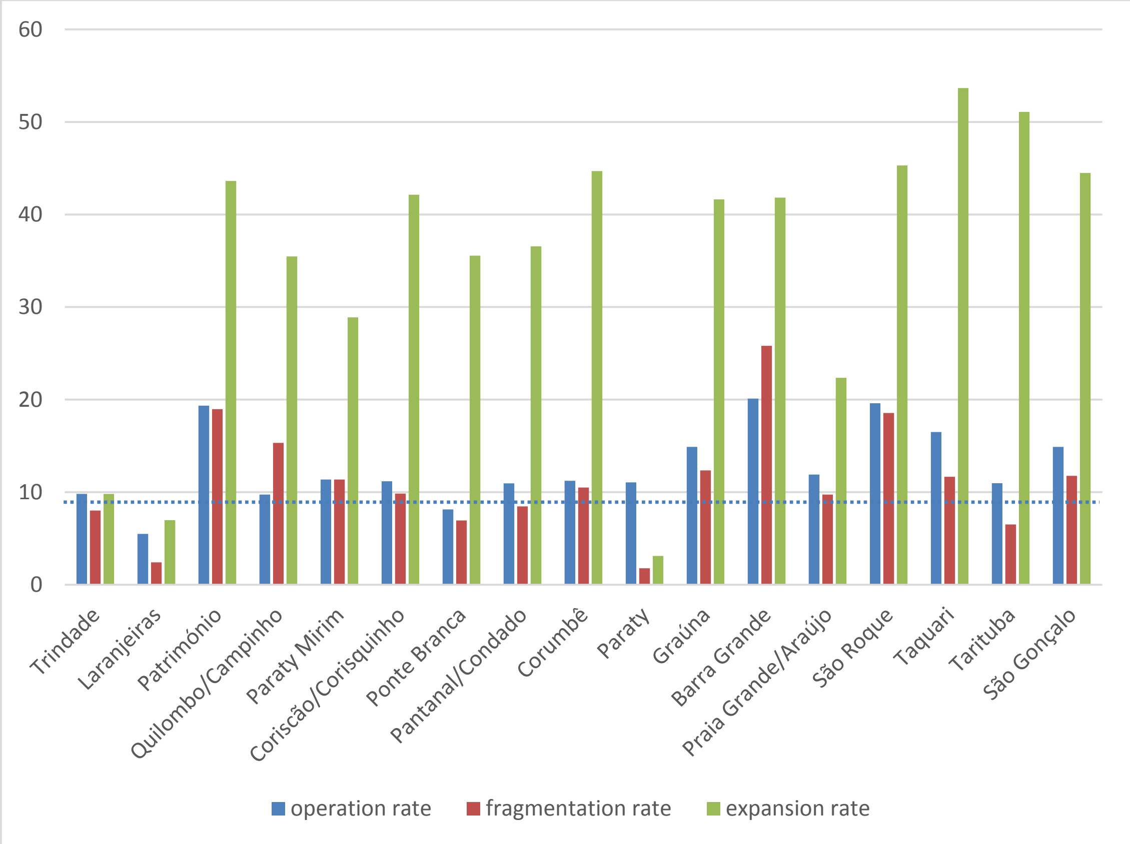


Fig. 81: Results of the comparative analysis of urban areas in the Municipality of Paraty

The figure above presents the summing-up of the results of the analysis of land-use change in the most populated areas of the Municipality of Paraty. The rates were obtained from calculating the rate of land-use change operations, the number of clusters (fragmentation rate) and an estimate of the expansion rate, all presented in annual percentage of growth. As it can be seen in the figure, the higher values of expansion rate x fragmentation rate occurred respectively in Taquari, Património, Corumbê, Barra Grande, São Roque, Pantanal, and Condado. In Corisquinho/Coriscão, Tarituba/Chapéu do Sol, Graúna/São Gonçalo, Praia Grande/Araújo, and Paraty Mirim, the expansion rate was also high but the fragmentation rate was close to average. Ponte Branca and Tarituba and Chapéu do Sol had higher expansion rates, but low fragmentation rates. This is because its original configuration, with smaller developed areas, produced more compact urban settlements. The higher values of land-use operations are registered in Património, Taquari, Barra Grande, São Gonçalo, and São Roque. What stands out from this analysis are the low values of expansion rate and fragmentation rate found in the city of Paraty, while the number of urban operations was average. This is explained by the size of the original settlement, since the expansion areas are proportionally small compared to the urbanized areas registered in 2001. It is noteworthy that Laranjeiras is the urban settlement that presents expansion and fragmentation values closer to the low rates of Paraty. This may indicate a high level of exclusion in the city of Paraty, although there is still a considerable portion of its area that is not yet developed.

Even without reliable studies and information about land provision and demand, it is clear that present regulations regarding land subdivision within the urban perimeter are not adjusted to the demand and possibilities of low-income groups, where the largest housing deficit exists.The absence of urban policies and land tenure arrangements for the provision of adequate sites at affordable prices have a close relationship with the emergence of illegal plot divisions and informal housing in upstream areas, which lead to environmental degradation and the aggravation of flood risks. The fragmentation of urban space and continued growth in the periphery are contributing to the deepening of spatial segregation and social exclusion in the municipality. Inadequate land-use planning and unregulated land tenure make the poor more vulnerable to flooding and related risks. Due to the lack of affordable alternatives and the absence of targeted schemes for low cost housing, the poor cannot afford to buy, build, or rent secure housing in safe areas, while lands of higher value are occupied by better-off urban residents.

As has been shown in the policy analysis, several factors shape other specific problems, such as the fast expansion of privately-owned developments, the destruction of important ecosystems, and uncontrolled urbanization. These trends, coupled with inadequate policies and enforcement of those in effect, result in the destruction of critical ecological assets and increase the vulnerability of infrastructure and land uses. Despite this evidence, land-use planning and a more stringent control of informal developments are not being seen as critical issues, resulting in lands being inefficiently utilized. The relevance of these factors increases where the ecological underpinnings of urban development are more fragile—in such areas, any significant additional stress can potentially lead to serious disruptive events and impacts.

10.5. The system of open spaces around and within the city of Paraty

The following description focuses on the lower region of the basins, namely the urban and peri-urban floodplain of the city of Paraty, comprising an area of approximately 1000 hectares. The City of Paraty can be subdivided into five sections: (1) Historical Center; (2) the Old City; (3) Mangueira; (4) Ilha das Cobras; and (5) Jabaquara (See Figure 84). Mangueira and Ilha das Cobras are the poorer areas of the City. The remnants of the floodplain which have not been urbanized have been converted for agricultural use, constituting a buffer zone between the city and the mountains. A substantial part of this area maintains ancient characteristics rooted in colonial land ownership regimes, and this is why the peri-urban landscape around Paraty is still being marked by the presence of large open spaces. The most important areas are described and illustrated in the figure below.

Fig. 82: Open spaces in the peri-urban floodplain around the city of Paraty

Stretching approximately two miles west from the urban area, the lands usually known as “Bananal” (area A in Figure 82), owned by the former royal family, still present the characteristics of a large farm along which the river Mateus Nunes was realigned in the 19th century. Since the extraction of gold in Minas Gerais, these farms have characterized the economic landscape of the Southwestern region of Brazil, signaling a distinct difference from other regions; agriculture in Paraty has declined, and today this farm is mainly used for pasture.

Fig. 83: Bananal area, upstream BR-101

North from the old town, the area of Jabaquara (area B in Figure 82) is mainly composed of wetlands belonging to another large landowner. Although this area has been classified as an urban expansion area since the first 1972 Master Plan, it still presents large open spaces, and the allotment approved in 1952, located in the stretch along the seashore, is not yet fully occupied.

Fig. 84: Jabaquara, downstream BR-101

The airport area (area C in Figure 82) also represents an important open space near the city. The aerodrome of Paraty serves only a very small number of users, constituted mainly of private airplanes. It lacks the appropriate infrastructure to be used for commercial purposes, and supports short regional flights. The landing track divides the city into two very well-defined areas, stressing the social differences existing on both sides and blocking the urban circulation as well. On the “other side” of the touristic historical center, Ilha das Cobras and Mangueira are the most populated neighborhoods. In 2001 a feasibility study was made to relocate the airport and build a new aerodrome in another location far from the city. The Rio de Janeiro State Transport Secretariat, the Transport Engineering Superintendent of Airway Coordination, and the Ministry of Aeronautics supported this project through the Civil Aviation Department (DAC) and developed their own studies. The studies pointed to the closing of the existing airport and recommended the area be occupied with another sort of equipment more adequate to the city, which would reestablish the continuity of the urban fabric as well as provide the desired safety for the area. The Aeronautics Technological Institute (ITA) and technicians specializing in airports with critical approaching procedures carried out studies to determine the area with the best air operation conditions. The site chosen, in a decision supported by studies carried out by the Civil Aviation Department, was Barra Grande. The creation of a Strategic Plan was then proposed—a management tool capable of congregating local businessmen, the government, investors, public agencies, and the local society. The conclusion drawn was that both the implementation of the project and the effective control of the urban transformations, arising out of the mentioned implementation, could only be achieved through the PPP (Public/Private Partnership). The relocation of the airport remains out of the political agenda, with strong resistance from the beneficiaries of the current infrastructure. It is noteworthy that the area was originally consigned for the airport, with the condition that it could only be converted for uses and purposes of public interest.

The remnants of the flooplain along Perequê-Açu river (area D in Figure 82) still present large open areas, although urbanization is proceeding. In a broader study of the Municipality of Paraty, the urban research group from the Federal University of Rio de Janeiro (PROURB) coordinated by Tardin has reflected upon the system of open spaces in Paraty and put forward three possible functions for these peri-urban areas: i) enhancement of the ecosystem services provided by the watersheds, with the potential to preserve vegetation, hydrography, and land structure; ii) a landscape perception area, involving a possible relation between natural and man-made landscapes; and iii) urban occupation as an opportunity to structure areas already in danger of uncontrolled urbanization (TARDIN et al, 2011).

As a last note to the spatial analysis of the study area, it is worthy to highlight a number of aspects of particular relevance to the hydrological study that follows, taking into account the physical and historical analysis of the evolution of the hydrological functioning of the basin of the rivers Perequê-Açu and Mateus Nunes:

i) the basins of the Perequê-Açu and Mateus Nunes originally conveyed their flows through a network of canals in downstream areas of the floodplain;

ii) the Perequê-Açu river has its plains slightly higher than the river Mateus Nunes;

iii) the river Mateus Nunes was rectified and this configuration has increased waterflow speed, increasing the erosive capacity of the river and generating depths of the riverbed that impede its natural communication with the floodplain;

iv) the loss of significant parts of the original vegetation has exacerbated the basin downstream flooding;

v) the Perequê-Açu floodplains are more intensely occupied than the Mateus Nunes and there are strong indications that urban occupation will intensify in these areas.

11. Hydrological study

This chapter is divided in three main sections: the first section introduces the theme of flood-related risks in Rio de Janeiro State and characterizes the hydrological regime of the Perequê-Açu and Mateus Nunes rivers. Rainfall and streamflow data and Intensity/Duration/Frequency (IDF) and Precipitation/Duration/Frequency (PDF) curves are presented; and time of concentration and rainfall events within the two river basins under study, as well as annual maximum flows and maximum instantaneous flows, are calculated. These data sets will constitute the input basis for the hydrological modeling exercise, described in the second section of this chapter. The third section is dedicated to the characterization of various hypothetical scenarios of urban development. These scenarios consider the physical components of the basin, such as topography, urban occupation, and physical infrastructure, among others. This methodological step considers the findings of the following analysis, involving a number of qualitative and quantitative urban parameters. Quantitative parameters include population density, size of lots, soil sealing rates, land cover (with corresponding values of run-off and manning), as well as existing infrastructure and services. Qualitative parameters include the consideration of landscape features, ecosystem services, and urban design, among others.

The development of alternative scenarios was developed in coordination with the hydrologic analysis, allowing the refinement of the various hypotheses according to the responses obtained by the modeling exercise. The different scenarios involving the simulation of the current trend of urban sprawl and alternative scenarios, from which are derived a set of variations, total 30 urbanization scenarios. These scenarios will be detailed after describing the pre-existing area of intervention. Each step that gave rise to the main results of the hydrodynamic modeling exercise are described in the methodology chapter. Flood maps and hydrographs for each time period are presented and described. The procedures for calibration and validation of the hydrodynamic modeling exercise are then explained in detail. Forty-four scenarios of urban development are tested by introducing in the model the corresponding land-use changes and structural measures proposed in these scenarios. The chapter ends by summarizing the outputs of the current exercise and by conducting a comparative analysis of hydrological costs and benefits for each scenario.

11.1. Climatic factors

The region of Rio de Janeiro State and the Southwestern coast of Brazil is affected by two macro-scale climatic phenomena: the humid air coming from Amazonia towards the southeast and the Atlantic currents moving southwards, which generate heavy rains during the hot season. The chart below presents a rough estimate of the occurrence of flood disasters and landslides caused by heavy rains in the state of Rio de Janeiro during the last 55 years. This information was collected from various government reports and local news published in the Brazilian press from 1966 to 2011 and should only be regarded as indicative of an apparent trend. The chart represents known numbers of deaths caused by floods and landslides combined, landslides being the main cause of deaths as a direct consequence of such geohazards; the number of deaths is normally registered as a whole, including the victims of floods or landslides that occur during the same disaster.

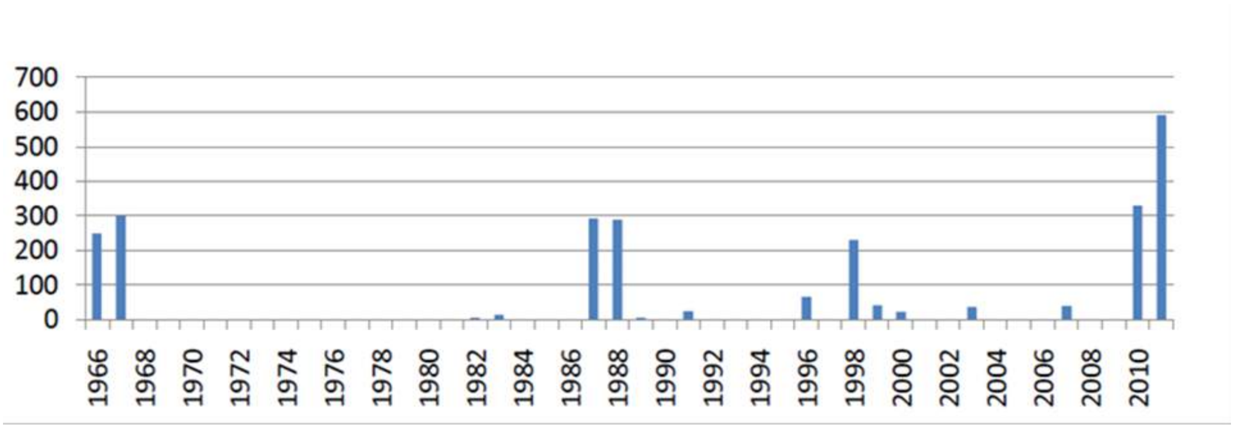


Fig. 85: Number of deaths during storm surges in the State of Rio de Janeiro (data collected by the author, various reports, and newspapers)

It is interesting to note that during this range of time, the occurrence of great disasters suggests a pattern cycle increasing in frequency (1966/67, 1987/88, 1998, 2010/11) and the number of deaths doubled. Also noteworthy is that the number of smaller occurrences increased significantly, and the number of deaths in 2010/11 was greater than any other registered before. In 2011, in the state of Rio de Janeiro, more than 600 deaths were registered, a number that surpasses any other previous disaster in the state, considering the month of January alone. According to the Brazilian Meteorology Institute, the rains that hit the region between the 12th and 14th of January, 2011, exceeded the expected rainfall for the entire month of January. In 12 days, it rained in Nova Friburgo 84% more than the amount (199 mm) expected for the entire month; from the 12th to the 14th of January, a rainfall of 182.8 mm was recorded. In Teresopolis, the amount of rain recorded in the same 24 hours reached 124.6 mm.

11.2. Rainfall and streamflow data

Rainfall data for the case study area was collected from the following rainfall gauging stations: 02344007-Paraty, 2344008-São Roque, 44006-Património, and 83786-Ubatuba, considering the time period between 1996 and 2005. Additional rainfall data was collected from the hydrological information system HIDROWEB, the National Water Agency (ANA), and the National Institute of Meteorology (INMET), as well as other hydrological studies conducted for the region. The characterization of the hydrological regime of the Perequê-Açu and Mateus Nunes river basins is based on the hydrological study presented in LABHID (unpublished report) and Marins (2013).

For accurate hydrologic analysis, a set of relations must be established between the variables through mathematical equations. These relations determine rainfall Intensity/Duration/Frequency (IDF) curves, defined as graphical representations of the amount of water that falls within a given period of time in catchment areas (Dupont and Allen, 2000). The IDF relationship comprises the estimates of rainfall intensities of different durations and recurrence intervals. A number of studies on rainfall intensities for the study area have been revised, namely the calculations of Otto Pfafstetter for Ubatuba (PFAFSTETTER, 1982), the study of heavy rains for the State of Rio de Janeiro (CPRM, 2001), the technical report of LabHid (unpublished), the MSc thesis of Sergio Vieira (unpublished), and the MSc thesis of Monique Marins (2013). The present study adopts the IDF curve and Precipitation/Duration/Frequency (PDF) relation calculated by Marins (2013) as the best available representations of rainfall data for Paraty. These results have been established through the method of Relations Between Durations as defined by Bertoni and Tucci (1993). The IDF curve established by this method provided values very close to the study of CPRM, previously adopted by the technical report of LabHid (unpublished). The IDF curve and PDF values have been based on rainfall data collected in the gauging station of Paraty, making the results closer to the values of precipitation in the region.

Maximum peak flow of the Perequê-Açu and Mateus Nunes rivers have been determined for the case study area by Marins (2013), which uses the Gumbel's distribution methodology. The Gumbel theory of distribution is the most widely used for modeling maximum peak flows. It is relatively simple and uses only extreme events (maximum values or peak rainfalls) for calculating the 10, 25, and 50 year return periods for each duration period. Since stormwater flow may vary significantly in a matter of minutes, especially in small river basins, Füller's criteria for determining the maximum instantaneous peak flow has been used.

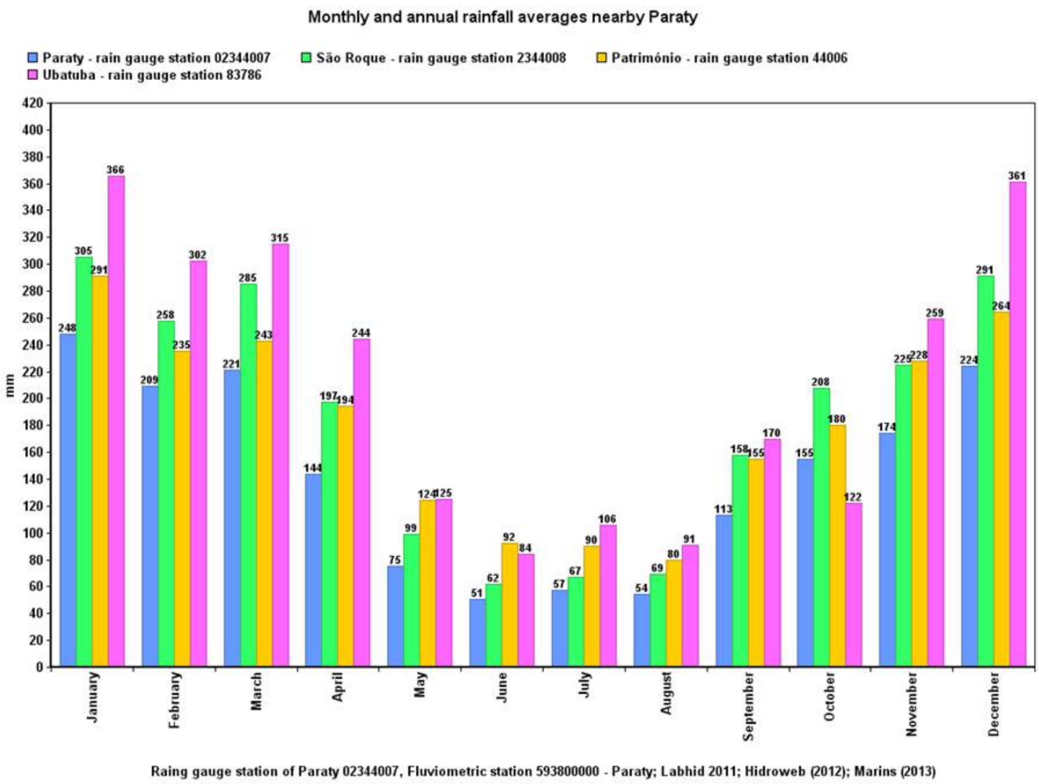


Fig. 86: Rain gauge station of Paraty 02344007, Fluviometric Station 595800000 – Paraty. Data collected from Labhif (unpublished report) Hidroweb (2012) and Marins (2013).

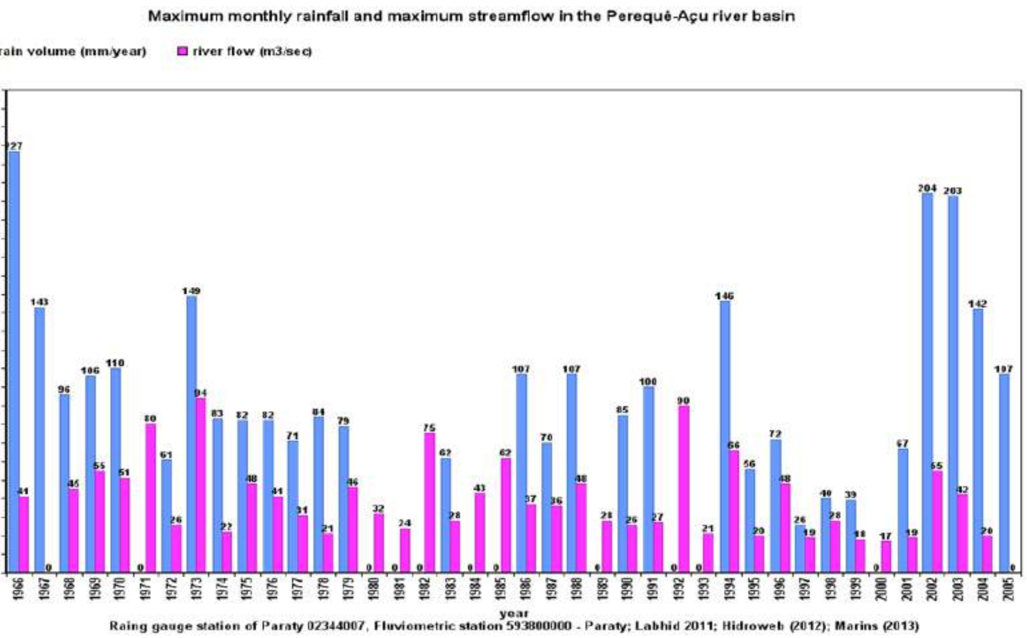


Fig. 88: Maximum annual rainfall and maximum streamflow in the Perequê-Açu river

Figure 88 presents the maximum annual rainfall and maximum streamflow in the Perequê-Açu river basin. Streamflow data was collected from the fluviometric station 593800000, located in the catchment area of the Perequê-Açu river. A fluviometric station for the Mateus Nunes river was not found, so streamflow data is restricted to the information for the Perequê-Açu. According to the technical report of LabHid (unpublished), the mean annual precipitation in the Paraty region is 1719 mm in Paraty, 2229 mm in São Roque, 2177 mm in Património, and 2645 mm in Ubatuba. Based on these data, an average value of 2200 mm is considered as the mean annual rainfall in the study area. As it has been justified in the methodology section, the IDF curve and the Rainfall/Duration/Frequency relation (RDF) adopted by Marins (2013) have been chosen as the best available representations of rainfall data for the study area. This choice is justified by considering the comparative analysis made by Marins (2013) of the available studies previously made for the region[71]. The RDF and IDF values are represented in Table 8.

DURATION		TR2		TR5		TR25		TR50	
min.	hour	RAINFALL	INTENSITY	RAINFALL	INTENSITY mm/hour	RAINFALL	INTENSITY mm/hour	RAINFALL	INTENSIT mm/hour
5	0,083	6,6	79,6	10,0	120,2	15,1	181,2	17,2	206,5
15	0,25	16,9	67,5	25,5	101,9	38,4	153,6	43,8	175,0
30	0,5	25,4	50,8	38,4	76,8	57,9	115,7	65,9	131,9
60	1	36,1	36,1	54,6	54,6	82,2	82,2	93,7	93,7
120	2	47,6	23,8	72,0	36,0	108,4	54,2	123,6	61,8
240	4	60,3	15,1	91,1	22,8	137,3	34,3	156,4	39,1
360	6	67,5	11,2	102,0	17,0	153,7	25,6	175,1	29,2
480	8	73,3	9,2	110,8	13,9	167,0	20,9	190,3	23,8
840	14	84,4	6,0	127,6	9,1	192,3	13,7	219,1	15,6
1440	24	96,4	4,0	145,6	6,1	219,5	9,1	250,0	10,4

Table 8: Estimated RDF and IDF relations for Paraty: method of relations between durations

[71] A comparative analysis of PDF and IDF curves is presented in Marins (2013, p. 99-100).

The definition of the design rainfall event was performed based on the IDF curve shown in Table 7. Different return periods have been considered (also known as a recurrence interval). A return period is an estimate of the likelihood of a flood event taken from the average interval of time within which a given flood event will be equaled or exceeded once (Am. Soc. of Civil Engineers, 1953, p. 1221). The following values are defined in Table 8: the precipitation values (total volumes) adopted for each time recurrence of 131.8 mm for TR10, 162.3 mm for TR25, and 184.9 mm for TR50. A return period of 10 years, for example, means that there is an accepted probability of 10% that a similar or higher flood occurs in one year. If it is a return period of 50 years, that means that there is an accepted probability of 2% that the corresponding event happens in a year.

The time of concentration is the time required for all the runoff generated in a watershed to reach the mouth of the river and is one of the most widely used measures of basin response for calculating design rainfalls and floods. However, it is also a hydrological parameter that designers find difficult to accept as a criterion because there is little information about the applicability of the various empirical formulas that are available, including those most commonly found in Brazilian technical studies (Silveira, 2005). In order to simulate the effects of a rainfall event distributed in a given watershed, the time of concentration has to be defined on a case-by-case basis, fundamentally depending on the length and slope of the main water course, but also requires the consideration of land cover and land uses in the watershed area. The rain period must be adjusted to an equal or longer period than the time of concentration, since when a rainfall event with longer duration than the time of concentration happens, the water volume flowing from upstream reaches will add to the precipitation falling in downstream reaches, causing a larger flood event. According to LABHID (unpublished report), the time of concentration calculated for the Perequê-Açu river basin is 398.37 minutes and for the Mateus Nunes is 290.15 minutes. Thus, a design rainfall event lasting 420 minutes (7 hours) has been adopted. Figure 89 shows the distribution of precipitation during the 420 minutes adopted for the design rainfall event, considering variations of intensity through time within each hour and using the logic of alternating blocks.

Tempo (min)	TR5	TR10	TR25	TR50
60	54.6	66.8	82.2	93.7
120	72	88.1	108.4	123.6
180	87.0	106.5	131.1	149.4
240	91.1	111.5	137.3	156.4
300	99.5	121.7	149.9	170.8
360	102	124.8	153.7	175.1
420	107.7	131.8	162.3	184.9

Table 9: Calculated rainfall volumes distributed in time for each recurrence time

The table above shows the peak flow for the recurrence times of 5, 10, 25, and 50 years used in the modeling exercise, along with an estimate of instantaneous maximum flows for the same recurrence times. These values have been calculated based on statistics available from the Fluviometric Station 595800000 in the Perequê-Açu river. In the absence of similar data for the Mateus Nunes river, and given its proximity to the Perequê- Açu river basin, a proportionally equivalent peak-flow rate was adjusted for the Mateus Nunes river, considering the relationship between the respective drainage areas.

Finally, the maximum annual and instantaneous flows are presented in Figure 89, showing the water volumes associated with the time recurrences of 5, 10, 25, and 50 years.

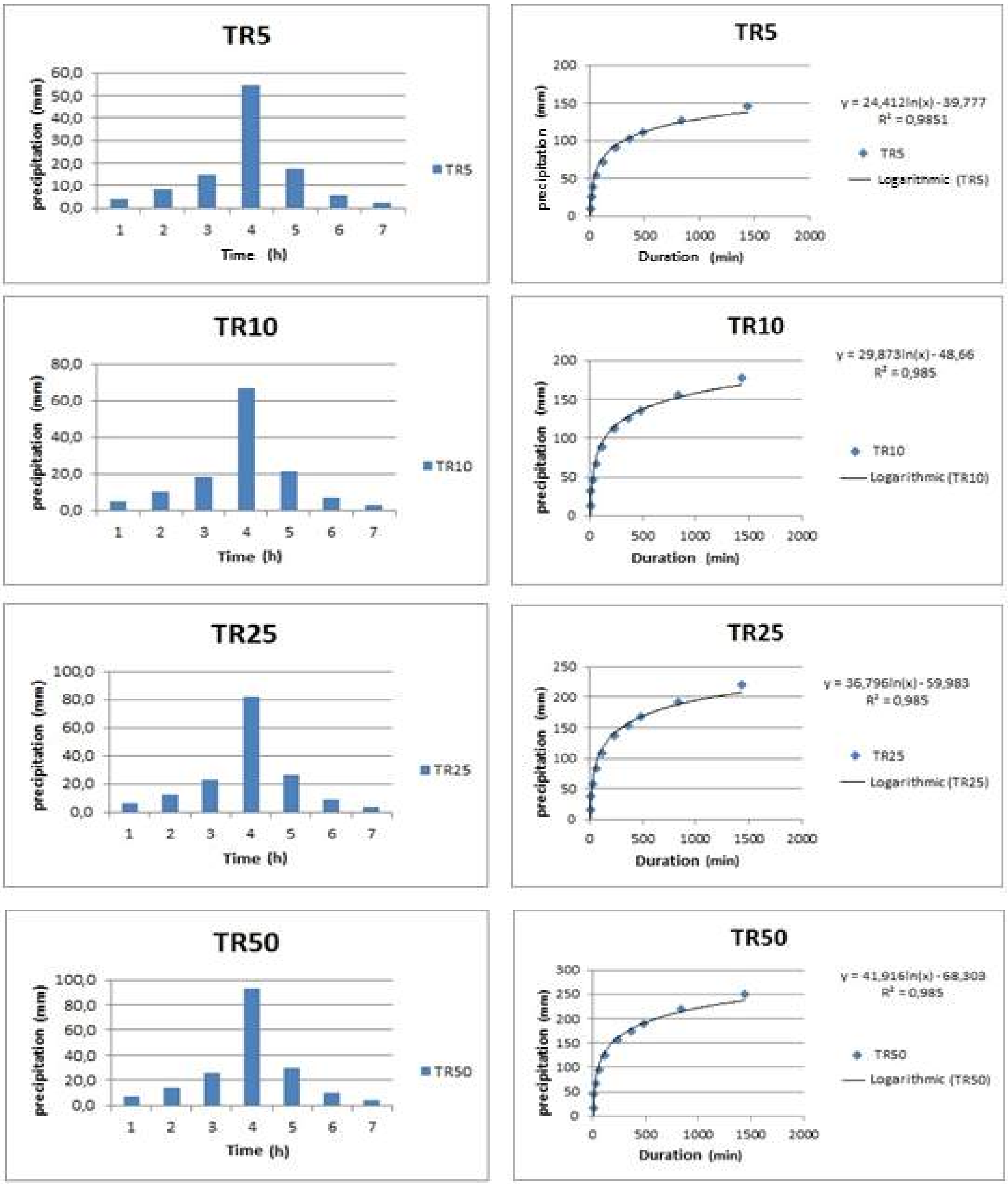


Fig. 89: Distribution of precipitation during the 420 minutes adopted for the design rainfall event and corresponding design rainfall event for each return period.

In the table above, the hydrograms and corresponding maximum water flow values of the Perequê-Açu and Mateus Nunes river basins are presented.

11.3. Scenario development and flood mapping

The flood maps that resulted from testing the above-described scenarios with the aid of the hydrological model of the study area constitute one of the main sources of information for this study and will be shown and described in the following pages. In order to allow for an adequate visualization of the distributed impacts of floods in Paraty, urban and peri-urban areas of the study area are represented separately from the rest of the river basins under study. However, it should be kept in mind that these maps represent the hydrological behavior of the whole watershed. As it has been described earlier, the river basins of the Perequê-Açu and Mateus Nunes have been modeled by a pre-defined set of gridcell types and discharge links articulating rivers, channels, floodplains, urban areas, reservoirs, and other landscape elements of both river basins. On the maps that are shown above, several urban structures and flow patterns are represented by the combination of these interconnected cells, reproducing the hydrological functioning of the basin according to the conditions defined for each scenario.

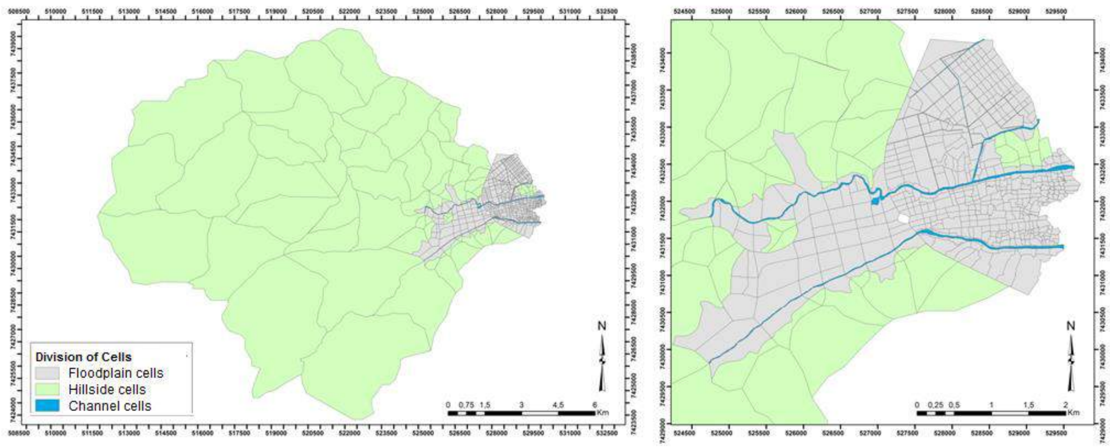


Fig. 90: Cells of the mathematical model developed for the Perequê-Açu and Mateus Nunes river basins, with the floodplain cells in purple.

The subdivision of the watershed comprises 569 cells representing floodplain areas, 120 channel cells representing the rivers and canals that make up the basins, and 72 cells representing the hillside areas, following the steps described in the methodology section. The last stage of the modeling exercise is to test the hydrological costs and benefits of various scenarios of land-use change. This involves the simulation of a past situation for calibration of the model, the present situation, the simulation of a “standard run” scenario reproducing the current trend of urban sprawl, a “cumulative scenario,” and alternative scenarios of urban development (compact, resilient, and integrated), from which is derived a set of variations, totaling 44 scenarios.

After calibrating the model based on the correct representation of the current situation, rainfall events were simulated for recurrence times (TR) 10 years, 25 years, and 50 years. As an additional condition, climate change scenarios were tested, considering a rainfall increase of 10% and an increase in mean sea level of 15 cm for the year 2040. The criteria for the adoption of these changes in rainfall and boundary conditions of the basin are based on the regional report of COPPETEC PPE 18954 (Rosman, 2015). According to the report, studies show that in recent decades the average sea level has elevated 4-6 mm per year. This report considers two climate change scenarios for 2040: in a likely scenario, one with sea level elevations of 10 cm, assuming a rise in average sea level of 4 mm/year (NNM1 scenario); and in a pessimistic scenario, 15 cm assuming a rise in average sea level of 6 mm/year (NNM2 scenario). The present study considers a time horizon of 2040 and adopts as general assumption the NNM2 scenario as characterized in the above-mentioned report.

The TR 25 is the reference of the Ministry of Cities for major drainage projects and, therefore, is the time used to make project assessments. The TR 10 is the design time used for evaluating microdrainage—this scenario has been used in order to make a more fine-grained analysis of smaller impacts at the local level. The TR 50 is widely used as superior verification of the model. The criterion adopted for the presentation of the resulting maps shows the most relevant maps for TR 25 scenarios (in yellow) in the expanded summary in Portuguese, and to present the most relevant maps for TR 10 (in blue) and TR 50 (in red) scenarios in the following pages.

All tested scenarios are listed on the table above and will be described in more detail on the following pages, accompanied by the resulting maps and corresponding hydrograms.

n.	Model	Scenary	Recurrence period	Climate Change
1	calibration	A1		-
2	current	B1	TR10	-
3		B2	TR25	-
4		B3	TR50	-
5	standard run	C1	TR10	-
6		C2	TR25	-
7		C3	TR50	-
8		C4	TR10	with CC, NNM2-2035
9		C5	TR25	with CC, NNM2-2035
10		C6	TR50	with CC, NNM2 -2035
11		C7	TR10(PA) TR50(MN)	-
12		C8	TR10(PA) TR50(MN)	-
13	cumulative	D1	TR10	-
14		D2	TR25	-
15		D3	TR50	-
16		D4	TR10	with CC, NNM2 -2035
17		D5	TR25	with CC, NNM2 -2035
18		D6	TR50	with CC, NNM2 -2035
19		D7	TR10(PA) TR50(MN)	-
20		D8	TR10(PA) TR50(MN)	-
21	compact	E1	TR10	-
22		E2	TR25	-
23		E3	TR50	-
24		E4	TR10	with CC, NNM2 -2035
25		E5	TR25	with CC, NNM2 -2035
26		E6	TR50	with CC, NNM2 -2035
27		E7	TR10(PA) TR50(MN)	-
28		E8	TR10(PA) TR50(MN)	-
29	resilient	F1	TR10	-
30		F2	TR25	-
31		F3	TR50	-
32		F4	TR10	with CC, NNM2 -2035
33		F5	TR25	with CC, NNM2 -2035
34		F6	TR50	with CC, NNM2 -2035
35		F7	TR10(PA) TR50(MN)	-
36		F8	TR10(PA) TR50(MN)	-
37	integrative	G1	TR10	-
38		G2	TR25	-
39		G3	TR50	-
40		G4	TR10	with CC, NNM2 -2035
41		G5	TR25	with CC, NNM2 -2035
42		G6	TR50	with CC, NNM2 -2035
43		G7	TR10(PA) TR50(MN)	-
44		G8	TR10(PA) TR50(MN)	-

Table 10: Scenarios A (1), B (2-4), C (5-12), D (13-20), E (21-28), F (29-36) and G (37-44)

SCENARIO A1 (Calibration Model) TR25

This scenario represents the physical situation of the study area, calibrated with existing data from 2007. Additionally, flood marks mapped by residents of reports have been considered in the calibration process. The reference flow used for calibration was the instantaneous maximum recurrence calculated for 25 years from Paraty's Fluviometric Station (151.5 m³/s), and the maximum flow obtained in the model was 146.6 m³/s.

SCENARIOS B1, B2 and B3 (Current Situation Model) TR10, TR25 and TR50

This scenario evaluates the current situation, obtained by checking the calibration setting that was set on A1. For Scenario B, the design of the Perequê-Açu river was updated according to current conditions. After several verifications of the response of the model with the direct observation of the study area, the model has been fine-tuned by comparing the response of the model with the actual observation of flood levels in several points, and by the information gathered in the field through interviews with affected residents, data from the Civil Defense of Paraty, and photographs of flood events in the study area. Maps B1 and B3 are presented below.

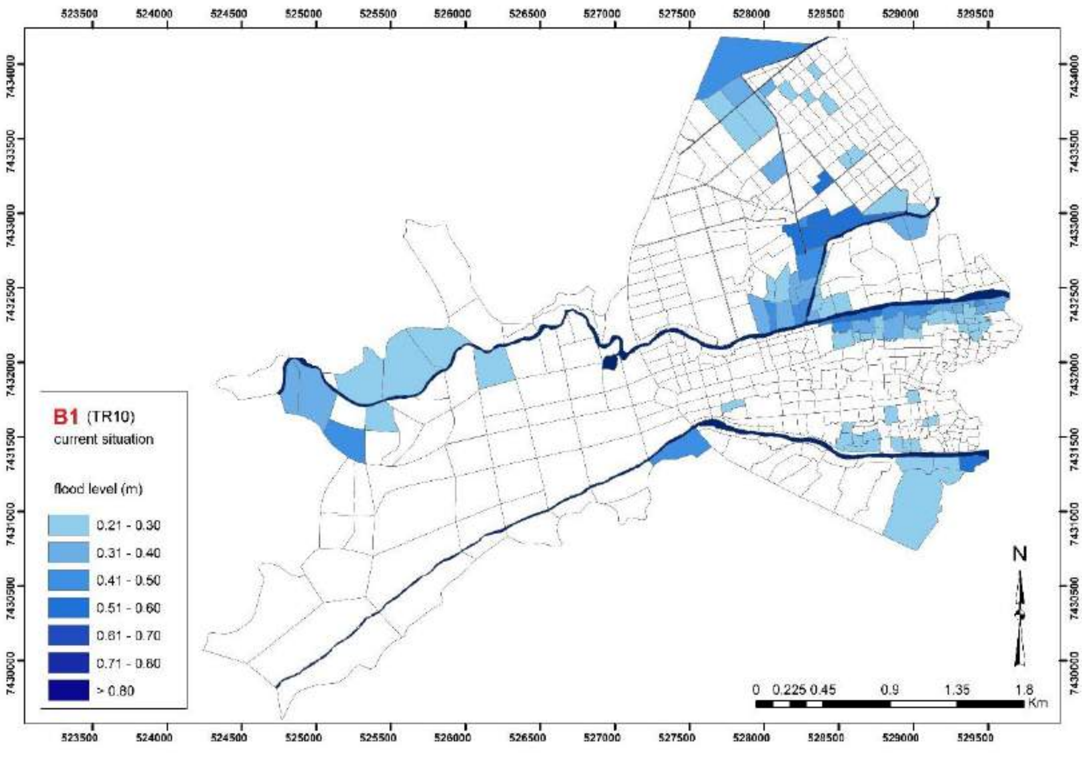


Fig. 92: SCENARIO B1 (current situation) TR10

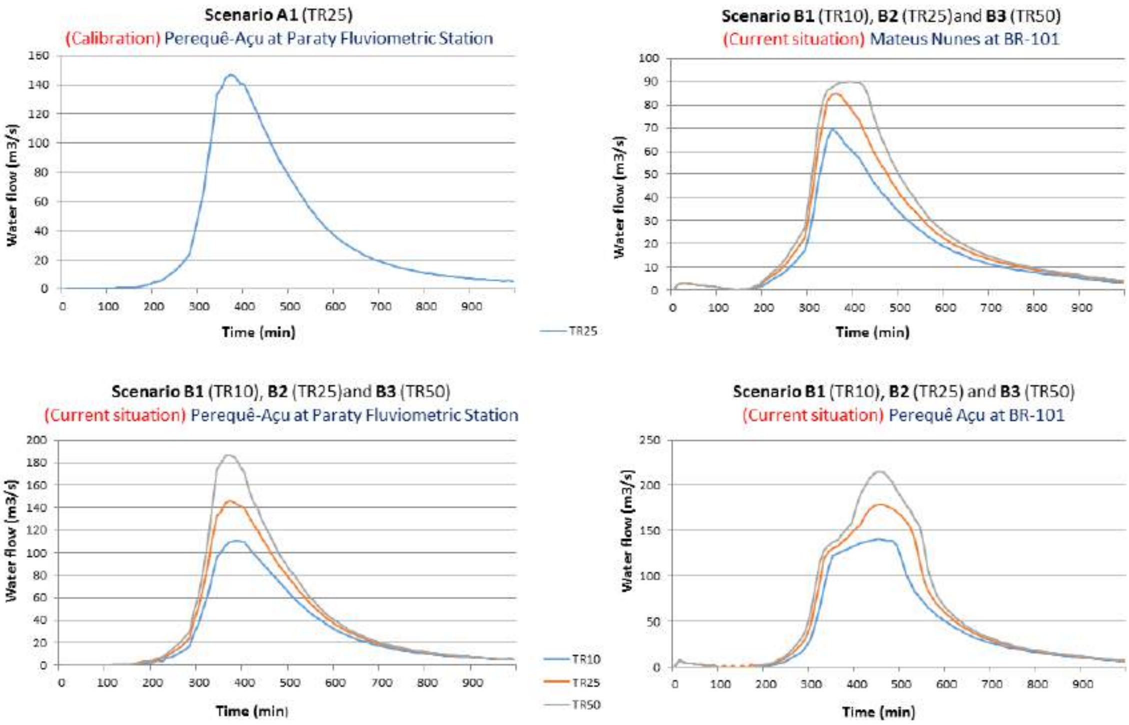


Fig. 93: Hydrographs of of Scenario A1, B1, B2, and B3

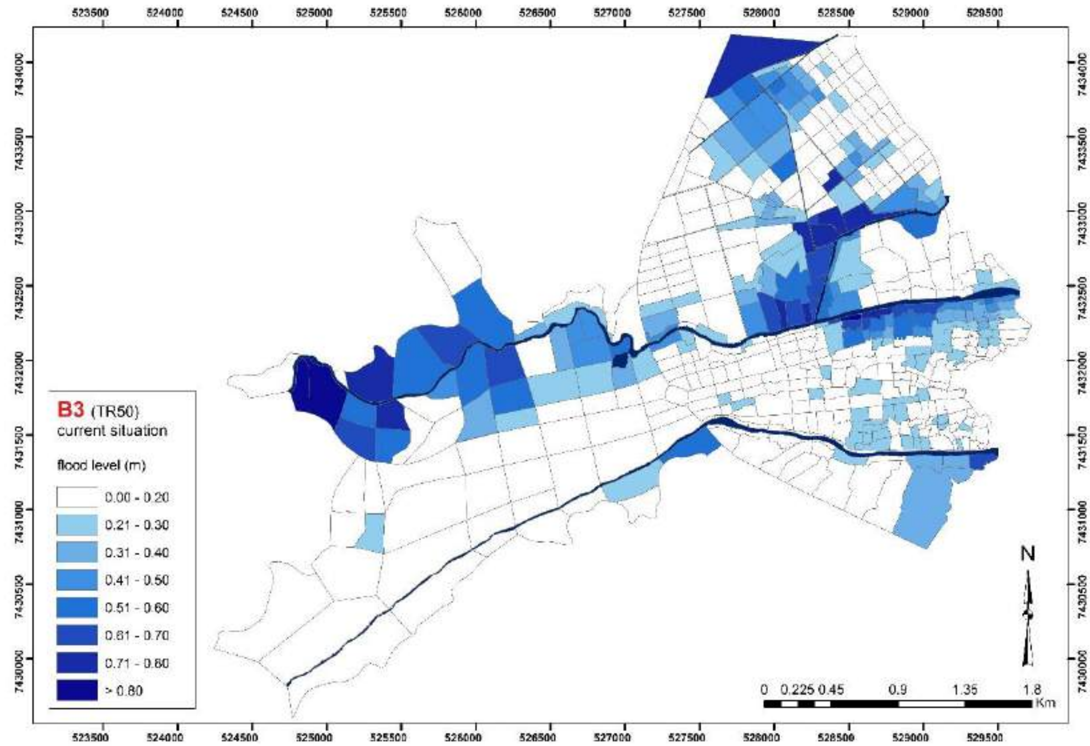


Fig. 94: SCENARIO B3 (current situation) TR50

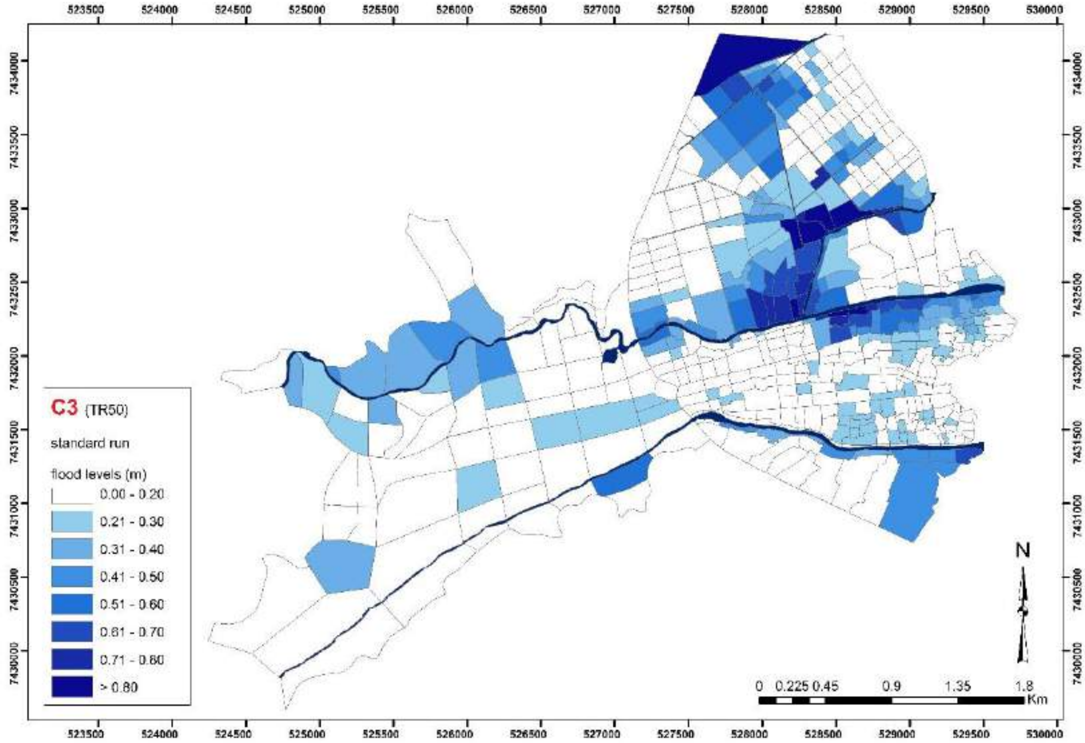
Figures 92 and 94 show the distributed impacts of floods in the study area in the present situation, considering a return period of 10 years (TR10) and 50 years (TR50)—these constitute the baseline for all other simulations.

SCENARIO C1 to C8 (Standard run Model) (TR10, TR25, and TR50 with and without climate change + alternating TR10 and TR50 in the two basins)

➢ The next step of the modeling exercise simulates the continuity of the current trend of urban expansion. This scenario foresees the expected result of the continuity of the current trend of urban growth, with no restriction on occupation of the remaining open spaces of the floodplain. This scenario simulates the occupation of upstream areas of the floodplain with low-density residential areas, considering an average landfilling of 1 m in upstream areas of the Rio-Santos highway (BR-101) in Jabaquara and other remaining open spaces of the floodplain. This scenario will make it possible to show the impact of the current trend of land-use change in case further occupation of the floodplain is not controlled and no systemic actions are set to contain urban expansion towards flood-prone areas. In scenario C, the following modifications to Scenario B were adopted:

- Landfill of 1 m in the floodplain areas located upstream of the BR -101, including the left bank of the Perequê-Açu ;
- Increase of runoff to 0.75;
- Decrease on manning coefficients, from 0.15 to 0.06;
- Decrease in the width of the links between the floodplain cells (the connection between the cells is reduced to the road network).

Scenarios C4, C5, and C6 consider as an additional condition climate changes in rainfall patterns with an increase of 10% and a sea level rise of 15 cm for the year 2040.



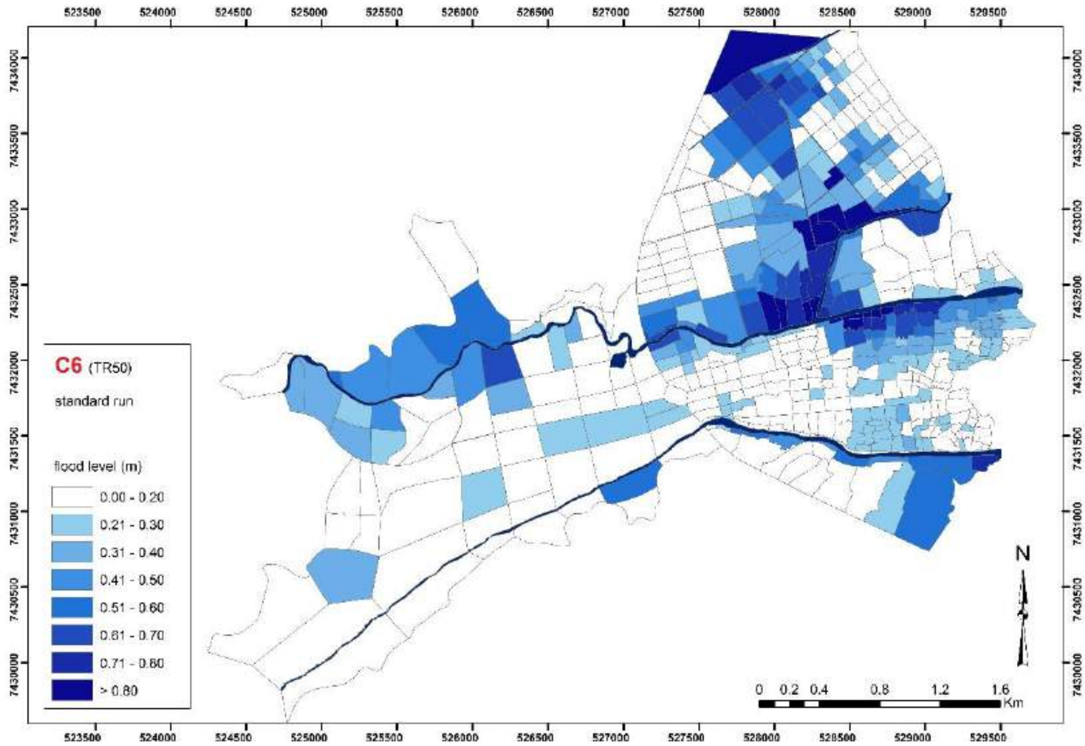


Fig. 95: Above, SCENARIO C3 (standard run TR50 without CC) and below SCENARIO C6 (standard run TR50 with CC)

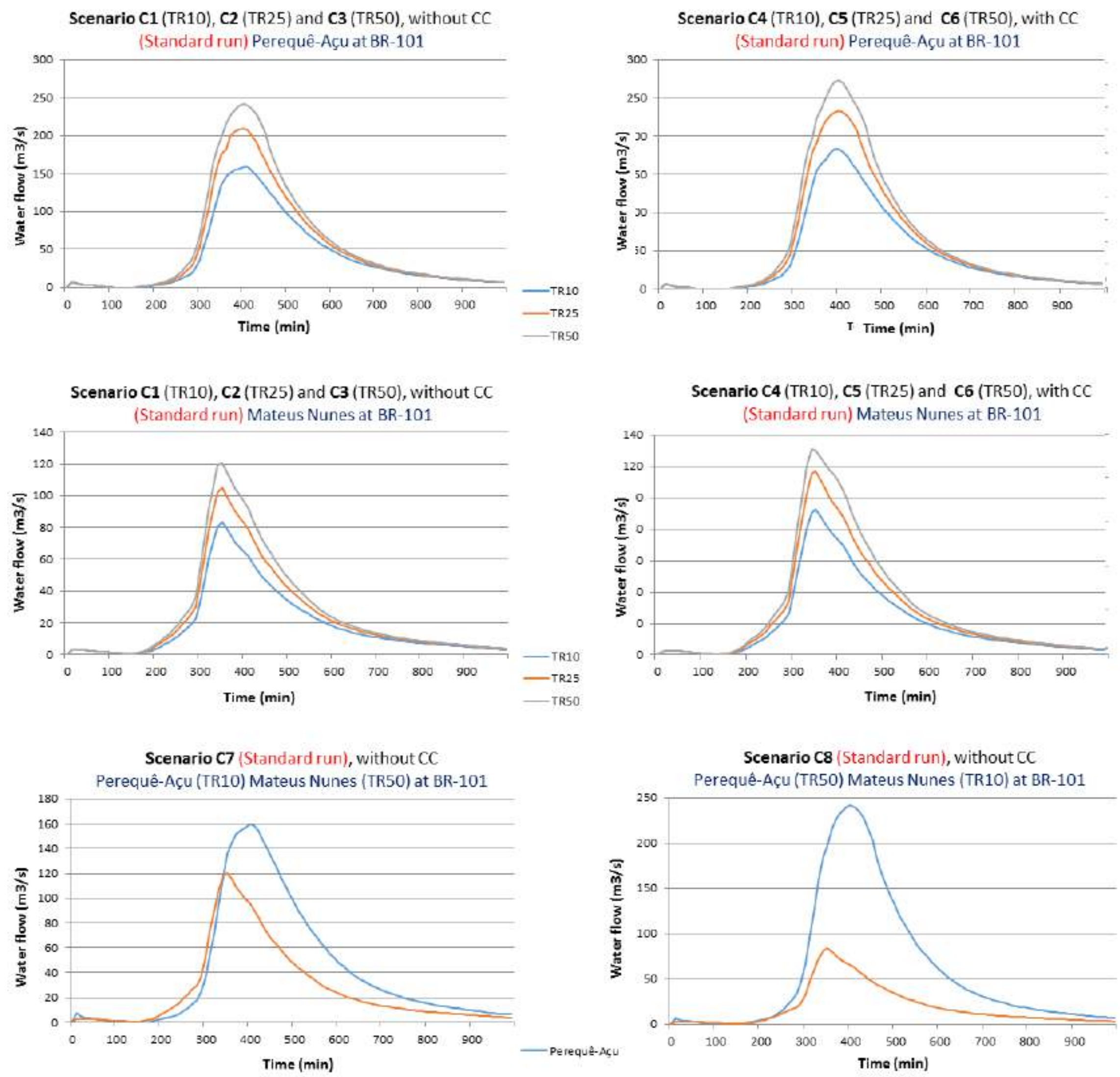


Fig. 96: Hydrographs of Scenarios C1 to C8

By comparing the map represented in Figures 94 (current situation scenario B3) and 95 (standard run scenario C6), it can be seen that the uncontrolled occupation of the floodplain will aggravate flood levels in downstream areas, including in the historical center of Paraty. It is interesting to note how landfill operations in upstream areas of BR101 will produce negative externalities on neighboring locations. Figure 96 presents the hydrographs of scenarios C1 to C6. In all future scenarios (C, D, E, F, G), different TR were also tested in the Perequê-Açu and in the Mateus Nunes river, as shown in scenarios C7 and C8. In scenarios C1 to C4, the impacts of climate change can be observed as the doubling of the increase on maximum peak flow due to land-use change. For example, from B3 to C3, maximum peak flows increased from 213 to 245 m^3/s, while from C3 to C6 there is an increase of 245 to 272.

SCENARIO D1 to D8 (Cumulative Model) Scenario C + Changes in Jabaquara, dredging of the Perequê-Açu and Mateus Nunes (TR10, TR25 and TR50, with and without climate change)

➢ This scenario sets up a situation of maximum anthropogenic action, assuming the land-use changes simulated in scenario 3, which reproduce widespread occupation of the floodplain. This scenario shows that uncontrolled urban expansion prevents the development of a solution that minimizes the risk of flooding in the city, with irreversible impacts to the hydrological functioning of the basin, even with new investments in infrastructural solutions to diminish flood exposure. For the modeling of scenario D, the following changes to scenario C were adopted:

- Landfilling of floodplain cells with smaller share than 1.50 m in Jabaquara;
- Increased runoff in the area, calculated according to the proposed occupation. The following values have been adopted: 0.75 for high density, 0.6 for mean density, and 0.4 for low density;
- Decreased manning from 0.15 to 0.06 and reduced the width of the links between cells, limited to the road system;
- Transformation of some of the floodplain cells into channel cells for representing the inclusion of the network of the proposed drainage scheme, which allows for communication between the margins of channel and floodplain cells;
- Lowering of the bottom of the channel cells of Jabaquara channels, Mateus Nunes river, and Perequê-Açu river in downstream areas of BR101, considering dredging from the BR101 to the mouth of the rivers;
- Decreased manning values on rivers sections due to dredging;
- Increased output conditions of the Jabaquara channel to the sea and increased the width of existing channels in Jabaquara.

Fig. 97: SCENARIO D4 (cumulative) TR10

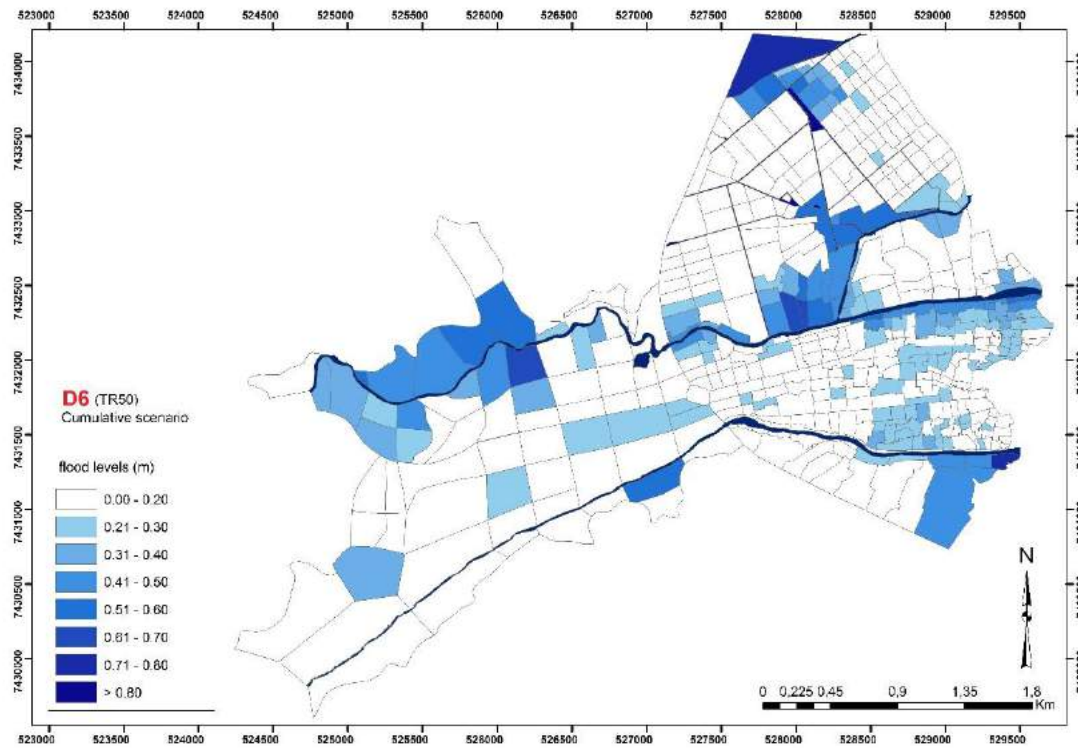


Fig. 98: SCENARIO D6 (cumulative) TR50

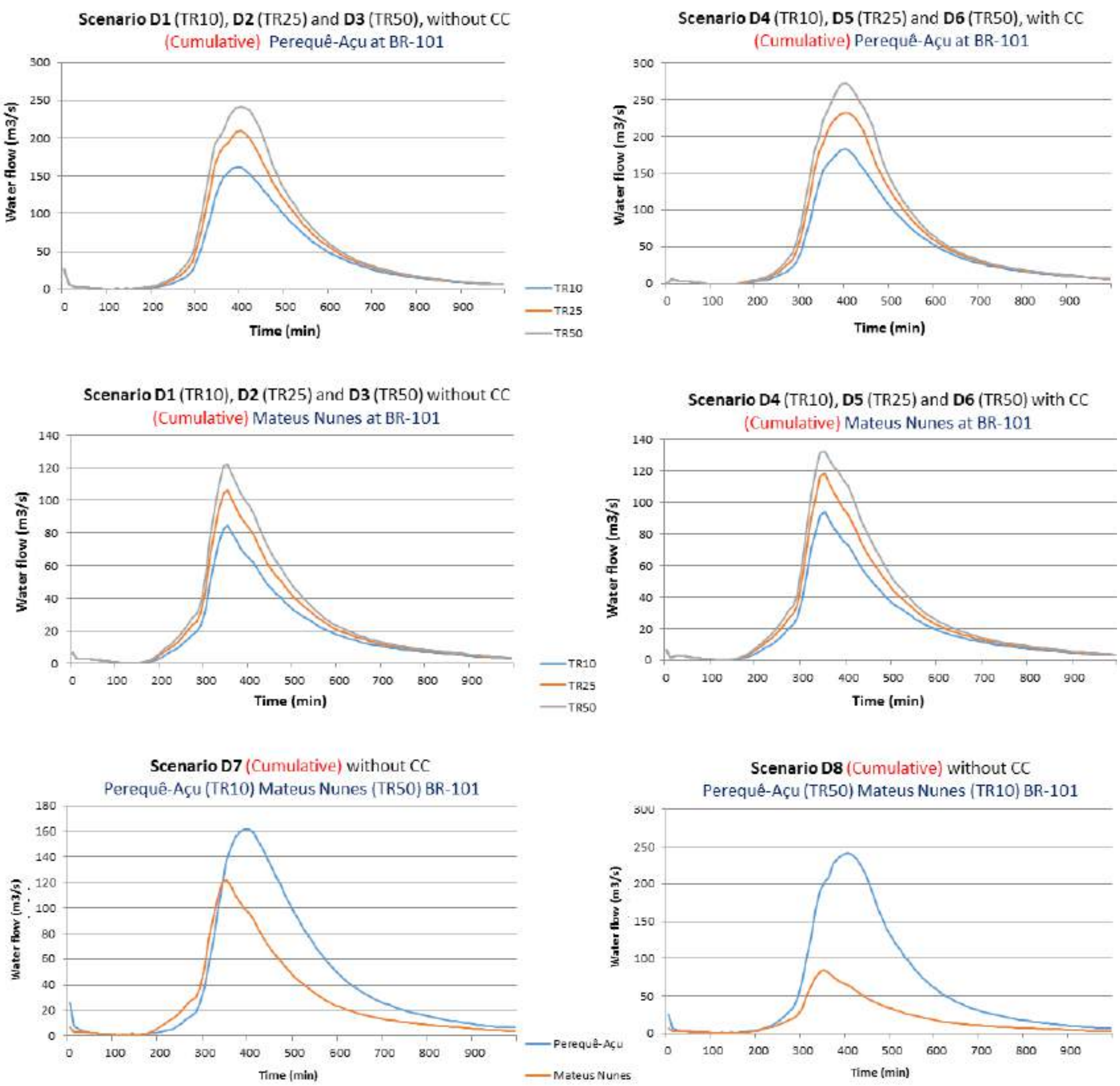


Fig. 98: Hydrographs of scenario D1, D2 and D3, D4, D5, D6, D7, and D8.

By comparing scenarios B1 and B3 with D4 and D6, it is possible to verify that the measures foreseen in scenario D, by dredging the rivers and channels of Jabaquara and landfilling the lowlands, are effective in reducing the flood levels of some floodplain cells. The hydrographs of the Perequê-Açu river show a decrease in maximum peak-flows due to the better performance of the dredged rivers and the new channels proposed in the area of Jabaquara. However, these measures are not effective in avoiding the aggravation of flooding in new areas, including in the consolidated urban area of Paraty, mainly due to the externalities of landfilling operations in upstream areas of the floodplain.

SCENARIO E1 to E8 (Compact Model) Scenario B + Park Perequê-Açu in the left margin/upstream BR101 + Changes in Jabaquara + dredging (TR10, TR25, and TR50, with and without climate change)

➢ This scenario adopts a more compact urban form, directing urban development to Jabaquara by adopting higher density rates in downstream areas of BR101 and avoiding urban expansion in upstream areas of the floodplain. This scenario follows urban theories that emphasize the need to halt further consumption of land resources by promoting compact cities (Rogers 1997), thereby proposing a radical reframing of the current trend of urban growth. With this purpose in mind, urban growth is directed to the remaining available open spaces located in Jabaquara. In exchange, the region upstream of BR101 highway is preserved from further urban occupation, functioning as a buffer zone between the urban area and the upstream regions of the floodplain.

In this scenario, water-flow regulation services are increased by directing part of the Perequê- Açu river flow to Jabaquara, thereby reconnecting the water system. It is important to note that the implementation of these channels, although artificial, recovers the natural distribution of flows within the lower areas of the floodplain, which originally drained large volumes to the zone located north of the Morro do Forte, today known as Jabaquara.

The proposed channel network is a defining element of the urban design proposed for this scenario as it takes advantage of these elements in the local landscape. Dredging of the Jabaquara channel and of the Perequê-Açu and Mateus Nunes rivers along the stretch downstream of the BR-101 highway is taken as a complementary intervention in order to remove the excess of sediments observed in the current situation. This is justified because river banks already present a high degree of intervention in almost their entire length of the urban area, contributing to the current stage of sedimentation in the lower reaches of the river courses.

Figure 99 shows the urban development proposal developed for scenario E.

Fig. 99 Urban development proposal for Jabaquara, Scenario E (compact)

For modeling scenario D, the current situation (scenario B) has been used as a basis, introducing the following modifications:

- Deviation of the Perequê-Açu to the proposed park in the area located upstream of the BR101. The new channel is 12 m wide with similar declivity to the river;
- Inclusion of three lakes for water retention, feeding two of the proposed channels (through a circular hole of 1 m diameter each), as well as the existing channel (through two holes of 1.20 m each);
- Landfilling of floodplain cells with smaller share than 1.50 m in Jabaquara;
- Increased runoff in the area, calculated according to the proposed occupation. The following values have been adopted: 0.75 for high density, 0.6 for mean density, and 0.4 for low density;
- Decreased manning from 0.15 to 0.06;
- Reduction of the width of the links between cells, which are limited to the road system;
- Transformation of some of the floodplain cells in channel cells to represent the inclusion of the network of the proposed drainage scheme, allowing for communication between the margins of channel and floodplain cells;

- Lowering of the bottom of the channel cells of Jabaquara channels, Mateus Nunes river, and Perequê-Açu river in downstream areas of BR101, considering dredging from the BR101 to the mouth of the rivers;
- Decrease in manning values on river sections due to dredging;
- Increase of output conditions of the Jabaquara channel to the sea and increase in the width of existing channels in Jabaquara;
- Inclusion of a new channel in the airport area transforming the floodplain cells into reservoirs.

On the next pages, the flood maps of scenarios D1, D3, D4, D6, D7, and D8 are presented. In the hydrographs, values for D2 and D5 are also presented.

As it can be seen in the figure below, the urban solution proposed in scenario E4 shows that it is possible to reduce flood events with at least a time recurrence of 10 years, practically eliminating floods in the entire urban area, even with climate change.

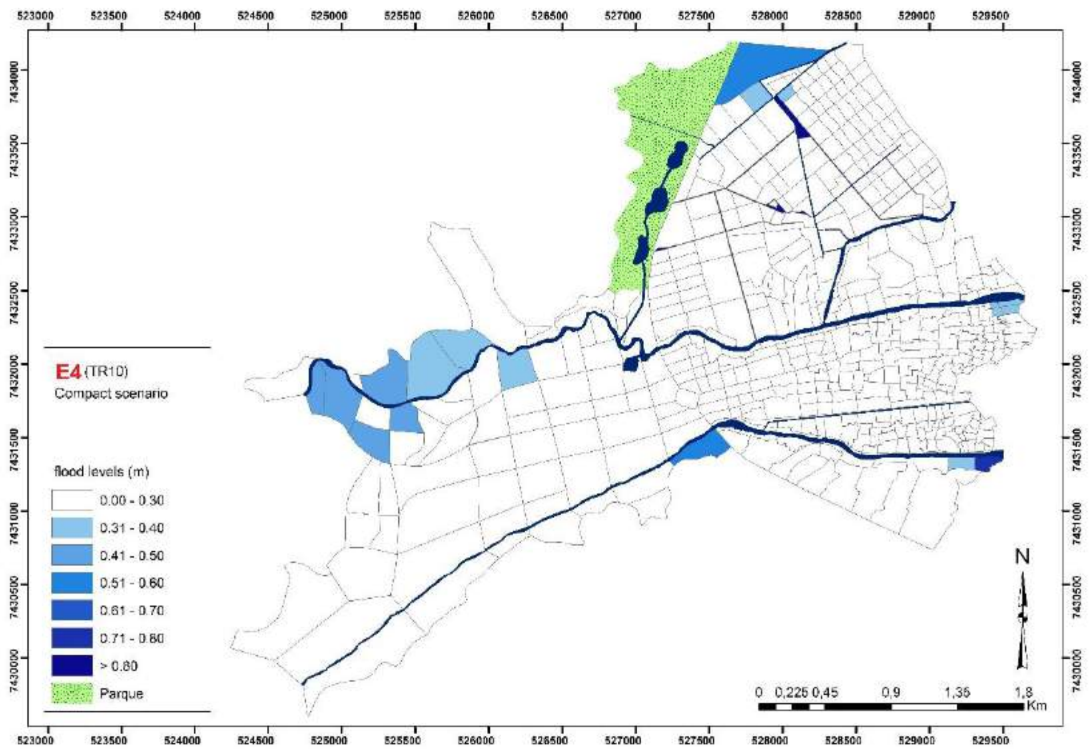


Fig. 100: SCENARIO E4 (compact) TR10

However, for extreme flood disasters, the floodplain areas which are currently under higher pressure for development in upstream areas around the Perequê-Açu river still present flood levels above 80 cm. It is noticeable that the positive impacts of the proposed measures are more visible for smaller flood events. Still, the measures proposed in scenario E are effective in reducing flood levels in the vulnerable areas close to the city center along the Perequê-Açu, and very effective in Jabaquara. Generally, the proposed solution has proven to be most efficient for high rainfall events with a predicted likelihood of 1 in 10 years, with the potential also to lower significantly the water levels in situations of high rainfall events for the time recurrence of 25 years.

Overall, the proposed scenario presents lower water levels than the current situation in most flood-prone areas of Paraty. As it can be observed in Figure 5, the measures adopted in the proposed scenario bring significant improvements to the present situation by reducing peak-flows in the Perequê-Açu river, slowing down the pressure in the case of coincidence with higher tides (i.e. when the town is threatened by high waters coming from both directions).

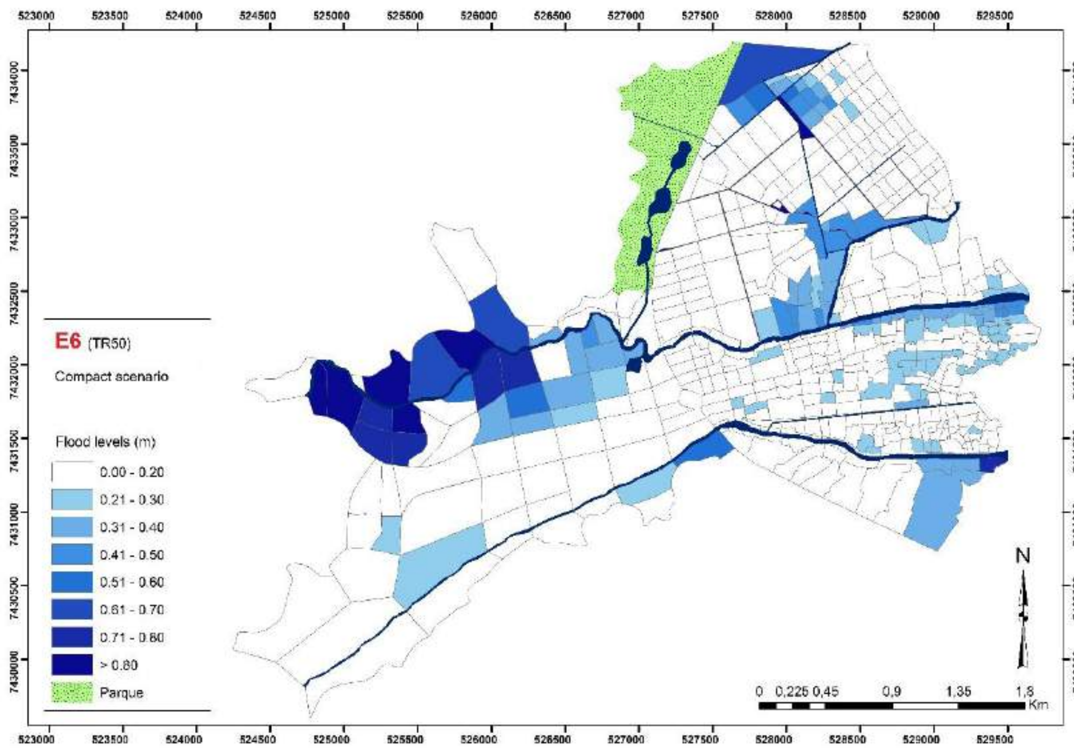


Fig. 101: SCENARIO E6 (compact) TR50

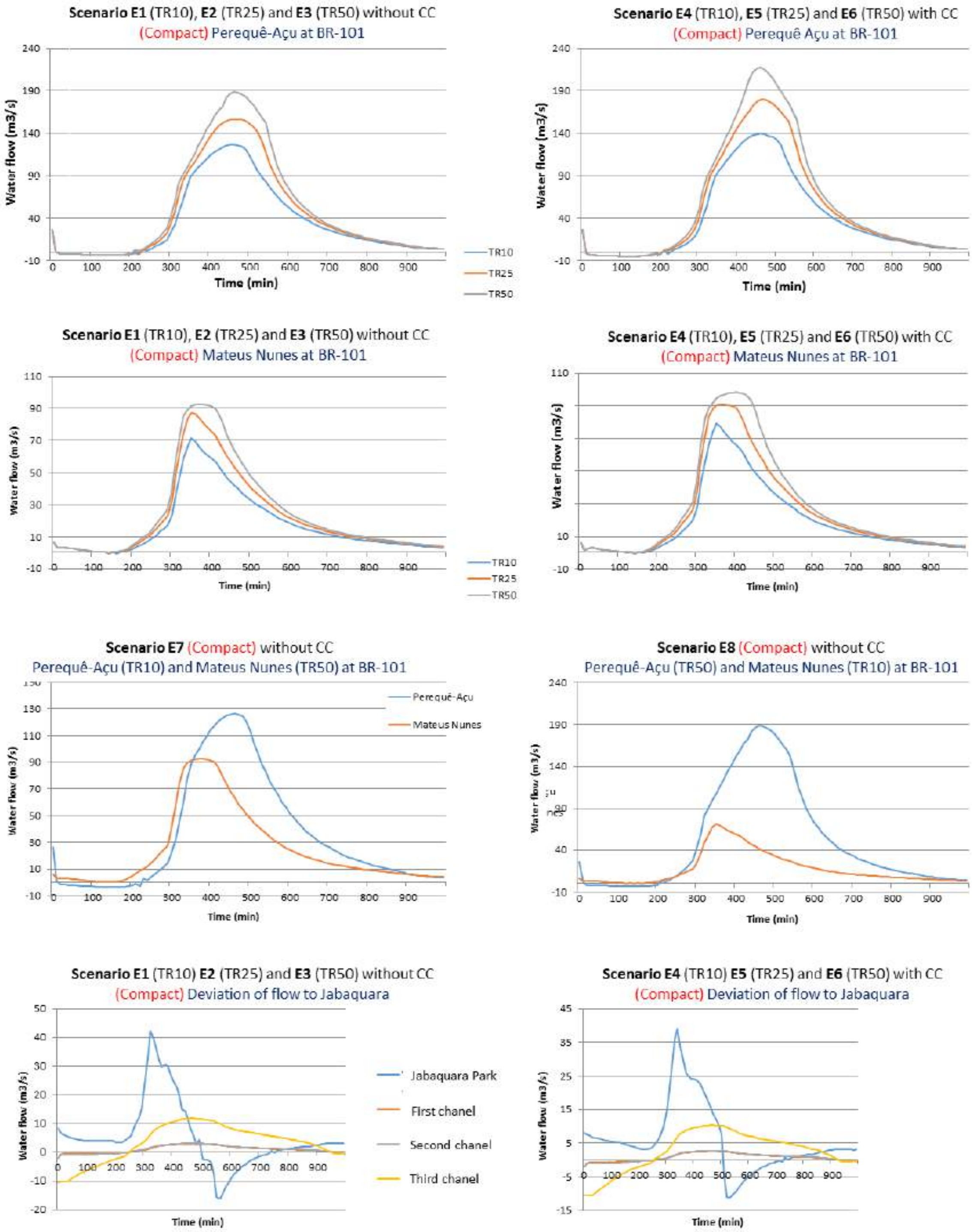


Fig. 102: Hydrographs of scenario E1, E2, E3, E4, E5, E6, E7, and E8.

Figure 102 shows the hydrographs of the river Perequê-Açu and Mateus Nunes. By comparing these with Figure 98, the abatement of the maximum peak-flows observed in the current situation are considerably reduced in the compact model (scenario E). The two hydrographs at the bottom show the transfer of water flows from the Perequê-Açu river to Jabaquara.

SCENARIO F1 to F8 (Resilient Model) Scenario B + Park Perequê-Açu in the left margin/upstream BR101 + Changes in Jabaquara + Park Mateus Nunes + connection of the river basins + sills (TR10, TR25, and TR50 with and without climate change + switching TR10 and TR50 in the two basins)

➢ This scenario seeks a compromise with the ongoing dynamics of land-use change in the study area, allowing for partial occupation of the floodplain but including significant restrictions in the most sensitive areas and avoiding generalized landfilling of the areas located upstream of the BR101. The areas of the left bank of the Mateus Nunes are converted into an urban park for sports and recreation, following the concepts of making landscapes multifunctional, recovering riparian vegetation, creating a buffer zone for flood abatement, and enhancing biodiversity and environmental quality. The selective and controlled occupation of the floodplain directs urban growth to the areas where land-use change dynamics are already occurring in order to structure ongoing developments and consolidate existing settlements, thereby safeguarding the necessary conservation of ecosystem services provided by the floodplain. This scenario proposes to reconnect the Perequê-Açu and Mateus Nunes rivers in order to increase the water storage capacity of the floodplain areas located in the upstream areas of the BR101. This connection has been designed in order to allow for the transfer of water from one river basin to the other, thereby increasing the flexibility of both river systems, restoring the natural distribution of water-flows across the floodplain, and alleviating maximum peak flows when higher and more intense rainfall occurs in one of the basins separately (in Mateus Nunes or in the Perequê-Açu), as has been observed in past events.

Since the river bed of the Mateus Nunes river suffered a process of erosion along its banks, and it would be unreasonable to dredge marginal areas (because this would require the removal of large volumes of land), an alternative technical solution is proposed by introducing submerged sills in the course of the Mateus Nunes, which induces the deposit of sediments for partially recovering the previously smoothest slope, allowing for extravasation in the proposed parks by the overflowing of the river Mateus Nunes. Additionally, a dike along the proposed lagoon is proposed—granted that the water volume of the peak flows of both rivers are decoupled—which would increase the water retention capacity when the Perequê-Açu is flooded. In turn, in the case of a major flood in Mateus Nunes, the ponds that link it to the Perequê-Açu would reduce its maximum peak flows.

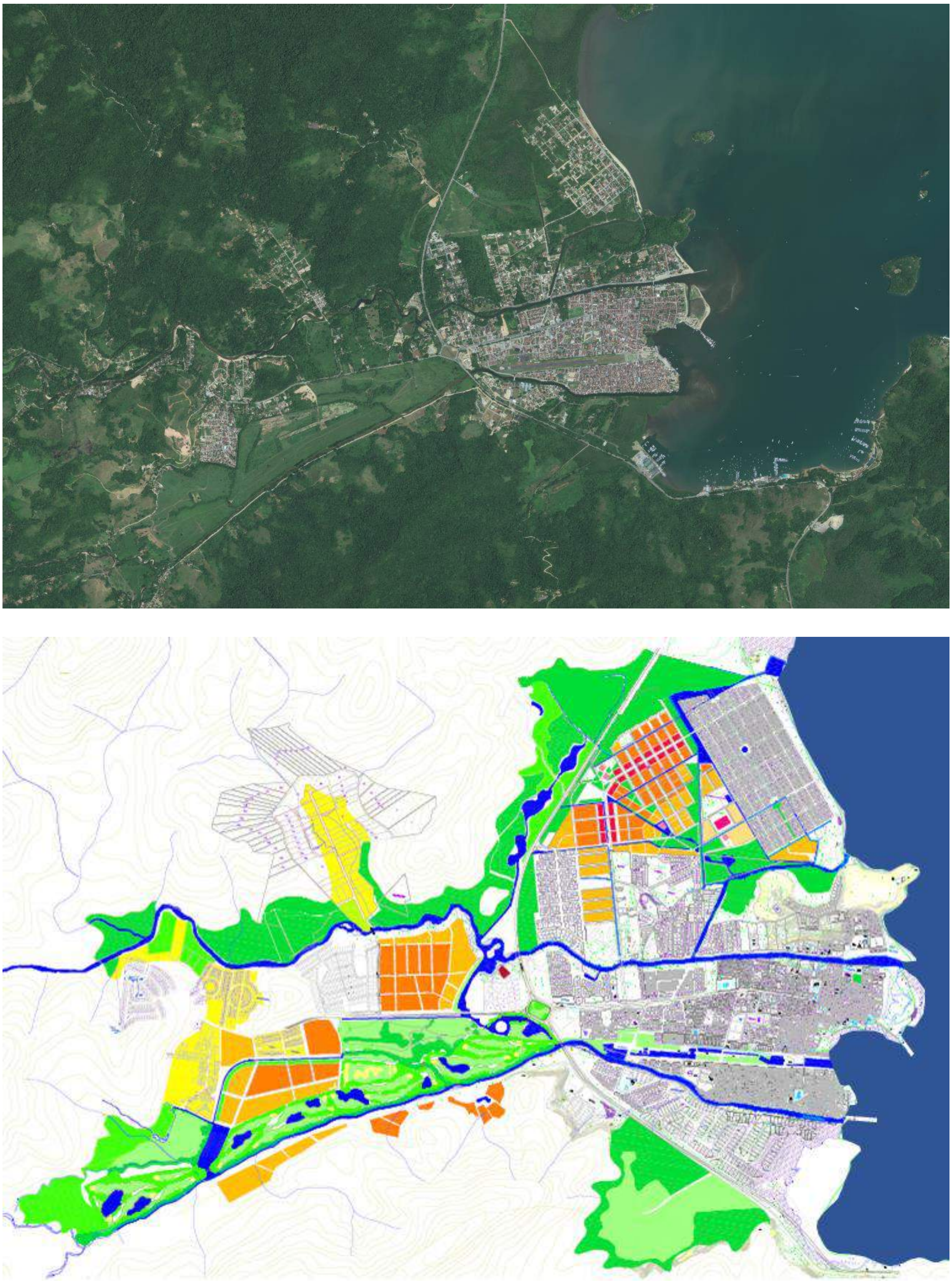


Fig. 103 Scenario F (Resilient) and G (integrative). Above, satellite image of the study area.

Scenario F takes Scenario E as the basis (including all measures proposed in this scenario), adding the following measures:

- Landfill of 1 m in the proposed urbanization areas located upstream of BR101;
- Increased runoff in the area, calculated according to the proposed occupation. The following values have been adopted: 0.75 for high density, 0.6 for mean density, and 0.4 for low density;
- Decreased manning from 0.15 to 0.06;
- Reduction of the width of the links between cells, limited to the road system;
- Creation of new channel cells representing the channel connecting the Perequê-Açu rivers and Mateus Nunes, so that they may share part of the floodplain. Through this connection between the two river basins, the Perequê-Açu transfers water to the canal when it reaches 1 m above sea level;
- Creation of a dike along the right bank with a height of 4.5 m, and another dike further upstream with a height of 4.8 m;
- Creation of two sills in the Mateus Nunes river, with a spillage quota of 2.5 m (further downstream) and another with a spillage quota of 3.5 m (further upstream);
- Creation of new cells to represent the new lakes proposed in the Mateus Nunes Park. In order to develop a realistic proposal of the dimension of these lakes, this solution relied on the collaboration of the Architect Jorge Santana da Silva, who developed a possible configuration of an 18-hole golf course, taking into account the bio-physical characteristics of this place. This design has been modified for optimizing its hydrological functioning by connecting the proposed lakes with small canals.

In Figure 103, also represented is the solution of urban renewal of the airport area developed by the Architect Marinho Velloso. The positive impacts of this solution can be seen in Figure 104.

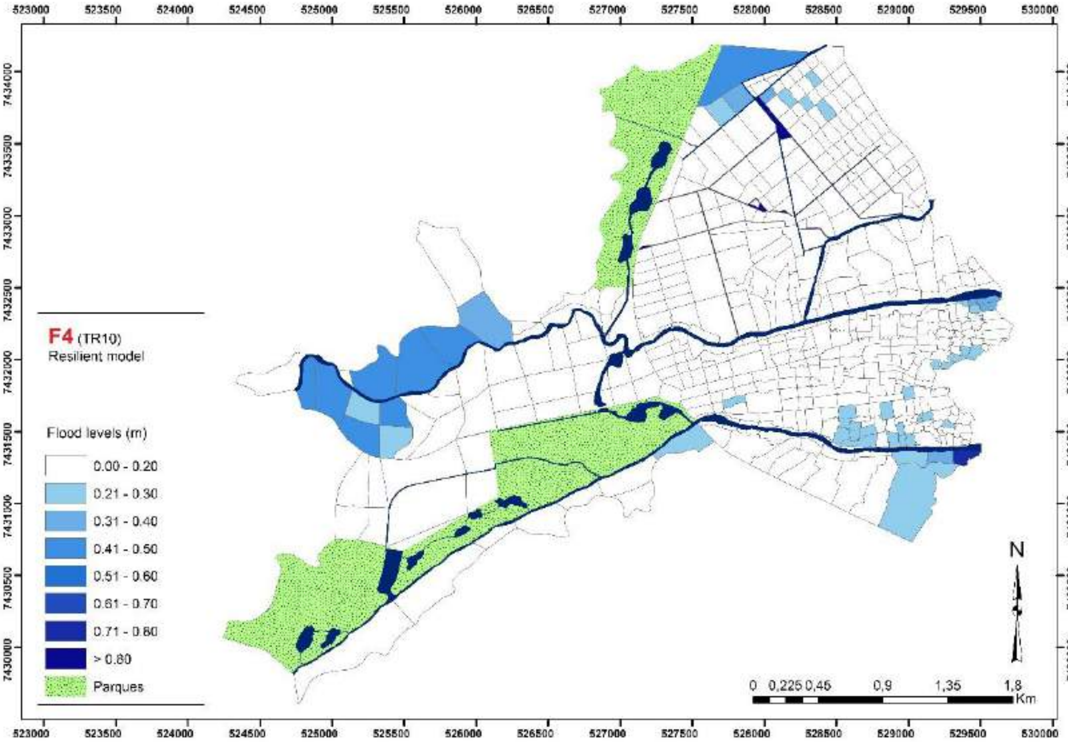


Fig. 104: SCENARIO F4 (resilient) TR10

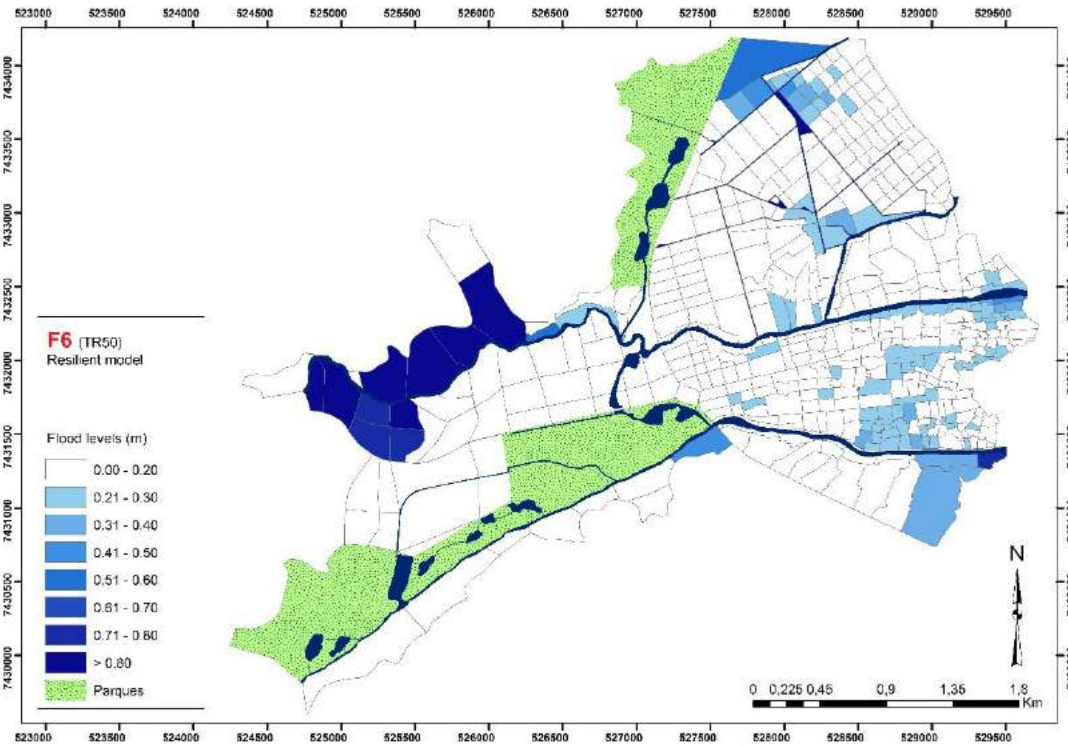
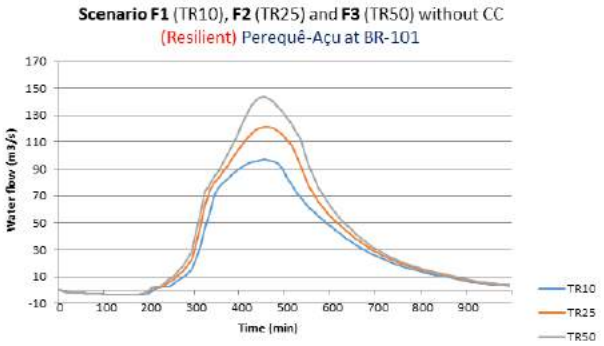
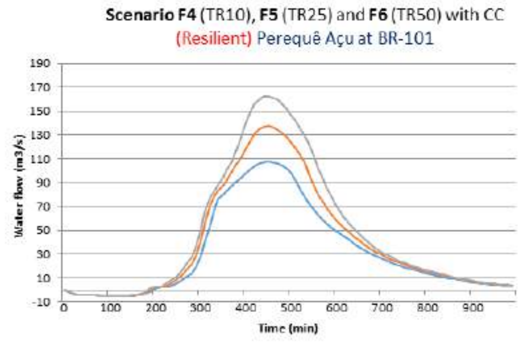
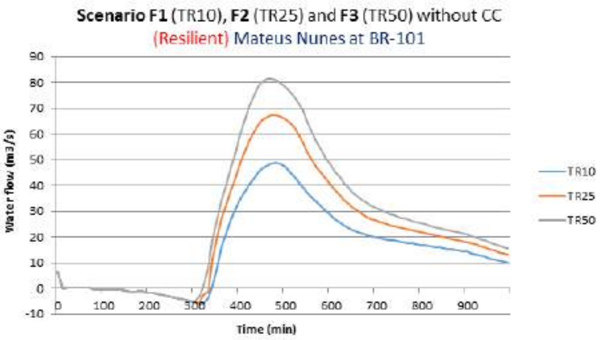
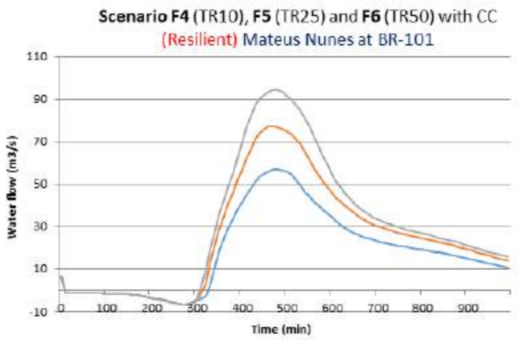


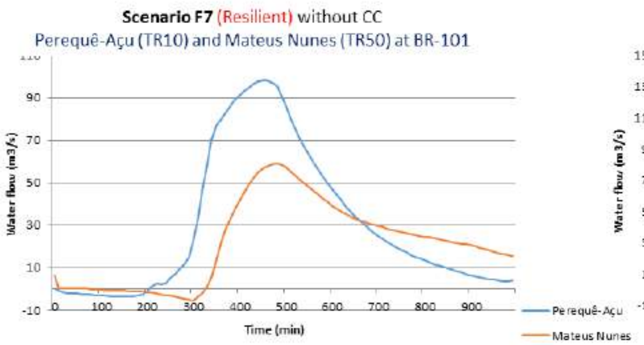
Fig. 105: SCENARIO F4 (resilient) TR50/ Fig. 106: Hydrographs of scenarios F1 to F8

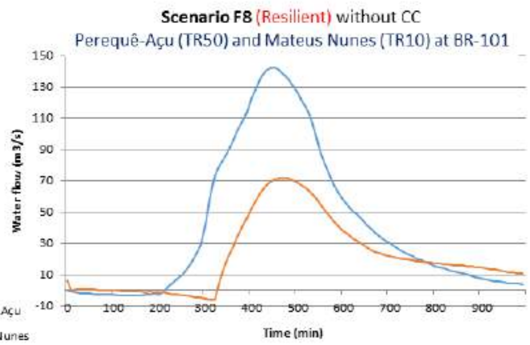

Scenario F1 (TR10), F2 (TR25) and F3 (TR50) without CC
(Resilient) Perequê-Açu at BR-101
Water flow (m3/s)
Time (min)
TR10
TR25
TR50

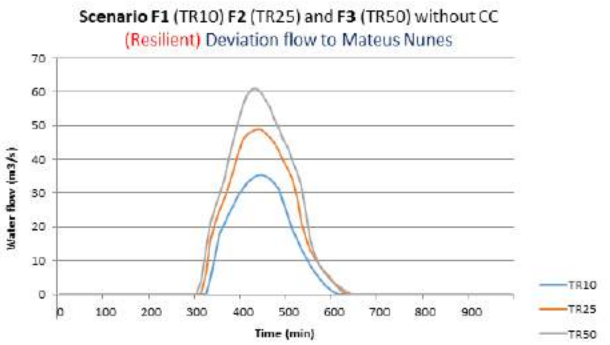

Scenario F4 (TR10), F5 (TR25) and F6 (TR50) with CC
(Resilient) Perequê Açu at BR-101
Water flow (m3/s)
Time (min)

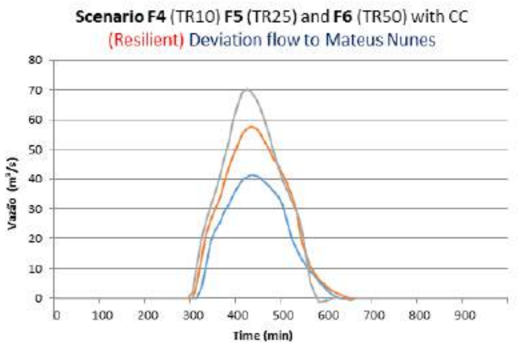

Scenario F1 (TR10), F2 (TR25) and F3 (TR50) without CC
(Resilient) Mateus Nunes at BR-101
Water flow (m3/s)
Time (min)
TR10
TR25
TR50

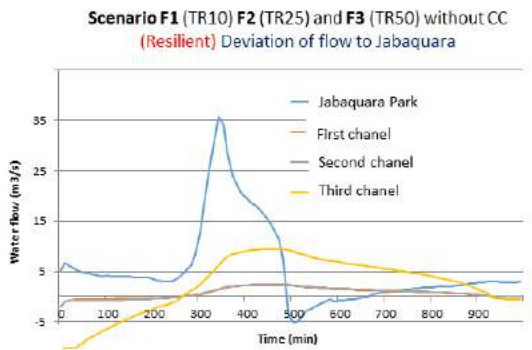

Scenario F4 (TR10), F5 (TR25) and F6 (TR50) with CC
(Resilient) Mateus Nunes at BR-101
Water flow (m3/s)
Time (min)

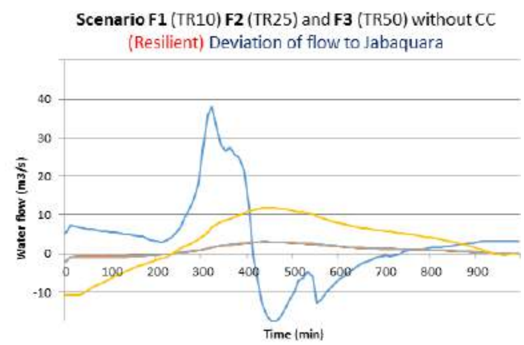

Scenario F7 (Resilient) without CC
Perequê-Açu (TR10) and Mateus Nunes (TR50) at BR-101
Water flow (m3/s)
Time (min)
Perequê-Açu
Mateus Nunes


Scenario F8 (Resilient) without CC
Perequê-Açu (TR50) and Mateus Nunes (TR10) at BR-101
Water flow (m3/s)
Time (min)


Scenario F1 (TR10) F2 (TR25) and F3 (TR50) without CC
(Resilient) Deviation flow to Mateus Nunes
Water flow (m3/s)
Time (min)
TR10
TR25
TR50


Scenario F4 (TR10) F5 (TR25) and F6 (TR50) with CC
(Resilient) Deviation flow to Mateus Nunes
Vazão (m³/s)
Time (min)


Scenario F1 (TR10) F2 (TR25) and F3 (TR50) without CC
(Resilient) Deviation of flow to Jabaquara
Jabaquara Park
First chanel
Second chanel
Third chanel
Water flow (m3/s)
Time (min)


Scenario F1 (TR10) F2 (TR25) and F3 (TR50) without CC
(Resilient) Deviation of flow to Jabaquara
Water flow (m3/s)
Time (min)

SCENARIO G1 to G8 (Integrative Model) Scenario B + Park Perequê-Açu in the left margin/upstream BR101 + Changes in Jabaquara + dredging + Park Mateus Nunes + connection of the river basins + sills + embankment + security height in Condado + new channel in airport area (TR10, TR25, and TR50 with and without climate change + switching TR10 and TR50 in the two basins)

This scenario is a variation of scenario F, created in order to evaluate the impacts of extra measures that optimize the positive impacts of this scenario. It includes a new channel in the airport area, with a proposed relocation of the airport and creation of a public space along this area. Flood security levels for construction are defined in the most vulnerable areas of Condado, in the left bank of Perequê-Açu river, where new developments are already at risk. This measure is justified because the area does not allow for the construction of dikes since the internal drainage would not exit the area except by flap gates or pumping. As a complement to Scenario 6, also proposed is an embankment of 1.50 m in the stretch further upstream the river Pereque Açu. By comparing the maps of Figures 105 and 107, the positive impacts of the new channel on flooding conditions are visible in some of the most vulnerable areas in Mangueira.

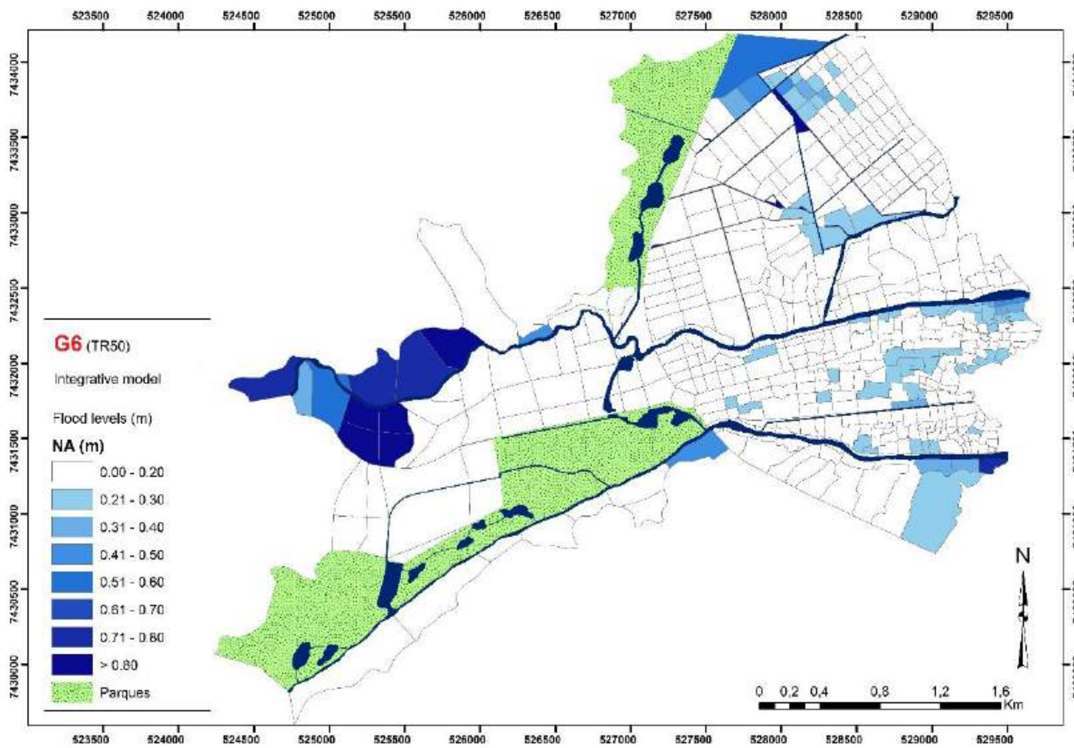


Fig. 107: SCENARIO G6 (integrative) TR50

11.4. Potentials and shortcomings of flood modeling

The hydrodynamic modeling exercise has effectively shown in a quantified manner the impacts of urban expansion into upstream areas of the floodplain. Testing hypothetical scenarios of urban development showed the benefits of adopting a more concentrated pattern of urban development, as well as the associated costs of urban expansion into upstream reaches of the floodplain. The results of the modeling exercise show that urban expansion as proposed by the Master Plan of 2010 (not approved) will result in increasing flood risks in Paraty. Negative impacts of new urbanizations will not only affect the future residents in these areas, but will also contribute significantly to increased flooding both in depth and extension in the consolidated urban area. This is because the consequent changes in land filling and soil sealing, as well as the reduction of green open spaces in the areas located in upstream regions, will contribute to the diminishment of important water-flow regulation services in the basin, decreasing water retention capacity and increasing the runoff.

According to this study's results, while the densification of downstream areas would have a minimal impact on flood risk, the further occupation of the upstream areas along the floodplain will not only lead to the worsening of flood risks in the recently urbanized areas, but will also bring additional pressure to downstream areas, endangering the existing built heritage and generating high costs for hard engineering infrastructure and maintenance services. These findings show the importance of land-use decisions at the local level and how they influence human exposure to flood risks in the future.

These results are particularly useful in informing the decision-making process, helping actors to understand the effects of urban expansion. In this regard, the Global Environment Outlook attaches particular significance to the risks of crossing thresholds, that is, the potential of reaching turning points in the relationship between people and the environment (UNEP, 2007). Even if we can neither foresee nor fully estimate probabilities of environmental degradation, the precautionary principle should be observed, avoiding land-use change dynamics that may reach such turning points. Quantifying the hydrological costs of future actions of landfilling and conversion of agricultural land into urban use makes it possible to evaluate their negative impacts, as well as to develop possible alternatives for urban development.

The cell model establishes a causal link between changes in land-use and the flooding externalities experienced by downstream parcels of land, enabling the establishment of a concrete causal link between urbanization in a particular upstream location and the flooding externalities experienced by the residents of particular downstream areas. The use of flood modeling and mapping also shows who bears the cost of the conversion of urban land, linking more directly those who may cause the aggravation of flooding to those who are affected by land-use decisions. The understanding of causal relations between different land uses makes it possible to identify who bears the cost of the conversion of urban land (in terms of flood risks increased by these actions). Also, this understanding makes it possible to identify beneficiaries and providers of water flow regulation services, creating a direct connection between those who benefit from ecosystem services and those who can deliver them.

The use of Modcel on the study territory has proven to be useful in estimating the effects of the optimization of water-flow regulation services in reducing urban flooding. The results of the tested scenarios of urban development show that the use of a complementary system of canals can be effective in reducing the flooding impacts of urbanization. These canals reinstate an element of flexibility to the Perequê-Açu and Mateus Nunes river basins, which in the present situation has been lost by the modification of river geometry and the progressive introduction of physical infrastructures. According to this study's results, water-flow regulation services may be improved through the combined implementation of land-use adaptation measures and reconnection of water ecosystems, reducing the risks of urban flooding to a considerable extent. The hydrograms of the hypothetical scenarios of urban development show that the restoration of connections between fragmented ecosystems can be effective in slowing down the runoff from heavy rains and reducing peak flows when flooding occurs by sharing the water volume of both watersheds. This confirms that watershed planning designed to strategically restore wetlands has the potential to provide dramatic benefits by restoring ecosystem-level processes (functions) that maintain water resource integrity (White and Fennessy, 2005). According to model calculations, the proposed land-use adaptation measures allow for the retention of an important share of the rainfall water when rainfall events coincide with higher sea tides. Complementary to these, the dredging of the river in downstream urban areas of the rivers has shown to be effective in lowering water levels and storm water discharges in the (mostly poorer) urban areas that are currently prone to flooding. These findings confirm that an appropriate combination of structural and non-structural measures (see Rezende, 2010) constitute the most efficient way for reducing flooding in (peri)urban environments.

Bringing flood-related problems into the public arena of debate and raising awareness of the implications of urban expansion on flooding are in themselves positive outcomes of this study. A lesson learned during this exercise is that it is not only necessary to effectively identify (and map) flood-prone areas, but it is also necessary to effectively communicate and engage in the local scene where land-use decisions are being discussed, increasing the chance of incorporating these concerns in zoning regulations. However, talking about something does not necessarily result in changes to existing political and socio-economic forces that actually influence land-use decisions. There is a long way to go between turning a specific socio-environmental issue into a legitimate subject of political debate and the taking up of these issues by responsible political authorities. Another communication problem that occasionally has been observed throughout this study is that sometimes the community living close to the area that needs to be adapted in order to adopt flood prevention measures does not suffer from flooding, reducing local acceptance of this kind of measure. Even in the case of the provision of new recreational areas, it is not always easy to convince local communities and stakeholders of the importance of these measures, as they often prefer landfilling and hard engineering solutions. These are then usually also preferred by all political forces, since politicians have in them a powerful mechanism to consolidate and expand their constituencies. Public acceptance of non-structural measures, in turn, are likely to be highly dependent on the capability of resolving conflicts among different groups and individual interests. In order to tackle these problems, the involvement of local communities appears to be a crucial element for the acceptance of land-use adaptation measures.

The implementation of land-use adaptation measures requires political will to sustain policy action and a relentless communication effort among stakeholders in order to develop a common understanding of the conditions and parameters for urban development. Furthermore, flood risk maps and flood management plans need to be connected with public investment and funding, which would enable local governments to manage strategic investments in vulnerable areas. Integrating risk criteria into urban planning and management requires the allocation of specific targeted schemes of investment to specific local interventions in key intervention points and priorities. In the absence of such incentives and funding mechanisms, non-structural measures based on preventative land-use adaptation are relegated to a second order of priority in relation to other infrastructure projects contained in these plans. The conditions are set for urban governments applying for funding from higher levels, such as requirements for local development plans to incorporate risk criteria. Hence, specific national and state funds are needed in order to support locally developed responses that will vary depending on the range and relative importance of identified risks.

The quantitative analysis of flood mitigation benefits provides important information for the assessment of wetland values at the local level and may be a useful reference while designing strategies for the conservation of peri-urban landscapes. It is worth noting that one of the most polemic issues in the literature about ecosystem services comes from the difficulty of identifying precisely the extent of the service (Pearce, 1998; Boyer and Polasky, 2004) and the value that can be put on it (Vandewalle et al., 2010). Carpenter et al (2009) noted that it is difficult to embed those concerns in the decision-making process because some evaluation practices intended to improve ecosystem services are based on untested assumptions and sparse information. Considering these limitations, our modeled scenarios provide quantifiable information about water-flow regulation services, which can be tailored to examine the trade-offs inherent in decisions that are actually being considered by the relevant authorities.

The results of the present hydrological study may contribute to a better understanding of the relationship between specific land resources and water-flow regulation services in a spatially explicit way. In one regard, establishing a concrete causal link between urbanization in a particular upstream location and the flooding externalities experienced by the residents of particular downstream areas helped actors understand the effects of their future actions, linking more directly those who may cause the aggravation of flooding to the victims of flooding events. In another regard, the visualization of positive impacts of land use adaptation measures through flood maps and hydrographs provides important information to support land-use decisions, contributing to a greater consideration of the benefits of preservation and enhancement of specific and localized land resources for the mitigation of flood risks.

12. A critical review of the 2010 Master Plan’s land-use proposals

Despite the remarkable importance of the cultural and environmental values of Paraty, the Municipality does not have a Master Plan that meets the minimal conditions established fifteen years ago by the City Statute. The first serious planning effort made in Paraty resulted in the 1972 Master Plan, which was strongly influenced by the preliminary studies of the Belgian architect Frédéric de Limburg Stirum (CNPI, 1972). This architect developed many pioneering studies for the city, with particular emphasis on the hydrological aspects to be taken into account in planning the urban expansion of the city. Although the 1972 Master Plan represents a remarkable effort and prescribed significant measures for flood management, the plan was never implemented. Subsequent planning processes have been undertaken throughout the last decades (1982, 1996, 2002, 2006, and 2010), but none of these processes have produced satisfactory results beyond the simple limitation of the height of new constructions and the imposition of low-density patterns of land occupation. Paraty has recently made an attempt to elaborate a new Master Plan, and the Municipal Council released a draft proposal of the macro-zoning for the land use within the municipal jurisdiction (UERJ, 2010). Although this Master Plan has not been approved, the land-use proposals contained in this plan constitute an important document of reference, since it has been the more recent effort of the Municipality to define public policies of urban development in Paraty. It is also expected that the Master Plan of Paraty will take this plan as a baseline for further development. As such, a critical review of the 2010 Master Plan is hereby presented, based on the analysis of the land-use proposals defined in Volumes 3 and 4, with special focus on the guidelines for municipal zoning of the city of Paraty and its surroundings.

Figure 108 shows the main areas defined by the Master Plan for the study area of the present study, broadly divided into Urban Area (Macrozone MA-3) and Urban Expansion Area (Macrozone MA-2). On page xiv of the introduction to Volume 3, it is noted that “this document is not final and is designed to give access to the information produced to date and receive critical analysis. (...) Considering that there is still a development stage, workshops and public consultation, for adjusting these territorial cuts, the third hierarchical level (microzoning) is not presented here, since it will be the subject of discussion in the necessary supplementary steps for the elaboration of specific rules of land-use and occupation of the municipal territory.” The present analysis intends to contribute to these adjustments by critically evaluating the suitability of the proposals made in the Macrozones and Mesozones as defined by the plan and identifying any ambiguities that require clarification in the plan.

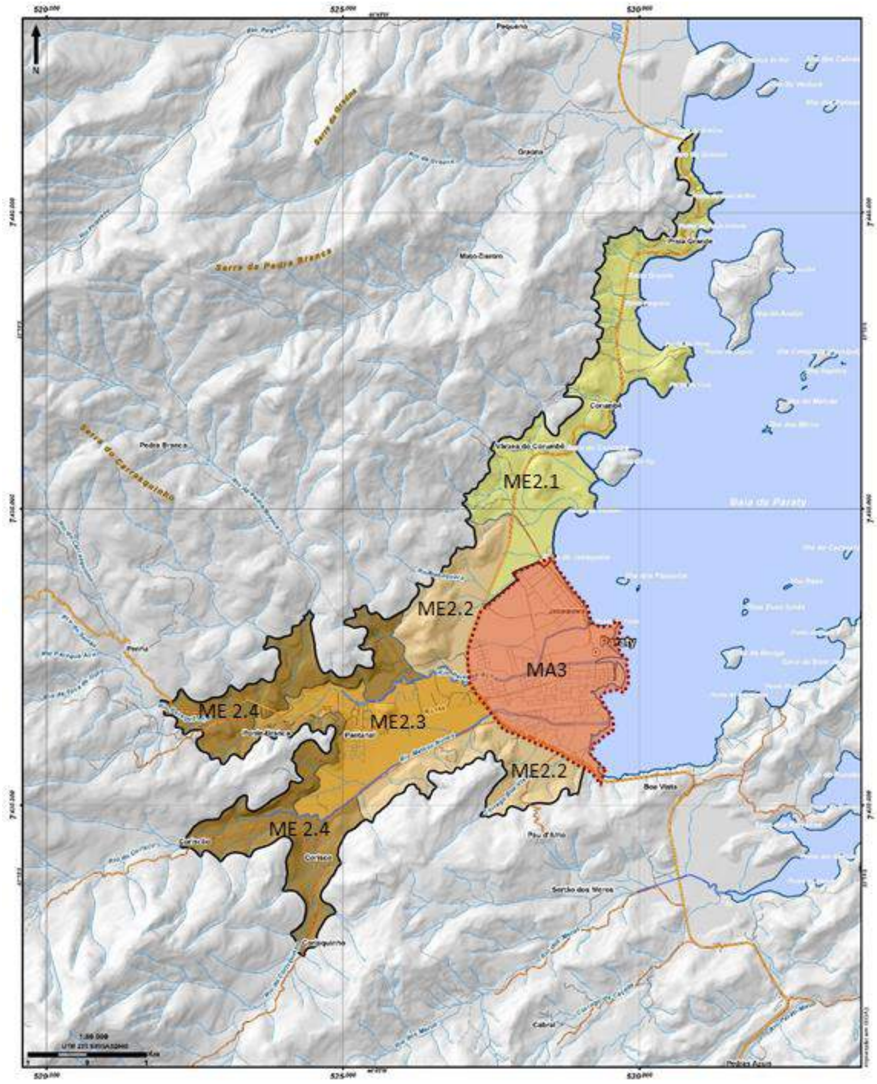


Fig. 108: Subdivision of the Macrozone MA-2 and Macrozone MA-3

According to the plan, the 11 Macrozones and 33 Mesozones intend to direct the development of guidelines that will compose the Master Plan. On page 21 of volume 3, the Municipal territory "is divided into three hierarchical scales of zoning, increasing the wealth of detail from Macrozoning for the Mesozoning, until the microzoning. (...) The third scale (microzoning), will specify new areas in order to spatialize the restrictions on land-use and occupation, as well as the key areas suggested for preservation, environmental conservation and restoration and other specific actions. The Microzoning will be prioritized to the areas densely populated with human occupation. It is also prioritized by the plan the preparation of microzoning in the macrozones of Urban Area and Urban Expansion Area, the isolated urban centers and the coastal area around Paraty-Mirim Bay, Mamanguá and Juatinga, given that this zoning will provide the definition of the necessary urban parameters to complement the law for the occupation of urban land."

On page 88 of Volume 4, Chapter VI, Article 289 states that "the Municipal Zoning established by this master plan takes place on two levels, namely: i). Municipal Macrozoning and (...) ii). Mesozoning (...)." On page 67, proposals for mesozoning "are (...) presented in order to define their final cuts, creating the possibility of continuity of participatory building process (...) aimed at defining the microzoning in areas with higher density population density and listed (...) as priorities for defining parameters and definitions of land-use and occupation of the municipal territory." Hence, the development of these microzoning plans are recognized throughout the text as necessary and complementary instruments to the macro-zoning proposals and mesozoning as presented in this plan. The land-use proposals of the plan at the macro and mezzo levels will be now analyzed, with a particular focus on proposals for urban expansion presented to the city of Paraty and its surroundings.

12.1. Urban Expansion Macrozone MA-2

On page 56, the "Summary of features and potentialities of macrozones" mentions important aspects of MA-2 area, which raise a number of perplexities about the classification of this area as "Urban Expansion Area." Since this is a central critic to the propositions of the Master Plan, four problematic aspects are highlighted:

i) "About 40% of its area is covered by forests of Atlantic Forest" (30% forest in Initial Stage of Succession); 20% of its area is protected by APA Cairuçu (Mesozone ME-2.2, with 523.29 hectares). Considering these characteristics, it is questionable whether the conversion of this forest area (40% of total) is urban expansion area, even with "very low density" as it is referred to by the plan on the Mesozona ME-2.2. In case this proposal is maintained, it is at least necessary to define what is meant by very low density, and to make a thorough study of the environmental impacts of housing developments within this highly sensitive area, especially with regard to the extension of infrastructure.

ii) "Almost 60% of its area consists of flat plains and valley bottoms, and 45% of its area presents steep slope gradients between 0 and 5 degrees." It is important to assess the water-flow regulation services provided by these low-lying areas to the population, in particular to the urban residents of the consolidated urban center.

As it was verified in the last great flood of 2009, many of these areas have been flooded with depths exceeding 1.5 meters. According to the Civil Defense of Paraty, in 2009 the water overflowing from the rivers merged the two basins in a range of approximately 500 meters immediately upstream of the BR101. The neighborhoods of Pantanal and Pedra Branca were also severely affected, with cars swept away and homes destroyed by the floods. In Princesa Isabel neighborhood, an embankment was built in order to protect the neighborhood, which has now had to be rebuilt after a second collapse. It is expected that the progressive landfilling operations in the urban expansion areas (similar to what happened in Caborê neighborhood) will contribute to the worsening of floods in downstream neighborhoods. All these areas are contained in the Mesozone ME-2.3.

On pages 70-71, section 5.2.2. "Mesozones of the Urban Expansion Macrozone of Paraty," the Mesozone ME-2.3 is featured "as the most densely populated area among the Mesozones of this Macrozone of Urban Expansion. It is suggested that the guidelines take into account the planning of the intensification of the densification process, setting a standard for the urban expansion of Paraty." This guideline recommends the favoring of urban expansion to the areas with higher flooding problems. Also noteworthy is that currently, the total built area of MA-2 is 174.92 hectares, while the proposed urban expansion area is around 400 hectares, which is clearly disproportionate, even if considered at macro level.

iii) In "other characteristics," MA-2 refers to "the presence of more intensive agriculture along the margins of the Perequê-Açu and Mateus Nunes rivers". However, and although we can observe the presence of vast areas with agricultural potential, the agricultural and agroforestry activities are not identified in the "potentialities of MA-2," ignoring the use that these lands have had for several centuries until the recent decline of agriculture production in the Municipality.

This section also mentions the potential of "Sustainable Tourism (develop incentive tourism programs taking advantage of the natural, scenic, cultural and historical attractive features, through tourism and sports)" and "Preservation of Cultural Heritage (incentives and prioritization of preservation and restoration activities of the cultural heritage of the city (...).” The plan points out the potential for “Socioeconomic Development,” mentioning the need to “facilitate socio-economic activities compatible with sustainable development, valuing the landscape and the protection of the physical environment as a fundamental element of the urban landscape.” Finally, the plan makes reference to the potentiality of Environmental Restoration (restore river shore areas and fluvial beaches, aimed at the protection and preservation of the environment). Considering these characteristics and potentials it is highly questionable if classifying this area as “urban expansion area” will contribute to these objectives, or, on the contrary, will contribute to a rapid degradation of this cultural landscape, as has been occurring with greater intensity over the past two decades.

iv) The first potentials of this area are, according to the plan, the “Ordered Human Occupation: provide ordered urban development of high and medium density for urban districts with occupation of urban voids and management of the construction standards in accordance with the landscape and cultural heritage; and creating an “Urban Services and Infrastructure Pole.” These objectives are reasonable, but what is questionable is the strategy itself: defining a vast area as an urban expansion area in which existing urbanized areas represent a minimal part of the plan runs counter to the pursuit of the very objectives of the plan. Opening the possibility for infrastructure expansion into a very large area necessarily limits the possibility of channeling the existing resources for the currently deprived areas. It can be argued that this urban expansion defined in macro- and meso-zoning may be limited in the micro-zoning. However, it is easy to predict that the private pressures operating in land parceling and construction in this area will be enormous, and will contribute to the pulverization of public investments and a progressive worsening of the current social and environmental problems. An alternative to this strategy would be the indication on the part of the plan to limit the existing (sub)urban areas, which is the opposite of classifying this vast area as “urban expansion area.”

To sum up, if 40% of the MA-2 is covered by forest and a large portion of the remaining 60% consists of drained wetlands (a region where floods are already a serious problem for the city), what are the arguments that support the proposal of urban expansion into these areas? The proposal seems to be based on the fact that MA-2 area is “the third largest concentration of inhabitants and households, and the second highest density of inhabitants and residences by builted area from the macro-areas,” with a “39% increase of the number of inhabitants (greater increase in the municipality) and an increase of 52% in the number of households (largest increase in the municipality).” On pages 91-93 of volume IV, subsection II, Article 298 states that the Macrozone of Urban Expansion of Paraty (MA-2) is characteristically marked as an area of urban expansion by the 2000 census data and the 2007 count held by IBGE. Thus, the proposal of urban plan expansion reinforces the recent trend of urban sprawl, rather than meeting solutions to curb this trend.

On pages 62-65, subsection II of Article 281, it is recommended that individual studies of neighborhoods and housing units contained in the Urban Expansion Area are conducted “for its consolidation (and) expansion.” This article reflects contradictory intentions, since it is difficult to reconcile in practice these two goals: either the intention is to consolidate these neighborhoods, through a firm containment of this urban growth, or to expand these neighborhoods, which would generate greater investment in infrastructure and extension of urban services to the newly urbanized areas. It is important to consider that these neighborhoods are not provided with basic sanitation and other essential services. It is therefore more economically viable and environmentally desirable to favor its densification and consolidation rather than promoting its expansion. It is worthy to emphasize that these neighborhoods are already designated in section III of Volume IV as areas of special interest in the city in Article 375. In section 4.3.5.3 (page 49), titled “Dynamics of population growth” of MA- 3 area, which is classified as an Urban Area of Paraty, a small increase, estimated at 16%, was registered both in population and households. The correlation between these numbers explains the lack of alternatives for the social groups that mostly occupy peripheral neighborhoods to the phenomenon of suburbanization: since a significant increase did not occur in the supply of residences in the available areas closest to the urban center, these people are forced to seek alternative solutions in peripheral areas.

In Mesozone ME-2.3, the presence of a landscape unit of great importance for the municipality should be highlighted: an old property along Mateus Nunes River and the Paraty-Cunha road, in the area commonly known as “Bananal” (Figure 3). By its size and landscape value, it would be suitable for this area in terms of two of the designations described in Chapter VIII of Volume IV: on page 105, Special Area of Environmental Interest (Área de Interesse Público) is defined as “spaces (...) whose elements of the natural environment assume a function of public interest, because they are important for the maintenance of the social and environmental balance of the Municipality"; and "Special Area of Interest of Cultural Heritage for the preservation, rehabilitation or compliance with sites (...) of cultural value, or of relevant (...) historical (...) and landscape significance."

The hydrological study presented in the previous chapter shows the negative consequences of the intensification of the urbanization process in the remaining floodplain areas of ME-2.3, especially regarding the hydrological functions of the basin. It is noteworthy that on page 89-90, Art. 292 defines areas with physical conditions adverse to the occupation as (...) low areas subject to flooding, flood, or relegation due to their morphological composition. Paragraph 2 also recommends that the lowlands of fragile areas have their uses conditioned to technical evaluation.

On page 42, Volume IV, section IV, Article 133 refers to "urban drainage." "The Municipal Sanitation Plan, referred to in Article 120, shall contain "Flood Control Plan which should establish (...) priority actions in the management of rainwater, such as: i) defining support mechanisms for land-uses compatible with areas of interest for drainage, such as parks, recreation and play area, community gardens and maintenance of native vegetation; and ii) implement flood prevention measures." Article 137 also states that "The Executive Municipal Power will create incentives to avoid soil sealing and favor the reuse of rainwater, especially in low-land and flat areas." However, beyond urban expansion's direct environmental impact on transforming the landscape of Paraty, the guidelines for it in the areas upstream may actually result in worsening floods that reach the downstream areas of the basin, and it will reduce the ability to retain flood water in the areas of natural preservation. It is vital that the institutions responsible for planning land use and regulating urban occupation in the municipality of Paraty take into account these problems, acknowledge the possible consequences of increased flood vulnerabilities, and take it as a starting point to revise and/or supplement the planning guidelines for this region so they do not culminate in the deterioration of flow conditions during flood events.

12.2. Urban Macrozone MA-3

On pages 100-101, section III of the mesozones (within the macrozone) MA-3, Article 330 defines the guidelines for these mesozones: ordered urban development and regulation compatible with the densification of occupation, provision of services and infrastructure, and incentives for the occupation of the existing intra-urban spaces.In this sense, the plan could be strengthened by including a set of guidelines for individual studies recommended in Article 279 (page 62 -65 of Volume IV). On the other hand, for further approach to urban expansion needs in the county seat, it is indispensable to make an objective analysis of the carrying capacity of the MA-3 area, designated as Urban Area (Área Urbana de Paraty). In a rough analysis of the existent open spaces within the 594 hectares of this area, about a fifth of this area is not occupied by urbanization.

It is worthy to note that the above-mentioned open spaces within MA-3 are both, from economic and environmental perspectives, the most suitable areas for controlled urban development as it has been advocated by the first planning initiatives carried out in the municipality by the architect Frédéric de Limburg Stirum (see CNPI, 1972). On pages 100 and 101, section II, Article 324 characterizes the mesozone ME-2.1, predominantly occupied by the Jabaquara neighborhood, as an area of lower density with prospects of future expansion in the long-term, having as guidelines to future occupation with appropriate planning and infrastructure for incorporating higher urban density patterns. Although the text recognizes this area as an area with growth prospects, it is not clear if there is an intention to prioritize urban expansion into this area.

Generally, the articulation between the land-use proposals contained in Volume III and the instruments foreseen in Volume IV may be improved in order to favor its possible and desirable effective application. For example, the plan does not point out the possible designation of Jabaquara as a Special Urbanistic Interest Area (Área de Especial Interesse Urbanístico) as it is foreseen on page 105, chapter VIII. Article 366 defines Special Interest Areas as spaces within the municipality that (…) are subject to specific urbanistic rules, concerning the implementation of urban development public policies. According to the plan, Special Urbanistic Interest Areas are the ones designated for specific urban (…) restructuring projects. The instruments foreseen on pages 21-24 of Volume IV also open interesting possibilities for the Municipality, especially for the creation of consortia for urban operations, in conformity with mechanisms foreseen in Articles 32-34 of the Federal Law 10.257/2001.

According to Article 65, Subsection IX of Volume IV, "The Municipality can, through specific municipal law, delimitate areas for urban consortia, especially concerning: i) the extension of public spaces and implantation of infrastructure; ii) implementation of housing programs and environmental valorization; iii) modification of indexes and characteristics of land parceling, use, and occupation, as well as the alteration of construction norms, considering their environmental impact and neighborhood impact (...)". In Article 67, it is defined that "the Municipality should promote and stimulate the feasibility of consortiated urban operations preferably in the Macrozones of Urban Environment and Urban Expansion". Article 69 indicates also that "The Urban Consorciated Operation areas, delimited through the Municipal Law referred in Article 65 may have differentiated coefficients" (obs: these coefficients refer to urban density and occupation indexes).

As a final note of the analysis of the land-use proposals of the 2010 Master Plan, the main challenge in reviewing this plan is considered to be the adequacy of the proposals of urban expansion in light of the real demands for housing in Paraty. The plan opens up vast areas for urban expansion without the necessary evaluation of the possibilities of directing urban growth to the available areas located in downstream reaches of the basin, such as Jabaquara, the airport area, and other smaller open spaces. These possibilities should be properly evaluated by undertaking a detailed analysis of the existent capacity of the remaining open spaces to accommodate urban growth in a sustainable manner. Relevant to the discussion of these options, the plan states that "the council's housing policy (section VI of Volume IV, in pp 62-65, Art. 198) (...) should prevent the formation of large clusters of low-income population distant from the work places," and paragraph 1 of the same article explains that "the solution should point to projects included within the urban area, using open urban spaces belonging or not to the municipality."

13. Guidelines for revision of the land-use proposals for Paraty

The last section of this discussion will indicate some possible pathways for reversing the current observed trends, and is to be conceived of as a set of guidelines for the elaboration of the land-use proposals of the future Master Plan of Paraty. Although the latest Master Plan proposals presented by the Municipality of Paraty in 2010 have not been approved, they are hereby taken as a point of departure since they constitute, in practical terms, the instrumental basis on which the future Master Plan will be discussed. As it has been seen in the analysis of the land-use proposals of the 2010 Master Plan, the urban expansion area as proposed by this plan is a clear sign that flood prevention is not on the political agenda to date and the consequences of urban expansion on increased exposure to flooding are not sufficiently understood by decision makers. Moreover, the analysis undertaken in this study presents a substantial and rich body of evidence of the many vectors favoring unsustainable patterns of urban expansion. By attempting to satisfy the premises of all interests at play without further detailing or considering their environmental impact, the 2010 Master Plan, as well as the shallower version of 2006 (presently enforced according to Municipal authorities but expiring in 2016 according to the City Statute), resulted in a generic proposition of a large urban expansion area that is clearly out of touch with the real needs of the municipality. Against this background, the central issues that need to be reworked and equated are the definition of the new perimeter of urban expansion according to present and future needs, and a common understanding of the essential ecological functions that need to be protected from the inherent threats of expanding this perimeter toward the peri-urban floodplain on which the safety of Paraty's inhabitants depends.

The present study brings a whole new range of elements to this discussion, broadening both the understanding of the social, political, and economic dimensions of land-use change processes occurring in the study area, and the set of instruments for analyzing the hydrological functioning of the river basins where the city of Paraty is located. These elements may contribute to raising the quality of the debate as well as to helping parties discuss the conditions under which a broad common vision for the city may be constructed, with the development of a shared strategy for sustainable growth and the lowest costs and risks to its community in mind.

As it has been emphasized in the policy analysis, land-use decisions are marked by conflicting interests, which are sometimes difficult to resolve, requiring negotiation agreements among various stakeholders with apparently antagonistic views. The disconnect between private economic interests and growing social needs constitutes the core problem of the current trend of aggravating flood risks in Paraty, thereby presenting a key challenge in articulating these interests and assuring that essential ecosystem services are preserved. In fact, at both extremes of the social pyramid lies the solution to apparently antagonistic problems and interests of the various stakeholders. The core problem is indeed how to bring these conflicting interests together into a coherent development strategy that puts the public interest at the center of land-use decisions. This study shows that this is, at least potentially, possible by making use of the available instruments foreseen in the Brazilian legal framework. The appropriate use and articulation of these instruments needs to be found locally and materialized fundamentally by the planned allocation of urban land through the Municipal Master Plan.

Such an articulation may allow for the integration of economic interests with societal needs through binding agreements capable of assuring that all social segments of the population are integrated. Rather than imposing solutions, the hypothetical scenarios developed throughout the modeling exercise may be instrumental in attracting the key actors identified in this study, which would make it possible to explore the potential benefits of encouraging these actors to play a more constructive role in the production of the urban space by taking into account societal needs, ecological integrity, and economic efficiency. The development of such an approach involves a more proactive role from State institutions in regulating land uses, especially in regards to the preservation of essential ecosystem services on which the urban community depends, as well as *dynamically equalizing* supply and demand of urban land on each urban agglomerate within the municipality, thereby directing urban growth instead of running after the process of land-use change.

As previously discussed, the Municipal Government plays a fundamental role as mediator and arbitrator between private and collective interests by promoting their harmonization and resolving contradictions between different interests, perspectives, and contentions. State level institutions may also play a fundamental role when voluntary compliance is unlikely. This might often be the case with the adoption of land use-based flood mitigation measures, which may need to be granted by compulsory resolution (e.g. creation of Environmental Protection Areas, restriction of functional uses, etc.). It is in the delicate balance between this double role of government authorities (negotiation and enforcement) that key actors may be brought into agreement with a broader vision of future development of the city, making it possible to pursue win-win situations through the appropriate use of the legal instruments and fair negotiation of mutual advantages for all parties involved. The Master Plan is the medium for the operationalizing this role, which involves defining where urban development should be directed, under what conditions urban operations should be enforced, and, more importantly, what resources need to be preserved, as well as assuring the safeguard of socioecological functions whether through direct negotiation or by means of regulatory actions. This operationalizing requires the development of a methodological framework of action focused on a continuous cycle of activities valuation, integration, and compliance, hereafter summarized and structured in three core planning blocks:

The first set of activities should focus on scientific valuation. Reliable studies and accurate information capable of illuminating alternative solutions to business-as-usual practices are key elements for adapting land-use change processes according to social and ecological functions. Indeed, an element that is lacking is a good method for considering the full range of benefits provided by the ecosystems that could positively affect flood risk reduction. One of the problems that recurrently comes up in the literature is the difficulty of quantifying the real value of wetlands based on the ecological services that these ecosystems provide (see e.g. CHAN et al 2006; KUMAR and KUMAR, 2008; COKRANE, 2010). In fact, a rigorous, systematic methodology for valuing the full range of services provided by different wetland ecosystems has not yet been developed, opening up promising avenues for innovative research. It has been seen throughout this case that the lack of an objective, spatialized definition of collective and diffuse rights—and not just in subjective and normative terms—inevitably makes short-term, scattered interests prevail over the public good. In the absence of a concrete definition of the social and ecological functions of each particular urban setting, individual rights trump collective interests through highly fragmented decision making. It is clear then that social and ecological functional relationships across each watershed need to be not only properly identified at the local level, but also formally recognized and turned operational through Municipal Land Use Plans. The account of planning activities presented below is not intended to be exhaustive, but rather aims to emphasize some fundamental aspects for developing a land-use adaptation policy, all of which have not been covered in the diagnosis made in the 2010 Master Plan.

i) *demographic analysis* – Projections of population growth, including migration trends of population inside the municipality and between neighboring municipalities, are an essential preliminary step of planning activities. An accurate study of demographic trends should provide a solid basis for estimating present and future demands for housing and urban land for each urban area. Collection of available data on household income and other socioeconomic data are also important, with particular attention paid to the effects of these dynamics over time and space.

ii) *hydrodynamic modeling* – The mathematical modeling of all river basins subject to strong anthropogenic influence, such as the one developed in this study for the Perequê-Açu and Mateus Nunes river basins, is a powerful analytical tool for weighing hydrological costs and benefits of land-use options grounded in a solid scientific basis. Risks associated with land-use change processes involving soil sealing, landfilling, and modification of run-off and manning conditions should be quantified by evaluating externalities and possible compensation measures. Systematic mapping of geo-hazards (flooding and landslides) and other environmental risks should be systematically integrated into a GIS database.

iii) *ecosystem services valuation* – The assessment and valuation of a wide range of ecosystem services should provide a clear understanding of gains and benefits of possible flood mitigation measures, as well as identification of beneficiaries and providers of these services. Equal emphasis should be placed on values and benefits of preservation, as well as on the assessment of risks described above. A comprehensive evaluation of the ecosystem services makes it possible to develop consistency in the appropriate allocation of uses, as well as to study how these uses may contribute to the well-being of the population and help enrich the local economy. At a mature stage of evaluation, cost-benefit analyses of conversion and preservation may be developed considering economic, social, and environmental aspects.

The second set of planning activities should seek to unlock the material basis for developing major land-use adaptation strategies of the plan (both concerning the areas where urban growth should be directed, as well as key land resources to be preserved). This requires an adequate integration of planning, legislation, and urban management, with strong leadership of the Municipality and coordination by key State institutions. Preliminary negotiation processes should be undertaken with key actors for the definition of special arrangements in the form of Memorandums of Understanding (MoUs). Such MoUs need to be tailored to specific, locally-based situations, observing the information collected in the preliminary phases of development of the plan. At this stage, leadership and autonomy of coordinating actors is important in order to avoid interest-driven distortions and a return to clientelistic decision making. A variety of scenarios should be taken into account, and for each of these scenarios, win-win situations should be pursued by taking into account all parties involved, including land owners, entrepreneurs, and the public authorities responsible for urban development and environmental management within these areas (i.e. Municipality, INEA, and SEA (State Secretary for the Environment)). In the particular case of this study, the participation of State and even Federal levels of government should not be ruled out in setting up the terms of reference of such preliminary agreements, considering the special status of Paraty.

The third set of measures regards the feasibility of the plan. In order to effectively articulate the legal instruments foreseen in the City Statute and in the 2010 Master Plan[72], they need to be specifically linked to concrete urban operations. The adoption of a management policy of “stick and carrot” should be followed in order to bring the main strategies of the plan into agreement. Resorting to enforcement actions may be needed, especially in preventing the occupation of strategic conservation areas for flood mitigation granted by compulsory resolution.

More specifically, the above-mentioned instruments should be used in two main directions:

[72] The use of this instrument is mentioned in the 2010 Master Plan, without, however, specifying where and how it should be used.

- **The floodplain area of Jabaquara should be designated as a Special Urbanistic Interest Area** ("*Área de Especial Interesse Urbanístico"*). Within this area should be delimited specific project areas for associated urban operations as defined in Scenario E, especially concerning public spaces, services, and infrastructures. Land owners may be encouraged to comply with the resolutions determined by the plan by applying progressive taxing (IPTU progressivo) to AREA 1, enforcing its immediate infra-structuration and occupation. If a voluntary agreement is not possible, public authorities may consider the possibility of undoing the appropriation of the lands by compensating the land owner with public debt titles, as foreseen in the law (although this would require approval at the Federal level).

- **The floodplain area located upstream of the road BR-101, between the Mateus Nunes river and the road Paraty-Cunha, should be designated as an Environmental Preservation Area** (Area de Preservação Ambiental). The distribution of the construction potential of this area should be concentrated in the area defined in Scenario F, and, if necessary, to other areas determined by the plan through transferable development rights. Land uses in this area should be adapted to compatible functions such as recreation, sports, amenity, non-intrusive recreation, and the continuation of traditional and non-intensive agricultural activities. Land owners may be encouraged to comply with the resolutions determined by the plan by establishing tax benefits and payments for ecosystem services, especially concerning water-flow regulation functions such as storm water retention and infiltration.

The measures proposed above are based on the results of the modeling exercise, and are hereby specified for a more concrete understanding of the possible connections to be established between major land-use proposals to be established by the plan and the legal instruments that may assure its implementation. However, these are not prescriptive; they allow for specific adjustments while ensuring a minimum level of consistency for effectively mitigating flood impacts from future land-use changes in the city of Paraty.

The fourth set of measures, and eventually the most important and difficult, concerns the setting up of the institutional and organizational changes required for existing governance structures, since the elaboration and execution of the Master Plan requires political commitment across a wide range of agencies that may not traditionally have had the organizational culture to develop effective collaborative partnerships. Previous urban studies in Paraty have already advocated for “the need to create a web of institutional relationships within continuous collaborative processes towards common goals” (MUNHOZ, 2003). As it has been seen while analyzing the Brazilian legal framework, cooperation and coordination among sectors and agencies are supported by law and are formally stated in political guidelines and juridical norms. However, these normative principles are not actually enforced at the local level, while the various sectoral agencies at the state and federal levels often find more reasons not to cooperate. This reminds us that policy changes have to align with institutional changes (GRÖßLER, 2010), which requires the development of new institutional arrangements at all scales of governance and sectors and involves the active participation of various levels of government and various entities located outside of government structures. It also entails the establishment of appropriate coordination mechanisms between the internal structures of political organizations and the external relationships between government institutions and economic instances. Such a coordination can only be assured by both attributing specific coordinating roles and establishing agreements of cooperation. This is what ROLLING (1997) called the need for a soft system, i.e. a space or platform designed to facilitate learning among stakeholders, share knowledge, and establish channels of communication between various government sectors and levels of governance.

It is important to note that the development of an effective land-use adaptation strategy is not independent from broader policies for the regulation of the production of the urban space. These policies include a strong focus on monitoring and controlling land-use change processes, with more stringent prosecution of illegal land parceling, and the design of effective taxation systems, which would promote the adequate use of underutilized urban land. The organization and restructuring of property registry systems are also fundamental elements, requiring the development of an updated geo-referenced database and the simplification of bureaucratic procedures.

PART FIVE: ARGUMENT SYNTHESIS

14. Discussion

The empirical work yielded results in various interrelated dimensions, which now make it possible to go back to the question posed at the outset of this study: what, then, are the root causes that are contributing to the current trend of increasing exposure of urban communities to flooding? In the preceding two parts, answers to this question have been sought in two directions: one by analyzing political dimensions of land-use decision making, and the other by analyzing existing socioecological conflicts within the study area and evaluating the hydrological costs and benefits of various scenarios of land-use change. Three interrelated theses have been deduced from the analysis carried out: the first is that the territorial transformations that are contributing to the reproduction of flood vulnerabilities are the result of a specific dimension of inequality related to the lack of access to urban land, an inequality related to the modes of capital accumulation performed by the elites who dominate the means of production of the urban space and ultimately contribute to deepening socio-spatial disparities and increased flood risks; the second is that this specific dimension of inequality is fundamentally reflexive[73], because it continually refers to the very process of social change of the population at large, by which socioecological conflicts are reproduced in the fragmented actions of individuals, reinforcing the conditions of urban vulnerability in a self-destructive cycle; and the third is that this embeddedness and reflexive nature of inequality is not only a product of historical conditions, but is also part of a set of emerging ways of politically handling social and economic pressures as an expression of a problem of *governability*, which may eventually correspond to what I provisionally call a *governmentality of urban land*.

[73] Reflexivity is hereby understood in the sense defined by Beck (1999) as reflexive unawareness. In referring to this specific meaning, Beck claimed that new forms of inequality develop on the basis of the distribution of the unawareness of unintended consequences. It is within this type of reflexivity that occurs an individualization of social risk (Beck, 1999). This is exactly what is meant here by the reflexive nature of inequality and the role it plays on the reproduction of socioecological conflicts and ever-increasing flood risks.

It is argued that by furthering the understanding of the relationships between formal and informal processes of land-use change, the root causes of increasing exposure of urban communities to flooding may be understood at a deeper level. This problem will be unfolded by unmasking the interdependent relationship between these processes; identifying the various modes of regulation, deregulation, and legitimation dictated by economic agents and government institutions; and disclosing the multiform tactics of individuals and social groups involved in land-use change processes. In the following sections, each of these aspects will be analyzed separately, forming the argument that the land-use changes at the origin of the current trend of increasing exposure to flooding are the result of a non-explicit and tacitly accepted socioeconomic-political pact between the logics of economic capital, government institutions, and societal systems of representation, indicating that significant changes can only be achieved by means of a political process that is capable of producing an alternative rationale for transforming these logics. This analysis will be followed by the identification of the impediments hindering a more rational use of land resources and the necessary transformations for adapting land-use change dynamics to social and ecological functions of the city.

14.1. On the logics of capital

A striking finding of this analysis is that the conversion of land for urban expansion has been disproportionately higher than population growth, while population densities have generally decreased. Another trend found in this case, which is common to many other small and medium cities in Brazil, is the growing informality of land parceling and illegal occupation of peripheral areas, while the formal housing market remains exclusively directed to a privileged minority of investors. These findings suggest an interdependent relationship between the speculation of land markets and the growing informality of land parceling, through which the first can only be sustained by the reproduction of the second. Indeed, the links between formal and informal land-use change processes seem to be generally overlooked, pointing to a grave Gordian knot in the political debate about the right to affordable housing[74]. Symptomatically, this

[74] The problems associated with the existing housing programs in Brazil are not covered in more detail since to do justice to this crucial issue would require a whole research project in its own right. As such,

disregard also points to a blind spot in the perception of authors such as Reid (2015), who recently wrote that "*the gross inequality of access to land* bequeathed broader socio-economic inequality, but it *was far less relevant in the overwhelmingly urbanized society of the twenty-first century."* The findings of the present work are in clear opposition to this observation - in fact, it is precisely the shortage of urban land for a large majority of the population, and the consequent generalization of illegal land parceling and occupation of peripheral areas, that better explains the increasing vulnerabilities of urban communities to flooding. The lack of recognition of this crucial aspect by many policy makers is partly due to the more granular perception of migration flows to large metropolitan areas, which has decreased significantly during the last two decades, while the more complex migration dynamics within peri-urban spaces in between small and medium Brazilian cities is least understood. In this regard, Maricato (2006) notes that if there is an indicator that expresses in a synthesized way the critical dimension of urban problems in Brazil, it is the huge illegality that characterizes the unlawful occupation, invasion, and parceling of land. This phenomena, the author argues, makes it possible to state that the exception is now the rule and the rule has become the exception[75]. The present case corroborates this observation, where informal urbanization and the illegal subdivision of land increased at a very fast pace throughout the last decade, while a significant proportion of the population with growing acquisitive power[76] boosted a new

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there is no intention here to present an extensive summary of the shortcomings of existing housing programs in Brazil, but only to note a key problem that is more directly bound to the focus of this discussion: even though the philosophy behind Brazilian housing policies of delivering finished housing units may be seen as a viable solution in many situations, one must acknowledge that it will not be sufficient to eliminate the enormous shortages of urban land, not only for the poor, but for the population at large. According to the report of Fundação João Pinheiro (2015), the housing deficit in 2010 was of almost 7 million units (6 940 000), with about 2 million units lacking in the States of São Paulo and Rio de Janeiro (1.495 and 515, respectively). Although the right to affordable housing is considered an inalienable constitutional right recognized by Brazilian law since 2000 (Pioli et al, 2002) and reaffirmed by the City Statute, national housing policies in Brazil have been treated in isolation from social-spatial dimensions and environmental concerns, ignoring the risks of creating new social problems (for an evaluation of housing programmes in Brazil see Bonduki, 2008; Neto, Moreira and Schussel, 2012; Amore et al, 2015).

[75] According to the UNCHS' Habitat State of the World's Cities report, about 70% of new land parcels in Latin American Countries are undocumented.

[76] Research on social and economic indicators clearly indicates a massive betterment of the living conditions of Brazilian population during the last decade. According to IMPE, during the period of economic growth in Brazil between 2003 and 2010, inequality declined in monetary terms. About 20

wave of (sub)urbanization occurring in peripheral areas. Equally important is the consideration of how recently urbanized areas, which resulted from an initial phase of informal process of land subdivision, are making room for a new type of housing for various segments of the population. In this perspective, it is also important to note the changes in access to credit and the recent changes in the composition of capital invested in the real estate and construction sectors (Costa and Mendonça, 2010). In the surrounding areas of cities with strong attraction for tourism, such as Paraty, the more "ad-hoc" informal occupations and land subdivisions are likely to turn into new business opportunities for the formal market of urban land, as well as to open new areas for the construction of housing units promoted by realtors and small scale entrepreneurs. All of these concerning factors reflect different social dynamics and a high complexity, which brings a whole new urgency to the problems rooted in the scarcity of urban land for the local population.

The findings of the analysis carried out suggest that this chronic deficit of urban land gave rise to a characteristic mode of appropriation and transformation of natural resources, where suburbanization appears as the flipside of the coin of an economic model based on speculation of land markets directed to the elites at the cost of the segregation of a large portion of the population. As noted by Ribeiro and Cardoso (2003), the continual reproduction of inequalities in the urban space is sustained by land-use change dynamics of permanent expansion and fragmentation, which allow for the accommodation of social conflicts inherent to the process of urban growth. As it has been shown in this analysis, these dynamics of land-use change are particularly evident in Paraty, since its specific property regime resulted in the presence of large open spaces in peri-urban areas where the most appropriate locations for urban development are reserved for the maximization of profits in real-estate transactions. As a consequence, the poor are continuously pushed into the most vulnerable peripheral areas, resulting in serious environmental degradation and aggravation of flood risks.

Looking at the results of the spatial analysis together with the results presented in the last section of the policy analysis, it is possible to identify a number of links between

million Brazilian came out of extreme poverty and more than 12 million benefitted from direct cash transfers through the redistribution program Bolsa Familia.

the current trend of urban expansion and the speculation of land markets. As it has been seen, the imperative to maximize capital gains stimulates a market directed toward a minority of the society (in marketing jargon known as classes A and B), thereby mobilizing interests to economic groups and individuals seeking the maximization of rents for investors and property owners. On the other hand, a new type of smaller scale housing development is sprouting along recently urbanized areas, which have been originally subject to informal processes of land subdivision. As it has been noticed in other studies, these new developments (directed to a more varied range of segments of the population) are gradually being transformed by new desires of consumption, generating a demand dictated by the logic of the market (MENDONÇA and COSTA, 2008). Apparently, there is a duality inscribed in this process through which formal and informal processes interact for the reproduction of capital gains. How are such logics of speculation of land markets affecting the current trend of urban expansion? Indeed, there seems to exist a more intimate connection between the observed trends of urban expansion and the logics of buying and selling urban land, which together generate a self-reinforcing cycle: the shortage of available land close to the city causes the demand and price for that land to rise, thereby stimulating illegal parceling of environmentally-sensitive areas in the urban periphery that, in turn, are over-valued because of their comparison to price increases in the real-estate markets of the best located peri-urban floodplains.

Perhaps the most problematic issue here is the underutilization of strategic resources that should be used for satisfying social needs, while real estate operations artificially increase the price of urban land by turning it into a commodity of outstanding value. In this regard, Evans (2004) sets forward various arguments showing why the owners of land may want to keep their land undeveloped. This problem is aggravated by the interactions between these players in wider logics of investment and an increasingly globalised economy where the deterritorialization of capital allows new forms of capital accumulation. The fact that investors and property owners are no longer tied to a specific location allows for more flexibility in managing their portfolios to their best advantage. Throughout this process, property owners wait for rising land prices and simultaneously use their capital for other investments. This flexibility favors the extension of speculation strategies in time and space, enabling pfrroperty owners to hold underutilized land while waiting for higher returns. In the case analyzed here, this lack of motivation of land owners results not only in an overall inefficient land market, but also in a chronic land supply deficit for a large proportion of the population with growing acquisitive power.

The perverse effects of the influence of such logics lie in a classic economic problem of correlation between supply and demand: if the valorization of urban land depends on its scarcity, then prices tend to be distorted by a self-contained and self-regulated market by restraining alternatives for affordable urban land in adequate locations. As noted by Evans (2004), the key aspect to be understood within this problem is related to the supply of urban land, even though the speculative nature of the market is basically concerned with the demand of selected segments of society, which make possible the maximization of profit margins. This mercantile logic is dictated by a self-regulated market economy, which may be described, in the words of Bourdieu (1998), *as “*an economic thinking inclined to *take the things of logic for the logic of things.”* Ultimately, this logic contributes to the aggravation of housing deficits, while the needs of the larger proportion of the population are more or less fulfilled by informal processes of land-use change. As observed by Harris and Todaro (1970), it is the informal sector that absorbs the excess (of demand), and it is the informal sector that adjusts (to the lack of alternatives of affordable land). Especially in small land markets limited to a reduced number of players, the process of speculation of land markets is artificially sustained by the growing informality of land markets to the lower segments of society (the larger proportion of Brazilians within classes C, D, and E).

Within this dual economy composed by formal and informal land markets, the fragmentation and expansion of the urban space are the by-products of a symbiotic relationship between the two interrelated dynamics of segregation and suburbanization. In neoclassical economics, the flaws of economic systems are said to be market failures through which negative externalities are not internalized by market players. In fact, one of the biggest challenges for land-use change processes is related to the difficulty of internalizing positive and negative environmental externalities. Bardhan and Dayton-Johnson (2002) explain that such market failures result from the difficulties of cooperation between the various actors using a certain natural resource. However, such problems are better described as the “privatization of benefits, socialization of costs” (LIPSHUTZ and ROWE, 2005); in disagreement with the neoclassical point of view, these authors note that it is not necessarily the case that the markets “fail,” but rather it may be that market players have organized with the intention of socializing certain costs and realizing private benefits. Therefore, furthering the understanding of this socialization of costs is an essential step toward understanding the economic logics behind land-use change dynamics:

i) the speculation of land markets is, in itself, expansionist, since it can only be sustained by an ever-expanding consumption of natural resources. Such a model of expansion of urban space does not account for the inherent costs of expanding infrastructure and services, contributing to a fragmented, inefficient, and expensive urban infrastructure;

ii) the logics of economic growth do not account for the negative environmental externalities produced by the fragmented actions of each of the agents involved in land-use change processes, leading to an increasing spiral of social and ecological costs;

iii) when the societal needs for affordable urban land are not properly considered by formal land markets, informal occupation of the remnant areas (usually the most vulnerable to flooding) eliminates the possibility of mitigating the effects of new urbanizations through the adoption of flood mitigation measures; and

iv) a large informal economy imposes heavy costs that deteriorate services and public goods, contributing to the reproduction of spatial divides and social inequalities, while flood risks are continuously created and amplified. This is because the ecosystem services of previous natural conditions fail to be considered in unplanned urban operations, neglecting important economic, social, and ecological costs.

It is important to consider that the abovementioned factors are interrelated: if flood disasters hit harder the most vulnerable groups (in the sense that these are more exposed to environmental variability), these territorial transformations contribute to a spiral of costs in infrastructure and maintenance services, which affects the community as a whole since the financial burden of damages is ultimately paid by public expenditure. Moreover, public costs are not internalized by the agents but are accruing for the private benefits of these operations, since these can move from one location to another after each transaction and thus are not directly affected by the externalities.

14.2. On the logics of government

While the previous section attempted to show the interdependent relationships between formal and informal processes of land-use change within the logics of capital, attention will be now paid to the modes of institutionalization and legitimization in this dualism, which characterize the above-described land-use change dynamics. The general environment of contemporary Brazilian politics was summarized by Alvaro Fonseca, the owner of a real estate agency in São Paulo, in an interview to the journal *Piauí* (2008, *in* REID, 2015): "They can say what they like about Lula, but he's managing to balance like nobody else the bankers and the MST." This short statement sums up quite well the political compromises made by the Brazilian Government during the last ten years, which allowed for socio-political arrangements to be made in response to social demands of the lower segments of society, but ones with limited ability to intervene in critical sectors historically dominated by powerful economic interest groups. Indeed, it is significant that in the period of exceptional economic growth between 2006 and 2012, the Brazilian economy was marked by compromises between strong social subsidy policies and state-oriented capitalism, with credit market reforms stimulating mass consumption. According to Nobre (2010), the rudiments of a welfare state were grafted into "the heart of the corporate State"—or, if we prefer the words of Bordieau (1998), "into the demands of the owners of capital on their pursuit of maximum profit, *instituted as a mode of rationality"* (my emphasis). While these opinions may be controversial, it is widely agreed that historically, Brazil has never experienced a distribution of rent as it happened between the early 2000s and the following mandates, which was followed by an unprecedented openness of access to credit. However, there were no major changes in the rethinking of urban land redistribution policies or any acknowledgement of the need for state regulation in order to ensure access to urban land at affordable prices for the overall population. In this context, the unleashed consumption needs of a growing middle class with increasing acquisitive power turned into a socioecologically explosive issue, which was aggravated by the lack of control of land-use change processes occurring at a very fast pace because of the general complicity of local governments.

Considering this more general socio-political context, it is reasonable to argue that the reproduction of socioecological conflicts such as the ones analysed throughout this study are not only tied up with a long history of domination of natural resources by the ruling elites, but also by the incapacity of the state to aggregate the fragmented demands of individuals and social groups into broader collective goals. In between the process of social change, together with the speculation of urban land, the State is never a neutral element, and is permanently tensioned between the growing needs for urban land at its weakest side and the imperatives of capital accumulation at its strongest. Amidst these conflicting interests at play, the state can be described as an *institutional ensemble* whose structure positions the various agents in certain ways, allowing them to exercise power but also to exercise bias in favor of some projects and against others (JOSEPH, 2012). The key question that stands out from the analysis of this case is how to unlock the capacity of this institutional ensemble by defining and defending broader public interests concerning the safety and well-being of urban communities in order to move beyond merely satisfying particular projects. But this would require that the state assumes responsibility over the production of the urban space by developing adaptive and creative capacities for public administration and by making use of the legal instruments at its disposal for the formulation and execution of long-term strategies for urban land planning and management.

Despite the highly disputed and ideologically-influenced discussions concerning the administrative reforms promoted by the Brazilian government throughout the last decades, it is fairly agreed upon in the literature on urban reform that, while the administrative control over (both rural and urban) land has historically privileged the land owners[77] (MARTINS FILHO, 1996), successive political governments are unwilling to extend their action toward a more interventional role of the State on urban land markets. As noted by Grau (1998), the failed attempts to eradicate the corporatist and even

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[77] The privileges holded by the rulling elites on the State apparatus is not a novel finding, reporting to a rich body of literature on social science which analyses at great length the complementarity between patrimonialism (FAORO, 1958) and clientelism (GALJART 1965), the relationships between clientelism and corporativism (KAUFMAN, 1977), and the compromises between elites and the bureaucratic apparatus (URICOECHEA 1978; DINIZ, 1986). The thesis developed by Raymundo Faoro (1958) exposes the origins of Brazilian patrimonialism (originally developed by Max Weber), characterized by the relation between the concentration of property, economic power and political power. Faoro's emphasizes the colonial origins of concentration of land property in Brazil, explaining how the instrumentalisation of the State generates an overwhelming bureaucracy designed for self-serving purposes, through which private interests "colonize" the centres of decision within the State apparatus.

patrimonialist characteristics of the public administration may be explained by its self-referenced and instrumental focus that the administrative reform adopted in the 1950s and 1960s, evincing the conditions the so-called “State-centered matrix” imposes on its apparatus and its relationships with society. This has been particularly noticeable in the analysis of this case where State institutions (as well as federal institutions represented at the State and local levels) still present signs of strong path-dependency from the more compartmentalized views of the inherited heavy bureaucratic apparatuses, which creates problems of coordination and limits opportunities for joint action in urban land matters.

In Rio de Janeiro, the Government of Leonel Brizola was an exception in the Brazilian political landscape, who advocated for an ambitious urban reform plan, that has never been implemented. His political campaign in 1981 centered on the slogan “each family one plot,” with the goal of settling one million families in the existing empty plots of the Metropolitan Region of Rio de Janeiro (RIBEIRO, 2003). The unsuccessful developments of this plan demonstrate that the most critical impediment to a more intervenient role of the State is at the Federal level. Still under the Military Regime, it has been submitted to the National Congress a draft project along the lines of the one proposed by Brizola for making a bill on urban development. However, the proceduring of the project in Congress was very slow, passing through successive amendments and changes. According to Ribeiro (2003), this process has been marked by the lack of parliamentary engagement and political will, despite the intense mobilization in support of this project by NGOs, professional associations, and social leaderships. The reasons for the unsuccessful outcomes of this bill are not yet clear. But further evidence of the lack of political will and parliamentary engagement in promoting land reform can be confirmed by the difficulties faced during the last fifteen years in revising the Federal Law 6766/79, which regulates land parceling operations[78] under the yet to be revised criteria of productivity of rural land (dated from the mid 1970s) and the pressures exerted by the agrobusiness lobby during the revision of the New Forest Code.

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[78] For a discussion of the Bill 3.057/00 developed by the Urban Development Commission of the Federal Council, see Gouvea and Ribeiro, 2006.

Since the 1990s, the patterns of exclusion of a large proportion of the population from regular practices of land tenure have been regarded by the public administration as a problem to be resolved essentially by improving the managerial capacity of government institutions (e.g. legalization of informal settlements), and by developing a new model of environmental management based on the New Public Management Model[79], which uses tools and practices of the private sector. From the perspective of decentralization reform, the emphasis is placed on the devolution of responsibilities to the local level of governance, focusing on widening spaces of direct representation and shared responsibilities (see GRAU, 1998). These have been also the general assumptions of decentralization, whose broad lines of institutional reform were defined with the 1988 Constitution. Reinforced autonomies were attributed to Municipal governments with the Complementary Law 140/2011, which attributes competencies to the three levels of government for environmental licensing. Yet, the analysis of this case presents a rich body of evidence of the shortcomings that Brazilian Municipalities (especially in territories with jurisdiction over small cities) face, regarding both its limited technical capacity and political will to intervene in areas with high political costs such as the ones related to urban land. The most sensitive issues concerning access to urban land for the population at large are usually left aside for their political complexity and long-term implementation character. This analysis also reveals that one of the main constraints for public authorities to incorporate concerns about urban flooding in their political agenda is due to the influence of organized economic groups, whose main concern is to maximize profits in the short term, while the local level of decision making is often too beholden to the interests of the *status quo*.

While the huge inequalities regarding the access to urban land have been puzzlingly ignored by successive governments, the conflicting interests regarding land use are so ubiquitous and stimulated by so many influences that often is claimed to constitute a problem to "governability." This problem of governability, referred to by mainstream politicians as a vital need of the State[80] has to do, on one hand, with the

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[79] The adaptation of the New Public Management model to the Brazilian context has been formulated by Bresser-Pereira (1998) in his book *Reforma do Estado e Cidadania*.

[80] The problem of governability is often used as a buzzword by mainstream politics in Brazil, particularly by the Brazilian Democratic Movement Party (PMDB).

domination of economic instances on government instances, within the conditions imposed by political actors by the mechanics of electoral cycles; and on the other hand, with the permanent need of the State to ease up social pressures and demands by running after the process through which people search for practical responses to living at the urban periphery. As exposed in the previous section, the legitimation of unlawful operations of land parceling are the necessary counterpart to maintaining speculative activities over land resources, through which both are taken as given facts of a certain culture of production of the urban space. These observations may be useful for explaining why the above-described dynamics of land use are not totally inconvenienced by the State, lending an ambivalence to government institutions. The analysis of the present case confirms that public institutions are subject to multiple and contradictory influences from micro to macro levels of governance, which render an ambivalent role for government agencies. This ambivalence confirms previous observations that certain governance patterns undermine themselves by inducing changes that affect their own working (VOß and KEMP, unpublished manuscript). Discussions on reflexive governance take account of these unintended consequences (VOß *et al.* 2006), highlighting the endogenous nature of steering political actors (RIP 2006). These observations may have their meaning more specifically directed to the focus of this study by elucidating how private interests are co-opted by State institutions, ultimately jeopardizing the regulation of key aspects of urban land governance.

The analysis of this case suggests that the tensions between economic interests and the pressing needs for urban land resulted in a non-explicit social pact through which the interests of both extremes of the social pyramid are more or less satisfied by a hybrid solution to the problem of inequality—a hybrid solution composed of formal and informal processes of appropriation and transformation of the territory. This social pact allows that both the ruling elites and the population at large incrementally achieve their goals through individualized tactics of division and subdivision of the territory. The rules of this social pact may never have been explicitly stated: they are tacitly accepted and recognized by all agents participating in land-use change processes and practically legitimated through the actions and non-actions of the State. Lending support to this thesis, it has been observed that the increasing number of illegal urban operations in more peripheral areas along river banks and other vulnerable areas did not make room for tightening regulations—if anything, they have been relaxed, in a general decline of mechanisms of land-use control and regulation. It is interesting to note how "business as usual" practices and "laissez-faire" politics reinforce each other in a self-destructive cycle, while, at the same time, work against the integration of society and economy by state regulation. For example, it has been observed in the course of the empirical study that elites with strong influence on decision-making processes often make use of a veto power over key land-use decisions. The exercise of this power of "*decision not to make a decision"* (BACHRACH and BARATZ, 1962) is also a very effective way of legitimizing unlawful practices, such as the systematic illegality and the generalized relaxation of norms observed in this case. As Gordon (1991) notes, "laissez-faire" politics is a way of acting, as a way of not acting. It implies, in Foucault's words, an injunction "not to impede the course of things but to ensure the play of natural and necessary modes of regulation, to make regulations which permit natural regulation to operate": "*manipuler, susciter, faciliter, laissez-faire.*"[81] The permissive meaning of laissez-faire needs to be understood in an activist, enabling sense, no less than in its character of passive abstentionism (in BURCHELL *et al* 1991).

In the absence of *ex ante* solutions to increasing needs for affordable land for the majority of the population, local governments run behind the process of urban expansion by legalizing new, informally subdivided areas. The tolerance of government institutions with respect to the illegal occupation of lands is also a reflex of the absence of effective policies to facilitate access to urban land for lower income groups. As it has been noted earlier, the Statute of the City and the Brazilian Constitution affirm the State's responsibility to ensure rights of access to urban land and to move progressively toward these goals. By failing to ensure access to affordable urban land for the population at large, a number of ethical problems may be raised concerning the obligations of the government in face of its fundamental duties. While pushing for the regularization of land tenure is in itself a desirable goal, it is not a sufficient response to the enormous deficits of urban land for the lower segments of the population, and ends up fostering illegality by stimulating the continuation of irregular and costly practices.

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[81] Lecture of Michel Foucault at College de France, 5th of April 1978.

The passive disregard of environmental norms and urban regulations is not only observable in the widespread informality, but also in the existent housing programs in Brazil. As noted by Araújo and Costa (2012), these follow a more permissive modality of licensing, putting these urban operations above the mechanisms of urban and environmental control currently in force with consequences yet to be fully evaluated[82]. Equally important counterproductive factors as the already-mentioned relaxation of restrictions and overregulation of formal processes of land parceling constitutes an impediment for lawful acquisition of urban land, making it too expensive for the population at large to acquire a piece of serviced land via the formal market. Impositions by municipal and federal laws limiting the minimum size of the parcel of land may turn urban lots provided by the formal market unaffordable to anyone below a certain income range. Moreover, by defining special reduced lot sizes for low-income residential areas, such laws are themselves deliberately discriminative, contributing to the furthering of socio-spatial divides. This sort of standard can thus be used precisely toward the opposite end, contributing to the reproduction of socio-spatial asymmetries through institutionalized modes of segregation.

Finally, in regards to the logics of government, it is important to consider that while there is a growing recognition of the need to establish cooperation among various agencies and sectors, the analysis of this case has shown that rather often, government institutions find more reasons not to cooperate. Co-management initiatives are increasing in Brazil, but State agencies generally lack the capacity, and sometimes the will, to successfully promote co-management arrangements and share decisions (ROCHA and PIKERTON, 2015). The difficulty of reconciling different sectoral views is particularly noticeable in the lack of integration between water management and land-use planning. This has been confirmed in the present study, where institutional and organizational problems have been identified at all levels of government and across various sectors. Indeed, the integration of different sectoral perspectives is a difficult endeavor, since most initiatives to promote coordination and cooperation among sectors face a number of endemic challenges due to specific complexities in each public policy area

[82] Recent evaluations of the housing program "Minha Casa Minha Vida" can be found in Amore et al 2015.

(WOJCIECHOWSKI 2009). As noted in previous studies, Miguez *et al* (2014), "the most complex task of the agenda of public managers really committed to build a sustainable future for cities refers to promote the integration of public policies concerning water resources, sanitation and urban land-use."

14.3. On the logics of society

Perhaps the most influential social hegemonic belief in contemporary studies of urban policy is that more sustainable patterns of social development may be driven by strengthening the participation of a wide network of civil society organizations, which supposedly would assure that the interests of the population are properly considered in decision-making processes. While this is unobjectionable enough, it is important to note that the communicative process concerning environmental affairs is inherently limited, among other things, by a complex array of social forces (VENTRISS and KUENTZEL, 2005). As noted by Grau, the hegemonic political narrative, as it has been broadly recognized, is fundamentally a story that not only attempts to uphold that all political power is public, but also that refers to the abstract notion of citizenship in its reference to the social public. Historically, however, the politically relevant sphere for effect of the exercise of public function was basically economic from the private property owners.

In Brazil, after the reforms promoted in the mid 1990s by the Ministry of Administration and Public Reform for implementing the New Public Management Model, the Societal Model of Public Administration[83] (*Administração Publica Societal)*[84] has been advocated by successive governments throughout the last fifteen years, and encouraging results based on successful experiences of participatory budgeting have been widely discussed in academia. However, there seems to be a strong expectation for

[83] The Societal Model of Public Administration has been advocated by intellectual circles since early mobilizations of the civil society during the Military Regime, but has been more strongly emphasized since the first Government of Lula da Silva. This model must be seen in the Brazilian context as a complementary model of public administration to the New Public Management model (Administração Pública Gerencial) promoted by Bresser-Pereira in the second Government of Fernando Henrique Cardoso. For a comparative analysis of the Brazilian models of New Public Management and the Societal Model of Public Administration, see Paula, 2005.

participation alone to resolve the actual deficiencies of the public administration, as if it would be a substitute to other important institutional weaknesses when it comes to environmental management and urban planning. In this case, the observation of deliberative processes has shown that existent practices of public participation have many pitfalls concerning the defense of diffuse and collective interests such as flood mitigation. Rather often, local communities are unable to negotiate any kind of cooperation whatsoever, or they reach an accord that nevertheless leads to environmental degradation. For instance, a community may have no incentive to provide flood mitigation services unless there is compensation or an agreement among beneficiaries and providers. As a consequence, a catchment subject to urban pressures tends to increase development in floodplain areas, which in turn leads to increased infrastructure needs and reluctance to undertake flood mitigation measures.

Examining land-use decisions in the specific politico-cultural setting of Paraty allowed for the identification of the difficulties of citizens and their governance structures in securing the preservation of ecosystem services on which the security of this community depends. It is therefore important to recognize that the realization of open discussions and the widening of public participation processes is not enough to make prevail the public good, raising a problem which too often goes unexamined within the dominant, traditional debate on society's political self-organization. To put it bluntly, it is neither realistic nor reasonable to believe that the participation of the various stakeholders involved in land-use decisions will ensure the prevalence of common goals beyond the horizon of the interests these social groups embrace, which are not necessarily those of the whole society. As it has been observed throughout this study, the main concern of each of the actors involved in land-use decisions is to use their influence to benefit the socio-economic groups they represent, making deliberation processes around land-use decisions highly constrained by many entangled interests. Moreover, the autonomy of social leaders and civil society organizations is affected by their economic dependency on financing sources, personal linkages with specific interests, and involvement with political structures of government. Such constraints often result in a general difficulty to resolve contradictions between different priorities and antagonistic views, and therefore the mitigation of flood risks is rarely prioritized.

Another problem of overreliance on participatory methods for the purpose of adopting preventive measures based on the adaptation of land uses is that such measures aimed at the reduction of flood risks may not be popular among the various social and economic groups directly affected by these measures. The conservation of floodplains, for example, is often seen as a constraint to the local economy by individuals with high stakes in land-use decisions, as well as by municipal officials and other influential groups. On the other hand, the vulnerability of urban communities to flooding may constitute less urgent concerns than the immediate satisfaction of the particular demands of specific social groups, even if the fragmented actions of local actors to these problems may involve high environmental costs in the long run.

Among a number of unresolved problems of current practices of "participatory planning," it is important to evaluate under what conditions social actors are called to participate in the deliberation of land-use decisions. Asymmetries in social representation, lack of conditions for exercising influence on land-use decisions, and the generalized low-level of the political debate often undermine fair deliberation and decision making. In the absence of appropriate information for evaluating different land-use options, the public debate may be undermined by what Habermas (1970) has called a "systematically distorted communication," referring to situations in which the communicative abilities of the actors involved in a certain socio-political context do not allow for the mutual understanding of common problems. The analysis of the participatory process of the Master Plan of Paraty conducted by Matos (2011) presents a rich body of evidence regarding the shortcomings of existent platforms of participation in this particular case, showing varying degrees of arbitrariness or manipulability of public deliberation processes. This problem has been recurrently found in the field work of this study, showing that when land-use decisions are so closely coupled with local politics, the complex array of conflicting interests around land-use change processes is not easily contained. The findings yielded during the follow-up of the monthly City Council meetings during the period of the field work demonstrate that existing practices of interaction between the Municipality and the civil society in Paraty are better described as forms of publicity for institutionally-fabricated information, than as true spaces of public deliberation free from interest-driven distortions.

Exposing the difficulties of participation and examining the pitfalls of existent spaces of public debate does not mean they are useless or rendered meaningless. On the contrary, the participation of civil society in land-use decisions is critical for identifying conflicting interests, their possible voluntary social agreement, and the eventual capacity for joint action. But if the participation of the various actors is considered only from an individualistic point of view, it can be regarded as a socially-embedded practice of legitimation of particularized interests. In order to avoid such unintended consequences and distortions of participatory planning, the organized sectors of society have the enormous responsibility of playing a decisive role in setting into motion opportunities for promoting concerted actions to the population as a whole. As noted by Arendt (1960), the organization of active citizenry capable of collective action can be used against the state apparatus by exerting a growing influence on bureaucratically-alienated representative powers and forcing these powers to take adequate account of societal interests. But collective action requires that these organized forces move from the mere defense of particular interests to a broader construction of shared political agendas, where common ground can pave the way for collective action. As Dantas (2008) notes, such a participation, even if inclusive of all forces, will never be effective if the practical, institutional, and organizational forms of political struggle remain defensively confined to the objective and subjective limits of the rules imposed by each player.

What is actually needed, is the overcoming of such defensive forms by "discussing the conditions for establishing mediation instances related with the bureaucratic apparatus, which may be capable of giving a public character to governmental policies and assure the public responsibility of its execution" (GRAU, 1998). However in practice, beyond the already-mentioned and well-documented experiences of participatory budgeting, with its undisputable merits for bringing more transparency to the allocation of public resources, there are few municipalities in Brazil where proposals for urban and housing policy are worked out together with Municipal administrations. Building an effective culture of participation, and not simply a process of pre-established political decisions, will require strong political will for changing the traditional concept of urban management and the engagement of organized sectors of society on ex ante political action instead of running after the always emergent priorities of particular social groups.

15. Conclusions

This thesis began by conceptualizing land-use adaptation as the organizing principle of a public policy specifically designed for curbing the current trend of increasing exposure of urban communities to flood risks. The definition of flood mitigation as a socioecological function has been used as a strategic entry point for giving legitimacy to this urban policy, thereby bringing the Brazilian Constitutional principle of the Social Function of Property to the center of its normative basis. The possibility of quantifying hydrological costs and benefits of land-use changes can provide new grounds for the politicization of land-use decisions, emphasizing the need for a more effective role of the State in regulating the production of the urban space. The particular importance of considering water-flow regulation services as an overarching criteria to be systematically introduced in the definition of socio-natural functions lies in their objectivity, in the sense that such ecosystem services are measurable and, as far as scientific prognostication can be, mathematically exact. As such, they introduce an element of mensurability in what is by definition incommensurable—that is the "public good"—which is in itself composed of many diffuse and common interests. Notwithstanding, the focus on the mitigation of flood risks should not overshadow the fact that land-use decisions involve many other factors that need to be taken into account. Land-use adaptation has to be multi-directional rather than single-focused, even if the impact on flood risks is an increasingly important factor to take into account in land-use decisions.

Adapting land-use change dynamics according to the socioecological functions of a given landscape unit is not limited to the "scientific assessment of the ecological importance of a property's assets to identify what parts of a property should be protected and restored and how the remainder should be developed in a manner compatible with the protection of these assets" (PEJCHAR et al, 2007). More than that, it is essentially a problem of ethically resolving socioecological conflicts by sharing and potentiating existing resources (SEN, 2014). As this study attempted to show, these conflicts are not only inextricably bound to each other, but are also tied up with specific institutional conditions and particular economic circumstances. These various dimensions of the problem of urban flooding are interrelated and need to be examined from an interdisciplinary and integrative perspective, enlarging the scientific focus from mere avoidance of risks to the positive possibilities of integrating urban development with the necessary protection and enhancement of key ecosystem services.

Land use adaptation in urban environments requires a profound transformation of the relationships between the state, the society at large, and the owners of economic capital participating in the production of the urban space. An obvious outcome of this study is that there is no way of talking about adaptation of urban communities to climate-related risks (in this instance, to flood risks) without an effective regulation on the necessary flows of land for urban development, as well as the safeguard of essential ecosystem services on which urban communities depend. Land has to be amply available, affordable, and accessible to all, while strategic resources for flood mitigation need more forceful means to protect specific ecosystem services of high socioecological value from depredatory practices. This requires the mediation and regulation of the State for assuring not only the right balance between supply and demand of urban land, but also the appropriate location of supply. While these constitute the basic ingredients for the effective mitigation of and adaptation to the current trend of increasing exposure to flood risks, eliminating the shortages of urban land involves perhaps some of the most difficult sets of problems to be addressed in the public domain.

During this study, a number of observations have been made that help to explain some of the impediments to changing the current trend of urban expansion and growing flood vulnerabilities. Some features have been identified in developing the argument of the presence of a dual economy regarding the provision of urban land. This study evinces that the logics of economic capital assume a dominant role, characterized by oligopolistic structures of influence that exercise hegemony over land-use decisions. It has been also possible to show how these logics are related to the shortages of urban land and, more importantly, to broaden our understanding of its interdependent relationship to informal land markets. The identification of symbiotic relationships between formal and informal processes of land subdivision and construction is useful for understanding how partial solutions to the governability problem of the State are combined, whereas political power is dependent on assuring the continuity of established structures of economic reproduction. These interdependencies explain why a more interventionist role of the state in assuring sufficient flows of urban land for the overall population has barely been taken as a serious political compromise by successive democratic governments in Brazil.

As it has been shown throughout the empirical study, the logics of appropriation and transformation of the territory are manifold, and the State is itself a socioecological player that develops rationalities and techniques to handle economic interests and social pressures. By discerning the logics of economic capital, the logics of state institutions, and the logics of societal systems of participation, I have intended to show that there is a general complicity between a certain model of economic production and government institutions, and this complicity is matched by the satisfaction of social expectations by the practical legitimation of informal parceling and illegal occupation of land. The rules and conditions imposed by state institutions in turn, shape the fragmented responses of individuals, which in turn reflect the wider process of social change by continuously creating new socioecological conflicts. As such, the vulnerability of urban communities to flood risks is not only socially and economically constructed, but also legitimized by a non-explicit social pact involving the logics of territorial transformation both from above and below the social pyramid in an interdependent relationship. In fact, the first is the consequence of the second, and the second is reflected through the first, whereas the voluntary subordination of the population to the hegemonic influence of private pressure groups involved in land-use change processes plays an important role in expanding and distributing flood risks. This complicity is configured by a set of practices of governance, expressed in the micro-scale of territorial transformations, where economic, social, and political logics of different social groups are *governmentalized,* by which the process of continuous depredation of natural resources is transformed in *raison d'État.* I have described these logics as the shaping elements of a *governmentality of the urban land*. Based on the findings directly extracted from this study, it is this specific mode of governmentality that best captures the social, economic, and political dimensions of this emergent mode of appropriation of nature, which is both the cause and the effect of socioecological conflicts and environmental vulnerability. However, the validity of this hypothesis cannot be conclusively proven at a more general level, requiring more comparative studies to confirm or deny further generalization of these findings. In order to advance in this direction, future research could investigate more into the methodological framework presented in this study in similar socio-economic contexts.

The findings of the present work are at odds with common criticisms found in political science literature concerning some connotations of Foucauldian-informed, poststructural accounts of governmentality. Generally, these criticisms are more concerned with the way some scholars have used the issues opened up by Foucault in the intellectual field for their own purposes than for the concepts themselves, as is clearly the case with the appropriation of these concepts by neoliberal thinking. It is interesting to note that such criticisms often acknowledge the relevance of the concept, while attempting to identify the boundaries of its usefulness in political science. For example, Ioris (2014) argues that governmentality certainly offers a valuable contribution to understanding core aspects of state practices and socioecological politics, yet fails to address the wider interconnections between the socioeconomic relations and the class allegiances that form the entirety of state politico-ecological commitments. This may be true in the sense that governmentality should not be isolated from deep-sociological theory such as the neo-Gramscian notions of hegemony. As noted by Joseph, governmentality and hegemony are overlapping aspects of the social whole, where the first provides an element of tangibility to the second, showing the ways by which hegemony is enacted and reproduced.

The findings of this case-study confirm that a more detailed investigation of the complementary nature of these concepts may be particularly useful for better understanding land-use change dynamics, which may potentially provide a more critical account of urban governance, showing the mechanisms which undermine the possibilities for a more rational use of urban land. In fact, the debate around the role of the State on assuring essential needs in key sectors of urban policy in Brazil has often been polarized between, on one side, the emphasis on the inefficiencies of the Government in redistributing social goods and delivering basic services, and on the other side, the denouncement that such social critique has been appropriated by neoliberal thinking in order to advocate for a minimalistic State through the generalized privatization of public services, the depoliticization of urban issues, and the reduction of public spending. The crux of the ideological debate is the liberalization of the market in opposition to a more interventive State, when in fact what is occurring is the domination of the logics of capital at the heart of the State apparatus, where self-contained structures of influence impose bottlenecks in land markets for obtaining higher margins of profit.

Rather than democraticizing the access to the urban space, the State assumes a central position on the reproduction of socioecological conflicts wether by over-regulating land-use change processes or by relaxing norms and control mechanisms, while an increasingly disaggregated multitude of informal networks constantly adjust to the changing wider balance of power. Understanding the back and forward of logics of appropriation and transformation of the urban land from an within the State requires an investigation of the social and historical reasons in Brazil for the lack of political mobilization towards urban land reform, the dissociation of housing policies from spatial and environmental aspects, and the overreliance on the construction and extractive sector, among other powerful lobbyes, for securing economic growth. Considering this wider picture, no single theory can fully explain the problems that are behind the current systemic crisis of Brazil today, and it is more and more necessary to creatively combine a wide range of analytical lenses if one wishes to identify some of its root causes. This could be an interesting approach for further research, possibly offering novel perspectives on existing concepts from a heterodox use of social theory for explaining problems of natural science.

Certainly, there is much more to the suggestion of a governmentality of urban land than the merely tautological problem of governability. A number of concluding remarks for bringing the concept of governmentality to the debate on land-use adaptation may be pointed out, and its validity and usefulness may be more easily grasped in opposition to the notion of governability. While governmentality highlights the manipulative nature of self-contained and auto-regulated economic structures of production of the urban space, governability limits itself to explaining the constraints imposed by such logics; where governmentality makes effective understanding of the government mechanisms for maintaining the status-quo, governability tends to legitimize these mechanisms as part of *realpolitik*; and while governmentality captures societal logics of participation as part of a political technology for governing populations, governability ignores that the representation of the interests of specific social groups does not necessarily lead to the definition of vital interests for the society as a whole. In short, where governability is reflexive (in the sense that it reflects a certain mode of handling political problems subjugated to the logics of capital), governmentality is reflective (in the sense that it invites reflection upon the way these problems are handled, demystifying its rationalities, thus offering more prospects for its transformation).

The importance given here to the distinction between governmentality and governability is justified by a fundamental problem: this distinction can lead to very different perspectives on adaptation. If it is possible to talk of a governmentality of urban land, even if in a fragmentary fashion or as part of a wider picture, then it becomes clear that an important component of institutional transformation is necessary if one wishes to better adapt urban structures to the socionatural features of a given territory and its population. By characterizing the logics that are behind ongoing land-use change dynamics, transformative adaptation gains a stronger theoretical relevance that focuses on broadening an understanding of what needs to be transformed in order to promote adaptation. On the other hand, the political and academic discourse on governability may have very sweeping implications on the interpretation of adaptation theories from a conformist standpoint. This standpoint contributes to the belief that the critical problems of urban land that have been chronically left behind have limited scope for practical application, because of its potential for conflicting with hegemonic structures of influence. On the other hand, it may lead to the conclusion that human societies are meant to be adapted to their institutional settings and bureaucratic apparatuses in a manner that is convenient to the calculations of key-decision makers, instead of understanding these as transitory modes of organization subject to the prejudices of sedimented self-serving practices that ultimately undermine the possibilities of social change.

It is possible that the relationships established between the logics of territorial transformation identified in this case are evolving faster than may be supposed into new forms of domination, and what has been portrayed here may correspond to a critical momentum resulting from a particular combination of social change and economic growth within a given period of time. It may also be the case that such conditions will change in the near future in the specific context of Brazil. The current political crisis that the country is living, the slowdown of Brazilian economy, the prospects of an aging population, as well as emergent dynamics of economic agents operating in land markets and the construction business, will certainly alter the conditions under which urban flood vulnerabilities will increase in greater or lesser degree. Indeed, there is no one single set of logics affecting land-use change processes, but a dynamic and evolving socio-political context that may be more or less transformed depending on the conditions of possible resistance to dominant destructive practices.

It remains a task for further research for debating the usefulness of the concepts used in the present work for studying land-use change dynamics, evaluating their explanatory power for understanding issues of environmental risk, social vulnerability and soecological conflict, as well as to reach the limit of their explanations for clarifying their root causes. As far as this research has gone, the theoretical framework explored in this study has proven to be useful for framing the various analysed aspects of land-use change processes and related decision making. In fact, by focusing on the logics of economic capital, the logics of government, and the logics of society, it was possible to highlight the specific use that can be made of mechanisms of legitimization of informal practices (of land subdivision and construction) and helps to understand how problems of governability are both connected to micro-politics that encourage individualized, fragmented responses to social demands, as well as to the macro-level of policy making.

Less controversial is the conclusion that the various logics of the agents participating in land-use change dynamics, being the logics of capital, the logics of government and the logics of society, are all together contributing to a self-destructive cycle of depredation of socionatural goods and an increasing exposure to geohazards, generating environmental degradation, entropy of ecosystemic functions, and flood disasters. It should be noted that the prerogative of the state on licencing land parcellment operations and other relevant activities concerning the production of the urban space, is grounded on the police power of the state to combat public calamities. As it has been noted in the policy analysis, it is this power-duty of the State that underlines the social function of property, giving the obligation to the State to assure the safety and wellbeing of urban communities through responsive policies and land market regulation.

At the heart of these questions lies the current lack of definition of common and diffuse interests by local, regional, national, and even global levels of governance. Such a recognition requires among other things, to overcome the traditional debate based on the confrontation of diverging interests (from different social classes to national interests), towards the defense of essential ecosystem services from which urban communities depend. The ideological dichotomies which characterize much of the theoretical discourses on inequality, needs to be superseded through an objective understanding of the fragility of the ecosystems that we are part of, and which are a matter of concern for the society as a whole. The lack of definition of the public interest leads not only to the progressive diminishment of important ecosystem services, but also for the underutilization of strategic resources for meeting social needs. The recent advances in

Brazilian legislation and the renovated compromises of the Brazilian government in adapting cities to climate related risks, open up new possibilities for introducing significant changes in the governance of land and water, offering niches of opportunity which have the potential to enable the emergency of a growing mobilization of knowledge for preventing negative externalities of “business as ususal practices”. Yet, the possibilities cannot become practical realities without the cooperation of key government institutions, various non-state actors, and the landowners themselves. If it must be unequivocal to public administrators that the public interest must prevail over the private when the two cannot be reconciled, it is also necessary to reckon that such conflicts cannot be systematically be solved by judicial coercive methods. The fundamental problem of land supply depends on landowner decisions, which may, to a large extent, lock or unlock the access to urban land. These decisions depend from the consideration of costs and benefits of urban operations, which in turn are conditioned by the constraints imposed and the possibilities opened up by economic agents and state institutions. These constraints and possibilities are not independent from the macro-scale of urban policy, requiring coordinated cross-sectoral policies which may determine the availability of land in appropriate locations for the community at large.

The case of Paraty, as a candidate city for World Human Heritage and containing unique cultural and ecological features, provides a clear example of both local and global common interest in halting the current trends toward unsustainable urban expansion. This case demonstrates how built capital and cultural heritage are created under economic conditions related to the transformation and appropriation of nature, but once the urban setting develops, it provides a new rationale to the use of surrounding landscapes. At a time of uncertainty regarding future changes caused by climatic factors, and at a time that a different and less materialistic set of values is most needed, adapting land-use to the Social Function of the Property and the City may be a viable way of curbing the current trend of increasing flood vulnerabilities, as well as promoting more equitable and sustainable cities.

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Annex 1: Carbon responsibility of the research

<u>Calculation of carbon footprint of research activities</u>

Values calculated at http://www.carbonfootprint.com/calculator.aspx

4 x Economy class direct return flight from Oporto to Rio **4.68 metric tons of CO2e**

3 x Economy class return flight from Oporto to Rio via NYC **5.77 metric tons of CO2e**

6 x Economy class return flight from Oporto to London **1.39 metric tons of CO2e**

Total Flights Footprint = 11.84 metric tons of CO2e

+ 16200 km travelled by bus Rio-Paraty-Rio

Total Bus Footprint = 1.76 metric tons of CO2e

TOTAL FOOTPRINT= 13,6 Metric Tons of CO2

Using the criteria of the Program of Carbon Compensation of LEPAC (5 trees/ton CO_{2e}) and according to the recommendations of WRI (World Resource Institute), a simple calculations was made:

<u>13,6 (Metric Tons) x 5 = 68 trees</u>

TOTAL TREES PLANTED (along the field work): 68 trees of the following species:

10 Palmito Juçara - *Euterpe edulis*

10 Copaíba - *Copaifera langsdorfii*

10 Pitanga - *Eugenia uniflora*

10 Guatambu - *Aspidosperma parviflorum*

5 Jequitiba Branco – *Cariniana estrellensis*

4 Guanandi – *Calophyllum brasiliensis*

6 Pau Brasil - *Caesalpinia echinata*

6 Pau Ferro - *Caesalpinia leiostachya*

4 Mangueira - *Mangifera indica*

1 Ingá Branco – *Inga laurina*

More information on forest restoration and environmental education activities promoted by the author along this research at **www.jogoverde.org**