Interreg
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SURICATES
European Regional Development Fund

WP T1 Deliverable 1.2. Sediment management GIS implementation

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INTRODUCTION

This deliverable T1.1.2 is one of the three reports of activity 1 of work package T1 of the SURICATES project. The objectives of Activity 1 were to develop a method for assessing social risk and prioritising opportunity to increase the acceptability of sediment reuse in projects. This activity was divided into three parts:

- Development and testing of an add-on to the GIS based on the CEAMaS outputs ready for use. This sediment management GIS system will be available for use and application by Port Authorities (Deliverable T1.1.1, not this report).
- Implementation of the GIS add-on within ports/waterways using local real field data to identify territories of maximum attractiveness and social acceptability; pilot port sites in North of FR and South of IE, Port of Rotterdam and SC as dissemination sites (Deliverable T1.1.2 this report).
- 3 locations with potential for new sediment use opportunities will be identified within the four NWE regions (North of France, South of Ireland, Bowling river site in Scotland and Netherlands) using field tested and validated GIS (Deliverable T1.1.3 not this report).

To achieve the objectives set by this activity T1.1.2. it was decided to run a number of interviews with local stakeholders, with sediment managers and public authorities in charge of ports infrastructure but also with selected scientists both matching GIS and environmental topics expertise. The aim was to implement the RAIES GIS tool (see deliverable T1.1.1.) in order to produce a territorial analysis of the societal acceptance of:

- Siting a transit storage facility to increase the volume of dredged sediment input in a circular path to be developed in the Rance estuary
- Constraints against a potential dredged sediment reuse application in respect of the national environmental regulations.

To succeed in implementing RAIES GIS tool to the four countries involved in the Suricates project GIS data collection has been ongoing since the beginning of this project activity with close collaboration with the UCC Partner. We have been focussing exclusively on open data repository available at national level to guarantee good information quality both in spatial coverage and in semantic description. For a good number of GIS layers, European data repositories, mainly Eurostats (https://ec.europa.eu/eurostat/fr/web/gisco/geodata), Copernicus (https://land.copernicus.eu/en) and European Environmental Agency (https://www.eea.europa.eu/en/datahub/), have been preferred to the national equivalent in order to implement the RAIES tool with a maximum of shared data at European level. While it was possible to gather more than 50 GIS data layer using French national open data repositories, the number of similar equivalent data for the four countries was reduced to 34 GIS layers (see table 1).

GIS data catalogue		
Urban fabric		Shrubs / herbaceous vegetation
Industrial areas		Open spaces with little or no vegetation
Commercial areas		Arable land
Heritage site		Fruit trees and vinyards
Green urban areas		Other agricultural areas
Airport areas		Water streams
Mine, dump and construction sites		Inland water bodies
Main roads		Inland wetlands
Secondary roads		Estuaries
Small roads & paths accessible to light vehicles		Coastal wetlands
Railroad network		Cliffs, beaches, dunes, and sand plains
Road & Rail stations		Sea and ocean
Artificial banks (i.e. quays, dikes...)		Shoreline with coastal erosion
Canals and waterways		Natural parks
Ports, harbours and ferry terminals		Natura 2000 areas
Ferries and sea routes		International natural protection areas (other than Natura 2000)
Forests		National natural protection areas (other than Natura 2000)

Table 1: GIS data catalogue used for interviews in the four participating countries

In many respects, this has made it possible to support the main objective of interoperability of European/National open data and reproducibility on a European scale. However, from one country to another, depending on the National/Regional/Local GIS data availability, it is possible to integrate a greater number of territorial constraints than the 34 retained in this operational implementation (see table 1).

1 SITING A TRANSIT STORAGE FACILITY

1.1 IMPLEMENTATION DESCRIPTION

The implementation of the RAIES model for decision support in sediment management has been made in two phases. The first one under activity of WP-T1 from the initial Suricates Project application form. The question asked to interviewees was:

- In your opinion, what are the geographical constraints on the siting of a dredged material storage facility?

This question has been asked using face to face meetings with local stakeholders, sediment managers and public authorities in charge of port infrastructure but also with selected scientists both matching GIS and environmental expertise. During these interviews, we have listed the GIS data available (see table 1), repeating the question when necessary and asking if:

- Each data was relevant for decision making about siting a storage facility?
- If "yes", then the RAIES model was set for these specific GIS layers (see methodology deliverable T1.1.1. for model parameters)
- If "no", then these specific GIS layers were excluded from the RAIES model, i.e. not participating to the decision making according to the interviewee's viewpoint.

Where a particular piece of geographic information was too obscure for an interviewee, a discussion was held to clarify whether that specific piece of data was relevant to the interviewee's decision-making process. We recommend that the person responsible for conducting the interviews should have a good knowledge of the GIS catalogue (see table 1) they are proposing to the interviewee. Indeed, with the exception of interviewees with expertise in GIS or geographical data, most local stakeholders, sediment managers and public authorities may need to translate into "simple words" the overly technical names sometimes assigned to the geographical data/information that can be used to draw up the most complete territorial analysis using the RAIES model.

Two runs of interviews have been implemented in this activity:

- The first one was implemented as a test with 12 interviewees from the Rance Estuary in 2020. It was before the Suricates project developed a new set of activities (i.e. WPT3 and WPI6) within the Capitalisation Phase extension (starting from June 2021 and ending in December 2023) including the "EPTB Rance Frémur Baie de Beaussais" public body as a new local partner.
- The second run of interviews has been undertaken with three sediment experts from fluvial waterways (PP Scottish Canals, Scotland), ports (PP Port of Rotterdam, The Netherlands and Fenit Harbour, Ireland) and one representative of a public body in charge of regional ports' infrastructure management (Hauts-de-France region). Most of the interviewees from the first run have also been interviewed in the second run but with a second different question:
    - What do you think are the geographical constraints on the reuse of dredged material in applications that comply with environmental regulations?

For the first run of interviews a full data catalogue of 51 GIS layers has been used while only 34 geographical data from the previous catalogue were used for the second run.

1.2 Interpretation of RAIES model outputs

As a spatial decision support system, the RAIES model provides results in a grid geo-referenced format that can be used directly for interpretation. But direct results (i.e. a map) can also be combined with other geographical layers or other geographical treatments such as statistical calculations, spatial clustering, etc. Remember a direct result from RAIES is a map of territorial constraints according to the interviewee's viewpoint (see deliverable T1.1.1.). It can be very subjective according the individual values one interviewee wants to push in his/her very own decision ruleset in the RAIES model (i.e. selection and setup of any number of layers from the available ones in the data catalogue). This is why each direct result from the RAIES model is already provided as a standardized grid of values (i.e. real number from 0 to 1). The objective here is to allow some GIS comparison between different interviewees, no matter the ruleset they developed at an individual level. In other words, for every interviewee:

- A "0" value in the result map is a "no constraint at all" to locate a positive answer to the asked question.
- A "1" value in the result map is a "maximum constraint possible" to locate a positive answer to the asked question.
- A NoData value in the result map is for a "sanctuarized" or an outside location within the territory of interest. As a default setting NoData value is not displayed (i.e. transparent) in the result map giving the impression that there is nothing to consider for decision making in these NoData areas.

The interpretation of grid maps (see figure 1) can also benefit from a histogram plot of cell values (see figure 2). Displayed in that form, the statistical distribution of grid map values can be commented from one interviewee to another without spatial consideration. It is very helpful if one wants to compare if an interviewee grid result is more open to implementing a solution than another one. GIS can also produce a synthetic summary table of the grid values of a map result (see table 2).

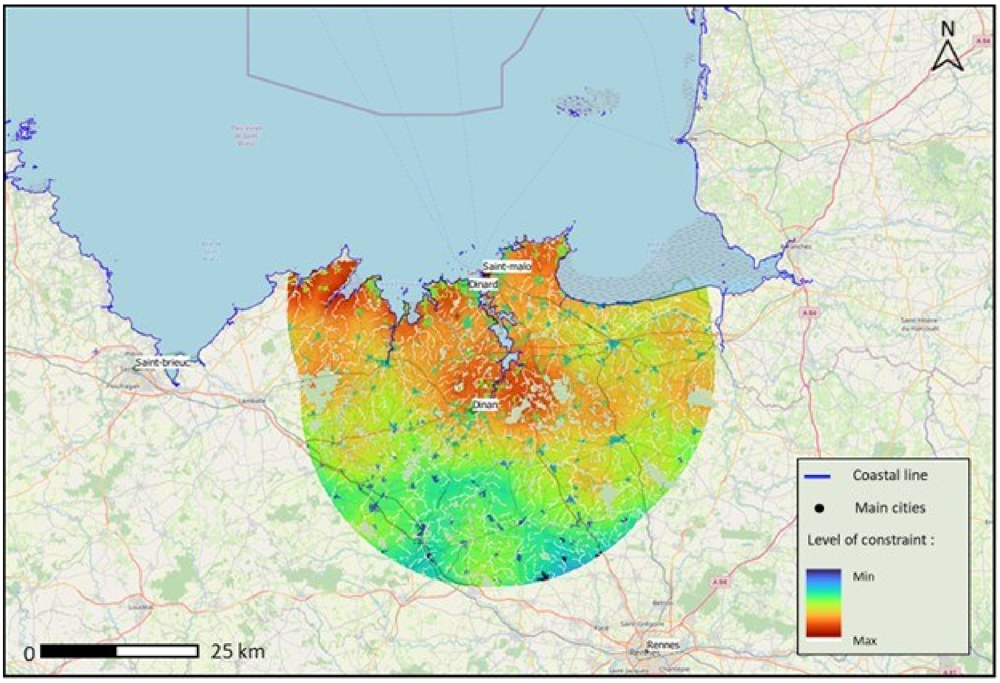

Figure 1: Result map in a grid format over OSM background (Environmental Ing.)

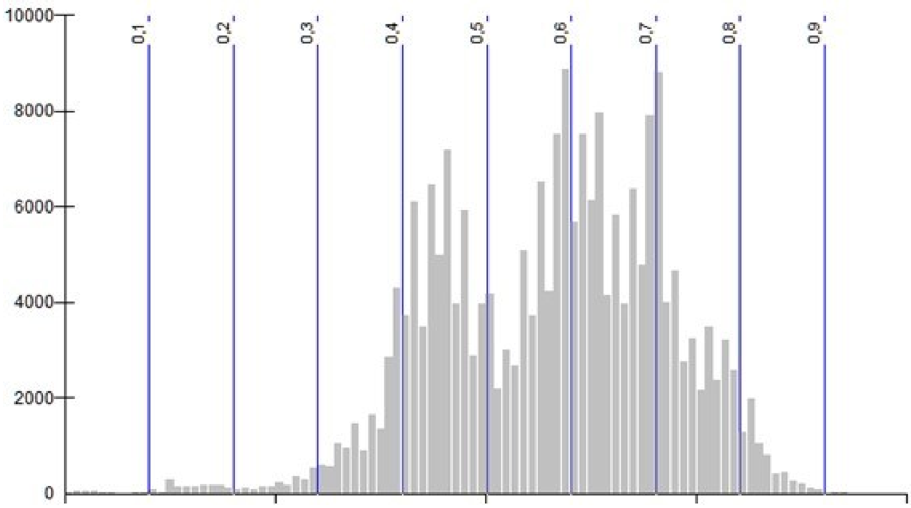

Figure 2: Histogram distribution of cell values result map (Environmental Ing.)

Environmental Ing.	Values
Min	0
Max	0.997
Mean	0.577
Std Dev	0.134
Ha <15% Constraint	930
Ha <10% Constraint	281
Ha total	220,156

Table 2: Synthetic data summary of a result map (Environmental Ing.)

The map is displaying territorial values in space (see figure 1). According to this interviewee (i.e. an engineer in charge of coastal environment and water quality) a better option to reuse sediment in any application following the environmental regulations (question asked for the 2 run of interviews) is located inland and far from the dredging site (i.e. the Rance Estuary). It is also clear that dumping at sea/in the estuary (i.e. relocation of sediments within the system) is a no way solution for this interviewee. The histogram distribution (see figure 2) together with the basic data summary (see table 2) of a large number of cell values are above 0.5 which is a quite a significant view point against a white card to reuse dredged sediment, even if the reuse application is following the local environmental regulation. Only a few cells of 1Ha each have received a low level of territorial constraint (see table 2) with 930ha under 0.15 value (i.e. 15% constraint) and only 281ha under 0.10 value (i.e. 10% constraint). The interpretation of this result must also consider that the interviewee is in charge of coastal and estuarian water quality which is very sensitive to the resuspension of fine sediment according to bio-ecological indicators used in water quality monitoring like turbidity for instance. The answer to the question using the RAIES model is therefore biased with the professional expertise of the interviewee. Another track to explain the final result is also to consider the training background of the interviewee which is ecology. Compared to other results from the two runs of interviews (see next chapter of this report) this first example stands quite above sediment/port managers with a Civil Engineering background.

This first example shows that the map result from the RAIES model provides the final user with very useful data to locate a potential solution based on the interviewee's view point about a specific question (i.e. in that case: constraints against a potential dredged sediment reuse application in the very respect of the national environmental regulations). It also demonstrates that the interpretation of the RAIES result, other than the best location to answer a question based on a collection of individual viewpoints, will benefit from social sciences skills applied to semi-directive interview driving but also to the analysis of interviewees profiles.

2 IMPLEMENTING RAIES MODEL TO IDENTIFY TERRITORIES OF MAXIMUM ATTRACTIVENESS AND SOCIAL ACCEPTABILITY

In this chapter, the implementation of the RAIES model is reported for the two runs of interviews:

Question 1: In your opinion, what are the geographical constraints on the siting of a dredged material storage site?

Question 2: What do you think are the geographical constraints on the reuse of dredged material in applications that comply with environmental regulations?

The result of these questions a reported in two different subchapters according to individual:

Territorial values from various stakeholder viewpoints (see chapter 2.2),

Territorial values from one sediment/port management expert in each of the four Suricates countries (see chapter 2.3).

A final average map per country site is also produced and demonstrate the capacity of the RAIES model to aggregate multiple viewpoints in a synthetic territorial constraint map.

2.1 THE GEOGRAPHICAL CONSTRAINTS ON THE SITING OF A DREDGED MATERIAL STORAGE SITE

2.1.1 French cases

Two French cases have been implemented within the activity 1.2 of Work Package T1. The first territorial case for implementation focused on the Rance Esturay where a tidal powerplant is responsible for over sedimentation in the tidal estuary, upstream of the power plant dam. The second case for implementation addresses sediment reuse opportunities in the Hauts-de-France Region.

2.1.1.1 Individual result maps for the Rance Estuary (Brittany, France)

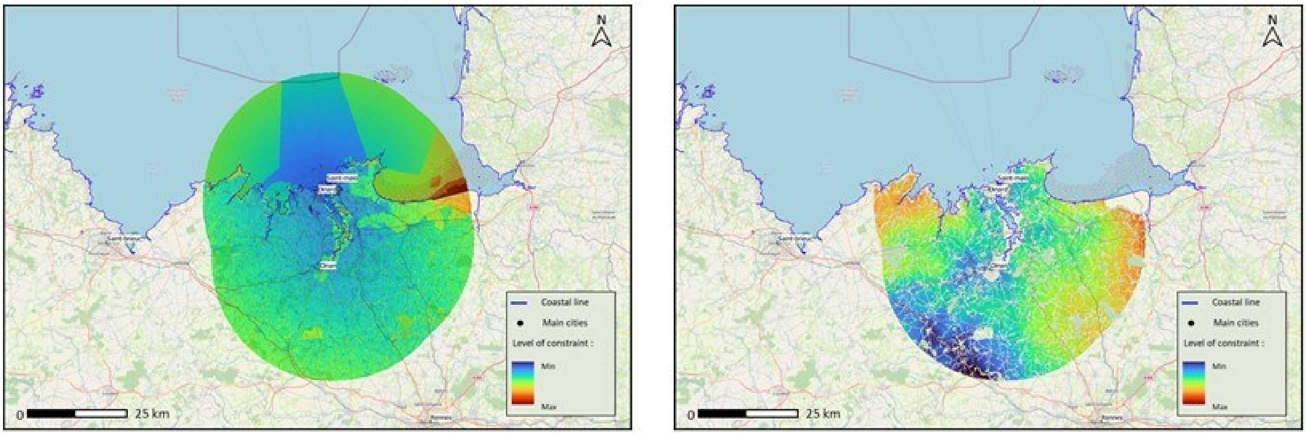

Figure 3: Result maps of two scientists with GIS expertise (left and right).

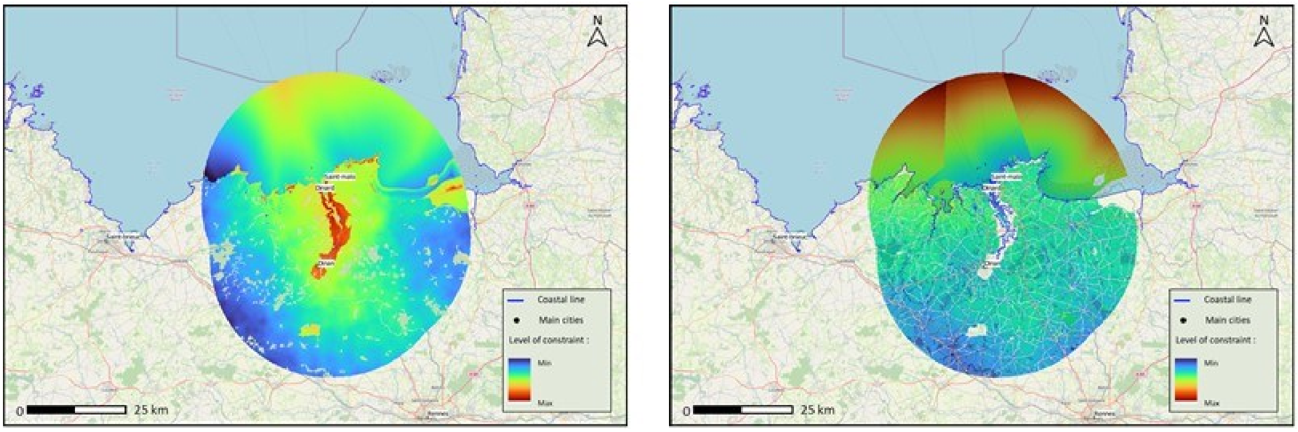

Figure 4: Result maps of one scientist with geographical expertise (left) and one engineer with tidal power plant expertise (right).

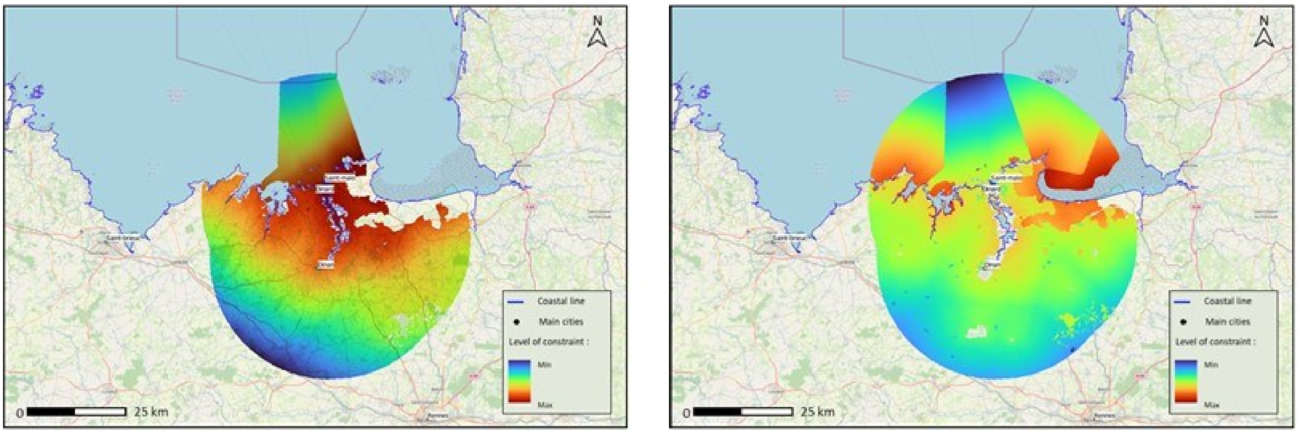

Figure 5: Result maps of two environmental engineers (public body), one with expertise in water treatment plant and aquatic ecosystems (left) and one with expertise in marine ecology (right).

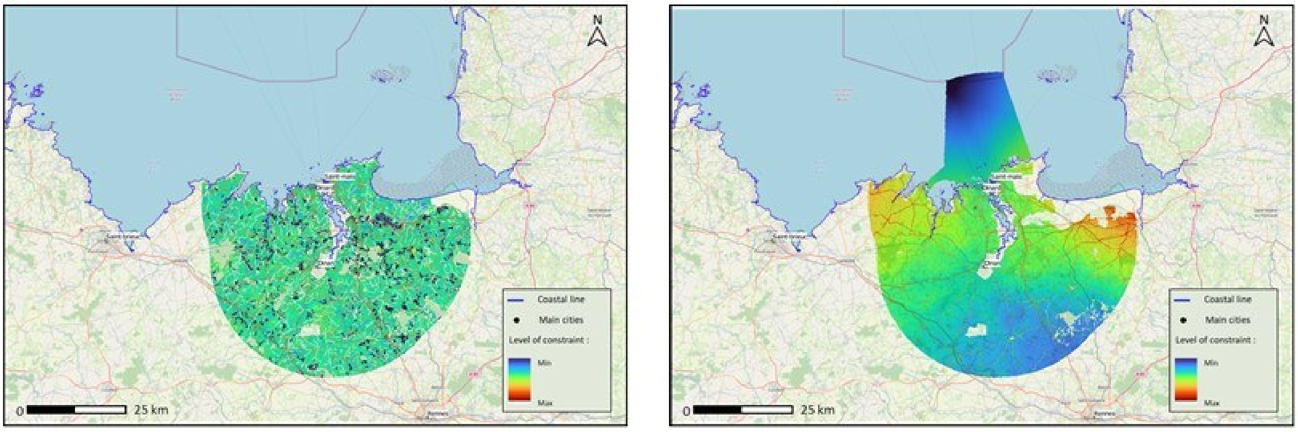

Figure 6: Result maps of one local NGO member with expertise in ecosystems and sediment management (left) and one expert from the GIS dept. from the Brittany Region authority (right).

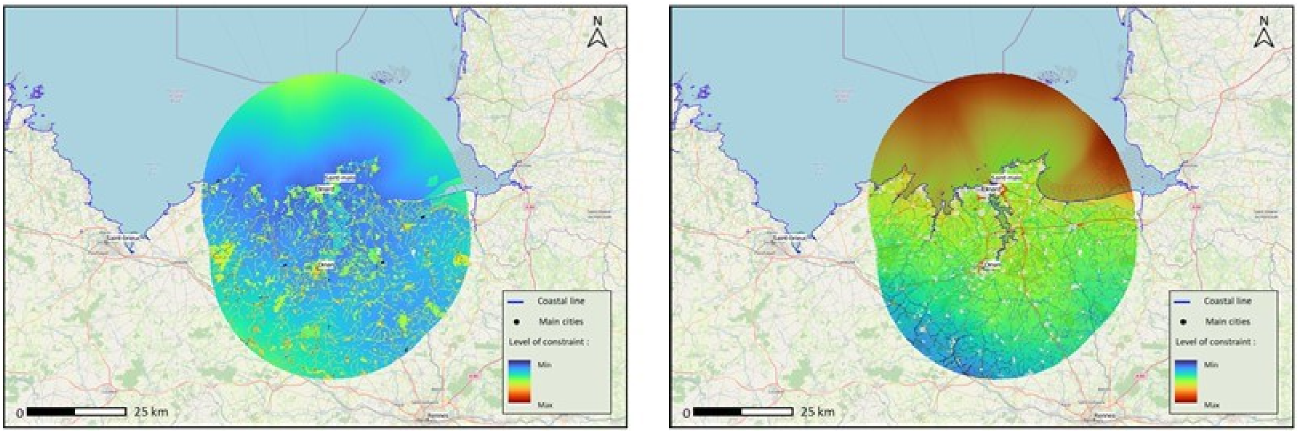

Figure 7: Result maps of one environmental engineer (public body) with expertise in dredging activities (left) and a small group of local elected representatives from the Urbanism & Environment dept. of a riverine municipality (right).

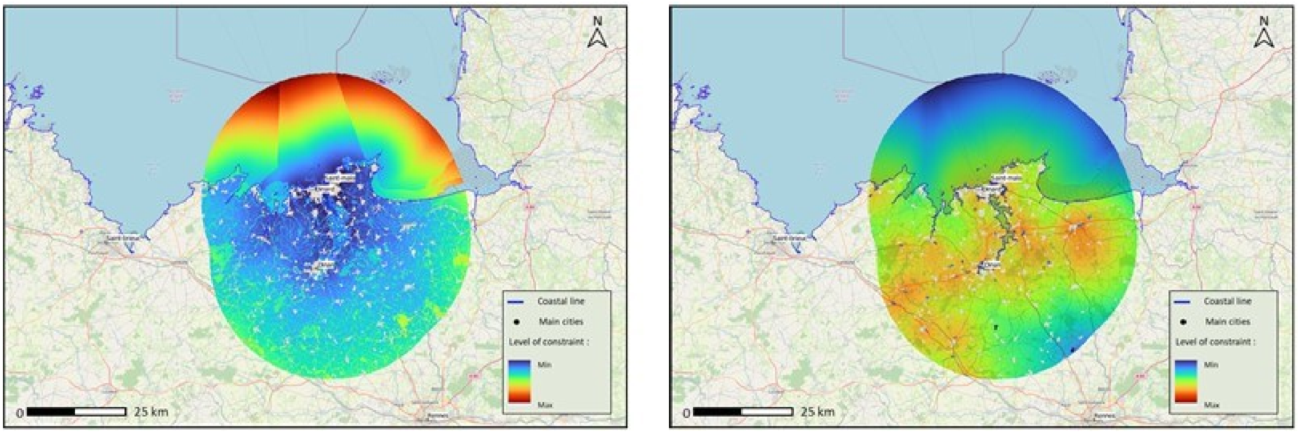

Figure 8: Result maps of one riverine municipality mayor (left)and one one riverine municipality mayor assisted by a municipality staff (right).

In this report we are not going to comment in great detail on every individual map but few lessons learnt can still be addressed below:

- The result maps are very sensitive to the contribution of each interviewee, since the twelve maps are significantly different. This means that each specific parameter given by an interviewee has a real importance in the calculations of the RAIES model. The model is therefore very sensitive to individual points of view, which is one of its main objectives, given that it aims at capturing the diversity of points of view that take part in a territorial decision-making process.

- The result maps are also sensitive, even if the interviewees share a similar area of expertise (see figures 3, 4 and 6 for GIS/geography or figures 4, 5 and 7 for engineering). This shows that the RAIES model does not only take into account education and professional training, but also the individual and personal values that a participant attributes to the geographic information he or she selects to build his or her own model of territorial constraints in order to solve a problem and make a spatial decision.
- Most results maps include storage facility location in the estuary of the coastal/sea areas except figures 3 (right) and 6 (left), rejecting any estuary or coastal/sea location for sediment storage. Figures 5 (left) and 6 (right) also reject a significant part of the estuary/coastal/sea area in their ruleset for decision making.
- Most result maps clearly demonstrate that the diversity of individual viewpoints play a significant role in any participative debate about locating a sediment storage facility in the Rance Estuary. This is clearly showcasing the need for a spatial decision support system tool to intermediate in the local decision process if one wants to advocate democratic/participative participation to reach societal acceptability.

2.1.1.2 Multi-stakeholders' result map for the Rance Estuary

The mutli-stakeholders' map is the output of an average calculation including all interviewees viewpoints with an equal weight i.e. an equal power in the decision process (see figures 9 & 10).

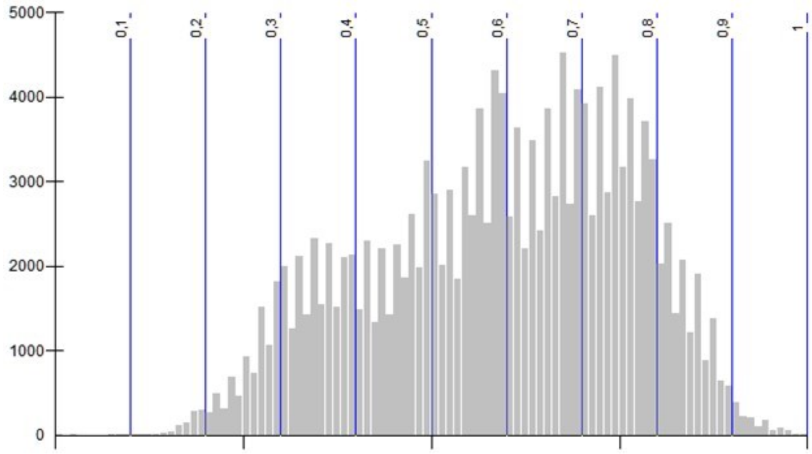

Figure 9: Histogram distribution of cell values result map (average viewpoint)

According the statistical distribution of the territorial constraint values (see figure 9), most areas of the Rance Estuary are receiving a constraint value above 0.5 with an average of constraint value of 0.59 (see table 3). This clearly demonstrates the existing tension between local stakeholders and experts about siting a new storage facility for dredged sediments. This is strongly confirmed by the cumulated hectares (Ha) under a certain threshold of territorial constraint (see table 3). Only 49 Ha are under a threshold value of 10% average territorial constraint. This value reaches only 9,102 Ha out of 161,899 Ha under a threshold value of 30% average territorial constraint. This demonstrates that stakeholders and experts do not agree at a territorial level to locate a potential new storage facility. Moreover the average map (see figure 10) clearly locates the area of minimum territorial constraint in the south of the area of interest, very far from the Rance Estuary itself. Low constraints location with a higher multi-stakeholders agreement are not well situated according to collected viewpoints.

Average map	Values
Min	0
Max	1
Mean	0.591
Std Dev	0.171
Ha <30% Constraint	9102
Ha <20% Constraint	3202
Ha <15% Constraint	94
Ha <10% Constraint	49
Ha total	161899

Table 3: Synthetic data summary of a result map (average viewpoint)

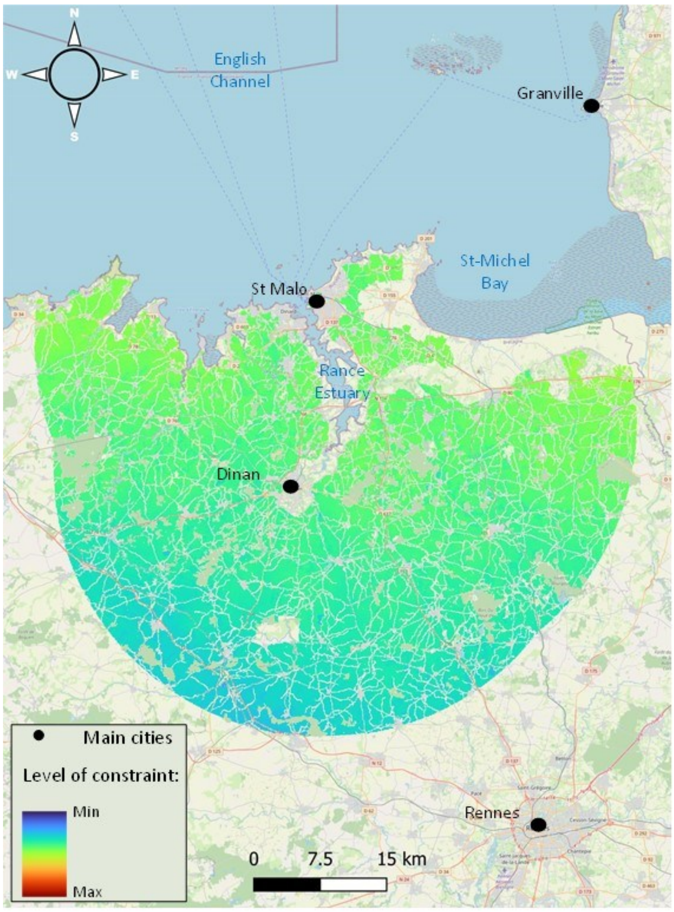

Figure 10: Result map of the average viewpoint about the territorial constraints to locate a new sediment storage facility for the Rance Estuary

In the Rance Estuary case, the location of a new storage facility will be far from a consensus between local stakeholders and territorial experts. This map also well reflects the tensions and conflicts about sediment management in the Rance Estuary. According to this map any local decision will be confronted with the adversity of local counter power which is already a well-known fact in this territory.

2.1.1.3 Rance estuary stakeholders's view point apply to the Hauts-de-France Region

If we apply the same set of interview results to the collected GIS data for the Hauts-de-France region, we can produce a new average viewpoint that is also very informative. This is only possible because we are using a common set of geographical information (i.e. the same GIS data catalogue) for both territories. What has been provided as a model of decision by one Rance Estuary stakeholder can be applied to an identical data set describing another territory. By doing this we are modelling a "what if the Rance Esturay stakeholders were using their own set of territorial values to address the same question to another territory", in the present case the Hauts-de-France Region.

Applying the Rance Estuary viewpoints to the Hauts-de-France Region produces different results, according to the differences in the geography of each GIS data from the catalogue. Not only the results of RAIES model is sensitive to individual stakeholder/expert input, it is also very sensitive to the spatial distribution of the geographic information. This is why the final result of the calculations varyies even with an equal set of inputs from the Rance Estuary interviewees. This variation is the spatial effect of any territorial geography to the output of the RAIES model.

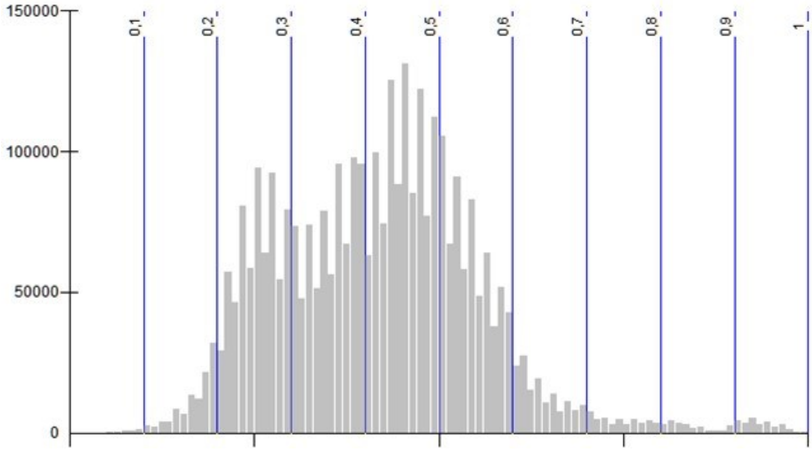

Figure 11: Histogram distribution of cell values result map (average viewpoint)

According the statistical distribution of the territorial constraint values (see figure 11), most areas of the Hauts-de-France Region are receiving a constraint value below 0.5 with an average of constraint value of approx. 0.42 (see table 4). This clearly demonstrates that the existing tension between local stakeholders and experts in the Rance Estuary has a lower impact at the Hauts-de-France Region scale. Siting a new storage facility for dredged sediments in this territory (i.e. Hauts-de-France) is offering better opportunities for territorial consensus among stakeholders and experts. This is confirmed by the accumulated hectares (see table 4) with 3,082 Ha under a threshold value of a 10% average territorial constraint and 761,158 Ha out of 3,373,170 Ha under a threshold value of a 30% average territorial constraint. The number of Ha in the Haut-de-Region (3,373,170 Ha) is of course far above those from the Rance Estuary (161,899 Ha) but the statistical distribution of the territorial values (see figure 11 and table 4) confirms that the geography of the Hauts-de-France Region offer a better ground for consensus than the geography of the Rance Estuary.

Average map	Values
Min	0
Max	1
Mean	0.419
Std Dev	0.138
Ha <30% Constraint	761158
Ha <20% Constraint	10157
Ha <15% Constraint	22409
Ha <10% Constraint	3082
Ha total	3373170

Table 4: Synthetic data summary of a result map (average viewpoint)

Likewise, as with the Rance Estuary, the Hauts-de-France Region geography reflects the difficulty in locating a potential new storage facility. The result map (see figure 12) gives potential locations in the very South-East of the Hauts-de-France Region even if a large number of hectares can be a positive opportunity to build this dredged sediment storage facility.

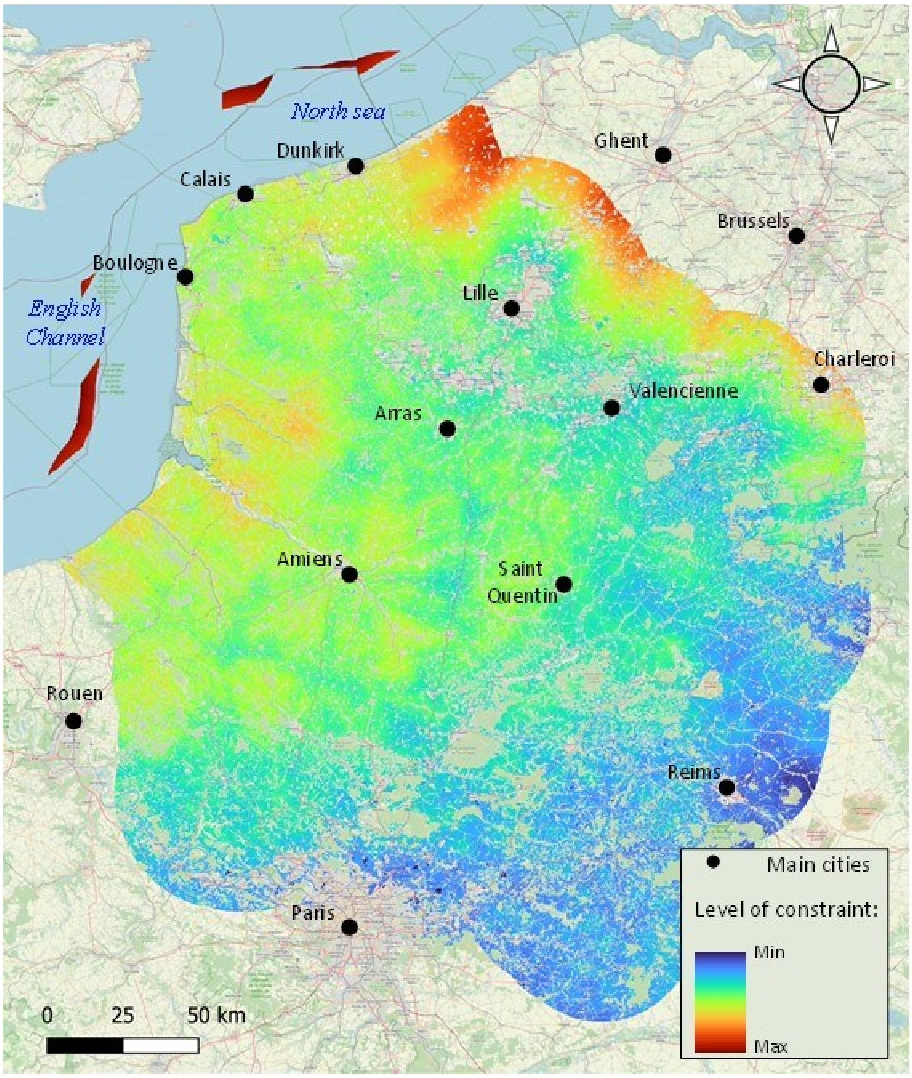

Figure 12: Result map of the average view point about the territorial constraints to locate a new sediment storage facility for the Haut de France Region

On the one hand, locations with a low level of territorial constraints are not relevant for marine ports sediment management but on the over hand they are well located for a number of dredging operations applied to inland waterways around Paris. This result demonstrates that if multiple stakeholders cannot agree on a consensus ruleset to locate a facility near marine port infrastructure, then the same ruleset applied to another territory will lead to a similar result unless other dredging opportunities such as inland waterways maintenance can match the multi-stakeholder's average viewpoint.

2.1.2 Irish case

2.1.2.1 Rance estuary stakeholders's view point apply to the South Western Ireland

If we apply the same ruleset set from the Rance Estuary interviews results to the collected GIS data for the Nuts 2 South Western Ireland, we can produce a new average viewpoint that is also very informative (see figure 13, 14 and table 5).

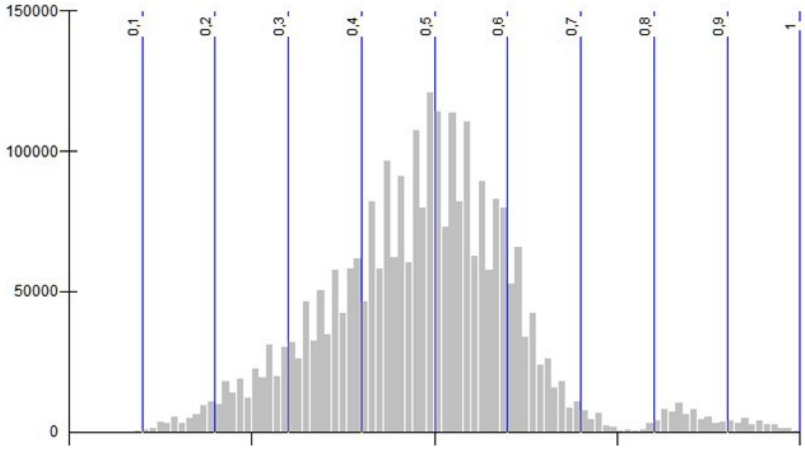

Figure 13: Histogram distribution of cell values result map (average viewpoint)

According the statistical distribution of the territorial constraint values (see figure 13), most areas of South West Ireland receive a constraint value below 0.5 with an average constraint value of approx. 0.48 (see table 4). Siting a new storage facility for dredged sediments in this territory (i.e. South Western Ireland) is offering a better consensus among stakeholders and experts far Inland (see figure 14). Only 342 Ha are under a threshold value of a 10% average territorial constraint but 239,549 Ha out of 2,760,755 Ha are under a threshold value of a 30% average territorial constraint.

Average map	Values
Min	0
Max	1
Mean	0.484
Std Dev	0.133
Ha <30% Constraint	239549
Ha <20% Constraint	44325
Ha <15% Constraint	12708
Ha <10% Constraint	342
Ha total	2760755

Table 5: Synthetic data summary of a result map (average viewpoint)

Likewise, as with the Rance Estuary and the Hauts-de-France Region, the South West Ireland geography is reflecting the difficulty to locate a potential new storage facility. The result map (see figure 14) gives potential locations far inside the South Western Ireland even if a large number of hectares can be a positive opportunity to build this dredged sediment storage facility. These locations are not suitable for Irish and marine ports infrastructure according to the Rance Estuary local stakeholders and experts. Moreover, there is no major economy relying on inland waterways transportation in central Ireland to convert inland opportunities of building a sediment storage facility to foster a local circular economy path with dredged sediments.

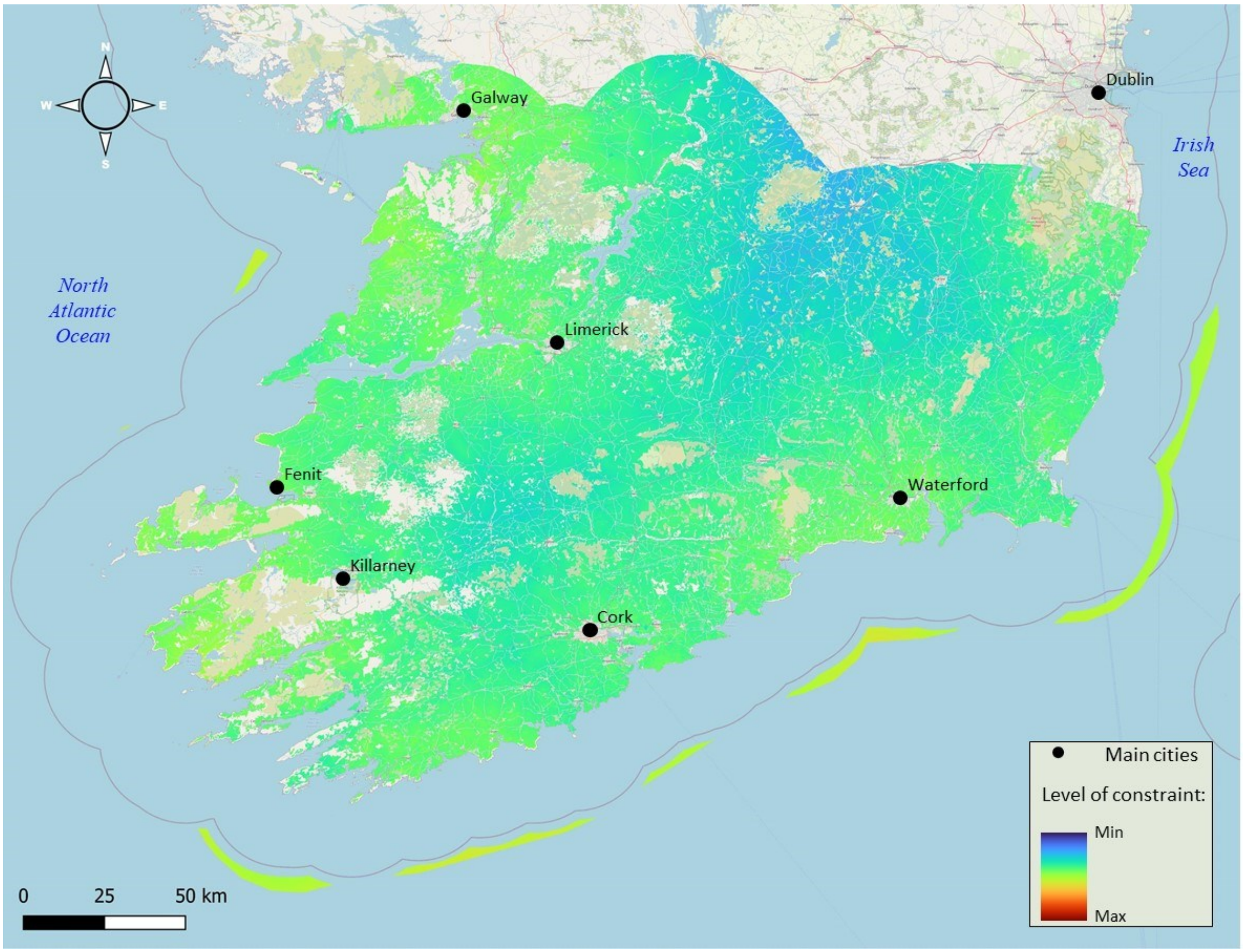

Figure 14: Result map of the average view point about the territorial constraints to locate a new sediment storage facility for the South Western Ireland

2.1.3 Netherlands case

2.1.3.1 Rance estuary stakeholders' view point apply to the Netherlands

If we apply the same ruleset set from the Rance Estuary interviews results to the collected GIS data for the Western Nuts 2 Region of the Netherlands, we can produce a new average viewpoint that is also very informative (see figure 15, 16 and table 6).

According the statistical distribution of the territorial constraint values (see figure 15), most areas of the Western Netherlands are receiving a constraint value between 0.5 and 0.8 with an average of constraint value of approx. 0.60 (see table 4). Siting a new storage facility for dredged sediments in this territory is offering a better consensus among stakeholders and experts in the eastern inland part of the country (see figure 16). Due to the high population density and land use constraints are very high considering the over 3 other countries.

Only 62 Ha are under a threshold value of a 10% average territorial constraint but 29,980 Ha out of 2,421,522 Ha are under a threshold value of a 30% average territorial constraint (see table 6). This is very low in comparison with results for France, Ireland and Scotland (see table 3, 4, 5 &7).

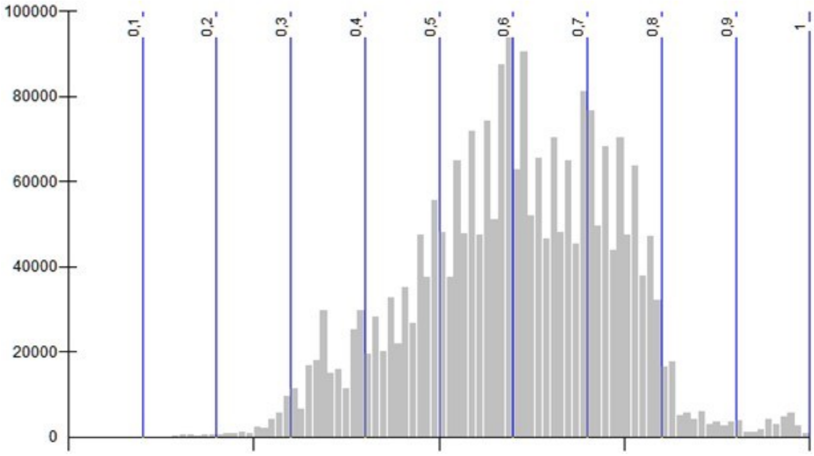

Figure 15: Histogram distribution of cell values result map (average viewpoint)

Average map	Values
Min	0
Max	1
Mean	0.60
Std Dev	0.134
Ha <30% Constraint	29980
Ha <20% Constraint	2353
Ha <15% Constraint	407
Ha <10% Constraint	62
Ha total	2421522

Table 6: Synthetic data summary of a result map (average viewpoint)

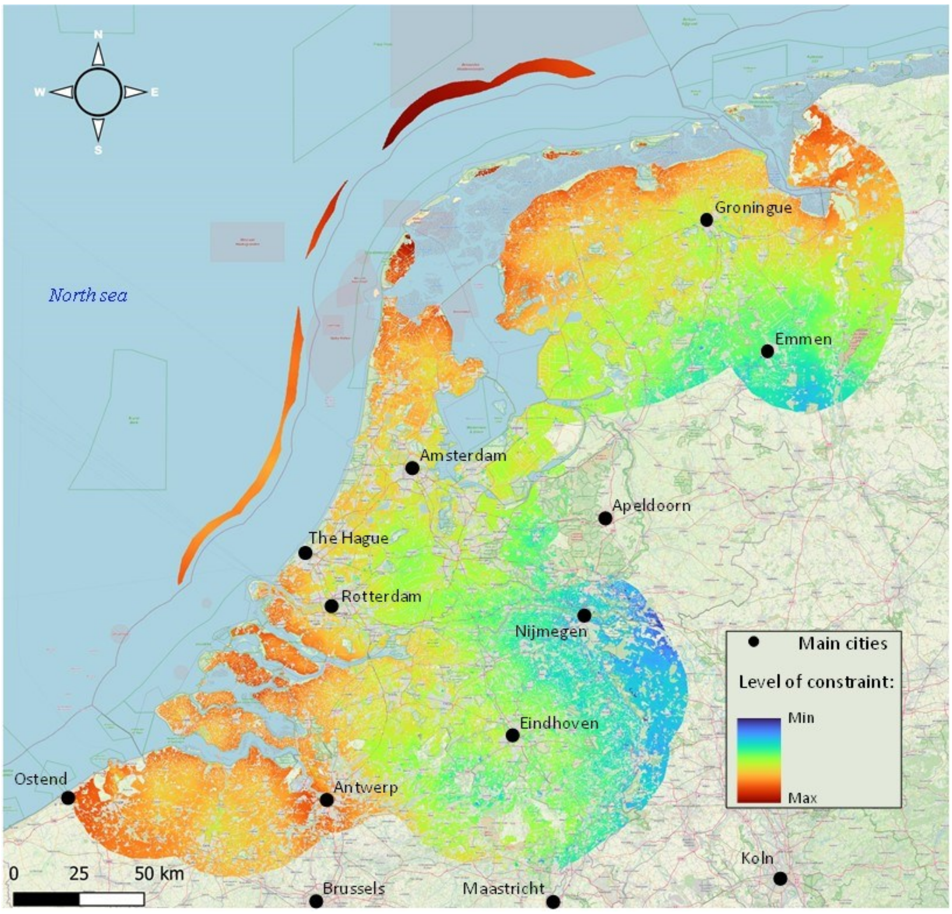

Figure 16: Result map of the average view point about the territorial constraints to locate a new sediment storage facility for the Netherlands

2.1.4 Scotland case

2.1.4.1 Rance estuary stakeholders' view point apply to Scotland

If we apply the same ruleset set from the Rance Estuary interviews results to the collected GIS data for the Nuts 3 Regions from Edinburg to Glasgow (i.e. Scottish Midlands later in this report), we can produce a new average viewpoint that is very informative (see figure 17, 18 and table 7).

According the statistical distribution of the territorial constraint values (see figure 17), most areas of the Scottish Midlands are receiving a constraint value above 0.5 with an average of constraint value of approx. 0.54 (see table 7). Siting a new storage facility for dredged sediments in this territory is offering a better consensus among stakeholders and experts in the western part of the Scottish Midlands (see figure 16).

If a small 281 Ha are under a threshold value of a 10% average territorial constraint, 42,980 Ha out of 375,959 Ha are under a threshold value of a 30% average territorial constraint (see table 7). Moreover, most of the lower constraints areas are located in the surrounding of Glasgow and the Clyde estuary. This a is very much better potential location in comparison with results for France, Ireland and Scotland (see figures 16, 14, 12 & 10).

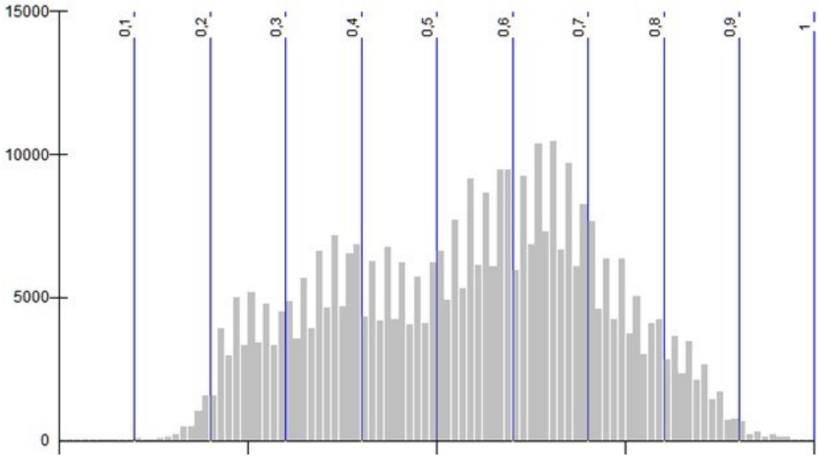

Figure 17: Histogram distribution of cell values result map (average viewpoint)

Average map	Values
Min	0
Max	1
Mean	0.539
Std Dev	0.175
Ha <30% Constraint	42093
Ha <20% Constraint	3942
Ha <15% Constraint	606
Ha <10% Constraint	281
Ha total	375959

Table 7: Synthetic data summary of a result map (average viewpoint)

The geography of the Scottish Midlands, specially for its western part is very open to multi-stakeholders' consensus to locate a potential dredged sediments storage facility (see figure 18).

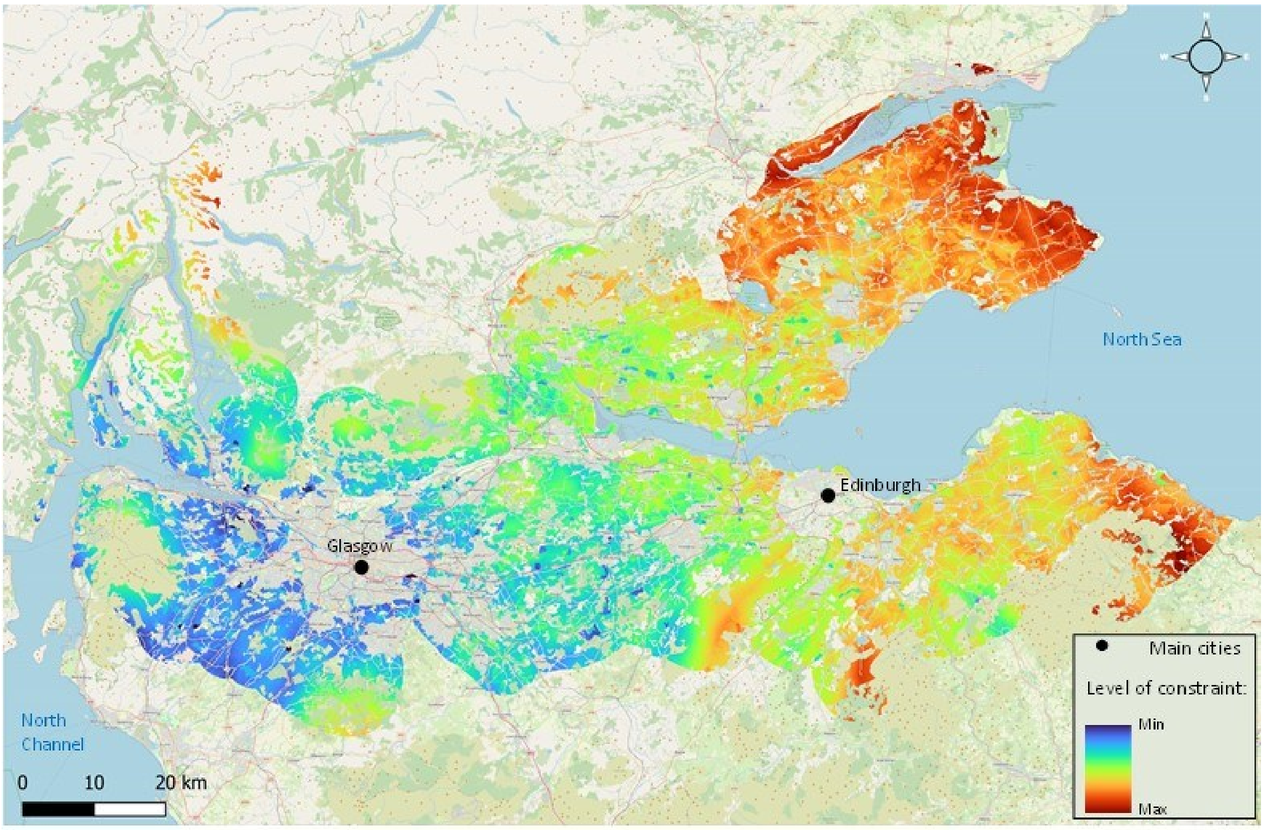

Figure 18: Result map of the average viewpoint about the territorial constraints to locate a new sediment storage facility for Scotland

2.2 The geographical constraints on the reuse of dredged sediments in applications that comply with environmental regulations

This subchapter reports on the second run of interviews about territorial values from sediment/port management expert in each of the four Suricates countries. In this second run of interviews the question asked was:

- What do you think are the geographical constraints on the reuse of dredged material in applications that comply with environmental regulations?

From the 15 interviewees participating, only two were also involved in the first run of interviews about locating a new storage facility for dredged sediment (see results in chapter 2.2).

In the following parts of this report only one expert result is provided per participating country to showcase the implementation of the RAIES model. We are using local real field data to identify territories of maximum attractiveness and social acceptability in North of FR and South of IE, Port of Rotterdam and SC as dissemination sites.

2.2.1 French cases

In France the Rance Estuary and the Hauts-de-France Region are the two sites of implementation where we are looking for the location of territories of maximum attractiveness and social acceptability for sediment Reuse, assuming that any reuse application would comply with local/national environmental regulations. As an introduction, a first general comment from all results from this second run of interviews is strikingly clear: the overall territorial constraint values are lower than those resulting from the first run of interviews (see previous report chapter 2.2). This comment will be the same for all results. Knowing that the reuse will comply with local/national environmental regulations is a key element for decision making.

2.2.1.1 Rance Estuary Expert result map

In the Rance Estuary, the interviewee is a sediment expert with a PhD in Geosciences, working in a public body in charge of sediment management. This expert was not part of the first run of interviews. The territorial constraint to reuse is quite low (see figure 19) in comparison to the location of a potential storage facility in the same territory according to an average viewpoint (see figure 10) or even a single interviewee viewpoint (see figures 3-8 in chapter 2.2.1.1).

According to the statistical distribution of the territorial constraint values (see figure 19), most areas of the Rance Estuary are receiving a constraint value below 0.3 (see figure 19) with an average of constraint value of approx. 0.28 (see table 8).

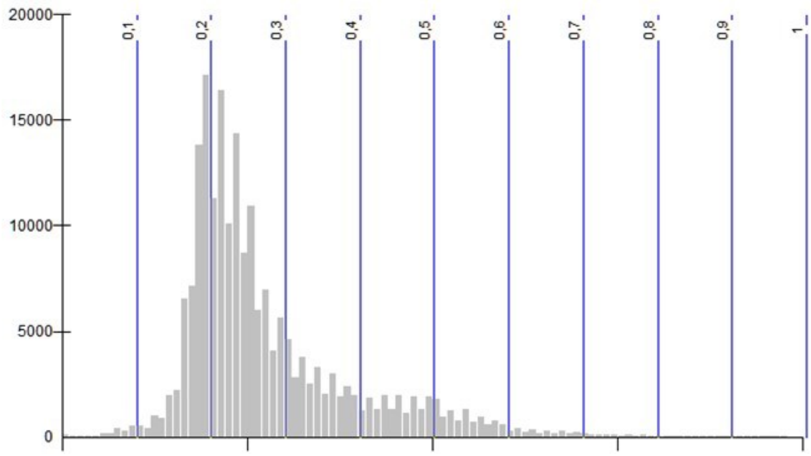

Figure 19: Histogram distribution of cell values result map (expert viewpoint)

1,632 Ha are under a threshold value of a 10% average territorial constraint and 148,006 Ha out of 205,516 Ha are under a threshold value of a 30% average territorial constraint (see table 8).

Reuse map	Values
Min	0
Max	1
Mean	0.276
Std Dev	0.117
Ha <30% Constraint	148006
Ha <20% Constraint	50100
Ha <15% Constraint	6173
Ha <10% Constraint	1632
Ha total	205516

Table 8: Synthetic data summary of a result map (expert viewpoint)

Moreover, most of the lower constraint areas for sediment reuse are located in the surrounding area of the Rance estuary, very close to the dredged sediment resource but also very close to the main populated area of Saint-Malo (see figure 20). This sediment expert ruleset for sediment reuse is therefore very positive for a large part of the Rance Estuary territory. This expert viewpoint is also motivated by a good knowledge of the high quality of the dredged sediments (i.e. “clean sediments”).

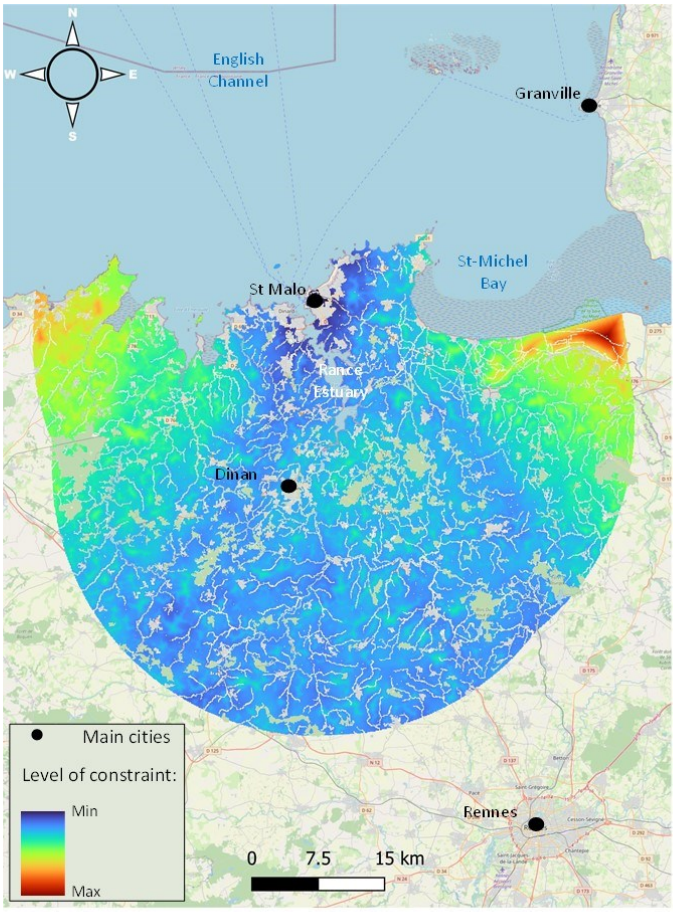

Figure 20: Result map of one sediment expert average view point about the territorial constraints to reuse dredged sediment in application compliant with environmental regulations

2.2.1.2 Hauts-de-France Region Expert result map

For the Hauts-de-France Region case, the interviewee is an expert in the protection and management of the marine environment advising Hauts-de-France marine ports' authorities. This expert was not part of the first run of interviews. The territorial constraint to reuse dredged sediment is higher (see figure 21) than for the previous expert (see figure 19).

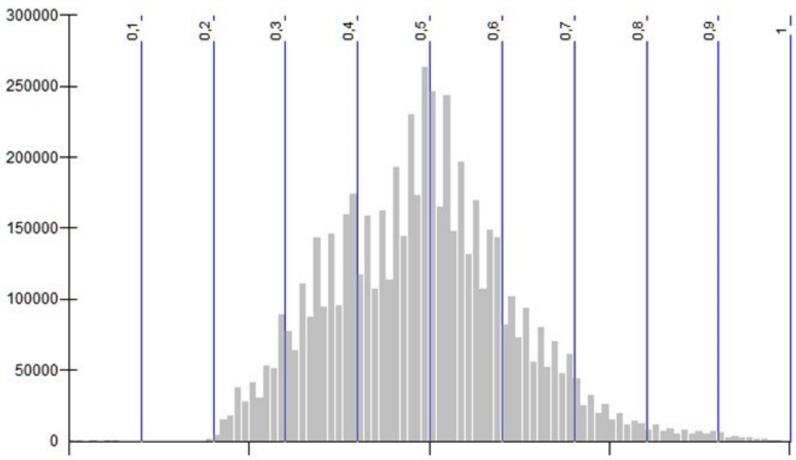

Figure 21: Histogram distribution of cell values result map (expert viewpoint)

According to the statistical distribution of the territorial constraint values, most areas of the Hauts-de-France Region are receiving a constraint value above 0.3 (see figure 19) with an average of constraint value of approx. 0.49 (see table 9).

Only 2,208 Ha are under a threshold value of a 10% average territorial constraint and only 368,244 Ha out of 5,907,851 Ha are under a threshold value of a 30% average territorial constraint (see table 9).

Reuse map	Values
Min	0
Max	1
Mean	0,489
Std Dev	0,126
Ha <30% Constraint	368244
Ha <20% Constraint	2997
Ha <15% Constraint	22087
Ha <10% Constraint	2208
Ha total	5907851

Table 9: Synthetic data summary of a result map (expert viewpoint)

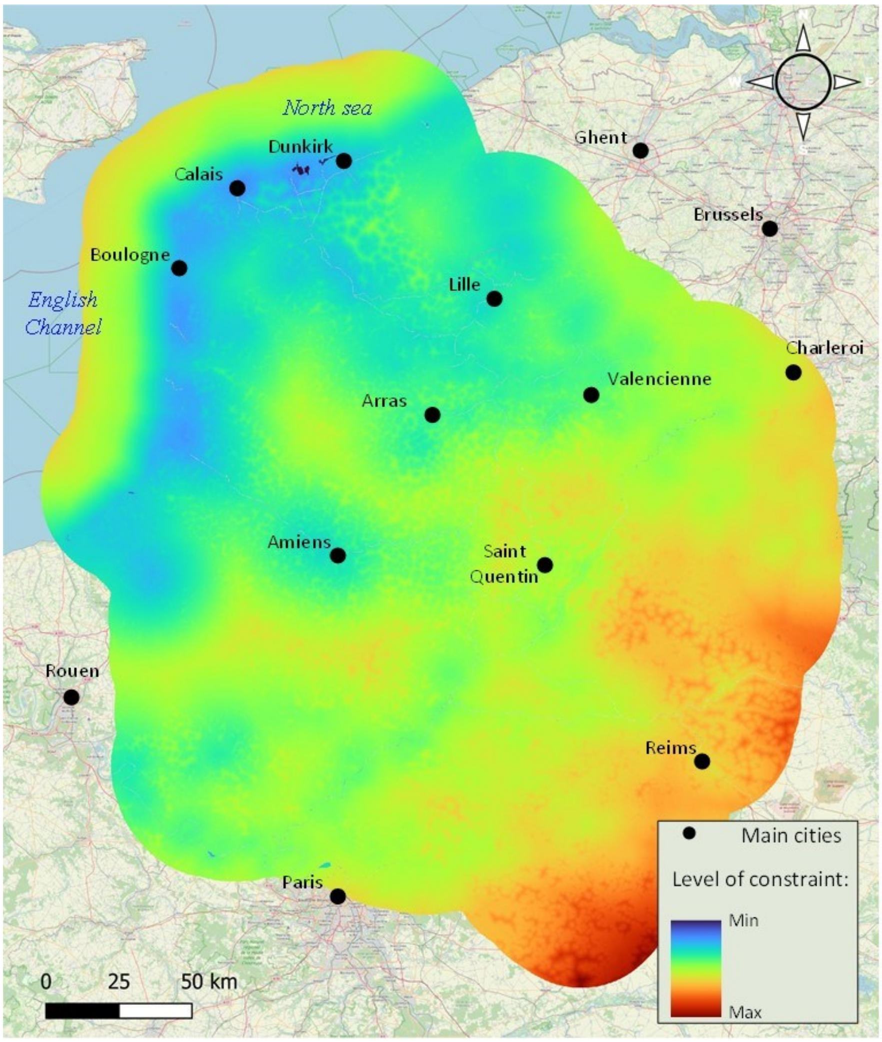

Figure 22: Result map of one port infrastructure stakeholder about the territorial constraints to reuse sediment reuse dredged sediment in application compliant with environmental regulations

Best locations (i.e. for a low to moderate low territorial constraint value) are located on the shoreline or inland but not far from the coast or from the main inland waterway. The dumping at sea, as a BAU solution, is not favoured by this expert and the non-realistic option to reuse inland far from the coast is also rejected by the result of the RAIES model according to the interviewee ruleset. Moreover these very low constraint values are located in the vicinity of Dunkirk harbour which is one of the main dredged sediment resources in the Hauts-de-France region.

2.2.2 Irish case

The Irish case is based upon the interview of a small port manager recently in charge of a significant dredging operation. This expert was not part of the first run of interviews.

2.2.2.1 Expert result map

The territorial constraint to reuse is very low (see figure 23) in comparison to the location of a potential storage facility in the same territory according to an average viewpoint (see figures 13 & 14).

According to the statistical distribution of the territorial constraint values, most areas of the South Western Ireland are receiving a constraint value below 0.3 (see figure 23) with an average of constraint value of approx. 0.3 (see table 10).

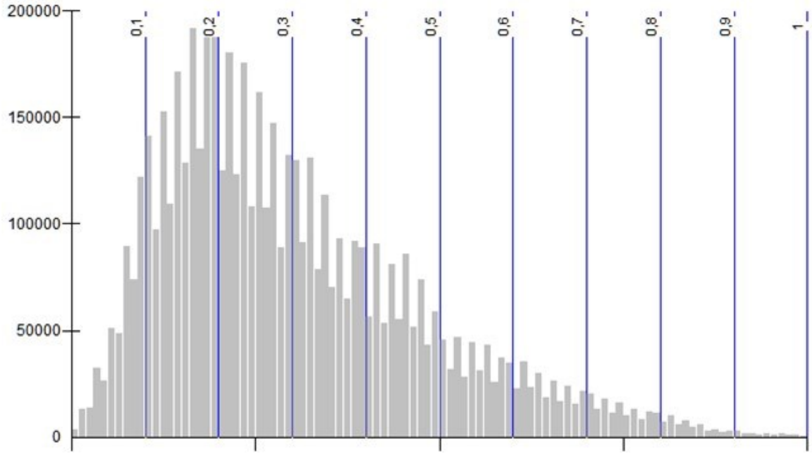

Figure 23: Histogram distribution of cell values result map (expert viewpoint)

If 445,356 Ha are under a threshold value of a 10% average territorial constraint, a significant part of the territory (i.e. 3,326,643 Ha out of 5,736,437 Ha) is under a threshold value of a 30% average territorial constraint (see table 8). This Irish port manager is very open to dredged sediment reuse if it is compliant with local/national environmental regulations.

Reuse map	Values
Min	0
Max	1
Mean	0.301
Std Dev	0.176
Ha <30% Constraint	3326643
Ha <20% Constraint	1934605
Ha <15% Constraint	1108753
Ha <10% Constraint	455356
Ha total	5736437

Table 10: Synthetic data summary of a result map (expert viewpoint)

More than 50% of the territory is below a constraint value of 0.3 which, according to this port manager is opening a number of locations and dredged sediment applications opportunities. Moreover the surrounding of Cork, Waterford and Galway harbours, as well as Fenit harbour are well located in the areas of lower territorial constraints for sediment reuse.

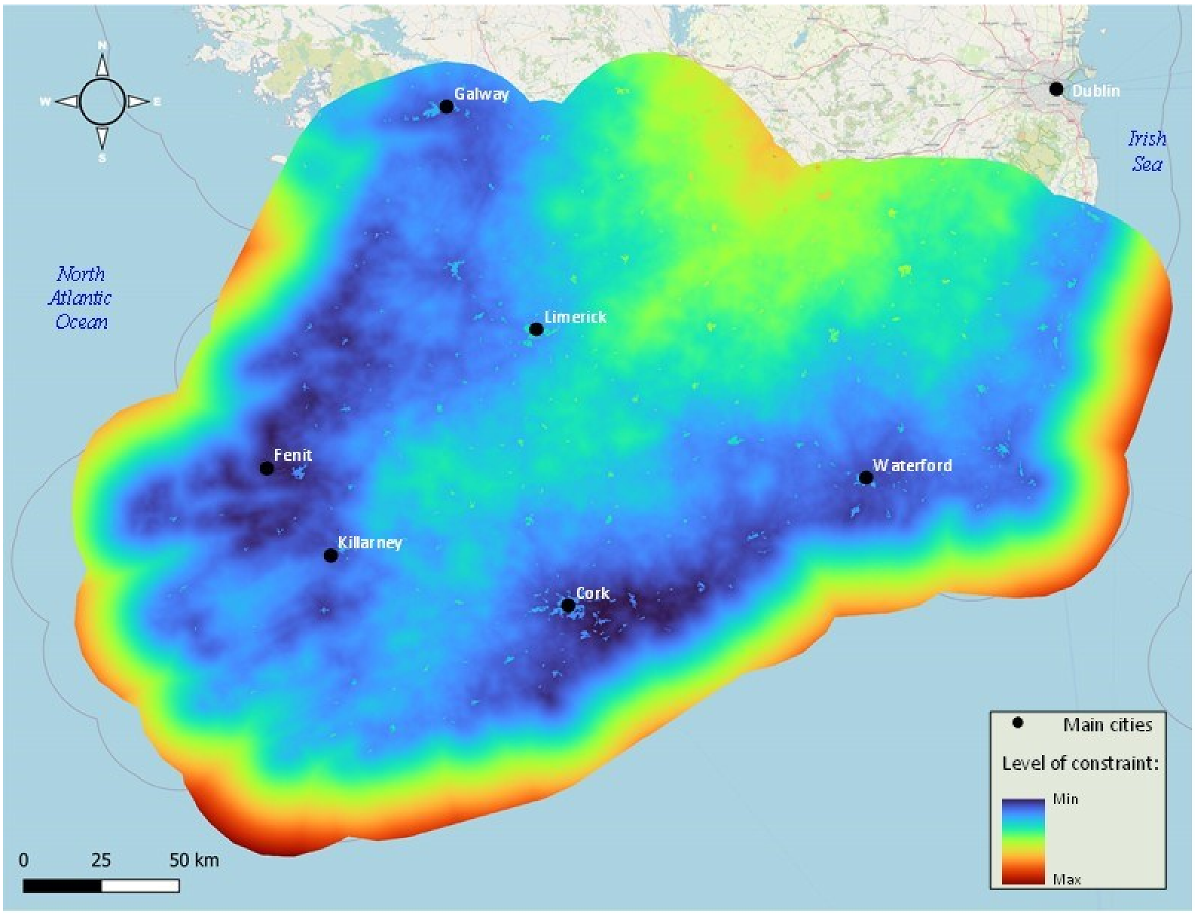

Figure 24: Result map of one port manager about the territorial constraints to reuse sediment reuse dredged sediment in application compliant with environmental regulations

2.2.3 Netherlands case

The Netherlands case is based upon the interview of a Dredging Engineer from Port of Rotterdam involved in the Suricates Project for the 219,000 tons of dry material extraction and reuse as of WPI1 activities. This expert was not part of the first run of interviews.

2.2.3.1 Expert result map

The territorial constraint to reuse is two times lower (see figure 25) in comparison to the location of a potential storage facility in the same territory according to an average viewpoint (see figures 15 & 16).

According to the statistical distribution of the territorial constraint values, most areas of South West Ireland are receiving a constraint value below 0.3 (see figure 25) with an average of constraint value of approx. 0.3 (see table 11). It is a very similar result compared to the Irish and the Rance Estuary cases (See table 5 & 7).

Only a 33,108 Ha are under a threshold value of a 10% average territorial constraint but a significant part of the territory (i.e. 3,343,147 Ha out of 5,781,898 Ha) is under a threshold value of a 30% average territorial constraint (see table 11). This Dredging Engineer from the Port of Rotterdam is very open to dredged sediment reuse if it is compliant with local/national environmental regulations.

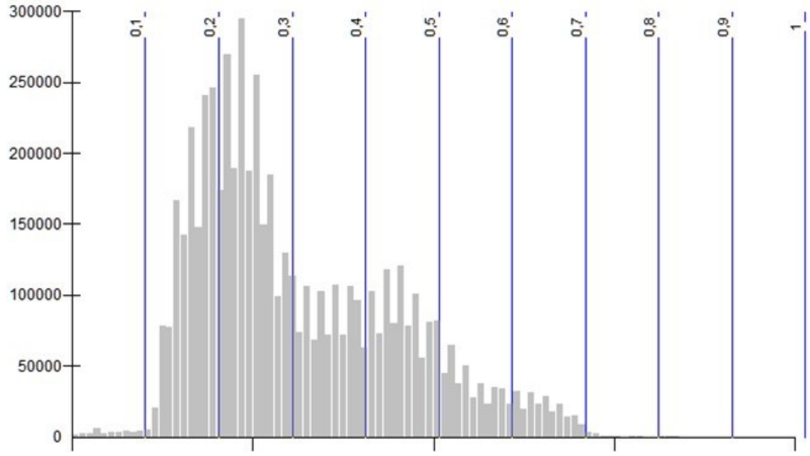

Figure 25: Histogram distribution of cell values result map (expert viewpoint)

Reuse map	Values
Min	0
Max	1
Mean	0.308
Std Dev	0.137
Ha <30% Constraint	3343147
Ha <20% Constraint	1369252
Ha <15% Constraint	376837
Ha <10% Constraint	33108
Ha total	5781898

Table 11: Synthetic data summary of a result map (expert viewpoint)

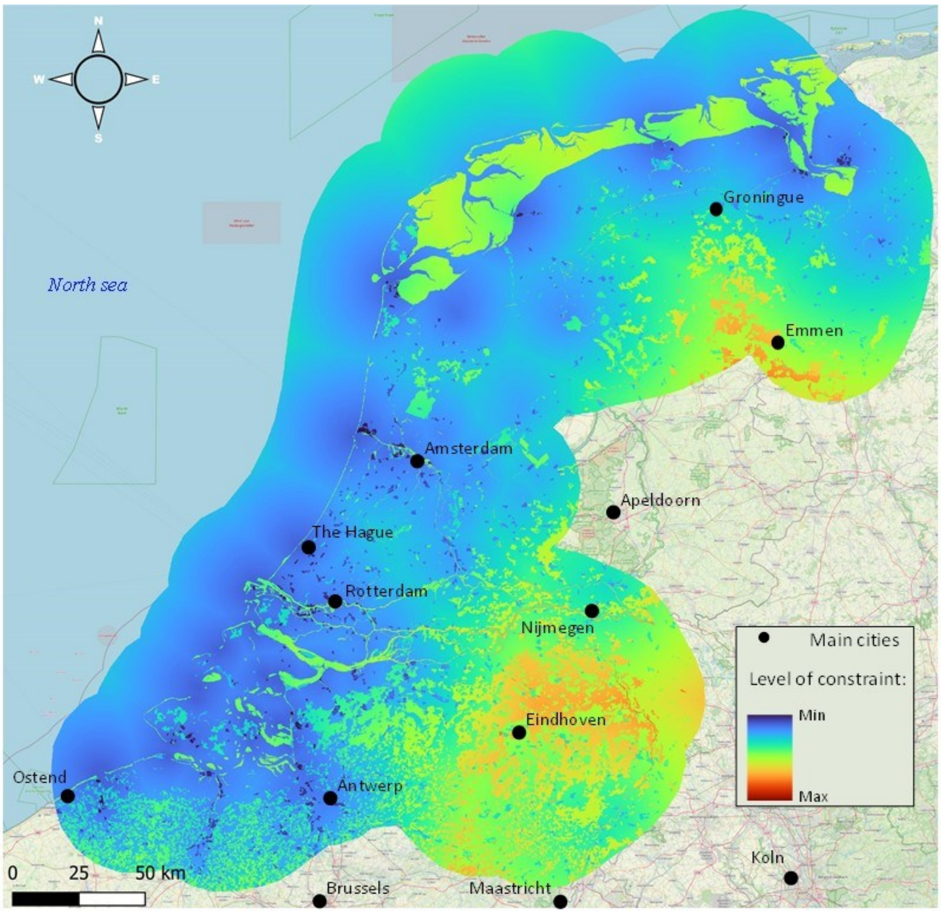

Figure 26: Result map of one sediment manager expert about the territorial constraints to reuse sediment reuse dredged sediment in application compliant with environmental regulations

2.2.4 Scotland case

The Scotland case is based upon the interview with a Civil Engineer from Scottish Canals involved in the Suricates Project for two years (i.e. 2021 & 2022). This expert was not part of the first run of interviews.

2.2.4.1 Expert result map

The territorial constraint to reuse is two times lower (see figure 27) in comparison to the location of a potential storage facility in the same territory according to an average viewpoint (see figures 17 & 18).

According to the statistical distribution of the territorial constraint values, most areas of Scotland are receiving a constraint value below 0.4 (see figure 27) with an average of constraint value of approx. 0.36 (see table 12). It's an in between case compare on the one hand to the Dutch, the Irish and the Rance Estuary cases (see tables 7, 9 & 10) and on the other hand to the Hauts-de-France case (see table 8).

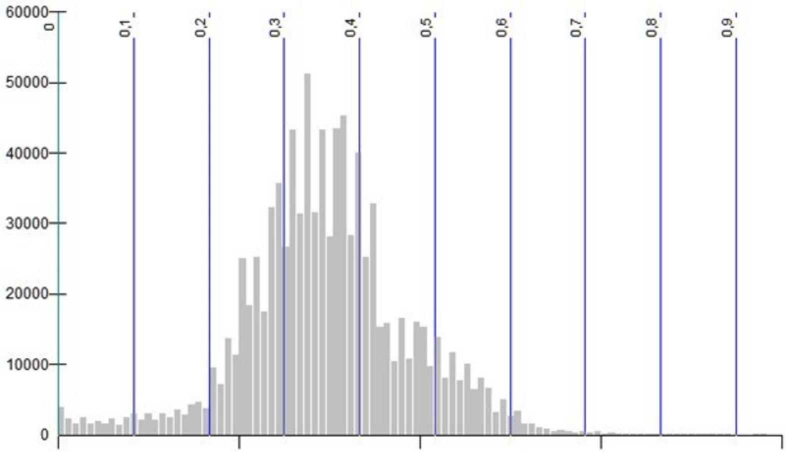

Figure 27: Histogram distribution of cell values result map (expert viewpoint)

Reuse map	Values
Min	0
Max	1
Mean	0.356
Std Dev	0.111
Ha <30% Constraint	215130
Ha <20% Constraint	54607
Ha <15% Constraint	35567
Ha <10% Constraint	21983
Ha total	928670

Table 12: Synthetic data summary of a result map (expert viewpoint)

Only a 21,983 Ha are under a threshold value of a 10% average territorial constraint and 215,130 Ha out of 928,670 Ha are under a threshold value of a 30% average territorial constraint (see table 12). This Civil Engineer from Scottish Canals is proposing a moderately open viewpoint about dredged sediment reuse if it is compliant with local/national environmental regulations. With his ruleset of decision, the Clyde Estuary and Forth banks and Firth of Forth protected areas remain out of any sediments reuse but adjacent places including near shoreline areas are matching a lower level of constraint. The surroundings of Glasgow (see figure 28) are also a potential location for sediment reuse which was already tested in the Suricates project under the activities and sediment solution replication of work packages T2, i2, i3, i4 and i5.

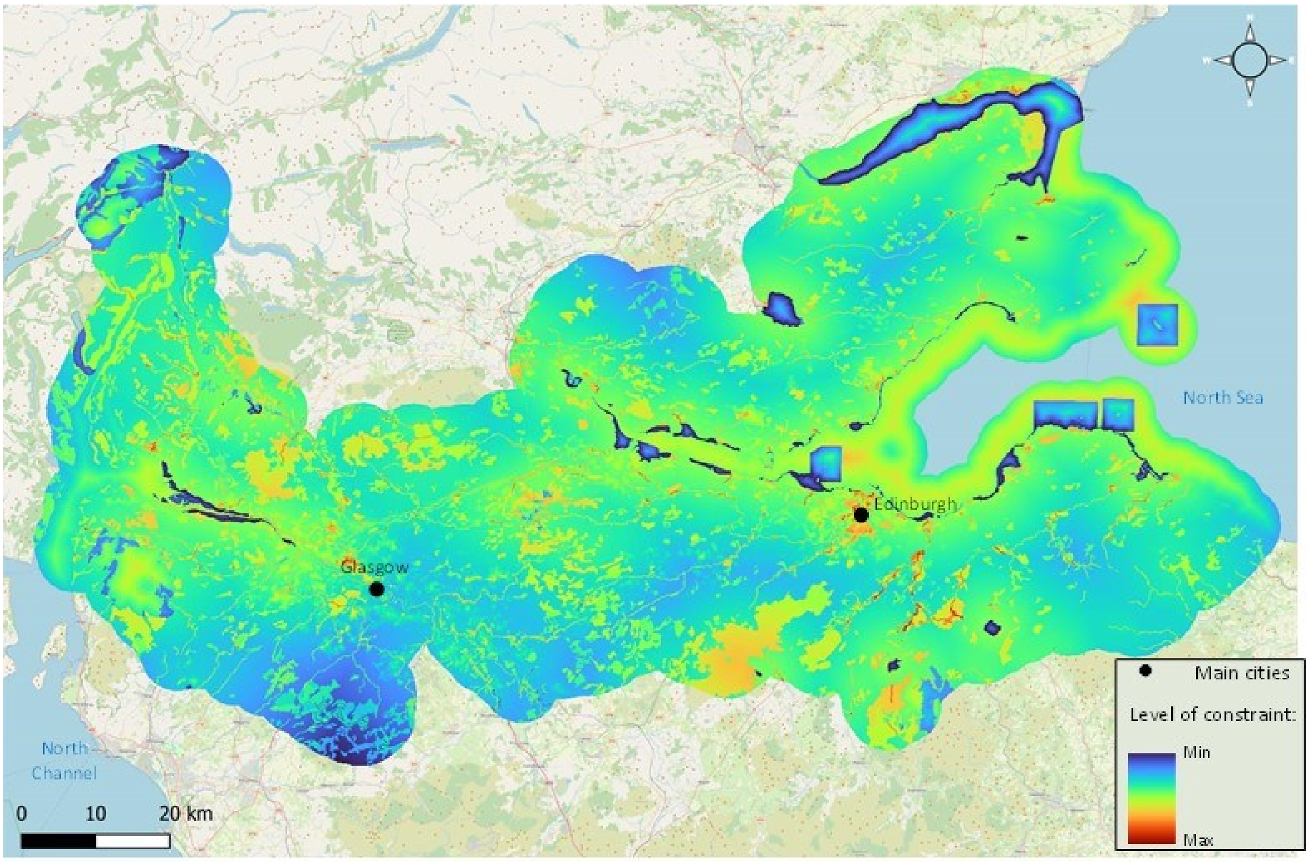

Figure 28: Result map of one sediment manager expert about the territorial constraints to reuse sediment reuse dredged sediment in application compliant with environmental regulations

CONCLUSION

The goals of Activity 1.2 of the WP T1 are:

- the implementation of the GIS tool within ports/waterways using local real field data,
- to identify territories of maximum attractiveness and social acceptability,
- the dissemination of the GIS tool in North of France, South of Ireland, Port of Rotterdam and Scottish Canals.

These three goals have all been successfully reached. Within this activity from WPT1.1.2 Suricates project partners involved have:

- used the official GIS data available according to the EU Inspire directive to implement participative decision making involving real field stakeholders from various background and from all four countries,
- produced maps of territorial constraint according to local stakeholders, sediment experts, NGOS and local representatives' viewpoints. These map results clearly identify territories of maximum attractiveness for all four countries involved in Suricates project,
- engaged with sediment managers/experts, ports managers and public environmental advisers from North of France (i.e. Hauts-de-France Region & The Rance Estuary territory), South West Ireland (i.e. Fenit Harbour), Scotland (i.e. Scottish Canals) and from the Netherlands (i.e. Port of Rotterdam).

The results are reflecting on two crucial issues to implement a circular path dealing with dredged sediment reuse which are the location of transit storage facility to sustain sediment offers and areas of maximum attractiveness to foster new projects using dredged sediments.

Lessons learnt from this activity are:

- RAIES tools have passed the test of being a spatial decision support system able to map the attractiveness of territories according to multiple local stakeholders, NGO's and elected representatives, sediment and civil engineering experts as well as GIS experts.
- Experts and territorial managers dealing everyday of their professional life with dredged sediments are eager for beneficial use in comparison with non-experts, NGOs etc. who might stand in a position of defence against sediment reuse, sometime very suspicious about potential environmental impacts even if the potential reuse application complies with environmental regulations and technical guidelines.
- Stakeholders or experts in charge of environmental protection or regulation are more cautious when it comes to sediment reuse, even if a sediment reuse application complies with the environmental regulations that they are responsible for enforcing.

References

Note that these references are reflecting the evolution of the RAIES model and its thematic applications in Interreg NEW project Suricates (2017-2023) and CEAMAS (2012-2015. Most of these references are in French and available at ResearchGate: https://www.researchgate.net/profile/Eric-Masson-2.

Joe Harrington, Arjan Wijdeveld, Alasdair Hamilton, Richard Lord, Keith Torrance, Tristan Debuigne, Eric Masson, Agnès Zambon, Walid Maherzi, Bruno Lemière, Branislav Batel (2023), Social, Economic and Environmental Analyses for Sediment Reuse Applications. 13th International SedNet Conference, Sept. 6-8, 2023, Lisbon (Portugal).

Bruno Lemière, Arjan Wijdeveld, Eric Masson, Richard Lord, Keith Torrance, Joe Harrington, Marco Wensveen, Alasdair Hamilton, Tristan Debuigne (2023), Beneficial use of sediments for our future: compared pathways for taking profit of them as resources for new challenges. 13th International SedNet Conference, Sept. 6-8, 2023, Lisbon (Portugal).

Eric Masson, Edwige Motte, Valérie Foussard (2023), A GIS methodology to set up beneficial uses of dredged sediment from La Rance Estuary (Brittany, France). International Conference "Infrastructure sediments: from resource to territorial re-use", Aug. 31 – Sept. 1, 2023, Saint-Malo (Brittany, France).

Eric Masson, Jean-Baptiste Litot, Edwige Motte et Olivier Blanpain (2022), RAIE : Des représentations spatiales à l'aide à la décision participative pour la localisation de sites. Peer-reviewing journal paper, Mappemonde, 134 | 2022, DOI : https://doi.org/10.4000/mappemonde.8134

Eric Masson, Edwige Motte, Guillaume Chevalier, Christelle Audouit, Philippe Deboudt, Olivier Blanpain (2021), Un outil participatif (RAIES) pour la localisation de sites de valorisation de dragage : application à l'estuaire de la Rance. Presentation given at a webinar « Valorisation des sédiments de dragage » organised by l'EPTB Rance Frémur Baie de Beaussais, January, 19 – 2021.

Eric Masson, Edwige Motte, Guillaume Chevalier, Christelle Audouit, Philippe Deboudt, Olivier Blanpain (2020), RAIE : un outil de cartographie de l'acceptabilité territoriale au réemploi de sédiments d'infrastructure portuaire. Proceeding of the merIGéo Conference "De l'océan à la côte : l'information géographique en movement", Nov. 24-26, 2020, pp 73-77.

Eric Masson, Jean-Baptiste Litot, Olivier Blanpain (2019) Modélisation des représentations spatiales pour la production de cartes mentales sur base d'ontologie déclarative. Presentation given at the conference « 3èmes Journées du Réseau Cartotête : Cartes mentales : Quelles méthodologies pour aborder les représentations socio-spatiales », MSHE, Besançon (France).

Eric Masson (2019), Comment évaluer l'intérêt et l'acceptabilité économique et sociétale d'un centre de valorisation ? Un outil SIG multicritères pour les collectivités. Presentation given to the Conference TEAM2EVENT « ÉCONOMIE CIRCULAIRE DANS LE BTP Quelles nouvelles avancées techniques et opérationnelles? », Lilliad, Villeneuve d'Ascq (France).

Eric Masson, Sarah Cabarry, Jean-Baptiste Litot, Olivier Blanpain (2019), RAIE : Un modèle d'analyse numérique du géopotentiel des territoires basé sur les représentations des contraintes spatiales. Presentation given at the conference « Quatorzièmes Rencontres de ThéoQuant Besançon », February 6-8, 2019, MSHE, Besançon (France).

Eric Masson (2018), Le SIG outil d'aide à la décision des territoires pour la collecte de plaquettes de bois et la gestion des sédiments de dragage. Presentation given at the conference « Le numérique : quels apports dans la chaine de valeur du recyclage pour favoriser l'économie circulaire ? », february 28, 2018, EuraTechnologies, Lille (France).

Eric Masson, Olivier Blanpain (2017), Building a Spatial Consensus from Geographical Constraints Modelling. Presentation given at the Conference UC ESRI 2017, Session: Applying Participatory GIS Approaches for Optimal Development Outcomes. July 2017, San Diego (CA, USA).

Eric Masson (2016). Le SIG comme outil d'aide à la décision spatiale (méthodologie SIG CEAMAS). Presentation given at the Conference « Journée technique : L'économie circulaire dans le bâtiment et les travaux publics - Enjeux et Innovations de la filière minérale », Lilliad, Villeneuve d'Ascq (France).

Eric Masson, Dounia Lahlou , David Roig, Gerry Sutton, Tristan Debuigne, Guillaume Chevalier, Olivier Blanpain (2015), Spatial DSS using GIS and weighted sum: application to the marine sediment re-use in the ports of North Western Europe. Procceding of the 29th EnviroInfo and 3rd ICT4S Conference, Copenhagen, Denmark, September 7-9, 2015, ISBN 13 978-87-7903-712-0, 7 p.