Business Case Living@Sea

D1.3

Grant Agreement No.	774253
Start date of Project	1 November 2017
Duration of the Project	36 months
Deliverable Number	D1.3
Deliverable leader	DeltaSync/Blue21
Dissemination Level	PU
Status	Version 1.5
Submission date	03-07-2020
Authors	DeltaSync/Blue21: Bart Roeffen, Karina Czapiewska, Fen-Yu Lin

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774253.

PU=Public, CO=Confidential, only for members of the consortium (including the Commission Services), CI=Classified, as referred to in Commission Decision 2001/844/EC.

Modification Control

Version #	Date	Author	Organisation
V0.1	14-11-2019	F., Lin	Blue21
V0.2	25-11-2019	F., Lin	Blue21
V0.3	11-12-2019	F., Lin	Blue21
V0.4	13-03-2020	B., Roeffen	DeltaSync/Blue21
V0.5	17-03-2020	K.M. Czapiewska	DeltaSync/Blue21
V0.6	24-03-2020	F., Lin	Blue21
V0.7	21-04-2020	B., Roeffen	DeltaSync/Blue21
V0.8	22-04-2020	F., Lin	Blue21
V0.9	24-04-2020	K.M. Czapiewska	DeltaSync/Blue21
V1.0	27-04-2020	F., Lin	Blue21
V1.1	27-04-2020	K.M. Czapiewska	DeltaSync/Blue21
V1.2	11-05-2020	M. Breuls	Mocean
V1.3	31-05-2020	K.M. Czapiewska	DeltaSync/Blue21
V1.4	24-06-2020	M. Breuls	Mocean
V1.5	26-06-2020	K.M. Czapiewska	DeltaSync/Blue21

Release Approval

Name	Role	Date
M. Breuls	WP Leader	24-06-2020
R.Reus - Das	Project Office	03-07-2020
M.B. Flikkema	Project Coordinator	03-07-2020

History of Changes

Section, page number	Change made	Date
		DD-MM-YYYY
		DD-MM-YYYY
		DD-MM-YYYY
		DD-MM-YYYY

Table of Contents

Executive Summary

The Living@Sea business case investigates the financial feasibility for the use of floating modular blocks developed for living at sea within the Space@Sea project. It is a compilation of all information collected during the business case analysis and process. The key purpose is to provide evidence and justification for a possible investment proposition. Two cases have been used as baselines in this study: "*Case I: Offshore Industrial Floating Accommodation*" and "*Case 2: Nearshore Urban Floating Community*". The study emphasizes on comparing floating development and other common practices such as offshore accommodation barges and land reclamation. The focus of the costs lies on the acquisition and implementation phases as they are assumed to play a the largest part in the calculation of the project.

Preliminary results have shown that floating development appears to be financially more interesting than land reclamation for near-shore conditions and accommodation barges for offshore conditions. Regarding nearshore urban environment, the unit price of Living@Sea as stand-alone islands for only living function is €3,037 (incl. VAT) per m^2 Usable Floor Area (UFA); the unit price of land reclamation is €4,335 per m^2 UFA. The unit price is calculated according to the chosen 'base case' (as shown in the project data assumption table 0.1). It is the price for the space in the buildings.
The costs for the newly created land, only the space of the modular floating platforms without any superstructures is €2,951 / m^2 and respectively €5,203 / m^2.

Table 0.1 General project data assumptions

PROJECT DATA ASSUMPTIONS

Category	Unit	Case 1	Case 2
Water depth	m	91	25
Platform size (L x W)	m	45 x 45	45 x 45
Platform/module height	m	11	6
Number of platforms		6	36
Building density		0.76	0.70
Number of floors		4	4
Residents	per platform	246	141

Regarding offshore industrial environment, the unit price of Living@Sea as part of the multi-use islands is €4,062 per m^2 UFA; whereas, the unit price of offshore accommodation barges ranges from € 5,000-10,000 per m^2 UFA. There are two ways to optimize the business results: 1.) to decrease the time needed to build, certify and install the platforms from 4 to 3 years, so as to speed up paying back for the loan, and 2.) to increase the unit sales price from €5,000 to €6,000/m^2.

The business case provides potential investors and developers with a first impression on the cost structures. However, many assumptions have been made during this study, due to the high amount of uncertainties and unknowns. Because of this, some costs may have been estimated too high and others too low, it is hard to say now, which ones are which. The cost estimates are now based on preliminary designs of platforms, connectors & mooring designs. Also, more clarity is needed on the manufacturing strategy, the means of transport and installation process the floating structures. Market researches will also be needed in order to find out the first potential clients and the range of price that they are willing to pay for floating structures. More importantly, challenges related to certification of the platforms for long-term living purposes, regulations, ownership issues, insurance and so on still need to be solved in order to make a more accurate financial projection. Due to the high level of complexity and the phase the designs of the modular blocks etc. are in right now, the business case results are preliminary and a more in-depth investigation is highly recommended. The ultimate aim for a business case development of Living@Sea should be to bring confidence and accountability into the field of making investment decisions.

1. Introduction

Land cultivation is often followed by human settlement and eventually leads to urbanization. Given the rapid increase of urban needs and marine activities, similar development is to be expected on the seas. Within Space@Sea, Work Package 7 (WP7): Living@Sea addresses marine floating islands intended for human habitation (living, working and recreation) from two perspectives: offshore and urban. The former focused on improving the status-quo of offshore living conditions for offshore workers in maintenance and storage for renewable energies like offshore wind, hydrogen- and algae bio-fuel industry; the latter investigated into the possibility of expanding existing coastal cities to the sea, as an interesting alternative to land reclamation.

In fact, sustainable floating city development has been gaining increasing popularity. Since April 2019, it has been viewed by the United Nations Human Settlements Programme (UN-Habitat) as a serious solution to climate change threats faced in urban areas where land is scarce and/or resilience is urgently needed[1]. More people are inspired by the innovative idea and ecological benefits of building on water as an alternative to land reclamation. Various types of development can already be observed across the world, ranging from large permanent floating settlement in the Netherlands, to temporary floating hotels in Qatar for the 2022 World Cup, or to floating swimming pools and saunas in the Scandinavian countries for recreational purposes. While floating is happening in the urban and coastal context, it has also been considered as alternative living quarters for offshore workers and their families in the offshore context.

In Task 1.3 Business Case Living@Sea, the financial feasibility of floating development for both offshore and urban context has been studied. This study looks into two cases: 1.) offshore industrial floating accommodation, and 2.) nearshore urban floating community. For Case 1, Living@Sea as part of the multi-use platforms has been compared to floating barges in the offshore context. For Case 2, Living@Sea as a standalone floating islands has been compared to land reclamation in the urban context.

1.1 Motivation

Living@Sea focuses on improving offshore living conditions for offshore workers and potentially family members as well. However, it has been concluded in Deliverable 7.3 that large-scale floating developments are likely to take place in front of coasts of an existing cities. Urbanization spurs a unique set of issues to both humans and the environment, and it is exacerbated by increasing population density and demands. By

[1] UN-Habitat. (2019). Retreived from: https://www.un.org/press/en/2019/dsgsm1269.doc.htm

2050, two thirds of the global population are expected to live in urban areas[2]. In a broader context, major cities in the world are facing several common challenges as shown in Figure 1.1.

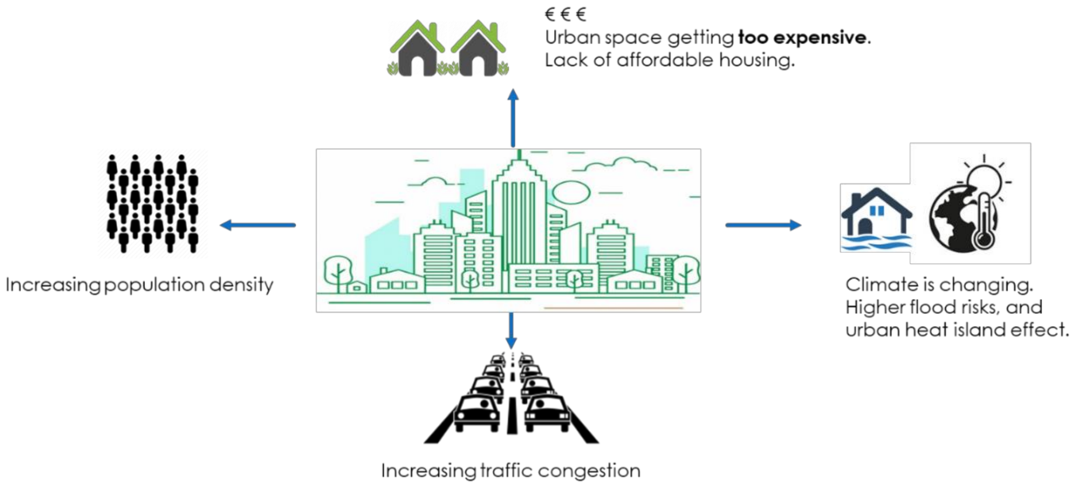

Figure 1.1 Major urban challenges (Source: Blue21, 2019)

[2] United Nations. (2018). Retrieved https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Figure 1.2 Examples of land reclamation plans around the world (Source: dezeen, 2019, Baird Maritime, 2017, : CNN, 2018, The Standard, 2018, DredgingToday.com, 2018, : ALIRAN, 2019

Many cities chose to create land in a conventional manner, which is by reclaiming or poldering. This can be seen in both developed and developing territories (see examples in **Error! Reference source not found.**). However, it remains debatable on whether land reclamation will be a sustainable and cost-efficient practice in the long run due to its detrimental environmental impacts and fast decrease in supply of sand[3].

Nearshore urban floating community is a multi-faced development. It is about creating a new community for the purpose of living, working and recreation. Different types of stakeholders have diverse concerns and objectives, and therefore other business models. A business model shows the rationale of how a party creates, delivers and captures value in economic context. This report focuses on the business case that presents a business idea to an investor, which could potentially be someone from the offshore companies, ocean investors, government entities, financial institutions, innovative and risk-taking real estate developers, or construction firms. By introducing floating development, the following business objectives are expected to be achieved:

- New land and new market → increase of sales revenue
- Competitive marketing → identity, market image and positioning
- Innovation → imagine of being the early adopter to such innovation
- Ecological benefits → less disruption to the ecosystem
- Lower flood risk → due to adaptability to sea level rise
- Flexibility to move and be repurposed → can be moved geographically and change functions
- Smaller initial capital expenditure (CAPEX) → faster building time, shorter time to deploy
- Reduction in construction time, quicker Return on Investment (ROI) → no soil settlement time needed, can be ready for development and pre-sale rapidly

[3] Bendixen, M., Best, J., Hackney, C., & Iversen, L. L. (2019). Time is running out of sand. Retrieved from https://www.nature.com/articles/d41586-019-02042-4

1.2 Subject

The study addresses the comparison between innovative floating solution (Living@Sea) offshore and near-shore with conventional technologies.

Two different cases have been investigated:

1. Offshore Industrial Floating Accommodation
2. Nearshore Urban Floating Community

These two cases have been compared to the following conventional technologies respectively:

1. Offshore Accommodation Barges
2. Nearshore Land Reclamation

Since construction accounts for a major expenditure in offshore projects, this study focuses on comparing the constructions costs of the abovementioned cases. Reference figures have been determined and the most important and immediate impacts described. It should be noted that the time scope (analysis period) of the business case is 5 year. This for the reason that most of the costs are expected to be at this phase, moreover the comparison was based on the choice on floating versus land reclamation. Which for the deep sea eventually resulted into comparing with large housing vessels.

1.3 Purpose

The purpose of the business case is to get a preliminary overview on the initial CAPEX of creating space, either for urban or offshore context, and by means of floating or land reclamation. Assuming that creating new space is necessary in either urban or offshore context, the conclusions should shed light on the best and the most financially attractive option to develop land for living and working purposes.

1.4 Structure of the report

This report is presented using the Business Case Framework developed by Filippos Kalofotias from Work Package 1. The business case investigates future projections and tries to balance between vision and financial feasibility of implementing innovative concepts such as Space@Sea.

Chapter 1 explains the motivation, subject and purpose of the business case. Chapter 2 describes the scope (of costs, benefits and time), definition of financial metrics, case design, major assumptions, data sources and data structure. In Chapter 3, a cost-benefit analysis (CBA) has been carried out. The results of the business case are presented in Chapter 4, showing case flow projections and general financial metrics. In Chapter 5, a risk analysis has been conducted, including sensitivity analysis and business risk register. Conclusions and recommendations have been described in Chapter 6. The essences are presented in the form of a modified business case canvas.

2. Methods and assumptions

This chapter consists of five sections which are scope, definition of financial metrics, case design, major assumptions, data sources and data structure. The objective of the chapter is to describe the framework and methodology of the business case.

2.1 Scope

The location of Living@Sea is assumed to be the French coast, Bay of Montpellier, in the Mediterranean Sea, due to a sufficient water depth (Figure 2.1). The current mooring system designed within Space@Sea has also been proven technically feasible for the Mediterranean Sea

Figure 2.1 Location business case Mediterranean Sea (retrieved from Space@Sea D3.3. report, 2020)

2.2 Definition of financial metrics

The financial metrics put an emphasis on the "acquisition and implementation costs" rather than operational (e.g., maintenance, electricity/fuel consumption) or growth/change costs (e.g., additional maintenance, inflation). This is because acquisition and implementation costs are more relevant to this stage of the decision-making process, choosing between floating development or land reclamation, the new typology of floating accommodation or existing technologies. The following additional financial metrics are required by the Business Case Guideline provided by Work Package 1:

- Cash flow and net cash flow
- Payback period
- Return on investment (ROI)
- Discounted cash flow (DCF) and net present value (NPV)
- Internal rate of return (IRR)

Cash outflow and net cash flow

Cash flow is the most basic metric or measurement in a business case. This means either cash flowing in the business or cash flowing out of the business. Net cash flow is the sum after cash inflows are deducted by cash outflows.

Payback period

The payback period is the length of time required to recover a cost of an investment. It is a useful metric for investment projects though it contains no information relevant to the time value of money or distribution of cash flows within this period.

Return on investment (ROI)

ROI is used to evaluate the efficiency of an investment. There are different metrics and the Simple ROI is being applied here. Simple ROI also neglects the time value of money and distribution of cash flows similarly to the metric of payback period.

$$Simple\ ROI = \frac{(Gains - Investment\ costs)}{Investment\ costs}$$

Discounted cash flow (DCF) and net present value (NPV)

Discounted Cash Flow (DCF) is a cash flow summary which has been adjusted to reflect the time value of money. When the discounted values of a cash flow stream extending across time are added together, the total sum is called Net Present Value (NPV). NPV for a cash flow stream is the financial metric used in this business case. DCF methods produce the NPV.

DCF method is based on the idea that money you have now should be valued more than an identical amount you would receive in the future. This adjustment is made to account for *inflation* and *capital cost of opportunity*, i.e. the loss of the opportunity to invest the future money today. What future money is worth today is called its Present Value and what it will be worth when it finally arrives in future is called its Future Value. What determines the amount of discounted value between the Future and the Present Value is the amount of time in between and an interest rate. DCF is then by calculated by:

$$DCF = \frac{(Future\ Value)}{(1 + Interest\ Rate)^N}$$

Interest Rate may be considered as the return rate we would expect from an investment and *N* is the number of periods (usually every period corresponds to a year) between the Present and the Future Value. When the above formula is applied to Net Cash Flows, Discounted Cash Flows are derived. The sum of Discounted Cash Flows represents the Net Present Value metric and the formula is expressed as:

$$NPV = \sum_{N=1}^{N=max} \frac{(Future\ Value)}{(1 + Interest\ Rate)^N}$$

Internal rate of return (IRR)

Internal Rate of Return (IRR) is the rate of growth a project is expected to generate. It uses the same formula as NPV. IRR corresponds to the *Interest Rate* for which NPV becomes zero. IRR tells you just how high interest rates must go in order to "zero" the gain from this investment. In general, an investment scenario with a higher IRR than others should be considered preferable. Especially in business cases with high uncertainty, a high IRR metric number creates confidence to the investors. Many organizations adopt specific thresholds for the performance of the IRR metric. The calculation of IRR is done by equating NPV formula to zero and iteratively solving for the Interest Rate since there is no analytical solution.

2.3 Case design

This study looks into two cases (offshore and nearshore) and comes to the following categories for the cost comparison:

- *Case 1: "Offshore Industrial Floating Accommodation"*- industrial, Living@Sea as part of the multi-use islands in **deep** water (91 m) (left in Figure 2.2 & Figure 2.3)
- *Case 2: "Nearshore Urban Floating Community"* - non-industrial, Living@Sea as stand-alone islands for solely living function in **shallow** water (25 m) (right in Figure 2.2 & Figure 2.3)
- *Comparison 1: "Offshore - Accommodation Barge"*- in **deep** water (91 m) (left in Figure 2.4)
- *Comparison 2: "Nearshore - Land Reclamation"*- reclaiming land in **shallow** water; a conventional coastal city expansion strategy (25 m) (right in Figure 2.4)

Figure 2.2 Floating island configuration: Case 1- offshore, industrial and as part of multi-use islands (left), and Case 2- near-shore non-industrial and stand-alone modules for living function (right)

Figure 2.3 Final visualization of floating development: Case 1 (left) and Case 2 (right) (source: Waterstudio & Blue21, 2019)

Figure 2.4 Conventional technologies: Comparison 1- offshore accommodation barge (left), and Comparison 2- nearshore land reclamation (right)

General project data assumptions taken into account for the two scenarios are included in Table 2.1**Error! Reference source not found.**.

Case 1: "Offshore Industrial Floating Accommodation" offers more comfortable staff accommodation for various offshore industries, also represented in Work Package 6. Based on the multi-use island layout design (left of Figure 2.2), it was calculated that six Living@Sea platforms should offer sufficient accommodation area for 500 to 1000 people (depending on the desired density). This total will include a 'support' staff (catering, cleaning, maintenance, management, etc.), the crew, family members of the crew and temporary guests during transshipment. An average of 25 m^2 is allocated per person, which should offer more spacious and comfortable accommodation compared to a standard offshore accommodation barge, even in more severe conditions.

Case 2: "Nearshore Urban Floating Community" represents a larger floating community. As indicated in Deliverable 7.3, large-scale floating development is most likely to be introduced firstly near an existing urban coastal area to cater to urban growth and needs. Traditionally cities expand by means of reclaiming land; however, in areas where the water depth is deeper, conventional land reclamation becomes increasingly expensive (see Figure 2.5) and faces several challenges, including environmental aspects and shortage of natural resources (sand/rocks). Floating could then be a favorable alternative. In this case an average of 40 m^2 is allocated per person.

Table 2.1 General project data assumptions

PROJECT DATA ASSUMPTIONS

Category	Unit	Case 1	Case 2
Water depth	m	91	25
Platform size (L x W)	m	45 x 45	45 x 45
Platform/module height	m	11	6
Number of platforms		6	36
Building density		0.76	0.70
Number of floors		4	4
Residents	per platform	246	141

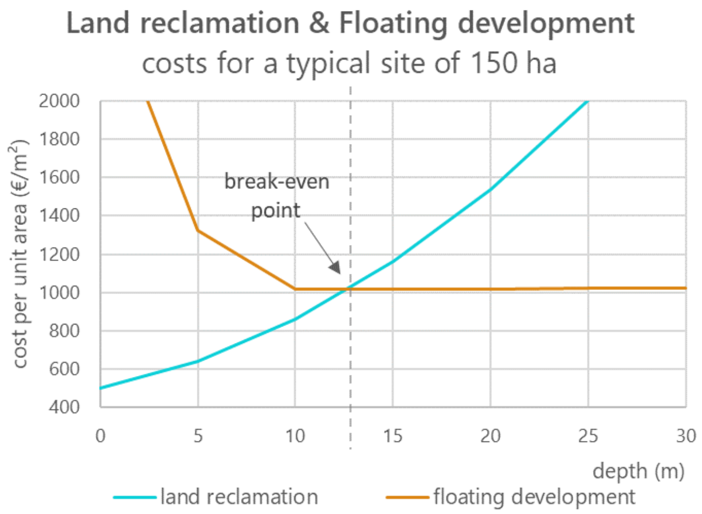

Figure 2.5 Costs comparison between land reclamation and floating development (source: Blue21)

2.4 Major assumptions

This study makes the following assumptions that serve as the foundation for the cost benefit analysis:

- *Case 1: "Offshore Industrial Floating Accommodation"* assumes that it will provide all the living space required for the staff of the multi-use islands, including Transport & Logistics, Aquaculture and Energy production.
- The cost data with respect to the floating structure, moorings and connections relies on the input from other work packages. Several cases have been modelled, but none of them identical to the two Living-@-Sea scenarios (defined in the previous chapter). Where appropriate, costs have been re-calculated to account for the difference in scale and purpose.
- The current cost estimate accuracy is limited and based on preliminary design and engineering results. It is assumed that the complete structures can be built in the nearest major port and shipped to the final location. No additional drydock costs were taken into account for building the superstructures.
- The location was mainly selected to provide realistic input characteristics on local economic and maritime conditions. The Mediterranean offers acceptable conditions, but is not intended as a best or worst case scenario. It was further assumed that this location would be open to the opportunity and would have sufficient demand for the presented cases.
- The business case is assumed to be presented to an investor or a developer who is an innovative and risk-taking front runner that cares for ecological benefits to which the project will bring, and wants to invest in floating development instead of land reclamation.

2.5 Data sources & structure

Parts of the data used in the calculations is derived from studies done for clients of Blue21. They can be made available in some cases upon signing a non-disclosure agreement. In terms of data structure, according to the business case guideline, there are two approaches, full value approach and incremental value approach. Full value approach refers to full value data being presented for all scenarios. Incremental value approach means that one scenario is benchmarked and the data of the other scenarios is presented as deltas. In this case, incremental value approach has been applied. *Case 1* and *Case 2* have been benchmarked.

3. Cost-Benefit analysis

This chapter gives the potential investors and developers a first idea on the costs overview as well as pros and cons when deciding between what option to choose, the innovative floating Space@Sea solution (ie. floating) or business as usual. The cost model describes the cost categories for the floating projects and for the comparison with existing accommodation barges and land reclamation costs. Key differences between floating and land reclamation are also presented.

3.1 Costs model

The various categories of costs that have been considered for floating development for *Case 1 & 2* are listed in Table 3.1.; the cost elements taken into account for Comparison 1 & 2 are included in Table 3.2.

Table 3.1 Categories of costs for floating development

Floating specific costs	Building construction costs	Markups
Module costs **Mooring** **Towing & installation** **Bridges**	Building costs o Direct costs o Indirect costs o Overhead Pavements/public space	Additional costs o Design/engineering o Classification /Permits/fees o Financing costs o Environmental assessment o Developer risk/profit margins VAT

Table 3.2 Categories of costs for comparisons

Accommodation barges	Land reclamation specific costs
- Unit price (2nd hand barges)	- Fill - Seawall costs - Settling time interest - Foundation

Module costs and metrics

The fabrication costs of the 45x45m modules have been provided by Work Package 1 (Table 3.3). For *Case 1: "Offshore Industrial Floating Accommodation",* the cost of module height 11 m has been used. Such height was concluded to be necessary in the report of Deliverable 7.3 Demonstrator Design where a preliminary intact and damage stability analysis was conducted. Moreover, it is not possible to reduce the height to less than 10 m as the connectors will have to be kept above the water level based on the current design. For *Case 2: "Nearshore Urban Floating Community",* it has been assumed that a different connector design would be applied to allow shorter distance from the connectors to water, thus a module height of 6 m has been selected.

Table 3.3 Fabrication cost of the modules extracted from the detailed design (retrieved and modified from WP1, February 2020)

Module height [m]	Tonnage	Cost of module	Application
6	3862	€ 2,993,050	Case 2: Nearshore
11	7080	€ 5,487,258	Case 1: Offshore
15	9655	€ 7,482,625	N/A in this study

Mooring costs

Mooring costs were not calculated specifically for the two cases. An estimation was made for mooring a different configuration in Work Package 3 (Figure 3.1 Mooring layout Mediterranean (source: Deliverable 3.3 Space at sea) Figure 3.1). Costs were estimated at €20M for 71 moorings, keeping 78 standardized platforms in place. Mooring (or drift) forces will depend mostly on the overall size of the floating development (the submerged area facing the currents and waves). This can be approximated by taking the combined maximum length and width of the complete island. The initial calculation has a length and width of 9 + 10 platform lengths (19 in total). The multi-use platform of *Case 1* has 12.3 + 13, a total of 25.3 platform lengths (including WEC units). It should be noted that the exact shape is not taken into account, only the difference in maximum length in both directions is. The difference in mooring loads is approximately a factor 1.33.

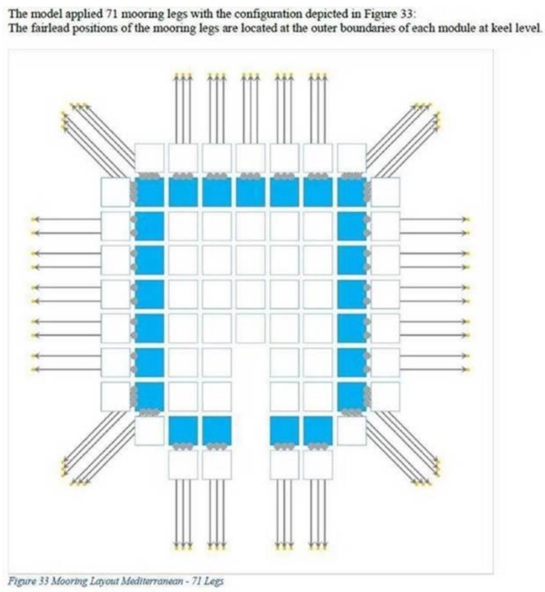

Figure 3.1 Mooring layout Mediterranean (source: Deliverable 3.3 Space at sea)

Linear extrapolation yields 95 moorings at a cost of €27M for 105 platforms (ie. 250k€/platform). The nearshore option of *Case 2* is 33% smaller and may require 47 lines, costing €13M (ie. 370k€/platform), but due to considerably shallower location, the length of the lines can be reduced and cost would be close to €9M (ie. 250k€/platform).

Towage and installation costs

Estimations for towage and installation were provided by Work Package 5: €1.28M per platform. The costs incurred for towing the floating structures to the offshore location and installing them can be considerable. The distance from nearest major port (Marseille) is about 70 nautical miles, which can take up to 16 hours of towing, possibly with multiple vessels. Connecting platforms to moorings and to adjacent platforms will be a challenge on the open sea, even if weather conditions are moderate. A more optimal strategy would be to connect three platforms together in protected water in (or near) the port and tow them as a larger vessel (of 45x145m). This would not cause any additional drag or negative effects on handling and it would save approximately 65% towage time and 35% installation time, together 50%. Installation nearshore is assumed to save half of the towage and installation costs, due to reduced distance, depth and milder conditions.

The preliminary costs for offshore/urban floating development are shown in Table 3.4. The capital costs encompass both construction costs and additional costs. The construction costs include building costs, module, mooring, towing installation, bridges, pavements and/or public space. Building costs consist of the costs to build the total gross area of the buildings on top of the platform. This includes all the direct (e.g., facilities, materials) costs, indirect costs (e.g., personnel costs, administration costs) and overhead (e.g., office, public relations, marketing, sales). Additional costs are estimated to be 35% of the construction costs. These include costs for design and engineering, fees for certificate of classification, planning, permit application, financing costs, fees for environmental assessment, as well as the developer risk/profit. Tax of 20% derived from the capital costs is also taken into account.

Table 3.4 Costs estimation of floating development for Case 1 (offshore industrial) & Case 2 (nearshore urban) per platform

FLOATING DEVELOPMENT	UNIT	Case 1 offshore	Case 2 nearshore
Module cost	Million euro	€ 5.49	€ 2.99
Mooring	Million euro	€ 0.25	€ 0.25
Towing / installation	Million euro	€ 0.64	€ 0.32
Bridges	Million euro	€ 0.13	€ 0.13
Substructure	Million euro	**€ 6.50**	**€ 3.69**
Superstructure	Million euro	**€ 6.62**	**€ 6.48**
CONSTRUCTION COSTS		€ 13.12	€ 10.17
ADDITIONAL COSTS	35%	€ 4.59	€ 3.54
CAPITAL COSTS	per platform	**€ 17.71**	**€ 13.66**
VAT	20%	€ 3.54	€ 2.75
Complete city costs (incl VAT)	Nr of platforms between brackets	**€ 128 (6)**	**€ 593 (36)**
unit price (incl VAT)	**EUR/m² UFA***	**€ 4,062**	**€ 3,037**
Price substructures (no RE&H)	**EUR/m² floor area**	**€ 5,203**	**€ 2,951**

**= Usable Floor Area

The preliminary costs for offshore/urban land reclamation are shown in Table 3.5. The construction costs consist of land reclamation costs for a platform size and the buildings costs. The reclamation cost per square meter can be calculated, considering major cost categories for land reclamation projects such as the fill, seawall, settling time and foundation. Additional costs are estimated to be 35% of the construction costs as described previously. Tax of 20% derived from the capital costs is also taken into account.

Case 1: "Offshore Industrial Floating Accommodation" has been compared to *Comparison 1: "Offshore - Accommodation Barge"*- in **deep** water (91 m), the barges range in price between € 5,000-10,000 per m^2. As a result, the crew is usually cramped in small 2-person or even 4-person rooms. Many accommodation barges are limited to mild wave conditions, due to their relatively small width (beam). *Case 1* presents the opportunity to improve wave behavior and provide more comfortable worker accommodation at a modest price level of € 4,062 which is a lot less.

Table 3.5 Costs estimation of land reclamation as a comparison to Case 2 nearshore urban

LAND RECLAMATION	UNIT	VALUE
Fill	per m^2	€ 435
Seawall costs	per m^2	€ 2,426
Settling time interest	6% annual interest	€ 968
Foundation	per m^2	€ 140
Reclamation cost per m^2		**€ 3,969**
Reclamation costs	per platform size	€ 8,036,343
Building costs	per platform size	€ 6,048,000
Pavements/public space		€ 30,375
CONSTRUCTION COSTS		**€ 14,114,718**
ADDITIONAL COSTS	35%	**€ 3,294,512**
CAPITAL COSTS	per platform size	**€ 17,409,230**
VAT	20%	€ 3,481,846
Complete city costs (incl VAT)	size of 36 platforms	**€ 752M***
unit price (incl VAT)	**EUR/m^2 UFA****	**€ 4,335**

*= Millions, **= Usable Floor Area

Comparison 2, land reclamation in comparison to *"Nearshore Urban Floating Community"*, results in €752 M for the complete development, which would set the unit price (incl VAT) per square meter to €4,335. Considerably higher than the floating option (€3,017). For *Case 1: "Offshore Industrial Floating Accommodation"*, at water depth of 91 m, land reclamation was not a feasible option. Costs would be about 10 times as high compared to the nearshore location. In short, it can be observed that in deeper water (>25m), floating development is a lot more interesting financially than land reclamation. In Chapter 4, the unit price will be discussed further with more price references.

It can be concluded from the different cost calculations that, first of all, in deep sea reclamation is not an option to compare with. Moreover, it can be concluded that the first estimate is that floating can offer a more cost effective solution than the current practice. The overall unit price and comparison for different practices is shown in Table 3.6.

Table 3.6 Unit price for different practices

	Land reclamation / Barges	Floating
Nearshore	€ 4,335	€ 3,037
Offshore	€ 5,000 – 10,000	€ 4,062

3.2 Main benefits of floating development

From the costs analysis, floating development appears to be cost competitive to land reclamation. This has to do with the benefits of floating development, which are absent in land reclamation practices, namely:

- **Improved flexibility and adaptability:** floating projects are flexible and can be towed to places and repurposed to different functions. Floating platforms are also adaptable to water level changes and can float in the face of rising sea level. Land reclamation on the other hand does not have such flexibility or adaptability. Once a land is created, it cannot be moved, and dykes will be required (and heightened) in the face of rising sea level.
- **Reduced sand/materials demand:** floating does not require a large volume of sand to be sprayed in order to create new land. No sand excavation and transport are needed, which saves many resources like fuels and personnel. In fact, land reclamation has become increasingly challenging as sand mining is seen detrimental to the environment (Table 3.7) and has been banned in several countries. As sand and gravel are being extracted faster than they can be replaced, the increasing demand has caused the price to soar (Figure 3.2). Such trends and pressing needs for new space have urged many to seek for solutions on water.
- **Faster building time:** floating development can be built relatively fast. There is no need to wait for the soil to settle as needed in land reclamation (which can take up to five years). Moreover, both the substructure and superstructure can be constructed elsewhere and assembled on site once they are completed, preventing the surrounding areas of the final site from long period of noises and other pollutions.

These major benefits have also been enlisted and linked to business objectives shown in Chapter 1 (Figure 3.3)

Table 3.7 The environmental impacts of sand mining for land reclamation[4]

Impacts on	Description
Biodiversity	Impacts on related ecosystems (for example fisheries)
Land losses	Both inland and coastal through erosion
Hydrological function	Change in water flows, flood regulation and marine currents
Water supply	Through lowering of the water table and pollution
Infrastructures	Damage to bridges, river embankments and coastal infrastructures
Climate	Directly through transport emissions, indirectly through cement production
Landscape	Coastal erosion, changes in deltaic structures, quarries, pollution of rivers
Extreme events	Decline of protection against extreme events (flood, drought, storm surge)

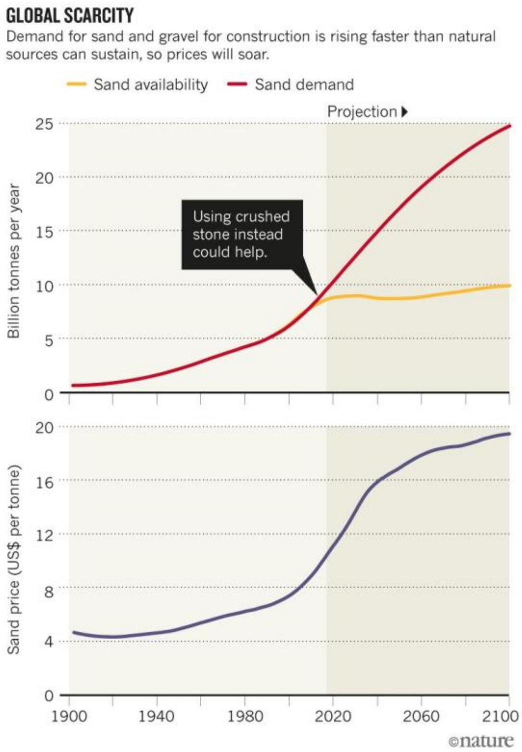

Figure 3.2 Global scarcity of sand[5]

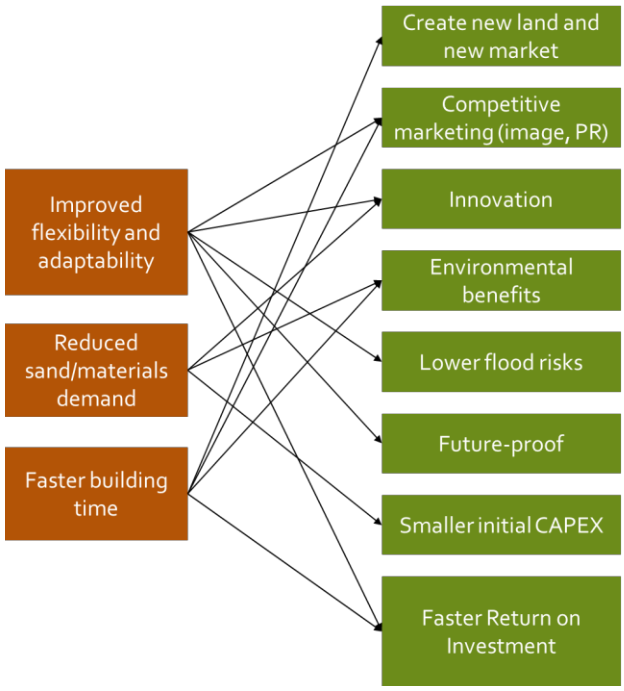

Figure 3.3 Benefits linking to business objectives

4 UNEP. (2014). Retrieved from: https://na.unep.net/geas/archive/pdfs/GEAS_Mar2014_Sand_Mining.pdf

5 Bendixen, M., Best, J., Hackney, C., & Iversen, L. L. (2019). Time is running out for sand. Retrieved from https://www.nature.com/articles/d41586-019-02042-4

4. Business case results

After gathering data on the costs, a cashflow projection for Case 1 (offshore) and Case 2 (nearshore) floating has been conducted and is presented in this chapter. Moreover, different input variables are changed to show the sensitivity of the calculations.

As the business case is developed for the French coast, real estate prices of nearby French coastal cities have been collected for reference (see Table 4.1). In the initial calculation, the square meter price of Cannes is used. It is assumed that this project will be the first of its kind and that many people will have the motivation to buy and own a piece of this floating city at this beautiful coast.

Table 4.1 Real estate price per m² in coastal cities in France (Mediterranean Sea)

(source: Repimmo, retrieved in 2020)

Coastal city in France	€/m²
Monaco	35,000
St Tropez	10,000
Porquerolles	10,000
Montpelier coast	4,000
Cannes	6,000

4.1 Results of Case 1: Offshore

Case 1:"Offshore Floating Accommodation" looks into Living@Sea as part of the multi-use islands in deep water conditions (91 m). In Table 4.2 the input variables of Case 1.1, 1.2 and 1.3 are shown. This case is built upon the following assumptions:

- The production rate of the platforms with the superstructures on top are 5 per year, this means that the construction time is 1.2 years for the 6 platforms.
- The sales price is based on the cheaper end of accommodation barges of €5,000 / m² .
- In Year 3, 20% of the projects is pre-payed, in Year 4 the remaining costs.
- There are no costs calculated for land acquisitions as the location is in deep sea.
- The discount rate is set to be quite low because it is assumed that the investor is also the client who will be using the platforms.
- For the alternative case, the production rate is changed, as this is a very uncertain input variable, from 5 to 6 platforms per year, which leads to finishing the project one year earlier. Which changes the negative net present value into a positive one.

- The other alternative case increases the pricing from 5,000 to 6,000 euro per square meter. This leads into even more positive results. However, the question is how relevant this is, as it has been assumed that the developing / investing company will also be the company that will be using the accommodations. In case of sales to a different client, this would be more relevant.

Table 4.2 Input variables for cashflow calculation Case 1.1, 1.2 and 1.3 (offshore)

Input variable	Value Case 1.1	Case 1.2	Case 1.3	Unit
Production rate platforms	5	6	5	# per year incl. superstructures
Number of platforms	6	6	6	
Total gross floor area/platform	6,156	6,156	6,156	m^2
Initial costs (unit price, incl. VAT)	4,062	4,062	4,062	EUR / m^2 usable floor area
Costs sub and superstructure	19,610,000	19,610,000	19,610,000	EUR
Installation costs	1,645,900	1,645,900	1,645,900	EUR
Total capital costs	127,535,700	127,535,700	127,535,700	EUR
Costs year 1 (of total costs)	90	90	90	%
Remaining costs (of total costs)	10	10	10	%
Sales price (based on barges)	5,000	5,000	6,000	EUR / m^2
Avg. annual inflation rate	1.9	1.9	1.9	%
Loan interest rate	6	6	6	%
Prepayment (in year 3)	20	20	20	%
Discount rate	10	10	10	%

Based on the input variables, shown in table 4.2, and the calculations for case 1.1 are shown in the following tables. For the base case a modest ROI of about 16% can be expected, however, the NPV is negative and the return rate is 5%. The main reason for this low NPV is that the square meter selling price is kept relatively low. Also, it is assumed that although it is a small project (6 platforms), the time before finished, certified and installed will be 4 years, which drives up the costs for the banking loan as well.

Table 4.3 Calculation Case 1 (4-year development)

Year	Costs x100	Revenues	Cashflow	Cummultive cashflow	Interest costs	Present value
1	€ 1.058.942		-€ 1.058.942	-€ 1.058.942	-€ 63.537	-€ 962.674
2	€ 224.717		-€ 288.254	-€ 1.347.196	-€ 80.832	-€ 238.226
3		€ 338.505	€ 257.674	-€ 1.089.522	-€ 65.371	€ 193.594
4		€ 1.354.021	€ 1.288.650	€ 199.128		€ 880.165

Table 4.4 Results of Case 1 (4-year development)

Results	Value
Return on Investment (ROI)	15.61%
Net Present Value (NPV)	€ -12,714,100
Internal Rate of Return (IRR)	5%

Although this is not bad for a highly innovative project with a lot of uncertainties, on the other hand, because of this, external investors would like to be compensated for the increased risks of a highly innovative project. To be able to do so, the other two cases proof that with increasing construction speed or the square meter price for the real estate could provide in this. By suggesting the payment period to Year 3 rather than Year 4, the results appear a lot more promising (Table 4.5 and Table 4.6)

Table 4.5 Calculation Case 1.2 (3-year development)

Year	Costs x100	Revenues	Cashflow	Cummultive cashflow	Interest costs	Present value
1	€ 1.058.942		-€ 1.058.942	-€ 1.058.942	-€ 63.537	-€ 962.674
2	€ 224.717		-€ 288.254	-€ 1.347.196	-€ 80.832	-€ 238.226
3		€ 1.692.527	€ 1.611.695	€ 264.499		€ 1.210.890
4						

Table 4.6 Results of Case 1.2 (3-year development)

Results	Value
Return on Investment (ROI)	21%
Net Present Value (NPV)	€999,000
Internal Rate of Return (IRR)	11%

Finally also the square meter pricing has been adjusted, by suggesting to change only the m^2 price for the real estate on the water from €5,000 to €6,000 (Table 4.6), the results are even more optimal as before (Table 4.7) with a net present value of €11,146,100 and a return of investment of 42%.

Table 4.7 Calculation Case 1.2 (€6,000/m² development)

Year	Costs x100	Revenues	Cashflow	Cummultive cashflow	Interest costs	Present value
1	€ 1.058.942		-€ 1.058.942	-€ 1.058.942	-€ 63.537	-€ 962.674
2	€ 224.717		-€ 288.254	-€ 1.347.196	-€ 80.832	-€ 238.226
3		€ 406.206	€ 325.375	-€ 1.021.821	-€ 61.309	€ 244.459
4		€ 1.624.826	€ 1.563.516	€ 541.696		€ 1.067.903

Table 4.8 Results of Case 1.3 (sales price at €6,000/m²)

Results	Value
Return on Investment (ROI)	42%
Net Present Value (NPV)	€11,146,100
Internal Rate of Return (IRR)	14%

4.2 Results of Case 2: Nearshore

Case 2:"Nearshore Urban Floating Community" looks into Living@Sea as stand-alone islands for solely living function in shallower water conditions (25 m), namely the floating city nearshore. The following assumptions apply to this case:

- The production rate of the platforms with the superstructures on top are 12 per year, this means that the construction time is 3 years for the 36 platforms.
- The sales price is based on the pricing of Cannes of €6,000 / m²
- After realizing the first 12 platforms the coupling and installation can start.
- The base case uses a shorter platform with a depth of 6 meters (instead of the deep sea option with 11 meter platforms).
- The initial land acquisition costs are set to zero.
- In the second case, it is assumed that the costs for the finishing of the real estate are higher (which are translated in higher m² costs for the superstructures. A symbolic land price of 1 € / m² is calculated and the loan interest rate is increased.
- Case 3 looks at the influence of a land price of 10 € / m² , which is on the lower side of what is payed for farm land in urban development on land.
- In Case 4 the substructure with 11 meters is used for the calculation.

In Table 4.9 the input variables for the cashflow projection of Case 2.1 – 2.4 are shown.

Table 4.9 Input variables for cashflow calculation Case 2.1,2.2, 2.3, 2.4 (nearshore) in green the difference between the cases.

Input variable	Value Case 2.1	Case 2.2	Case 2.3	Case 2.4	Unit
Production rate platforms	12	12	12	12	# per year incl su-perstructures
Number of platforms	36	36	36	36	
Total gross floor area/platform	6,379	6,379	6,379	6,379	m^2
Plot size	72,900	72,900	72,900	72,900	m^2
Total capital costs	592,837,600	661,555,800	592,837,600	592,837,600	EUR
Cost 1 substructure	4,848,700	4,848,700	4,848,700	8,889,400	EUR
Cost mooring, installation 1	1,127,500	1,127,500	1,127,500	1,645,900	EUR
Cost real estate and housing	10,491,400	12,400,300	10,491,400	10,491,400	EUR
Land value	0	1	10	0	EUR / m^2
Avg. sales price	6,000	5,000	6,000	6,000	EUR / m^2 UFA
Avg. annual inflation	1.9%	1.9%	1.9%	1.9%	
Loan interest rate	6%	10%	6%	6%	
Discount rate	20%	20%	20%	20%	

Based on the input variables, the results of the financial metrics are shown in Table 4.9 and Table 4.10.

Table 4.10 Calculation Case 2.1 (nearshore base case)

Year	Costs plat-forms	Installation	Costs RE&H	Revenues	Cashflow	Cummultive cashflow	Interest costs	Present value
0	€ 581.849				-€ 581.849	-€ 581.849	-€ 34.911	-€ 581.849
1	€ 592.904	€ 137.873			-€ 765.688	-€ 1.347.537	-€ 80.852	-€ 638.073
2	€ 604.169	€ 140.493	€ 1.307.269		-€ 2.132.784	-€ 3.480.321	-€ 208.819	-€ 1.481.100
3		€ 143.162	€ 1.332.108	€ 4.130.566	€ 2.446.477	-€ 1.033.844	-€ 62.031	€ 1.415.785
4			€ 1.357.418	€ 4.209.047	€ 2.789.598	€ 1.755.755		€ 1.345.292
5				€ 4.289.019	€ 4.289.019	€ 6.044.773		€ 1.723.660

Table 4.11Table 4.10 Calculation Case 2.1 (nearshore base case)

Year	Costs plat-forms	Installation	Costs RE&H	Revenues	Cashflow	Cummultive cashflow	Interest costs	Present value
0	€ 581.849				-€ 581.849	-€ 581.849	-€ 34.911	-€ 581.849
1	€ 592.904	€ 137.873			-€ 765.688	-€ 1.347.537	-€ 80.852	-€ 638.073
2	€ 604.169	€ 140.493	€ 1.307.269		-€ 2.132.784	-€ 3.480.321	-€ 208.819	-€ 1.481.100
3		€ 143.162	€ 1.332.108	€ 4.130.566	€ 2.446.477	-€ 1.033.844	-€ 62.031	€ 1.415.785
4			€ 1.357.418	€ 4.209.047	€ 2.789.598	€ 1.755.755		€ 1.345.292
5				€ 4.289.019	€ 4.289.019	€ 6.044.773		€ 1.723.660

Table 4.11 Results of Case 2.1 (nearshore base case)

Results	Value
Return on Investment (ROI)	102%
Net Present Value (NPV)	€1,783,371,000
Internal Rate of Return (IRR)	44%

The results for Case 2.1 are very optimistic, because of a quite optimal base case scenario. For this reason in the next calculation several variables have been adjusted. Which still lead to modest positive results (table 4.11 and 4.12) and a quite attractive rate of return of 20%.

Table 4.12 Calculation Case 2.2 (nearshore)

Year	Costs platforms	Installation	Costs RE&H	Revenues	Cashflow	Cummultive cash-flow	Interest costs	Present value
0	€ 1.066.723				-€ 1.066.723	-€ 1.066.723	-€ 64.003	-€ 1.066.723
1	€ 1.086.991	€ 201.263			-€ 1.352.257	-€ 2.418.980	-€ 145.139	-€ 1.126.881
2	€ 1.107.644	€ 205.087	€ 1.307.269		-€ 2.765.139	-€ 5.184.119	-€ 311.047	-€ 1.920.235
3		€ 208.984	€ 1.332.108	€ 4.130.566	€ 2.278.428	-€ 2.905.691	-€ 174.341	€ 1.318.534
4			€ 1.357.418	€ 4.209.047	€ 2.677.288	-€ 228.404		€ 1.291.130
5				€ 4.289.019	€ 4.289.019	€ 4.060.615		€ 1.723.660

Table 4.13 Results 2.2 (nearshore)

Results	Value
Return on Investment (ROI)	41%
Net Present Value (NPV)	€ 2,764,000
Internal Rate of Return (IRR)	20%

Results of case 2.3 show, that when the '(sea) land owner' would sell the plot for a modest price, the results can still be positive with nearly the same rate of return of 22%.

Table 4.14 Calculation Case 2.3 (land costs 10)

Year	Costs platforms	Installation	Costs RE&H	Land aquisition	Revenues	Cashflow	Cummultive cashflow	Interest costs	Present value
0	€ 581.849					-€ 581.849	-€ 581.849	-€ 58.185	-€ 581.849
1	€ 592.904	€ 137.873		€ 247.617		-€ 1.036.579	-€ 1.618.428	-€ 161.843	-€ 863.816
2	€ 604.169	€ 140.493	€ 1.545.117	€ 252.322		-€ 2.703.944	-€ 4.322.372	-€ 432.237	-€ 1.877.739
3		€ 143.162	€ 1.574.475	€ 257.116	€ 4.130.566	€ 1.723.576	-€ 2.598.796	-€ 259.880	€ 997.440
4			€ 1.604.390		€ 4.209.047	€ 2.344.778	-€ 254.018		€ 1.130.776

5				€ 4.289.019	€ 4.289.019	€ 4.035.001		€ 1.723.660

Table 4.15 Results 2.3 (land costs 10)

Results	Value
Return on Investment (ROI)	68%
Net Present Value (NPV)	€21,948,581
Internal Rate of Return (IRR)	22%

Finally, if the project would be needed to build with the same size of platforms (11 meter) as the deep sea projects, the businesscase still remains positive.

Table 4.16 Calculation Case 2.4 (11 m platform)

Year	Costs platforms	Installation	Costs RE&H	Revenues	Cashflow	Cummultive cashflow	Interest costs	Present value
0	€ 581.849				- € 581.849	-€ 581.849	-€ 34.911	-€ 581.849
1	€ 592.904	€ 137.873			- € 765.688	-€ 1.347.537	-€ 80.852	-€ 638.073
2	€ 604.169	€ 140.493	€ 1.307.269		- € 2.132.784	-€ 3.480.321	-€ 208.819	-€ 1.481.100
3		€ 143.162	€ 1.332.108	€ 4.130.566	€ 2.446.477	-€ 1.033.844	-€ 62.031	€ 1.415.785
4			€ 1.357.418	€ 4.209.047	€ 2.789.598	€ 1.755.755		€ 1.345.292
5				€ 4.289.019	€ 4.289.019	€ 6.044.773		€ 1.723.660

Table 4.17 Results 2.4 (11 m platform)

Results	Value
Return on Investment (ROI)	68%
Net Present Value (NPV)	€52,847,296
Internal Rate of Return (IRR)	27%

A careful conclusion can be that the projects could yield a positive outcome, in many scenarios. Although there is still a very high square meter price that needs to be paid for buying the real estate that will be developed in the floating city and that this first project would only be affordable for people with a high income. Nevertheless, for a first pilot it proves that such a project could be worth investing in, when the circumstances are right.

Also the costs for the sea plot are very low, on the other hand, it can be argued that on forehand, that plot didn't have any value at all. How to determine the value of the water in the sea is a topic that needs to be addressed by the city or nation that chooses to create more land / expand the territory using floating structures, in this case the French authorities. When coming back to the reclamation comparison, it can be concluded as follows: if the necessity of expanding a location (nation) is high, floating structures do outweigh the investment costs for land reclamation in the traditional way.

4.3 Non-financial results

How the results of different practices contribute to business objectives has been shown in Figure 4.1. In summary, *Case 2 Nearshore Urban Floating Community* contributes to all business objectives; whereas, *Case 1 Offshore Industrial Floating Accommodation* is regarded less innovative relatively, its potential to be future proof, namely with regards to sea level rise, and to scale up and cater future needs remains low.

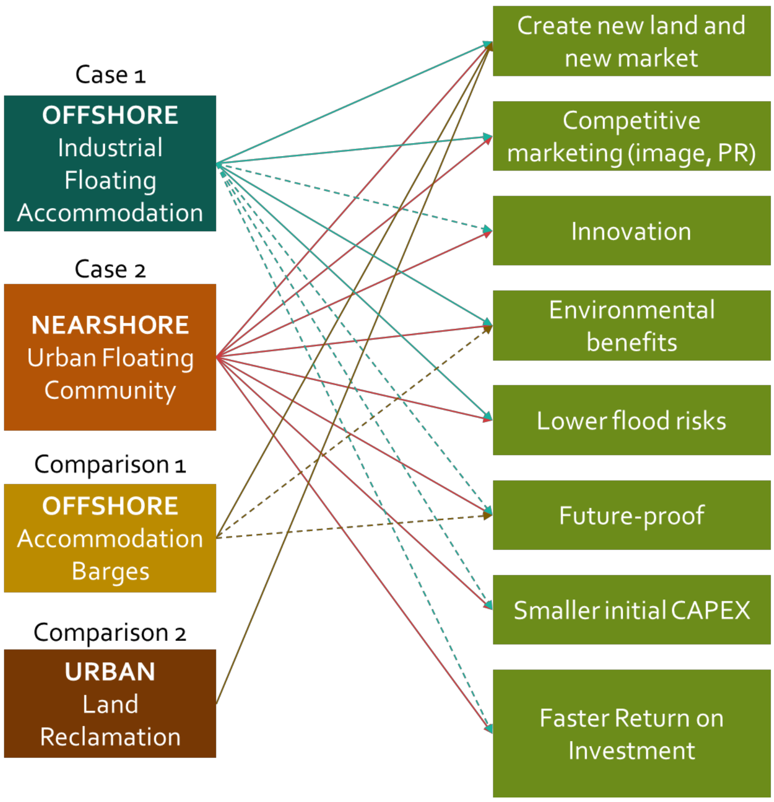

Figure 4.1 Different practices contributing to business objectives (the dotted lines show a less direct relation).

4.4 Concluding

Floating development is competitive to land reclamation in both deep and shallow waters (when exceeding certain depth). In fact, land reclamation in deep waters does not make much sense. The floating Space@Sea platforms are innovative but floating for offshore housing is not very new as ships and barges are currently a common used practice. It does, however, offer a competitive option to current second-hand barges in terms of space and quality and in comparison with the new crew ship which it competes financially. It is worth further investigation and production.

Floating development also has a lot more environmental benefits as it does not wipe out bentho community growing on the seabed or cause other damages. Additionally, floating has a very innovative and visionary image, which contributes to the PR and marketing value for projects.

5. Risk analysis

This chapter describes the potential risks for the business results deprived in the previous chapters. Firstly sensitivity analysis is presented, followed by business risk register and other considerations which could influence the business case to a large extent.

5.1 Sensitivity analysis

Sensitivity analysis will challenge the important assumptions made for the financial results presented in the cash flow statement. It will provide information regarding which assumptions are important for the business case outlook. In this case, the most sensitive variables are time and rent costs. At the moment it has been assumed that the project can be realized in a certain time frame, however, there is not enough knowledge on how this will look like in reality. There are a couple of unknowns here, for instance:

1. How long will it take to manufacture the floating platforms in a drydock.
2. The time to tow and install the platforms (depending on the strategy to tow and install).
3. The time it will take to construct the superstructures on top (in the case of the coastal floating island).
4. The time until the first platforms are ready for use, as in the case of the large project now it is assumed that after every 12 platforms are installed, construction works can begin. It could be that this is already the case with 9 platforms, or that this is not possible and that all 36 platforms need to be installed before construction work can start.
5. As this is a rather innovative project, it is highly likely that an average bank will not be interested in financing it. This could lead to the need of finding investment from for instance, the world bank or development bank, which usually does not fit the high-end business case approach (as the mechanism set in place is often non-for-profit). Finding a risk-taking investor can also be an alternative. On the other side, there is a large chance that a (local) government can also guarantee the loan to make the investment more attractive.
6. Large chance, as this is an innovative project, interest rates will be rather high then low.

5.2 Business risk register

Business Risk Register by Work Package 1 is used for the qualitative analysis of risks which might lead to significant deviations in variables connected to the adopted assumptions. When a risk is identified, a probability of occurrence and the impact of the event will need to be estimated. A heat map has been provided to assess the risk level and prioritize the risks (Figure 5.1). The indication for each color of risks has been included in Table 5.1.

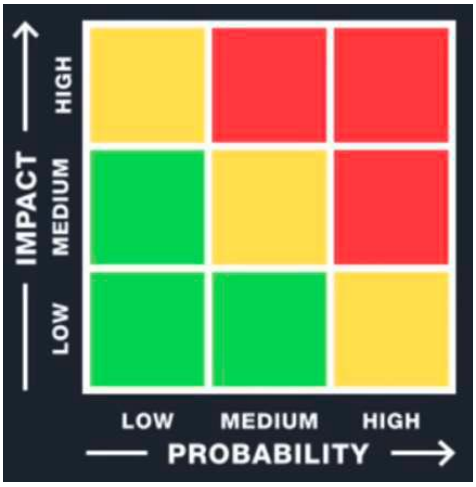

Figure 5.1 Risk prioritization heat map

Table 5.1 Implications of the color of risks

Color	Level of risk	Implication
Red	High	A proactive response plan needed
Yellow	Medium	A response plan might or might not be developed
Green	Low	Only monitored without adopting a specific response plan (until their status changes)

In terms of manufacturing/production, the exact location to produce the modules have much impact on the cost estimation. The further the production is from the installation site, the more transport cost there will be, for instance. The production scale refers to the exact amount of modules and superstructure that will be built. Numbers in this study are assumptions and economies of scale are not considered for mass production.

Regarding construction, the mooring and connector designs from Space@Sea have yet to be been tested. Whether they will be functional and effective as designed remains unknown, which pose high impact to the overall costs of the project. Decommissioning could also affect the costs. Decommissioning is costly for offshore oil and gas industry, as most of the companies have their offshore assets in place for exploiting the resources. After for instance, 30 years, when the resources have been depleted, the structures will have to be removed. However, Living@Sea is designed for long-term stay (30+ years), depending on the regulations and other requirements, it might or might not be decommissioned after certain amount of years. In short, the overall business risk register for Living@Sea is shown in **Error! Not a valid bookmark self-reference.**

Table 5.2 Living@Sea risk register

Risks	Impact	Probability	Risk level
Manufacturing/Production			
Location unknown	High	Medium	High
Production scale unknown	Medium	Low	Low
Construction			
Mooring design untested	High	Low	Medium
Connector design untested	High	Low	Medium
Decommission	Medium	Low	Low
Business development			
Competition with offshore companies	High	Medium	High
Competition with other technologies	High	Medium	High
Regulation and financial instruments not in place	High	Medium	High

In terms of business development, Living@Sea has an advantage of providing more comfort for long-term stay offshore in comparison to offshore accommodation barges. However, there are potential competitions with offshore companies providing accommodation barges with more advanced technology ready to go. Moreover, this study has not investigated into other technologies and solutions such as piled offshore structures, which could also pose potential competition to Living@Sea deep sea floating solutions. Last but not the least, regulations for offshore industrial floating accommodation with more eased regulations that are closer to urban standards are not yet in place. Whether financial institutes would be willing to provide financial instrument to fund building of such floating structure remains unknown.

Other important criteria which could influence the development of the Living@Sea business case are as follows:

- ***Certification***: who have both knowledge on maritime and urban safety requirements that can develop guidelines and can certify Living@Sea in semi- urban and semi-offshore context?
- ***Regulations***: what international and national laws and regulations address floating city development? If not, what measures can be taken to address knowledge gaps?

- ***Insurance:*** what are the concerns of insurance companies on insuring the safety of the floating platforms and superstructure (buildings and infrastructure)?
- ***Ownership:*** who can own the floating platform and buildings on top? The government, the real estate developer, the housing corporation, the construction company, the investor or the resident?
- ***Mortgage financing***: depending on how the floating buildings will be legally defined and who would own the buildings/plots of platform, it might or might not be possible for residents to apply for a housing mortgage.

Many issues that are out of the scope of this task have to be further investigated and addressed before Living@Sea could even be made possible. The ownership of the platform or the building atop, as well as the business model of the buildings, whether they will be leased or sold all have to do with the return of investment. There are currently too many uncertainties and challenges in terms of regulations, policies and insurance issues that still need to be solved so that meaningful numbers could be extrapolated. In the report of Deliverable 7.2 A catalogue of technical requirements and best practices for design, such issues have been scrutinized. For the business case developed in this deliverable, we assume that individuals will be able to buy the real estate and own part of the platform from the real estate developer.

6. Conclusions & recommendations

Living on floating islands both in the deep water offshore or in the shallower water nearshore for a long period of time is an innovative concept. Offshore living on water is commonly practiced by offshore workers who have to carry out maintenance or exploitation work at sea. These workers usually stay temporarily on offshore accommodation barges or living quarters built on mounted offshore structures. Whereas, nearshore living on water was practiced commonly by fishing villages in the old days and was not perceived high level of comfort or safety. In the face of climate change, sea level rise and urbanization, creating comfortable and safe living space on water for long term as expansion of existing coastal cities seems to be an interesting alternative.

This study investigated the financial feasibility of Living@Sea, assuming two cases for floating development: "*Case I Offshore Industrial Floating Accommodation*" and "*Case 2 Nearshore Urban Floating Community*". *Case 1* has been compared to *Offshore Accommodation Barges* and *Case 2* to *Nearshore Land Reclamation*.

In short, main conclusions and recommendations have been listed in the following:

- Floating development appears to be financially more interesting than land reclamation for nearshore conditions and accommodation barges for offshore conditions.
  - Regarding nearshore urban environment, the unit price of Living@Sea as stand-alone islands for only living function is €3,037 per m^2 UFA; whereas the unit price of land reclamation is €4,335 per m^2 UFA.
  - The newly created land, (substructures and all installations, without the real estate) can be valued at €2,951 m^2 for the near shore option and €5,203 m^2 for the offshore option.
  - Regarding offshore industrial environment, the unit price of Living@Sea as part of the multi-use islands is €4,062 per m^2 UFA; whereas, the unit price of offshore accommodation barges ranges from € 5,000-10,000 per m^2 UFA.
  - There are two ways to optimize the business results: 1.) to decrease the time needed to build, certify and install the platforms from 4 to 3 years, so as to speed up paying back for the loan, and 2.) to increase the unit sales price from €5,000 to €6,000/m^2.

The business case provides potential investors or developers with a first idea. However, more market researches are needed in order to find out the first potential clients and the range of price that they are willing to pay for floating structures. Moreover, challenges related to certification, regulations, ownership and insurance still need to be over-come in order to make a more meaningful financial projection.

Appendix 1: Business case canvas Living@Sea

The results of Living@Sea could be concluded and presented in the following business case canvas shown in Table A2.1.

Table A2.1 Business case canvas of Living@Sea

Problem
- Lack of space
- Climate change
- Urbanization
- Overpopulation

Strategic align
- Climate adaptation
- Contributing to SDGs #11 Sustainable Cities and Communities & #14 Life below water

Key stakeholders
- See Annex 3

Strengths
- Flexibility
- Adaptivity
- Cost efficiency for deep water

Weakness
- More interesting financially for deeper water
- Unknown willingness of clients to develop

Solutions
- Expansion of coastal cities on water
- Floating structures: less disruptive to the environment

Economics

Return on Investment (ROI)	102%
Net Present Value (NPV)	€1,783,371,000
Internal Rate of Return (IRR)	44%

Opportunities
- Combine both land reclamation and floating development

Threats
- Not many references
- Competition with existing offshore technologies, land reclamation, etc.

Costs

Unit price (€/m²)	Land reclamation / Barges	Floating
Nearshore	€ 4,335	€ 3,037
Offshore	€ 5,000 – 10,000	€ 4,062

Benefits
- Ecological habitat created, less disruptive
- Scalable and no time needed for soil stabilization
- Adaptive to sea level rise
- Resistant to earthquakes and tsunamis
- Possible prefabrication elsewhere with fast deployment

Appendix 3: Stakeholders of Living@Sea

In Deliverable 7.2 of Task 7.3 Technical, comfort and safety requirements of Living@Sea, four main types of stakeholders in the development of floating islands have been identified (Figure A3.1). In Table A3.1, examples of these four types of stakeholders have been listed as well as main objectives of each type of stakeholders (Table A3.2).

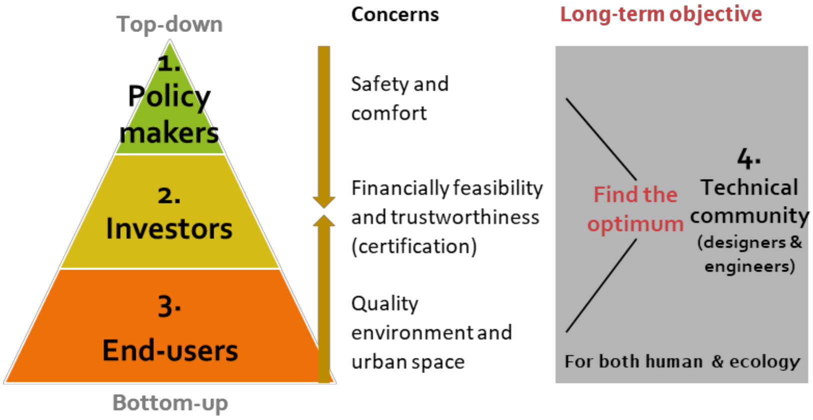

Figure A3.1 Synergies between the four main types of stakeholders of Living@Sea

Table A3.1 Four main types of stakeholders of Living@Sea

STAKEHOLDERS			
1. Government-Public	**2. Finance**	**3. Users**	**4. Suppliers**
Municipalities	Investors	Homeowners	Contractors
The State	Insurance companies	Landlord (i.e. plot/building owner)	Engineers, Designers
Regulators	Real estate developer*	Renter	Developers
NGOs	Classification society	Certification	Building materials suppliers
IMO – Building codes	Housing corporation	Housing corporation	Maintenance crew

Local communities			Utility companies (e.g. water, energy, food, telecom, waste…)
Housing corporation			Housing corporation

*= on which the perspective of business case is based

Table A3.2 Objectives of each type of stakeholders of Living@Sea

OBJECTIVES			
1. Government-Public	**2. Finance**	**3. Users**	**4. Suppliers**
Environmental benefits	Lower flood risk	Living near water	Generate turnover
Climate adaptative	Fast building time / easy to build	Safety – comfort	Decent profit
Safe for inhabitants	Shorter return on investment	Cheaper – affordable housing	New market
Sustainable – Circular	New market	Lower maintenance	Grow client base
Land/urban expansion	Smaller initial cost – initial risk	Status/Image - pioneer	Innovation
Job/ Economic growth	Repurposing		Image, PR
Inclusive society			Competitive marketing
Secure livelihood			