2. Methodology

2.1 Knowledge-based design
2.2 Graduation planning
2.1 Knowledge-based design

2.1.1 Relationship between design and research

What is a scientific research?
Research is a systematic inquiry to describe, explain, predict and control the observed phenomenon. The most important thing of research is actually the thinking behind the research: What we really want to find out? How we build arguments about ideas and concepts? (Anglin, Ross, and Morrison, 1995).

Design as research
Gall, Borg and Gall (1996) proposed four types of knowledge that research contributed to education, including: Description, Prediction, Improvement, and Explanation (The last type research subsumes the other three). From this point of view, the knowledge-based design could be regarded as research, and the reasons could be listed as follow:

- Firstly, it is the goal-oriented interdisciplinary approach. It is stimulated by the general research questions which based upon design study;
- Secondly, it describes the phenomenon, predicts the consequences that “will occur at time Y from information at an earlier time X (Gall, Borg and Gall, 1996)”, and identifies the general principles (“Design research”);
- Thirdly, it explores the effectiveness of intervention. The research approach includes experimental design and evaluation research (“Research-by-design”).

2.1.2 The graduation project as a form of research combining research inquiry and design thinking

The general research question
“How can the integrated flood risk management improve the estuarine and agricultural ecosystem, and the spatial quality for the urban-rural fringe area of Dutch delta?”

Design research: Reliable scientific work
“Design research describes and analyses existing designs with a known context (De Jong and Van der Voordt, 2002).”
- Modes of research:
  - Literature review and comparative study in order to generate design tools, and it is also a way to evaluate study of the existing theories and project.
  - Aims:
    - Understanding the relationship between urban, rural and delta branches;
    - Figure out what is the problem of the current flood risk management and what is the integrated flood risk management (IFRM).

The design research is based on the existing theories and practices. It provides a generic knowledge which could be used to other situation as well. In this graduation project, the generic knowledge is the integrated flood risk management toolbox (IFRM Toolbox), which has been developed based on documented, examined and evaluated existing theories and projects, such as “room for the river” program, LIFE project, the Deltaworks, etc. The Toolbox will work as the design tools for the next step to guide the spatial planning and to enhance the water safety. With different combinations of the tools based on the concrete situations, the toolbox could provide new opportunities for further research and design activities. Take the regional structural measures (such as Concrete Dam) for example, although it has not been developed a lot in this graduation project, but we could further test and imply such kind of tools in other deltas which are facing situations much more complex and urgent. Therefore, the Toolbox is like a laboratory rather than a concrete design solution. It contains thousands of probabilities, which should be examined and evaluated in a broader context.

Research-by-design: Creative design and evaluation
“Research-by-design is about study through design using knowledge acquired by design research (Nijhuis, S. and Bobbink, 2012).”

The “Research-by-design” is useful for testing whether scientific theories and models actually work in the real world. It is also a method used to narrow down a very broad field of research into one
easily researchable topic.

- Modes of research: Experimental design study by using the IFRM Toolbox; Design study to visualize and evaluate the interventions.
- Aims:
  - Test the IFRM Toolbox under concrete requirements and situations;
  - Turn the flood risk management into benefit to bring together the hydraulic infrastructure, ecosystems, and spatial planning on different levels.

In order to test the effectiveness of the generic knowledge that got from the previous design research, various types of tools will be involved into the experimental design study according to the concrete requirements and situations of the specific location. For Rijnmond-Drechtsteden region, three alternatives have been considered. They range from storm surge barriers option to super dike option and the most preferable alternative will be further explored in the next step (design study). As can be seen from the diagram on the right side, the design study involves diverse types of techniques, including case study, mapping, modelling, etc. It tries to visualize and evaluate the preferable alternative on different levels: Delta level, dike-ring level, local level and building level. And the co-relationship between these four levels will be further explored through the key intervention of the village – Numansdorp. The key intervention also shows the probability of strengthening the relation between occupation layer and landscape layer with the help of water infrastructure layer.

2.1.3 Techniques
In figure 11, the methods and techniques are shown in relation to the products. The techniques will be involved to answer the sub questions, as explained further below.

Figure 11. Approach, methods and techniques used for this graduation project
Source: Author, 2013
Integrated flood risk management
- What are the negatively impacts of existing flood risk management strategies on the natural processes and why?
  • Domain(s): Urban design & Ecology
  • Method(s): Design Research. Including Layers Approach, Literature Review.
  • Implementation: Diagram shows the relationship between natural processes(Landscape layer) and Human interventions (Infrastructure layer and Occupation layer);

- What are the core principles and beliefs behind such theories as “Integrated flood risk management” and “More resilient system”?
  • Domain(s): Urban theory
  • Method(s): Design Research. Including Literature Review & Project Study
  • Implementation: Literature review paper on "Integrated flood risk management"; Chatagory the existing structural and non-structural measures into a “integrated flood risk management Toolbox” based on the core principles of the integrated flood risk management.

- What are the flood hazard and vulnerability of this region in the long term with a time horizon of 50-100 years?
  • Domain(s): Cross-disciplinary study, engineering
  • Method(s): Design Research. Including Literature Review & Expert Interview
  • Implementation: Mapping and sketching based on the current researches.

Water hazards
When the Haringvliet sluices need to be closed temporarily,
- How to cope with the unexpected water level along the Haringvliet- Hollandsch Diep-Biesbosch?
  • Domain(s): Urban design, Ecology & landscape planning
  • Method(s): Site Analysis & Literature Review, Sketching
  • Implementation: Mapping, testing the toolbox, project study.

- How to retain and store the storm water while it cannot discharge into the river due to the high river water level?
  • Domain(s): Urban design, Ecology & landscape design
  • Method(s): Site Analysis & Literature Review, Sketching
  • Implementation: Mapping, testing different combination of the toolbox, project study. This research will provide design inspiration by discovering the requirements of the water safety tasks. And in the design process, these knowledge could be used as the urban design tools to influence the natural, cultural and spatial aspects.

Delta level & Dike ring level: Estuarine dynamics
- How did the Foreshore area function historically as an ecological system?
  • Domain(s): Landscape design & Ecology
  • Method(s): Historical Analysis (before deltaworks), Spatial analysis (foreshore area) , Mapping, Sketching.
  • Implementation: Research on the intertidal wetland, including the tidal range, typical fauna/flora and their preferred habitats. Explore the changing situation of the foreshore areas with the help of models and sections.
- In order to restore the estuarine dynamics, what kind of alternatives could be tested? and how does it works?
  
  - Domain(s): Landscape design, Civil engineering & Ecology  
  - Method(s): Literature review, Modelling, Mapping.  
  - Implementation: Comparing the existing 4 alternatives of the Haringvliet sluices management. The research results will form a basis and spatial framework for design on the dike ring level, namely estuary restoration.

- Local level: Eco-structure
  - What are the typical identities of the agro-ecosystem in the past?
    
    - Domain(s): Urban design, Ecology & landscape planning  
    - Method(s): Site Analysis, Literature study, Mapping,  
    - Implementation: Through historical analysis and spatial analysis, the typical identities of the cultural landscape will be summarized. As well as the existing problems.
  
  - How to enhance the quality of agro-ecosystem in such a way that it could benefit the ecostructure, recreational functions, and spatial quality?
    
    - Domain(s): Urban design, Ecology & landscape planning  
    - Method(s): Site Analysis, Literature study, Mapping, Case study.  
    - Implementation: Cross-discipline study on the requirements of the robust agro-ecosystem and the creek networks. Then combine the knowledge with the stormwater management and urban design to enhance the safety and dynamics of the cultural landscape.

- Building level: Spatial quality
  - How to deal with the relationship between urban and rural, natural areas? and Which chances can be addressed from the point of view of the (potential) spatial and functional quality of the region?
    
    - Domain(s): Urban design & landscape design  
    - Method(s): Site Analysis & Literature Review, Sketching, Modelling.  
    - Implementation: Research on the theoretical model of the relationship between landscape and urban areas. Based on the spatial analysis and the green-blue structure, the theoretical model will be further developed into spatial strategies.

- The relationship of different levels: Tested district
  - How does different levels work together to establish a safe and dynamic Delta New Frontier?

    - Domain(s): Urban design, Ecology, Civil Engineering, Architecture & landscape design  
    - Method(s): Site Analysis, Case study, Modelling, Sketching.  
    - Implementation: It is also the knowledge-based design. The knowledge of historical development, survey, and spatial analysis will work as the basis for the design proposals. The draft concept will be improved by experimental design study and case study.

  - What can we learn from the specific location when testing the IFRM Toolbox and using the strategies gain from the previous research and design?
    
    - Domain(s): Urban design, Ecology, Civil Engineering, Architecture & landscape design  
    - Method(s): Sketching, Reflection.  
    - Implementation: Actually this subquestions will be raised and addressed, raised and addressed...all the time, even after finishing the graduation project. It could help to gradually update the IFRM toolbox, and to test the other possibilities under different context.
2.1.4 Dilemma: Evaluation research in a design proposal

“Objectivity” is the foundation for academic research since it aims to explain and improve the objective phenomenon. In the traditional thinking, design is more intuitive which is based on personal experiences and emotions. But “in a University of Technology, designs are made not only intuitively, but based upon study, documented, examined and evaluated” (De Jong and Van der Voordt, 2002). Therefore, the “Knowledge-based design” could be regarded as “Scientific work”. As for scientific work, the evaluation research is an important component part in order to make the research reliable and convincible to the public. However, as for a design intervention, there are still difficulties in the evaluation research, especially taking into account that there are hundreds of other probabilities of the design proposals. There are mainly two types of questions: the first one is “How to evaluate a design proposal?”, and the second one is strongly related to the first one and it is “How to figure out the best option? Or, perhaps the intention to ‘figure out the best solution’ is just an illusion?”

Possible answers to question one: Evaluation research runs through the whole project (figure 12)
- Evaluate study of the existing knowledge: “plan analysis” & “comparative study”;
- Evaluation by design in a context: “site analysis”, “experimental design” & “design study”;
- Evaluation by public: the design proposal, research approach and design tools will be judged scientifically by the public. And the IFRM toolbox could be examined in other deltas as well, in order to continually improve its effectiveness under different circumstances.

Possible answers to question two: Acquiring knowledge through goal-oriented design
De Jong (2012) explains that: “It is the task of empirical research to find probabilities, but it is the task of design to find improbable possibilities.” (De Jong, 2012, p.6). In this graduation project, with the help of in-depth analysis and experimental design study, several “improbable” possibilities have been discovered, and the one of the probabilities has been studied thoroughly. Under such circumstances, the graduation project is not aiming to figure out “what is the best solution for Rijnmond-Drechtsteden region”, but the thinking behind the design is more important: It aims to explore the probabilities to “turn the flood risk management into benefit to balance the relationship between human interventions and natural processes”. Although the design proposal is based on specific location and requirements, some of the discoveries could add to a more general body of knowledge: Firstly, the design proposal makes it possible to test the hypothesis, and in this case, the hypothesis is “the flood risk management can be turned into benefit” (chapter 1), which has been testified and visualized by design proposals (chapter3-5); Secondly, the creative design thinking could arise new research topics. For example, in chapter 5, the mutual benefit relationship between agro-ecosystem and local storm water management has been discovered, and the effectiveness of such kind of strategy could be further studied by doing small-scale experiments.

![Figure 12. Design as one component of research](image)
Source: Author, 2013
2.2 Graduation planning

- Literature Review; Thesis Plan
- Comparative Study
- Field Trip
- Site Analysis
- Project Position, Concept
- Strategies on different levels
- Tested District
- Report
- Master Thesis
- Reflection

My Experience...
Literature:


What can we learn from this research?

6 Discussions and conclusions
Generic lessons

The project is goal-oriented research, which is triggered by the general research question: “How can the integrated flood risk management benefit the natural dynamics, agro-ecosystem, and spatial quality?” As a result, the following conclusions could be drawn:

- The linkages between flood risk management, biodiversity, urban design and climate change initiatives are beneficial. Integrated flood risk management strategies are naturally designed to fit in with water-related planning issues and can be part of a wider agenda such as urban expansion, eco recovery or climate change adaptation. Specifically speaking, On the delta level, the new sluices management could bring the tidal range back into the whole region and enhance the unique identity of the green and blue heart; On the dike ring level, with the help of dike strengthening work and floodplain management, the natural dynamics could be restored; On the local level, the eco-structure will further develop inland with the creeks transform from hard edged landscape into a natural embedded elements providing (fresh) water storage and robust agro-ecosystem; On the building level, the settlement also gain benefits from the flood risk management on spatial, social and economic aspects. With all the levels working closely together, the transition zone (urban-rural–nature) could be transformed into a “SAFE and DYNAMIC Delta New Frontier”, with the unique delta landscape penetrates into the urban area, while the urban functions bring new opportunities to the rural areas as well.

- A totally open delta is not preferable for the dense-populated Dutch delta. Since it is too risky for the economic sector, and the cost-efficiency is relatively very low, therefore the totally opened Delta has been denied by the local municipalities. This project explores a more preferable option, “Controlled Tide”, which is partly open Haringvliet sluices even during the high tide. Through the design study one can see that, with the help of integrated flood risk management on different levels, it could also restore the foreshore wetland and enhance the eco-structure further inland, and at the same time, the water safety could also be guaranteed for the dense-populated urbanized delta.

- The decisions on larger levels will result in water hazards on smaller levels, but if we could smartly use the water in spatial planning, such kind of challenges will be transformed into development opportunities. The graduation project shows the important role of water infrastructure for urbanized delta. Instead of traditional flood risk management, which is “one standard for the entire area”, appropriate strategies should be applied on different levels based on the specific flood risks and spatial development requirements.

- The engineering structure can be transformed into benefits by relating them with other functions, such as residential, recreational, and ecological functions. The project aims to turn the flood risk management into benefit, especially on the ecological and spatial aspects. The design research explores the probabilities of water infrastructure, and the design proposal visualized the theoretical models.

- An integrated strategy requires the combination of structural and non-structural measures and good metrics for “getting the balance right”. The two types of measure should not be thought of as distinct from each other. Rather, they are complementary. The most effective strategies will usually combine several measures.

- The IFRM Toolbox will not only benefit the researchers and designers, but local people could also make use of the tools. For example, on the local level, the communities could design and build the retention ponds by themselves under the guidance of experts, as explained in 5.1.4.

- The IFRM Toolbox should be evaluated within a broader context by peer review. And strategies should be carried out through a participatory process involving all those stakeholders that have an interest in flood management, including those people at risk or directly impacted by flooding.

Research approach: Design as research?

To sum up, this graduation project is:

- Goal-oriented research;
- Reliable: Based on the description, evaluation and comparison of the existing theories and practices;
- Flexible and creative: The feasibility and effectiveness of the generic knowledge are tested and visualized by in depth design study under a concrete situation;
- Evaluation research runs through all the process. Further research should involve peer review and stakeholder participation.

Design could be regarded as research because of that we could use (one-case) design to test and visualize the scientific model. However, some argue that the design is such a narrow field that
they show only one narrow example and its results cannot be extrapolated to fit an entire question. On the other hand, some people argue that the design could provide more realistic responses than pure statistical method. Besides, design could bring flexibility to the research. Whilst a pure scientific research is trying to prove or disprove a hypothesis, the design might “introduce new and unexpected results during its course, and lead to research taking new directions”. What is more, perhaps one design cannot be extrapolated to fit an entire question, but it could provoke reasoned debate in in broader context. The approaches and results of (one-case) design could be evaluated and Developed by piers and the public. For example, other researchers could apply the IFRM toolbox into their design. As a result the effectiveness of the toolbox will be gradually improved with the help of collective knowledge.

**Recommendations**

- The integrated flood risk management aims to combine the water infrastructure with spatial planning, so it highly rely on the water hazard and vulnerability map. The project explains the probabilities of the toolbox on the specific location, but in order to make the project more reliable, more precise and latest data should be involved into the research process, and planner should work closely together with experts from other disciplines.

- Test the IFRM Toolbox under more complex context to figure out its probabilities and limitations. In this graduation project, Rijnmond-Drechtsteden region has been chosen for the in-depth research. In order to evaluate the IFRM Toolbox in a more scientific way, the toolbox should be tested in a broader context, especially for those areas which are facing severe conflicts between flood risks and rapid urban expansion, such as the Pearl River Delta in China.

- When the sea level rise more than a meter by 2100, in addition to closable Haringvliet sluices, several barriers around the greater Rotterdam are needed. If that happened, local water management and non-structural measures will become even more important in coping with the longer period of high water, the potential failure of engineering structures, and the longer dry season. From this point of view, the strategies explored in the design study is not a concrete “plan” for the future, it is more like a framework which is resilient for future uncertainties and new techniques, and that is also the reason why developing the IFRM Toolbox is so important, for it could provide numerous probabilities for different areas, and for diverse future scenarios. Just as mentioned before, “the heart of the research is not on the final products, but the thinking behind the research.”

- **Design as scientific work**
  The design study is unlike a scientific report due to that it is more creative and intuitive, and there is no strict set of rules. It is very easy getting lost into a lot of irrelevant information. So the most important thing is making sure that the research is focused and concise.