COASTAL
Collaborative Land-Sea
Integration Platform

Multi-Actor Analysis of Land-Sea Dynamics
Deliverable D04 - Revised

WP1 Multi Actor Analysis:
T1.2 – Multi-Actor Analysis ; T1.3 - Conceptual Analysis of Land-Sea Dynamics

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Dissemination level		
PU	**Public**	**X**
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified information as referred to in Commission Decision 2001/844/EC)	
Deliverable type		
R	Document, report	**X**
DEM	Demonstrator, pilot, prototype	
DEC	Web sites, patent fillings, videos, etc.	
OTHER	Software, technical diagram, etc.	
ETHICS	**ETHICS**	

Partnership:

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List of Acronyms

BAU	Business-As-Usual (scenario)
CLD	Causal Loop Diagram
FCM	Fuzzy Cognitive Map
H2	Hydrogen
MAL	Multi-Actor Lab (case area)
MSP	Marine Spatial Plan
RDI	Research, Development and Innovation
SF	Stock-Flow (model)
WP	Work Package

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1 COASTAL motivation and background

COASTAL represents a unique collaboration of coastal and rural business entrepreneurs, administrations, stakeholders, and natural and social science experts. Local and scientific knowledge are combined to identify problems and develop practical and robust business road maps and strategic policy guidelines, aimed at improving land-sea synergy. A multi-actor approach is followed to analyse the social, environmental and economic land-sea interactions in a collaborative System Dynamics (SD) framework, taking into consideration the short-, mid- and long-term impacts of decision making and feedback mechanisms on coastal and rural development.

The project is organised around interacting Multi-Actor Labs (MALs), combining tools and expertise for six case studies representing the major coastal regions in the EU territory. In each MAL local actors and experts participate in collaborative exercises to analyse problems, analyse the causes, propose and discuss solutions, and validate and interpret the impacts of simulated business and policy decisions. The MALs are connected into a durable platform for collaborative knowledge exchange which is underpinned by a generic set of tools and performance indicators.

Figure 1 Multi-Actor Labs in COASTAL

The COASTAL platform and synergistic tool set will be further exploited and developed beyond the project life time. The ultimate ambitions of COASTAL are to inspire strategic land-sea planning and contribute to the formulation of integrated coastal-rural regulations at the regional, national and EU level.

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2 Role of Deliverable

Deliverable D4 is a detailed report that describes the road towards and the actual first round of multi-actor workshops held in all case study areas following the completion of the sectoral workshops held during the first eight months of the project period that resulted in the submission of D03 (D1.1).

The deliverable describes the stepwise approach we took in this project, based on the timelines of Tasks 1.1 and 1.2. For each case study a facilitator led mental mapping seminar was planned to condense the initial mental maps into smaller versions that would then be developed into semi-quantitative Fuzzy Cognitive Maps (FCMs), combining the outcomes of the sector workshop with the expertise of the case area leaders. The stakeholders and actor partners were then shown with the mental maps and analyses of the FCMs during the first round of multi-actor workshops to evaluate the feedback structures and obtain suggestions for improvement.

The Multi-Actor Workshops (MALs) that are reported on this deliverable play a central role in the project and the co-creation process. Task 1.2 differs from Task 1.1 reported on in D03. (D1.1) in that the coastal and rural sectors were combined in joint collaboration for coastal-rural exchanges during the MAL workshop, and the aim was to develop mental models, gather perceptions and formulate case-specific transition pathways. It was also a step towards their validation of the variables that are to go into the final model.

The case area leaders were responsible for the local coordination of the multi-actor workshops, and engaging stakeholders. The main outcome for each case study area was a conceptual model of the land-sea interactions at the regional scale, to be used as a basis for the quantitative modelling tasks in WP2 and WP4. This extra step beyond the sectoral workshops allowed for additional stakeholder input and strengthened the inter-sectoral exchanges of knowledge and experiences, validating the results of Task 1.3 where the initial mental maps were condensed, and prepared the ground work for the post-project exploitation of the project outcomes.

Because the case areas have different angles towards the methodology, there are some differences in output and visualizations of results in the following sections. However, this is not unusual, given that the workshops were led by different facilitators with different backgrounds. Their baseline was the work in D03 (D1.1) where the general methodology was described and taught, and where the path forward is described qualitatively. The aim was to ensure some methodological coherence with the mental mapping seminars, though that too was only as guidelines for the final work done at the case area level.

The role of the deliverable is to report on these outcomes, which will later be used by the local R&D partners, and the lead partners for WP1, WP3 and WP4 to develop integrated coastal-rural mental maps for each case study. Furthermore, the validated results from the MALS reported on in this deliverable are used to define mental maps and FCMs that surpass the case studies, adding to the generic qualitative instruments for knowledge exchange. and quantitative analysis of land-sea dynamics, thereby also contributing to *Task 4.3: Generic toolbox for quantitative modelling of coastal-rural synergy*.

During the spring of 2020, and in preparation for the second round of MALs, facilitators will go on further mental mapping seminars to the case areas to further delimit the results and ensure even more coherence in result presentations to the stakeholders, so that during the final joint international MAL, the stakeholders will all have seen similar presentations of causal loop diagrams, scenarios and fuzzy cognitive maps, and will be able to jointly discuss these from not only a national, but a regional EU perspective.

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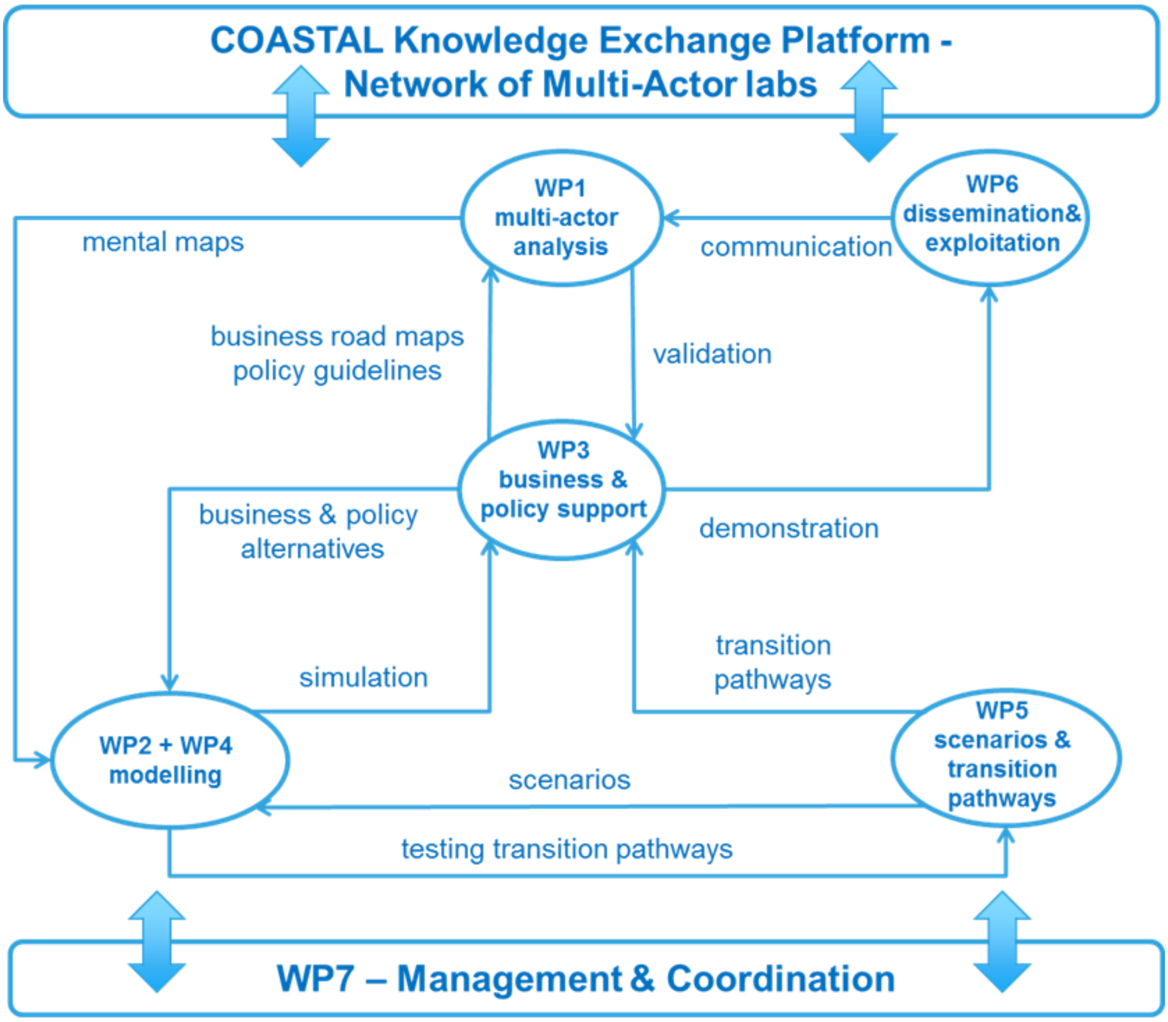

Figure 2: COASTAL platform diagram. D04 contributes to knowledge transfer and sets the stage for the work to be done in WP2 and WP4. It also contributes to aid WP3 and WP5 in their continued work.

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3 Multi-actor analysis - Background

This deliverable partially fulfils all of the four objectives of WP1 – Multi Actor Analysis as described in the Grant Agreement.

These objectives, which are not specifically for D1.2 alone, but for all of the work that is planned done for WP1 throughout the four-year project period, are to:

1. Adapt and apply the state-of–the-art methodology for participatory, multi-actor approaches to enable mental mapping of the feedback structures of the land-sea system for the case studies;
2. Develop transferable and generic mental maps allowing application to other study regions or adaptation to new problem contexts;
3. Engage with the relevant actors and stakeholders for the different cases during the participatory sector workshops;
4. Push interdisciplinary collaboration beyond the state of the art towards an actor-driven, iterative, and bottom up approach with generic, qualitative tools which are developed in collaboration with the sectors, stakeholders, and administrations; and
5. Provide a solid basis for evidence-based analysis of business and policy strategies, and systems modelling, and platform for knowledge exchange.

3.1 General Methodology

In this deliverable, we report on methodology and results from the condensing seminars held with the six case study sites in their respective areas. Recall that during the initial sectoral workshops reported on in D03 (D1.1), we developed case and sector specific shared mental maps of the land-sea system in the given case area by bringing together for each a number of domain experts, rural and coastal stakeholders and administrations. The work for this deliverable was based on a combination of both T1.2 and T1.3 – of which the former was the preparatory work and the latter was the implementation of the multi-actor workshops.

As a first step following the workshops, we organized meetings with each of the case area leaders to condense and polish the initial mental maps from the sectoral workshops, combine them into one regional mental map with preferably less than 70 variables in total. This was done in collaboration with facilitators from SINTEF Ocean. Together with the stakeholders, actors and R&D partners we also developed Fuzzy Cognitive Maps (FCMs) during these meetings. FCMs are weighted, directed graphs, based on the simplified mental maps, with positive and negative strength values assigned to each interaction to indicate the polarity and significance[1]. Generally the weights are allowed to fall in a specified range [-1, +1], as was the case for COASTAL.

Two MALs decided not to have post-processing workshops with the WP1 lead partner to simplify their mental maps – Spain and Sweden. Both MALs did their own simplification work – without the on-site workshop facilitating of the WP leader partner organization (SINTEF Ocean). Although there was no SINTEF staff present in Spain or Sweden, exactly the same methodology was used for simplification by experienced staff in these two case areas, that was instructed previously by SINTEF about methods, and results were validated through another conference call with SINTEF. This was because of logistical reasons, in that these partners had a very good grasp of the methodology a priori and were able to discuss this with the WP leader via Skype,

[1] Some partners preferred to do this in collaboration with the Stakeholders during the MALs instead. Those that set the values at the preparatory meetings presented their interpretations of the stakeholders during the MALs and had these validated or changed based on their preferences.

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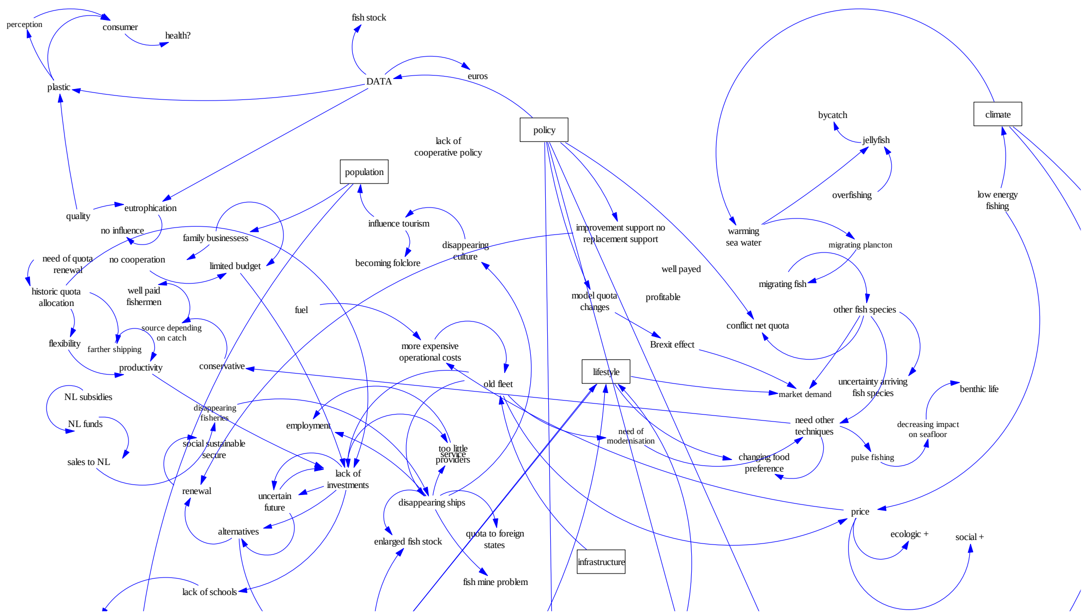
not needing the face-to-face interaction. The work and their results were equal in quality to that of the others. This also led to less travelling for a number of participants.

In order to assess the validity and quality of the results of this first round of multi-actor workshops combining the coastal and rural sectors, it is technically important to first distinguish between the following results from the first round of sector workshops, as reported on in D1.1, and secondly the multi-actor workshops:

a) **Sector mind maps:** these are graphical representations of the problems, solutions and opportunities showing the social-economic, physical and administrative interconnections as perceived and agreed on by the stakeholders during the sector workshops. These sectors are, for example, Nature/Environmentalists, Agriculture, Spatial Planning Administrations, Blue Industry (offshore activities, ports, …), Fisheries & Aquaculture and Tourism. The mind maps resulting from the sector workshops and main conclusions for each sector are described in detail in Section 5.2 of the first WP1 deliverable D03 (Tiller et al., 2019). It is important to emphasize that these mind maps are raw unprocessed mental models of the stakeholders, generally complex with variation in the level of detail depending on the development of the discussions and group power dynamics. Inconsistencies as well as missing elements (implicit knowledge) cannot be ruled out. An example of a section of the mind map obtained for the Belgian MAL and sector "Aquaculture & Fisheries" is shown below.



b) **Causal Loop Diagrams or CLDs**: These are system conceptualizations which take the sector mind maps one step further by including feedback loops, and further polishing (see Sections 1 and 2 of first WP4 deliverable D12 (De Kok et al., 2019). Causal Loop Diagrams or CLDs are useful tools for visualising the feedback mechanisms inherent to the problems and solutions identified by stakeholders. Well-designed and polished CLDs are also important for system modellers as they capture the feedback architecture of the systems that need to be modelled quantitatively. An example of a CLD for agriculture, obtained after polishing the raw mind map is shown below.

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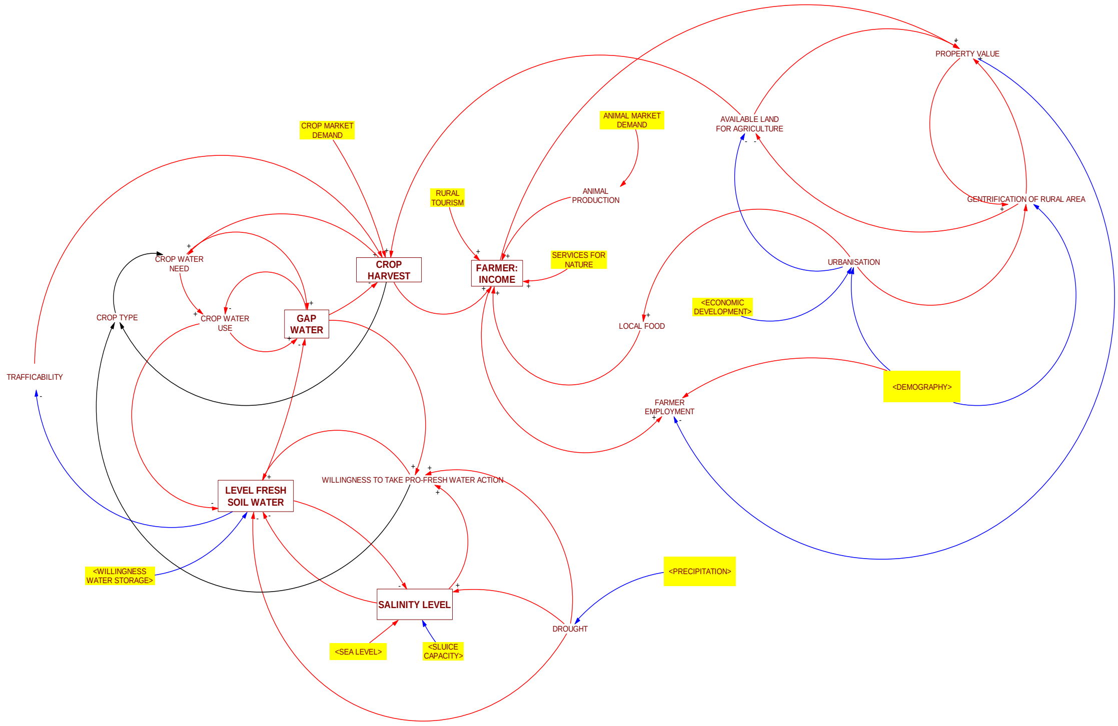

c) **Fuzzy Cognitive Maps (FCMs):** : These are semi-quantitative models with "*fuzzy*" weights assigned to each interaction between two variables (referred to as "concepts" in the literature). Generally, the weights are allowed to fall in the range -1 to +1, indicating the significance and polarity of the interactions (De Kok et al., 2009; Gray et al., 2015; Kosko, 1986; Tiller et al., 2016; Tiller et al., 2017) and the concepts are allowed to vary over the range between 0 and 1. The idea to have concepts with a value of zero (not activated) or one (activated) is derived from neural network theory (Kosko, 1986) and was further developed by allowing the concepts to vary over the full, "fuzzy" range 0-1.

Methodologically, FCMs are semi-quantitative and take a position in between purely qualitative, conceptual models and quantitative system dynamics models using a mathematical representation of the system, potentially including time delays. Therefore, scenarios can be interpreted with care as long as time is not explicitly included. The step-wise iteration of the model and analysis of the resulting changes can help understand the role of system feedbacks and effectiveness of management options under different scenarios. It is very useful for the researcher's understanding of the dynamics of the model that the system evolves. Fuzzy cognitive mapping allows semi-quantitative analysis of the system feedback that surpasses the conceptual nature of complex, inter-disciplinary discussions or narrative storylines as used in e.g. participatory modelling such as those developed during our system thinking exercise alone. This is because FCMs take conceptual modelling (Systems Thinking), assigns weights to the visible causal links in the system and apply matrix algebra to derive the change of the system state. The combination of semantic, conceptual networks with iterative computation of state changes makes this semi-qualitative modelling technique transparent in nature, adaptable to problems of arbitrary complexity and highly interactive.

It is useful to distinguish between three types of variables in the FCM (Papageorgiou and Kontogianni, 2012):

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- o exogenous driver variables or policy settings, so-called “transmitters” which influence other variables within the system, but are not affected themselves;
- o endogenous or “ordinary” variables which are influenced by one or more variables, but also have an impact on one or more variables;
- o outcome or “receiver” variables reflecting policy indicators, which are at the end of the chain and are affected by one or more variables without affecting other variables

A proper balance in the distribution over the three variable types reflects the quality of the FCM. FCMs with a large number of transmitters are less flexible, the behavior of the system is not generated by the feedback but imposed externally, making the system less self-organizing and “intelligent”. Several related FCM characteristics, taken from graph theory, are:

- o The indegree (number of ingoing connections) and outdegree (number of outgoing connections) of a concept;
- o The centrality of a concept, defined as the sum of the indegree and outdegree;
- o the connectivity: ratio of the number of connections and the squared value of the number of variables (which is the theoretical maximum number of connections); for a fully connected FCM this is 1.0;
- o the ratio of the number of receiver and transmitters – a measure of the complexity of the FCM; an FCM with a large value of this ratio primarily generates the system behavior endogenously

Quantitative metrics such as the in- and outdegree, centrality, connectivity and complexity can be used to systematically analyse and/or compare FCMs and are useful for assessing the quality of FCMs, need for adjustments, and role of individual concepts in the FCM.

In an FCM, variables refer to state variables whereby the state can vary from high (represented by value 1) to low (represented by value 0). Each variable has an initial state, which represents the starting situation of the variable. An initial state of 0,5 refers to an ‘average’ or ‘medium’ level of the state of the considered variable. E.g. when the variable “Water Quantity” has an initial state of 0,5 this means an average quantity of water in the given agricultural system. The relations are depicted in the FCM as arrows which are assigned ‘fuzzy’ weights in the range [-1,+1] expressing the strengths of the causal relations. The weights are representations of the strengths of the positive (reinforcing) and negative (balancing) direct impacts variables have on one another, and usually defined in a range between -1and +1, with the number of values discerned depending on the level accuracy of understanding the causalities. In this case a distinction between the values ‘low’, ‘medium’ and ‘high’ was considered sufficient. A positive weight in the FCM implies that a variable is affected positively: in case of an increase of the influencing variable will increase as well or it will decrease in case the influencing variable decreases. In case of a negative weight the variable affected decreases when the influencing variables increases or vice versa.

Typical strengths of FCMs include the ability to represent and analyze system feedback in an intuitive and transparent way using graphics, allowing quick and interactive use with stakeholders, the usefulness as a semi-qualitative basis to ensure the consistency of conceptual models, domain independence without limitations to the complexity of the concepts used and the ability to combine FCMs constructed from different viewpoints.
Well-designed FCMs can be iterated a number of steps and used for **scenario and policy analysis** to address problems (Kok, 2009; Tiller et al., 2017) using simple matrix algebra. To what extent these scenarios are of practical use is a subject of ongoing scientific debate. FCMs cannot capture the feedback as well as as fully quantified stock-flow models (see next category) due to the absence of a

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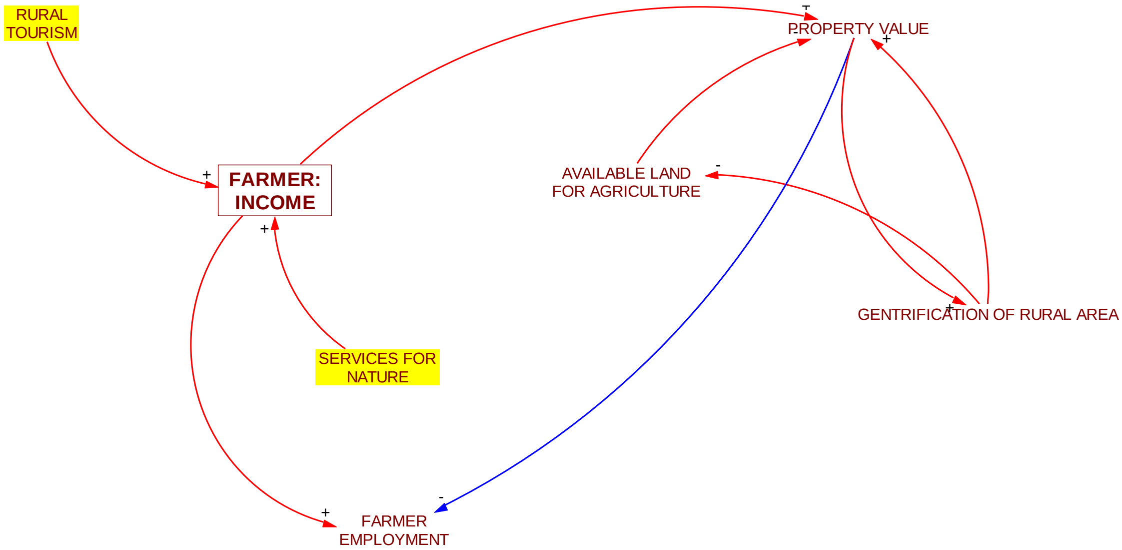
continuous concept of time. Time delays and non-linearities, both important for feedback dynamics (De Kok and Viaene, 2019), are not included in standard FCMs. For the context of this study, the application of FCMs for scenario analysis proved indeed to be more difficult than anticipated for the diagrams developed in the sector workshops. Nevertheless, some very useful examples were developed to explain the potential to the participants of the multi-actor workshop. An example of an FCM for agriculture, used to explain the FCM methodology for the Belgian MAL, is shown below.



d) **Stock-Flow or SF Models**: These, finally, are fully quantified system models describing problems and solutions through system feedback with mathematical equations and including non-linearities if necessary. An SF model conceptualizes the system graphically in terms of 'stock' variables, considered as reservoirs which can increase or decrease in value, and in- and outgoing 'flow' variables causing the 'stocks' to decrease or increase. Depending on the type of modelling software used the stocks and flow are sometimes referred to as 'levels' and 'rates'. Systemic limitations, time delays and initial states are to be defined to complete the model design. The CLDs developed in WP1 are the starting points towards these, that will be developed in WP4. An example of a simple SF model for offshore sand mining with the non-linear dynamics generated for the stock variable 'Offshore Sand Stock' by the model is shown here:

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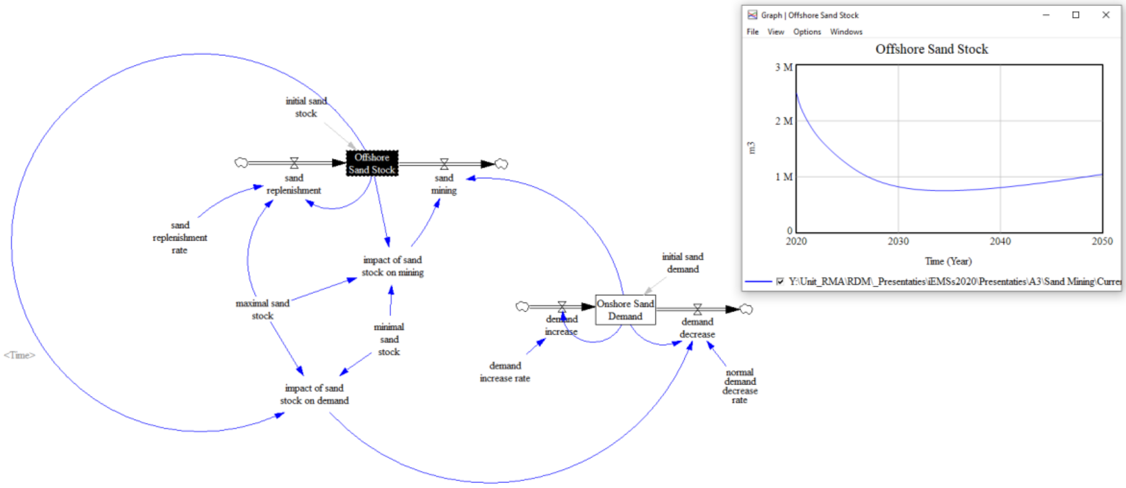

The leaders of the Multi-Actor Labs (aka MALs or case study areas) took the responsibility for the local coordination in their respective areas, engaging stakeholders and ensuring their active participation in these combined coastal-rural interactions where the aim was to validate the CLDs and the scenarios developed based on the sector workshops, where the main outcome were joint conceptual models of the land-sea interactions at the regional level as well as FCMs and scenarios. A more detailed account of the workflow followed for WP1 and the multi-actor analysis is provided in the following sections.

3.1.1 Mental Mapping Seminars

Where the main purpose of the five sectoral workshops was to engage stakeholders in an open discussion, aimed at identifying the main issues, opportunities, obstacles and solutions in the context of land-sea interaction and their own sector or field of expertise (for example tourism, farming, water management, spatial planning), the aim of the MALs was more specifically targeted towards obtaining practical and feasible solutions for the problems identified by the stakeholders in the first round of sector workshops

3.1.1.1 Simplifying mental maps

To achieve this, the initial mind maps, which often had more than 60 variables per mind map, had to be substantially simplified, by combining variables and removing those that are superfluous for one reason or another. It was also important to land on variables that had data associated with it, whether qualitative or quantitative, in order to prepare for the later modelling in WP4.

The case area leaders used VenSim® for the mental mapping in the sectoral workshops as this was also to be used for the SD modelling in WP4 later (Tiller et al., 2019). Detailed information about VenSim® was presented in D03 (D1.1). This was therefore also continued for the simplification process.

30 sectoral workshops had been held in total in the six case areas during 2018, and the mental maps developed were in some cases representatives of the “horrendograms” in that they were overly detailed and contained a number of variables that in many cases were opinions, just key words or other non-descript narratives. In order to simplify the mental maps, and prepare them for the stock-flow modelling (De Kok et al., 2019) to take place in WP4 and assess the volume of data to be collected in WP2 to account for the findings in WP1, the meeting ideally followed these steps:

1) Printouts of all the initial sector workshop mental maps on A0 (poster size) were posted for the participants to consider the variables;

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2) Discussion were done about each of the workshops in the order they were done originally;
3) Each workshop was "restarted" on the whiteboard – while having the original available for reference, facilitating the case leaders to speculate about each variable on the original map, and encouraging them to combine variables when possible and come up with new ones that better represent a group of variables;
4) The facilitators and participants also had to consider data sources, or proxies for data, for each variable they decided on in the process as "keepers" for the CLDs;
5) The process had to ensure that there were arrows between each of the variables that were decided upon, and that they each had values from -1 (negative effect of one variable to the next) to +1 (positive effect on the origin variable on recipient variable) – this was to prepare for the fuzzy cognitive mapping in Mental Modeler;
6) The participants also had to identify variables that exist in already processed mental maps so that they were not duplicated, but in fact could serve as "links" between the new simplified models, preparing for joining them all together;
7) The aim was that each new model would not have more than 12 variables on average when they are finished condensed and processed;
8) Simultaneously with the whiteboard, another participant at the meeting was developing the Vensim representations – putting in + (plus) or – (minus) on the arrows from one variable to the next – not from -1 to +1 as this was later done in Mental Modeler for most;
9) Finally, the participants combined the variables and models in the Vensim® software, using the shared variables as links. This was done by cutting and pasting first model two into model one (the new versions) with two different colours. Vensim would then identify if there were identical variables – but often, a manual inspection could easily identify these as well (there can be spelling errors, or similar interpretations of variables but with different words to them, which makes human inspection more reliable). At this stage, we drew arrows between models as well, with those that link the variables from one to the other.
10) Finally, we saved a full regional model of land-sea perceptions and interactions, where all variables ideally either had existing data available or at least proxies thereof available. This is to later be the basis for the SD modelling in WP4– but also what was presented to the MALs later for validation and feedback.

3.1.1.2 Narrative analysis

Narrative analysis was important here as well in points 3-6 above, and we built a lot of the simplification process on our knowledge from this analysis in D1.1. when we transcribed all the sectoral workshops. Narratives can be described as "discourses with a clear sequential order that connect events in a meaningful way for a definite audience and thus offer insights about the world and/or people's experiences of it" (Hinchman and Hinchman, 1997). To get the narratives from the transcription of the recordings from the workshops in T1.1 (seen in deliverable D1.1), we concocted narratives based on the researcher's interpretation of what was discussed during the workshop, rewritten from its original form. Another option would have been to analyze the narratives as special kinds of texts, in and of themselves, using conversation analysis (Czarniawska, 2004). It i s also valid to use a combination of the two, where you interpret the narratives within the context of the workshop setting, and other times treating the text literally as it related to the output of the systems thinking analysis from the workshop. The most important role of the narrative is the knowledge content that can be extracted that might be missed from the model conceptualization process alone. This is in line with Elliott's account of narratives as being instrumental because "*...internal validity is...thought to be improved by the use of narrative because participants are empowered to provide more concrete and specific details about the topics discussed and to use their own vocabulary and conceptual framework to describe life experiences.*" (2005).

3.1.1.3 Designing the Fuzzy Cognitive Maps

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The MALs translated their Causal Loop Diagrams for the combined coastal-rural system into Fuzzy Cognitive Maps by polishing the CLDs and assigning weights to each interaction shown in the diagram. The standard procedure for interactive design of an FCM with stakeholders usually involves these distinct steps:

a) Plenary introduction to explain what FCMs are and how these can be used, demonstrating a simple FCM as example;
b) Interactive discussion or break-out sessions with stakeholders to verify the polarity of each interaction: positive (reinforcing) or negative (balancing), and assign a weight indicating the strength/significance of the interaction;
c) Design of transmitter scenarios and running the scenarios to produce either bar graphs showing the end states for relevant concepts after a sufficiently large number of iterations or graphs showing the transient behavior of the concepts during these iterations.
d) Feedback session with stakeholders to compare and analyse the scenarios, discussing the policy implications

By itself, the purely qualitative steps a and b can be considered very useful for discussing system feedback, and running policy scenarios may not always be necessary or is less desirable to avoid methodological problems with the interpretation, in particular when the next step concerns the design of stock-flow models (see meeting minutes with Advisory Board – D28, De Kok, 2019).

3.1.1.4 Scenario and Policy Analysis with FCMs

The term 'Scenario' comes from the Latin word scaenarium. Scaenarium, which in term is based on the Latin word scaena, signifies a location where one erects stages (Merriam-Webster, 2012). For the current deliverable, we will use the academic definition of scenario that covers our aim: "*Scenarios are consistent and coherent descriptions of alternative hypothetical futures that reflect different perspectives on past, present, and future developments, which can serve as a basis for action*" (Notten, 2006). Herman Kahn, who founded the Scenario method, described scenarios as a set of hypothetical events that define images of potentials in the future. Scenario storylines, also known as visualizations of different futures envisioned, were according to Kahn supposed to be: "...lively but realistic and attempt to draw attention to causal relationships between developments and the possible interventions policy makers or businesses can prepare for in the event of an actualization of a given scenario"(Botterhuis et al., 2010; Tiller et al., 2013). The literature on scenarios generally highlight that we cannot treat scenarios as predictions (Hugues, 2000; Kristóf, 2006; Lena Börjeson et al., 2006; Steven P Schnaars, 1987). Furthermore, scenarios can be proposed and they can be explored, but are not possible to validate until it is observed (or not) at a future time.

Mathematically an FCM are represented by a square matrix with weights indicated for the elements were variables interact. The majority of the elements have a weight equal to zero as no connection was indicated so the matrix is normally a 'sparse' matrix as variables interact only with a limited number of other variables. Scenarios can then be defined by making assumptions on the development of selected transmitters over time (the scenario) and applying these to the FCM iteratively using standard matrix algebra, starting from an initial state. The outcomes for selected variables (receivers and/or ordinary variables) can be examined and their interpretation is part of the scenario. After each iteration step, the result can be "squashed" back to ensure the resulting variables are still in the allowed range 0-1.

The actual computations with the FCM can be done in a spreadsheet model or dedicated tools such as MentalModeller[2]are based on simple, linear matrix algebra to obtain the new vector of all system concepts (variables) from the values for the previous step. For the majority of FCMs this can result in values exceeding

[2] http://www.mentalmodeler.org/

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the allowed range [-1,+1]. In this case the values can be clipped off at the range between a minimum and maximum using so-called “squashing” functions. The type of squashing function used can affect the results (Tsadiras, 2008). For this reason it is important to test different squashing functions. The algorithm used for the variable update is:

$$S_i(t+1) = f\left(\sum_{j=1, j\neq i}^{N} w_{ji}\, S_j\,(t)\right)$$

$$S_i(t+1) = f\left(\langle S_1(t) \ldots\ldots\ldots SN(t) \rangle \times \begin{pmatrix} w_{11} & & & w_{1N} \\ & \cdots & & \\ & & \cdots & \\ & & \cdots & \\ w_{N1} & & & w_{NN} \end{pmatrix} \right)$$

$$\text{example trivalent squashing: } f(x) = \begin{cases} 1 \ \ if\ x > 0 \\ 0 \ \ if\ x = 0 \\ -1 \ \ if\ x < 0 \end{cases}$$

where $S_i(t)$ is the value of concept *i* for iteration step *t*. Comparison of scenarios may focus on the differences between the end states for selected concepts after a number of iterations or transient behavior of the concepts during the iterations (Kok, 2009). Although the latter approach may produce interesting results the graphs showing the transient behavior may wrongly be interpreted as time-dependent dynamics. In addition, the transient behavior is more complex to interpret correctly and it can take a number of iteration steps to stabilize. These are among the reasons why FCM tools such as MentalModeller[3] use the end state based approach for visualizing the differences between scenarios. An example for agriculture is shown in Figure 3.

[3] http://www.mentalmodeler.org/

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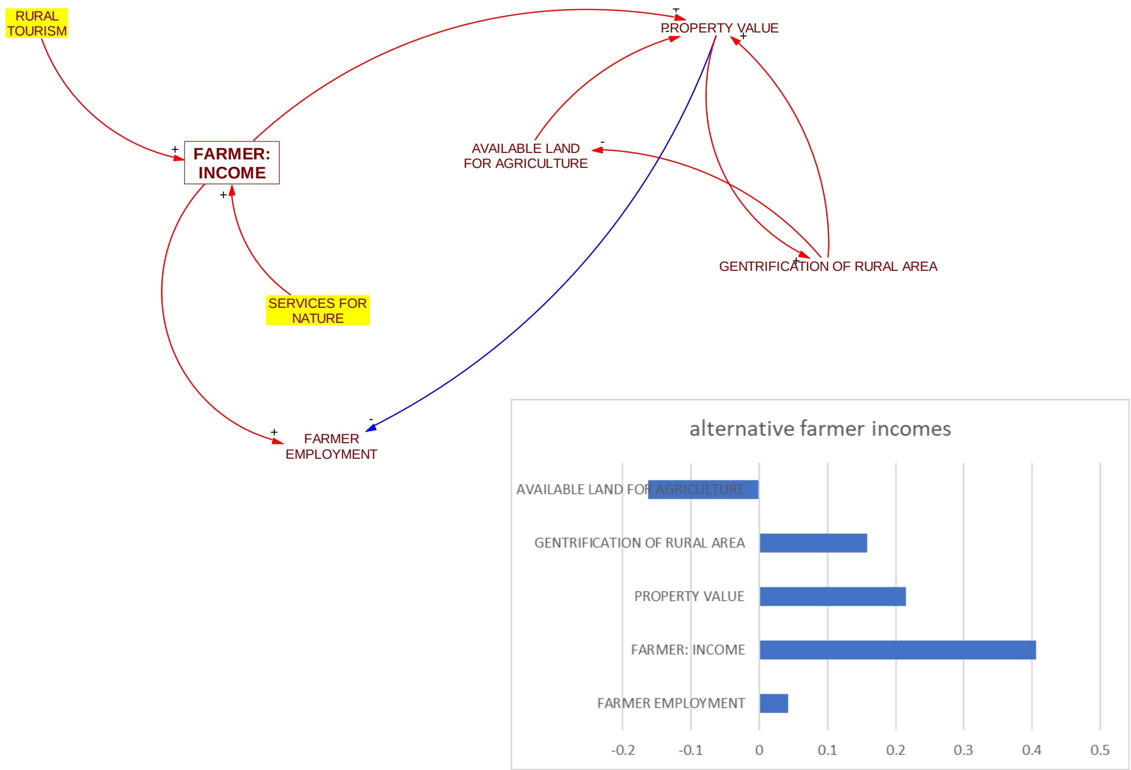

Figure 3 Example of a scenario analysis for agriculture with an FCM.

MentalModeller[4] was used by the majority of the MALs to construct the FCMs interactively during the multi-actor workshops, because of its user-friendliness and the built-in functionality to export the model to spreadsheets. The presence of so-called 'transmitter' variables representing exogenous system drivers or policy interventions (Kontogianni et al., 2012) with a one-way impact on one or more other variables are those that actually drive the system. A vector of consecutive values for the transmitters defines a scenario. For instance, if Sea Surface Temperature (SST) is a transmitter, a scenario could be to explore the effect of an increase from 0 (minimum value) to +1(maximum value). Another scenario could be to see what 0,5-0 would do to the system, relative to the stakeholders' perceptions. The scenarios are as such not "real" numbers, but fall within the definition of scenarios as a series of hypothetical events or potential futures, in this case in the commercial future of the olive oil industry in Messina for example (Kahn, 1968). The original purpose of the scenarios was to draw management attention to relationships that existed between actual developments and the possible interventions that could be prepared were a given scenario to be actualized (Botterhuis et al., 2010). We examined the outcomes and compared the different scenarios using a simple MatLab script that created an Excel spreadsheet from the MentalModeller result that could be used for interactively exploring the effect of changes to the drivers in the model.

Although the interpretation of scenarios generated with FCMs can be challenging an advantage is that the sensitivity of key variables under different scenarios can be compared in a more consistent manner. For example, a comparison can be made of the impact of business/policy interventions and exogenous drivers (drought, economic crisis, etc.) between a standard Business-As-Usual (BAU) scenario and a custom scenario. This can help determine the sensitivity of the land-sea system and rank variables by their significance, which

[4] www.mentalmodeller.org

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is later used in other deliverables in the COASTAL project. This is important, since, in COASTAL H2020, we focus on scenario analysis (i.e. what if?) where changes in conditions (for instance increased sea surface temperature in Belgium) may be used to update our prior understanding of an event (e.g. the priority issue in our model) to posterior understandings. These can then be addressed with the functionalities of FCMs.

3.1.1.5 Stakeholder Selection for actual MALs

We selected the groups of stakeholders for the multi-actor workshops in each case area from the initial pool of stakeholders during the sectoral workshops (see D01 for details on initial stakeholder mapping), as well as from those actors that are partners in the project. These multi-actor workshops, as opposed to the initial six, were intra-sectoral in nature in each of the six case areas. Participatory approaches support stakeholder involvement, through which stakeholders can exchange their share experiences, learn about other perspectives, and (qualitatively or quantitatively) examine their perceptions to better understand system behavior (Sterman, 2000). We used this approach because the quality of the results sampled from this group would outweigh the relatively small number of informants the method usually produces. This is often the case in qualitative research studies. Sometimes, large samples can in fact be ineffective and not provide the detailed and contextual information desired by the researcher. For the purposes of the participatory workshops in this study, we considered fifteen to be the maximum of what would provide a holistic narrative of feedbacks and validation of the simplifications we had made of their initial workshops. It is also a number that allows all participants were provided ample opportunities to share their perceptions and feedback to the researchers. The sample size can be as small as one or two as well, if this participant has information which is of critical value for the given sector and advances the research towards a specific goal (Sandelowski, 1995).

From a natural science perspective, we reiterate that this may seem like a small number of observations. However, samples in qualitative research tend to be smaller than one would expect in the more numerical sciences. This is to support the depth of case-oriented analysis that is fundamental to this mode of inquiry, such as with the participatory workshops where the aim is to get a conceptual map. The samples were also purposive in that they were selected by virtue of the respondent's capacity to provide richly textured information that was required specifically for this study, relevant to the phenomenon under investigation and the validation we needed them to make of our interpretations in the simplification process. As such, this purposive sampling (as opposed to probability sampling that is customarily employed in quantitative research) selects 'information-rich' cases or respondents. The more useful the data sampled from each of the participant is during these sessions, the fewer respondents are needed. In fact, research has shown that after 20 responses, there is seldom any new information to be gained that is analytically relevant (Green and Thorogood, 2018), hence why the ideal "limit" of 15 persons per workshop was suggested.

The following is an overview of reflections on stakeholder mapping from the case area leaders for this first round of multi-actor labs.

Case area	Stakeholder mapping process – MAL I and future steps for MAL II and beyond
MAL 1	For the **inter-sectoral multi-actor workshop** the Belgian project partners jointly prepared a list of persons to be invited based on the diversity of each sectoral workshop and the ability of participants to think at a system level. In this case, the people who were invited also attended, with a total presence of 9 persons representing coastal and marine sectors and 10 persons representing rural/inland sectors. Nevertheless, some invitees sent other persons to represent their organisation than those that had originally attended the sectoral workshop. This combined multi-actor workshop was condensed to an afternoon only. The first part focused on integrating the coastal and sector causal loop diagrams into a combined

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	system diagram. The second part was aimed at preparing visionary scenarios for the future in breakouts. The participants actively contributed to both activities and, interestingly enough, there was no dispute between the coastal and rural stakeholders as anticipated prior to the workshop. This intersectoral challenge was also one of the reasons for breaking up the sectors in the first workshops. The multi-actor workshop resulted in a broadly supported but complex causal loop diagram with over 100 variables for this Multi-Actor Lab. For the second MAL workshop, we expect to limit ourselves to two scenarios, and invite only those expert stakeholders that are best suited to come with input to the process, and who has shown a distinct wish to use the results of the modeling efforts once completed, in line with the RRI expectations and impact ambitions of the project.
MAL 2	The MAL workshop was attended by all actor MAL partners and a selection of stakeholders from the sectoral workshops. We decided to select which stakeholders would attend the MAL in an effort to have equal representation of all sectoral groups as some of were significantly larger than others (Farmers vs Fishers for example) as well invite those who had shown a greater interest in the processes and were more engaged in the conversations. From the *group of farmers-agronomists*, we selected the 2 agronomists who participated in the sectoral workshop, and 2 farmers who were the most engaged in the conversation and the process. From the *group of local industry*, we invited all 3 participants who participated in the sectoral workshops. The fishers group was once again a difficult group to activate. Member of the cooperative running the lagoon fishing as well as a couple of coastal fishermen who had shown somewhat greater interest in the conversations were chosen to participate in the MAL discussions and although they had given positive replies to the invitations they were not present in the discussions. From the *group of tourism*, we selected the representatives of the local associations linked to tourism, a representative from the biggest hotel investment in the area (who is also an Actor Partner in COASTAL), and a representative focusing on outdoor activities. For the *policy group*, the selection was more challenging as we had to exclude participants to ensure equal representation from each sectoral workshop, even though we would like to invite more. Eventually, we invited authorities that were linked to agriculture and fishing, water, forestry and environmental management. From the *group of Institutions/NGOs* we invited the 2 NGOs who participated in the sectoral workshop, and the local university. For the second intersectoral MAL workshop, we intend to keep the structure of the MAL I, but with better representation from the fishing sector. As described above, the participation of fishers is challenging, but we have already identified a new stakeholder who recently took over the fish management of the lagoon and they are willing to participate in the workshop. The participation of coastal fishers still remains a challenge. We don't foresee major challenges in finding stakeholders for MAL II even though it might be challenging to organise such a workshop via an online platform. We do expect to need to add some new stakeholders. In addition to the representative from the fishers' group mentioned above, we would like to invite a representative from the Management Body of Natura 2000 areas as well. The agency was established in early 2019 and until present it was not adequately staffed, and has therefore not been included so far. We also want to include a representative from the Messinia Union of cooperatives who were also not included in our first selection of stakeholders, and a representatives from the port of Pylos and the Ephorate of Antiquities of Messinia – the latter of which were present in the sectoral workshop but were not included in MAL I.
MAL 3	Representatives from key actors attending the sector workshops were also invited to the first inter-sectoral workshop for the Swedish MAL. In total, 45 person representatives from 26 actor organizations, including the local partners were invited to attend. The invitation selection was

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	based on a combination of the actors' responsibilities/ activities/ expertise/ experiences and their contributions and inputs to the sector workshops. In total, 18 person representing 11 actor organizations were registered and participated in this intersectoral workshop where all participants had the opportunity to openly discuss their perceptions and share their knowledge, in particular with regard to the unified, simplified causal loop diagram (CLD) constructed by the SU team from the six different, yet related CLDs given by the stakeholder participants in each sector workshop. For the second round of inter-sectoral workshop, which is planned for November 2020, the actors from the first round are again invited to attend, and 11 out of the total 18 person representatives (10 out of 11 actor organizations) have already confirmed their participation. Overall, most of the invited actors did not respond to the invitations for this intersectoral workshop either, as with the sectoral ones presented in D01. Some of them were not available at the specific workshop times, and some did not consider the incentives be high enough for participating in such workshops, since decades of intensive eutrophication mitigation efforts for the Baltic Sea have still not been successful. Thus, main challenges in engaging actors in the Swedish workshops were related to lack of time and availability (most of the actors are generally very busy) and lack of incentives to further discuss case-related problems and potential solutions after decades of not very successful solution efforts.
MAL 4	Twenty four stakeholders were selected for the MAL workshop in MAL4 on the basis of their previous participation to the six sectorial workshops and of their interest for the coastal project and attended the inter-sectorial workshop. The main criteria for being invited to this workshop were, abide their stated interest for the project, their involvement in land-sea dynamics and interdependencies.
MAL 5	The first intersectoral MAL meeting for the Danube's Mouths - Black Sea Case Study, had 22 participants, and included partners from the Research Institute for Agriculture Economy and Rural Development (ICEADR), Local Activity Group Danube Delta (GAL DD) and Local Activity Group Central Dobrogea (GAL DC). The meeting was also attended by local actors, representing municipalities, research institutions/academia, authorities, entrepreneurs and civil society, who all contributed to develop future narratives about the development of the region. It was not very difficult to find relevant stakeholders because of Partners' long experience in the study area working in several projects with different stakeholders and because most of them had already engaged in previous participatory activities organized by other projects in relation to the Danube's Mouths - Black Sea Case Study. The stakeholders mapping process took into account ensuring sufficient diversity in terms of area of activity (agriculture, tourism, fishery, infrastructure, water, environment, strategic management), organizational affiliation (entrepreneurs; government and public authorities; civil society; practitioners), gender, etc. We expect it to be more difficult to bring stakeholders during the pandemic COVID-19 health crisis for the second round of intersectoral MALs during 2020-2021 though. We will try to overcome this shortcoming by organizing a hybrid workshop (physical and online) as per the updated plan of action to adapt to the new situation. We will use the same network of stakeholders, sending the invitations one month before the event. If we do not have enough confirmations, we will invite other stakeholders in the network, taking care to respect the distribution and diversity in terms of their activity and affiliation.
MAL 6	For the first multi-actor intersectoral workshop in Spain, we selected participants that had attended the sectoral workshops, including our MAL actor partners (FECOAM and CARM). A total of 14 representatives of the sectoral workshops attended the first multi-actor workshop. We decided on which participants to select based on several criteria. One of them was their

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	participation level during the previous workshops, so that most active and interested representatives were favored. In addition, we wanted to ensure that all sectors were represented. Finally, representatives of institutions that played a major role in the area, such as entities with high influence on others were prioritized. We defined "influence" in this case as the capacity to mobilize society and businesses, or to take management decisions. For the second multi-actor workshop we aim to welcome the same participants as during the first MAL workshop. However, we will invite more people than those that attended the first one to make sure we have enough representation of all sectors, including both coastal and rural actors, in case any of them cannot attend the workshop. We also plan to invite experts who have given input to the model between workshops to attend, since they will probably be able to support us explaining the model architecture to the stakeholders.

3.1.1.6 Multi-actor workshops

The draft agenda for the multi-actor workshop was as follows, based on the main expected outcome of the MAL being the validation of the simplification process and the identification of which potential solutions/which parts of the system, would be modelled and what data would be needed to do so.

1. **Present and validate merged CLD** from all the sectoral workshops (or FCM results if the case area had these already developed) from the simplification process. Indeed, the full complexity CLD of the entire system was considered to be too complex to present directly to the participants so the facilitators were encouraged to work with already strongly simplified/generalized version of the CLD (or FCM) when presenting the entire system. In fact, even getting the simplified CLD right was considered a challenge after the simplification workshop, which demonstrated how complex the systems in each case area was;
2. **Prioritize/rank main issues and problems** identified during sectorial workshops and combined in the simplification process into the merged CLD (in general, the facilitators presented those issues that were considered most mentioned during the merged sectorial workshops and that were highlighted during the simplification process). This merged part is critical, given the holistic nature of both the main problems and potential solutions. We therefore specifically needed the stakeholders to focus on the interactions between sectors since the CLDs were not limited to interactions within the sector but included cross sectoral interactions as well;
3. **Discuss and prioritize selection** of solutions to be modelled with SD;
4. **Identify variables/data needed** for the SD models for each solution:
    a) For some solutions we will already have a proposal (system inventory)
    b) Identify model boundaries (spatial and temporal).

To sum up, during this first multi-actor workshop the different case areas looked for: 1) agreement on the simplified CLD (or FCM) of the full system, and 2) a prioritization of potential solutions for which would allow them to develop more complex models based on more detailed interactions from the sectorial CLDs. This information would help in the selecting/prioritization of most promising solutions to be further evaluated with the models.

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4 The General Data Protection Regulation

As WP leader and participant in the data collection process of COASTAL, Partner 4 (SINTEF) was required to notify the National Data Protection Official for Research when processing personal data in the same way as for data collection in Norway. The research conducted in the third country (i.e. Norway) is limited to (1) briefings of the partners/persons coordinating the multi-actor sessions and (2) post-processing of these data. It can be legally carried out in at least one EU Member state. Supporting evidence will be kept by the Coordinator and provided upon request.

COASTAL emphasizes that the regulations in Norway are in line with *The European Code of Conduct for Research Integrity* as well as the cross-cutting issue of Horizon2020 on *Responsible Research and Innovation*. The regulations are also in line with Directive 95/46/EC, which specifies that personal data must be processed according to certain principles and conditions that aim to limit the impact on the persons concerned and ensure data quality and confidentiality. This is also in line with the **ethical standards and guidelines of Horizon2020.** Data transfers within the EU/EEA are not subject to specific requirements (i.e. specific authorisations or other restrictions), and COASTAL therefore only need to comply with the general requirements of Directive 95/46/EC.

The new EU Regulation 2016/679[5] builds on the earlier General Data Protection Regulation (95/46/EC) or GDPR and is aimed at ensuring the protection of natural persons with regard to the processing of personal data. The main goal is to increase the accountability and transparency of the data processing, and data protection rights of individual persons. It is not referring to the use and/or protection of research data (see COASTAL deliverable D26 – Data Management Plan). **Personal data** refers to information corresponding to a natural person (a so-called ‘data subject’) who has been or can be identified directly, or indirectly. In particular this will be the case if identifiers such as names, addresses, id numbers etc. are used. It also refers to person-specific factors such as gender, physical, mental, social-economic and cultural characteristics. The **data processing** refers to the collection, recording, storage, adaptation, disclosure, forwarding, destruction, and all uses of the data.

Important to keep in mind are a few **key principles**:

- The personal data should be adequate, relevant and limited for the intended use, rather than what data are desirable to collect and process
- Accountability of the data processing and data replaces a compliance-based approach (record keeping)
- It is mandatory to appoint an independent data protection officer, who will provide advice and can evaluate the data processing against compliance with the GDPR
- The rights of the data subjects are strengthened, for example natural persons should give explicit consent before personal data can be collected, and the data can be removed upon request

In addition, two general approaches are allowed in the GDPR and useful for projects such as COASTAL:

- **Anonymisation**: this means that personal data are processed in a way that makes the risk of identification negligable. For example, interview data can be collected without storing the names, gender, age of the data subjects responding to the survey

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN

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- **Pseudo-anonymisation**: here direct identifiers such as names and addresses are replaced by indirect identifiers (for example numbers) in the data set. A separate data set, known as the 'key', is used to link the indirect identifiers to the direct identifiers

Limited use was made of personal data in COASTAL for the purposes of the sector workshops, focused primarily on audio recordings which were temporarily kept during the processing of intermediate results of these co-creation activities until these had been analysed for the purposes of this deliverable.

To ensure compliance with the EU Regulation 2016/679 on the protection of natural persons with regard to the processing of personal data during the sector workshops, COASTAL took the following actions:

- all project partners have been **informed** and **reminded regularly** of the obligations with respect to the collection and processing of personal data related to EU Regulation 2016/679
- effort have been made by means of technical and organisational measures to ensure the collection and processing of personal data are transparent, lawful, and limited to the purposes specified to the data subjects (natural persons) following (EU Reg. 2016-679 – Art. 28)
- a central, independent Data Protection Officer (DPO) has been appointed for the duration of the project to monitor compliance with the Regulation and provide advice to the project consortium members (EU Reg. 2016-679 – Art. 35)
- pseudonymisation will be used to reduce the risks to the data subjects and assists the data controllers and processers with their obligations with regard to the Regulation (EU Reg. 2016-679 – Art. 32)

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5 Multi-Actor Workshops

The following table gives an overview of the multi-actor workshops for the COASTAL MALS (Task 1.2). Sections 5.1 – 5.6 elaborate on the results of each of the MAL case areas.

Table 1: Overview of case areas, respective stakeholders and key issue areas for the multi-actor workshops

Country	European Sea	Specific case	Number of participants	Key results from MAL
Greece	Eastern Mediterranean Region	SW Messina	19	• Awareness is not the problem and the solutions are known • Implementation is more difficult and requires a clear vision and mutual trust; more meetings are needed
Belgium	Southern North Sea	Belgian North Sea (BNS), Coastal Zone and hinterland (Province West Flanders)	18	• Multi-functional use of space is important for off- and onshore activities • Importance of "building with nature" -to be integrated with coastal flood defense • Sand (for inland construction and flood defense) is becoming a limiting factor – alternatives are needed • Fresh water is becoming a limiting factor • Offshore (renewable) energy development will be essential; need for balanced grid connection and energy storage (H2 technology) • (see also Section 5.2.3.2)
Sweden	Baltic Sea	Norrström	18	• The co-created mind maps included both theme-sector-specific aspects as well we joint issues/priorities/solutions among all sectors. • Freshwater quality and coastal water quality were the central aspects and highly affected in the developed CLD for MAL3. • The developed future narratives for MAL3 covered the three pillars of the sustainable development.

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Romania	Black Sea	Danube Mouth	22	• Existing legislation and continuing bureaucracy are important obstacles; in addition, demographic decline is a problem • The conclusions of the COASTAL workshops are in line with the 2030 Vision for the Danube Delta • The main sectors to develop are tourism, fisheries and agriculture
France	Atlantic region	Charente River Basin	24	• Agricultural production plays a central role • Water resources (both quality and quantity) are a common concern • The main activities are agriculture and shellfish farming
Spain	Western Mediterranean	Mar Menor Coastal Lagoon	14	• The land-sea system is complex with multiple issues • Nature based solutions (crop diversification, vegetation buffers, conservation practices, …)

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5.1 Greece - South West Messinia (Eastern Mediterranean Region)

5.1.1 Executive summary

The case study of SW-Messina, Peloponnese, Greece, is a representative example of an interlinked coastal-inland area in the Eastern Mediterranean region. Agriculture (olive groves mainly) and coastal tourism are the two major economic activities in the area, while fisheries is another important aspect of primary economic sector for the area. Besides the presence of olive groves, the land cover consists of a variety of Mediterranean habitats included in the reference list of the Natura2000 initiative and several important cultural sites are scattered within the study area.

The MAL was co-organised by HCMR and NEO/SU and was held at NEO premises in Messinia on June 26, 2019. In total 19 participants attended the meeting, representing the six sectors of the sector workshops organised between June and October 2018.

5.1.2 Background

Agriculture, mainly represented by olive trees, and coastal tourism are the two major economic activities in South-Western Messinia, Greece. Tourism is expanding and goes hand in hand with infrastructure development such as hotels, roads and airports. This sector as such can provide both opportunities for diversified livelihoods, but also increases the pressures on the environment and cultural sites. Coastal areas are also affected by agrochemicals, soil erosion, solid waste landfills, and wastewaters. Climate change is expected to lead to more frequent occurrence of extremes (e.g. extended heat waves, droughts, floods) and decrease the availability of freshwater in this area. This in turn increases the risk for saltwater intrusion into coastal wetlands and aquifers. There are also plans for offshore oil and gas exploration in the area that could have implications for the area's rich coastal biodiversity.

The case study of SW-Messinia, Peloponnese, Greece, is therefore a representative example of an interlinked coastal-inland area in the Eastern Mediterranean region, well situated to represent many islands and coastal areas of the region. It is comprised of several important cultural sites and Mediterranean habitats included in the reference list of the Natura 2000 initiative. Based on the different workshops, the local Multi-Actor Lab, with the exchanges with the COASTAL partners, the results include the development of a number of alternative strategies for local economic development that will allow a diversification and strengthening of a sustainable local economy, while minimizing the impact on the Natura 2000 sites and enhancing ecosystem services. Long-term planning for tourism and agriculture will also have to consider the area´s and the population´s resilience to the effects of climatic changes through consultation with the expertise and experience of local stakeholders.

5.1.3 Mental Mapping Seminar

SINTEF Ocean visited the Greek partners on January 17 and 18, 2019. During this two-day workshop five Greek team members (from HCMR, NEO/SU, and ICre8) worked with SINTEF Ocean to condense the mind

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maps resulting from the six sectoral workshops, and to better understand the local stakeholder interactions, issues, pressure and drivers of Messinia's coastal-rural system.

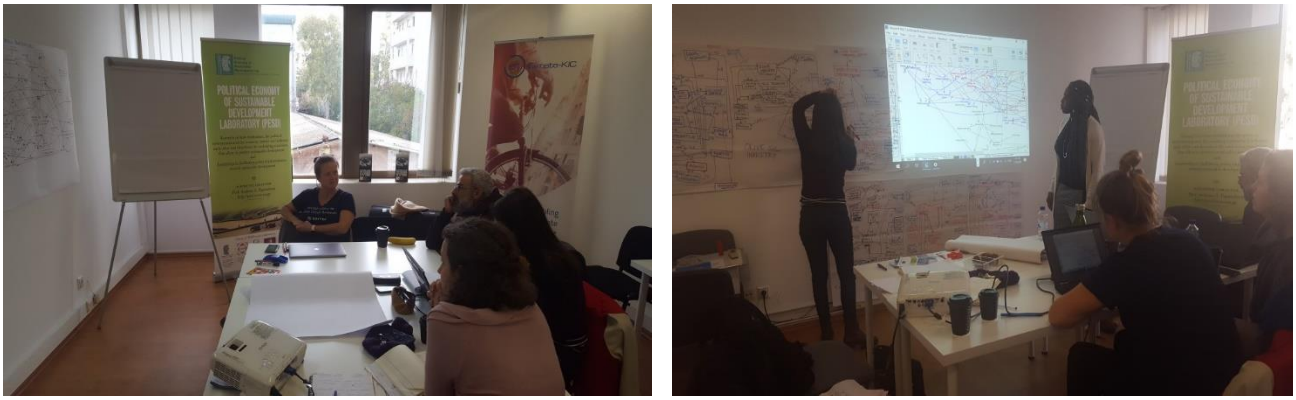

Figure 4: Mental-mapping seminar held in Athens at ICre8 premises

During this seminar, the team discussed the different mind maps separately in an attempt to condense the variables, and standardize the principles behind them. The goal was to simplify the maps as much as possible without losing important details and strive to convert all descriptive variables into measurable characteristics of a system (e.g. climate change to temperature or lack of cooperation to memberships in cooperatives), and without omitting important qualitative aspects of the land – sea system interactions.

Some of the questions we were asking throughout the process was:

1. What does the label mean?
2. Is it tangible or intagible?
3. Is the meaning/aspect or system characteristic identified in another variable within the sector or another sector?

In general, the process aimed to:

- Omit sidesteps that were too detailed;
- Identify and omit duplications;
- Rename or redefine variables to ensure clarity and avoid vague meanings; and
- Rename variables to connect different sectors.
-

As a result, the variables of each sectoral mind map reduced to almost one third of what it was initially.

5.1.3.1 Condensed Vensim Diagrams

The condensed causal loop diagrams generated for each sector workshop contained only those stock variables that were necessary.

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During the condensation process, the team took (where possible) into account whether a variable of the mind map could be quantified and whether data would be available. In addition to the general changes, and compared to the initial mind maps, in the newly generated CLDs a ***plus or minus*** sign was added indicating whether a variable is increasing or decreasing when the initial conditions are increased (e.g. if the memberships in cooperatives would increase, this would increase the employment opportunities and would decrease the cost of production).

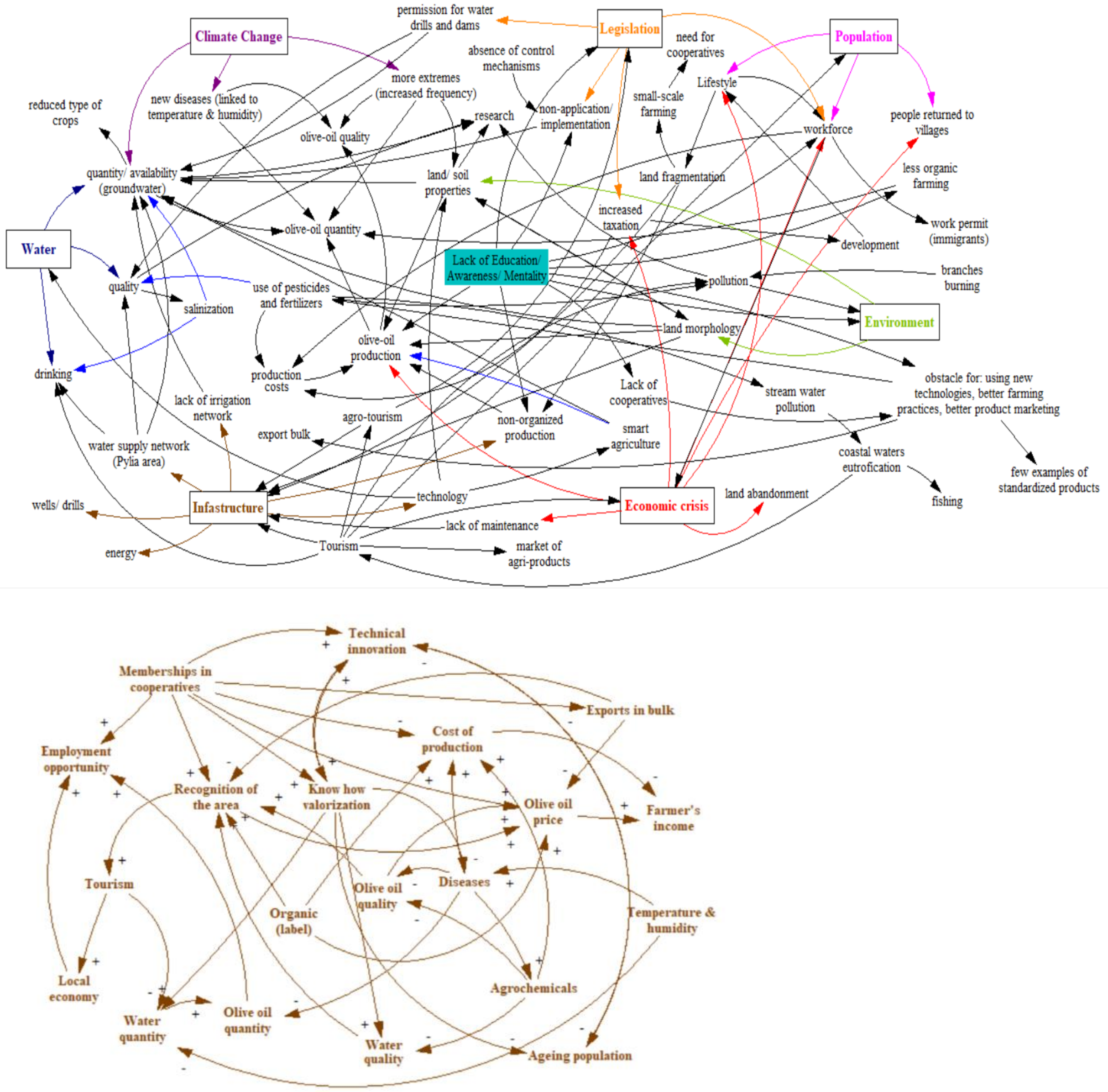

Figure 5: Causal loop diagram of the agricultural sector (olive-oil producers and agronomists), before (top) and after (bottom) the Mental Mapping seminar (generated in February, 2019).

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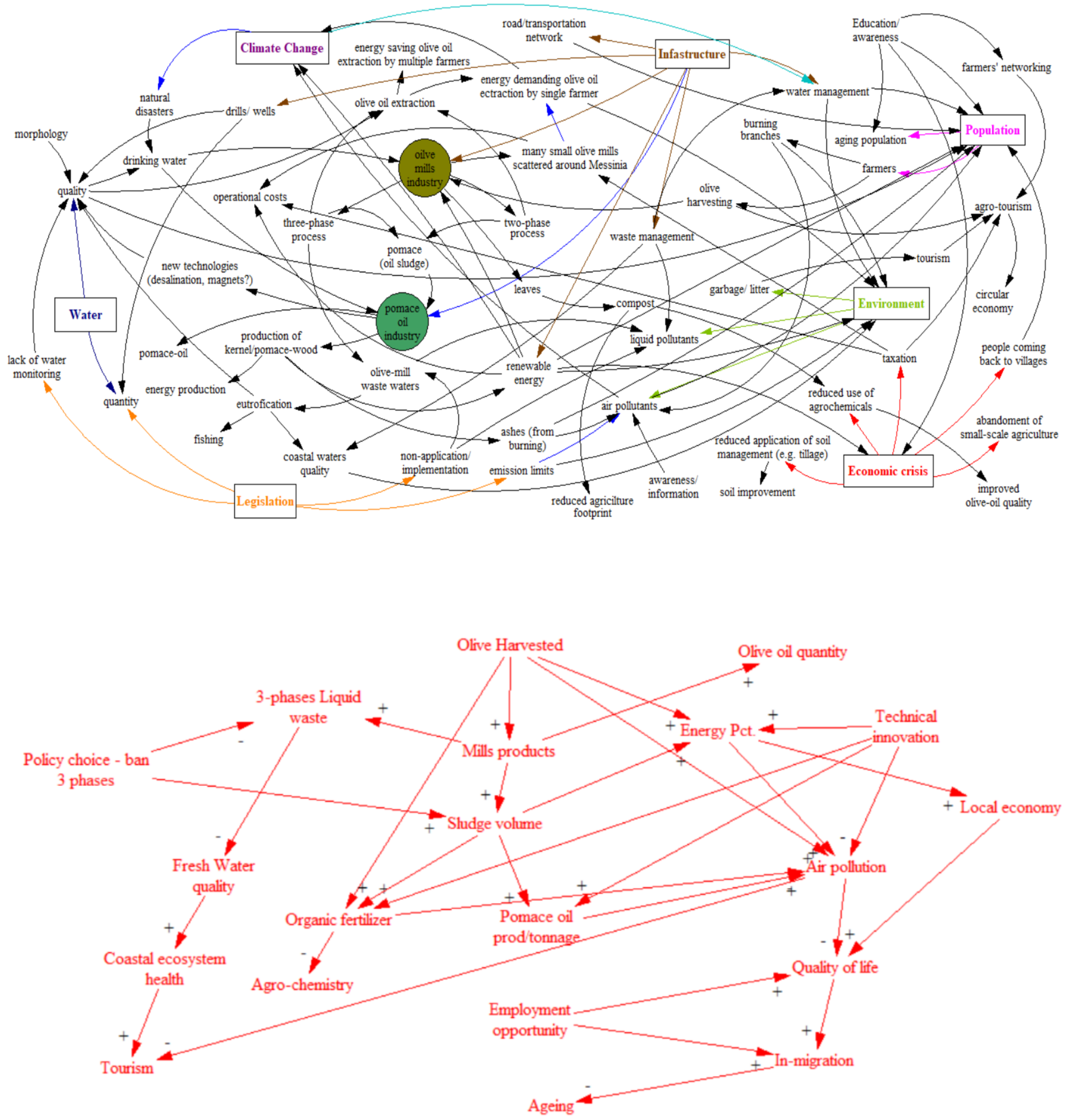

Figure 6: Causal loop diagram of the local indusrty sector (olive mills and pomace mills), before (top) and after (bottom) the Mental Mapping seminar (generated in February, 2019).

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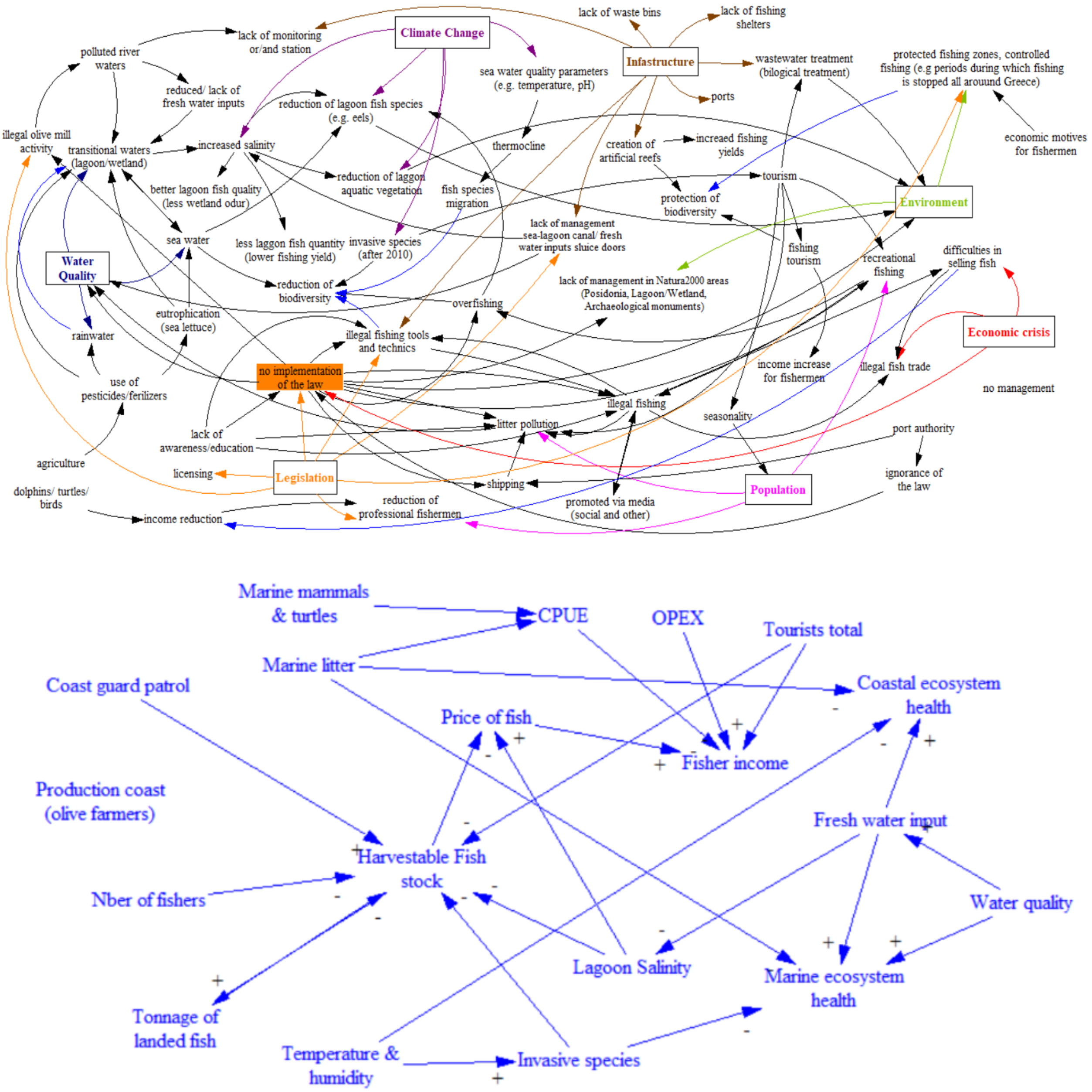

Figure 7: Causal loop diagram of the fishing sector (coastal waters and transitional waters fishermen), before (top) and after (bottom) the Mental Mapping seminar (generated in February, 2019).

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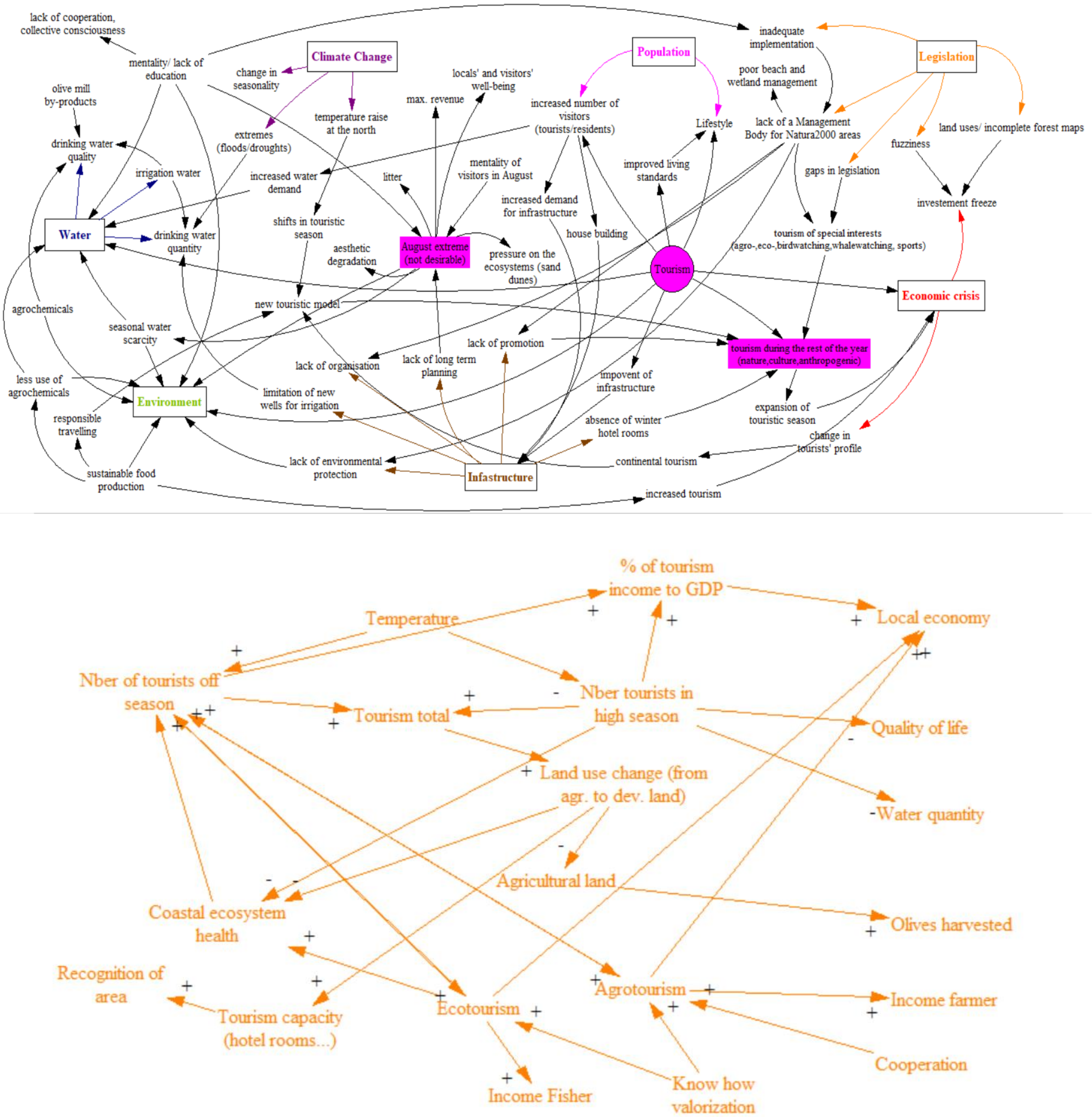

Figure 8: Causal loop diagram of the tourism sector (tourism operators, outdoor activities, hotel-restaurant owners), before (top) and after (bottom) the Mental Mapping seminar (generated in February, 2019).

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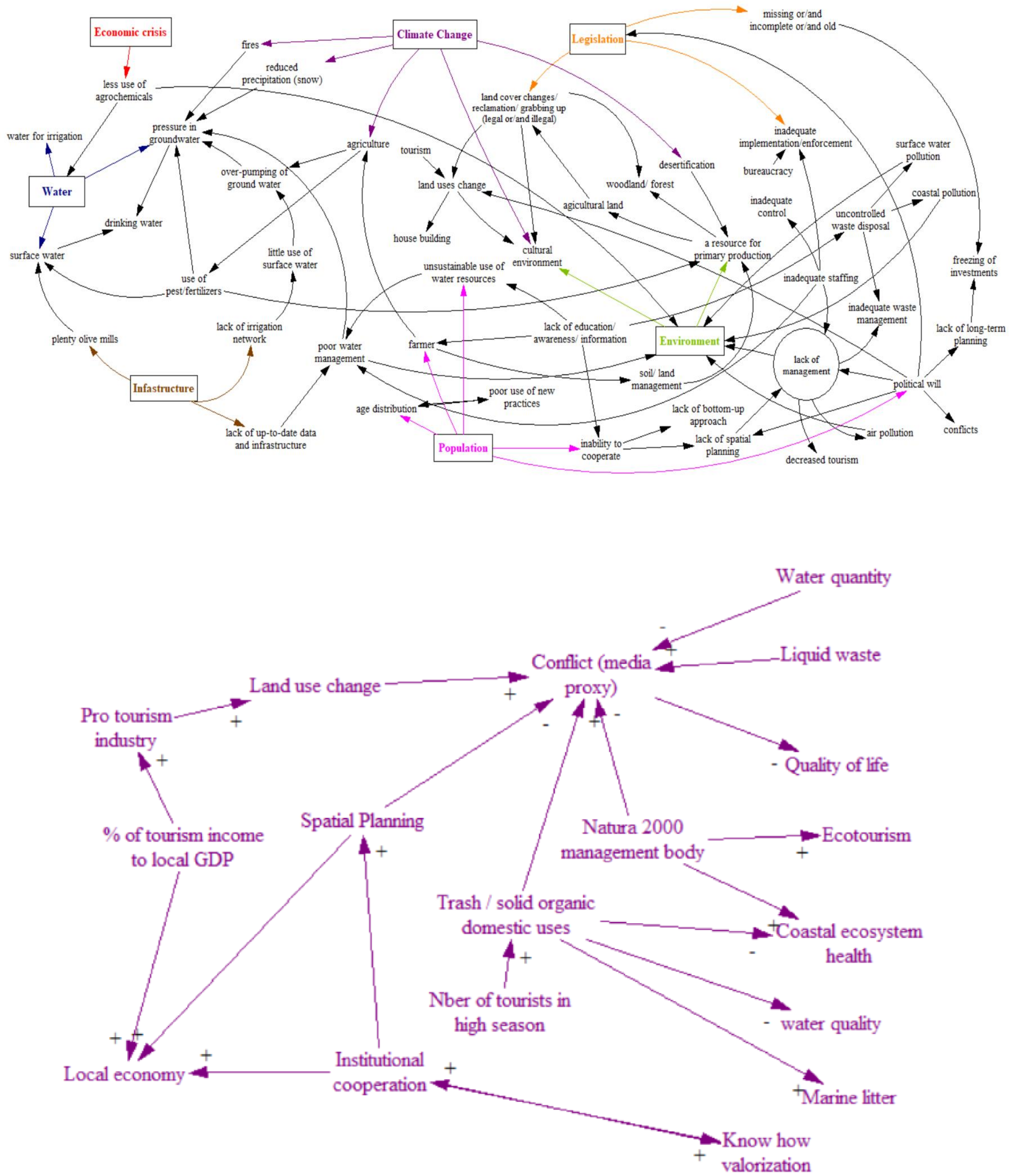

Figure 9: Causal loop diagram of the public sector (local authorities, reginal administration), before (top) and after (bottom) the Mental Mapping seminar (generated in February, 2019).

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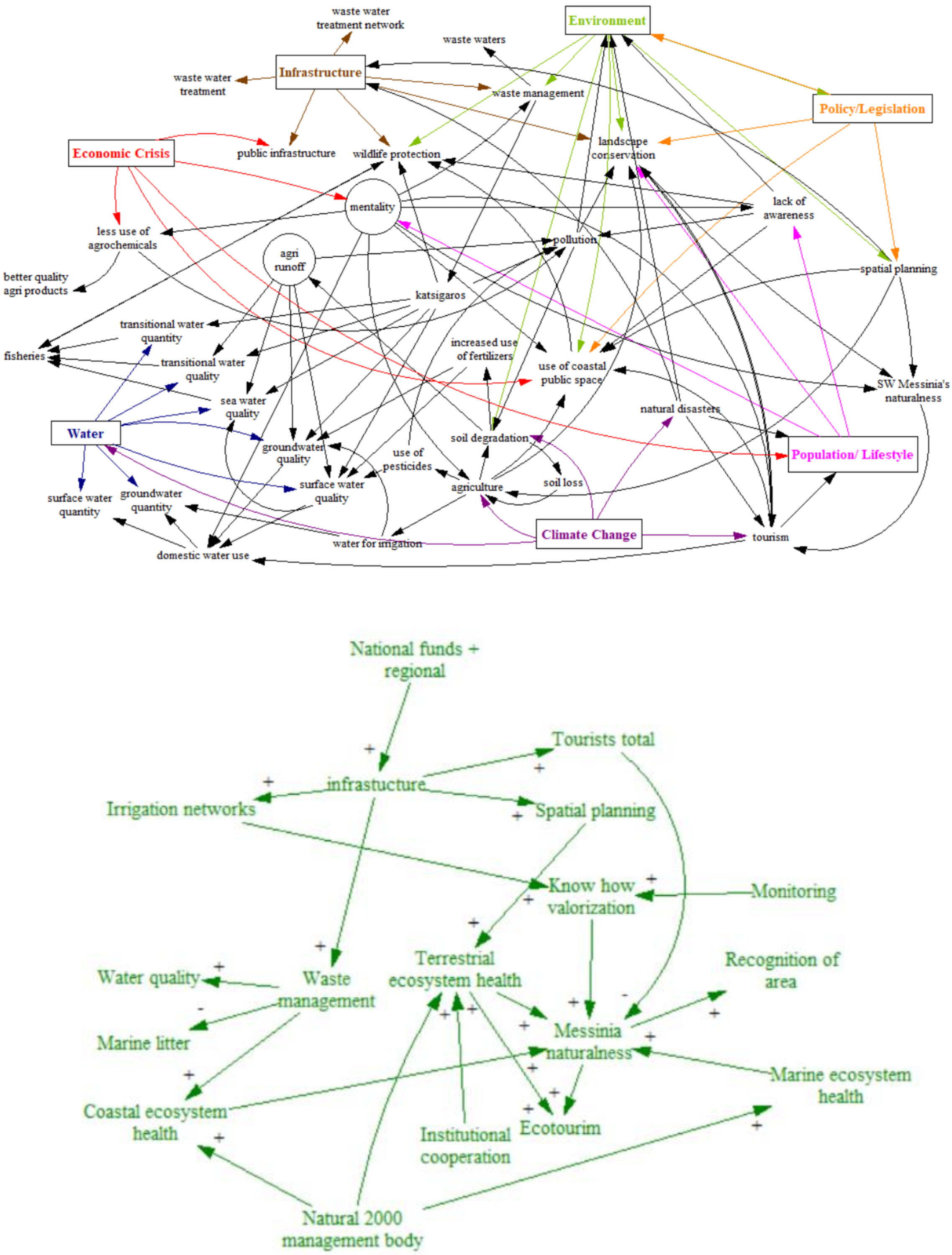

Figure 10: Causal loop diagram of the Institutions sector (universities, research institutes, NGOs), before (top) and after (bottom) the Mental Mapping seminar (generated in February, 2019).

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5.1.3.2 Combined Vensim – Regional Mental Map for SW Messina

At a second stage, the different sectors were then combined in order to create a causal loop diagram for the Greek coastal-rural system. The generated CLD was then further simplified were possible, by merging variables and deleting variables that occurred multiple times. The final result of the mental mapping seminar is shown below:

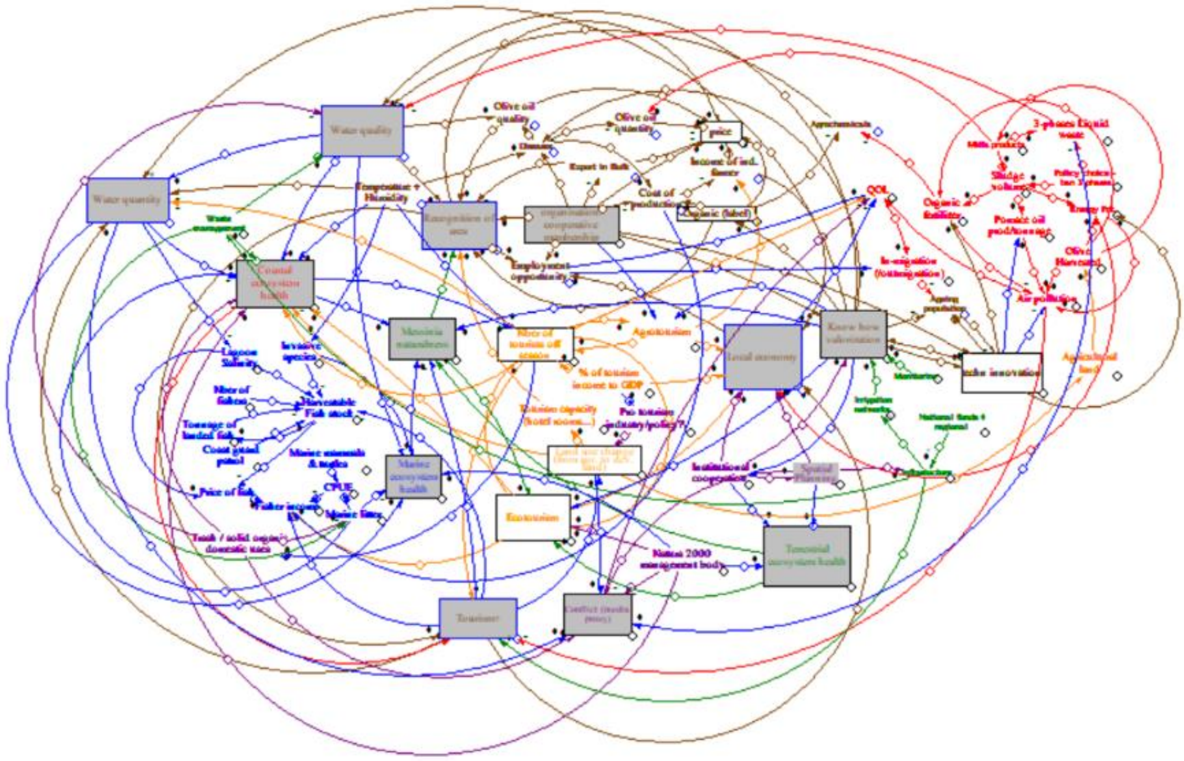

Figure 11: Causal loop diagram for the land-sea system resulting from the mental mapping seminar retaining significantly lower number of variables (January, 2019).

The most important shared variables (feedback loops observed in the causal loop diagram) were:

- **Water**: quantity and quality of fresh water, transitional waters quality and quantity, sea water quality, salinity problems, related actions. These were shared by all the sectors.
- **Lack of communication and cooperation** primarily within the sectors, and secondarily among them, together with issues linked to the **awareness, mentality** and **lack of education** in the local population were shared by all sectors. These variables were identified as major obstacles to advances in local economy That these variables are shared by so many sectors is indicative for the multifunctional use of the variables.
- The need for a better **management of the Natura 2000 areas**, was shared by most sectors, except the one of the local industry sector. A better management could improve fish stock but also provide alternatives for eco-tourism. In fact, **agro-, and eco-tourism** were shared by the sectors of tourism, agriculture, local industry and Institutions/NGOs.

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5.1.3.3 Fuzzy Cognitive Maps

During the last phase of the Mental Mapping Seminar, the causal loop diagrams were translated into Fuzzy Cognitive Maps (by assigning weights for the interactions in the range -1 to +1 (where -1 is low, 0 is moderate and 1is high interaction). The whole work was done in Mental Modeller. The weights were based on

a) the input of the stakeholders during the sector workshops, in which they already indicated the strength or importance of relations between the system characteristics, and

b) expert judgement from our multi-disciplinary team that has extended experience in environmental and social processes in the South-west Messinia coastal region. The project team verified and completed the weights after the meeting.

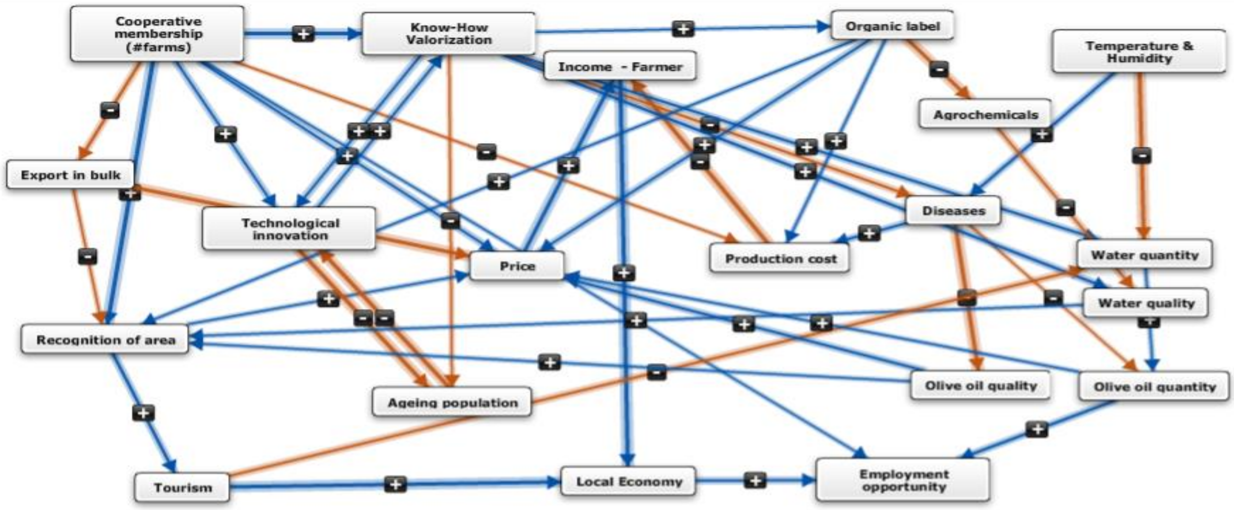

Figure 12: Fuzzy Cognitive Map of the agricultural sector as it was created during the Mental Mapping seminar (January, 2019).

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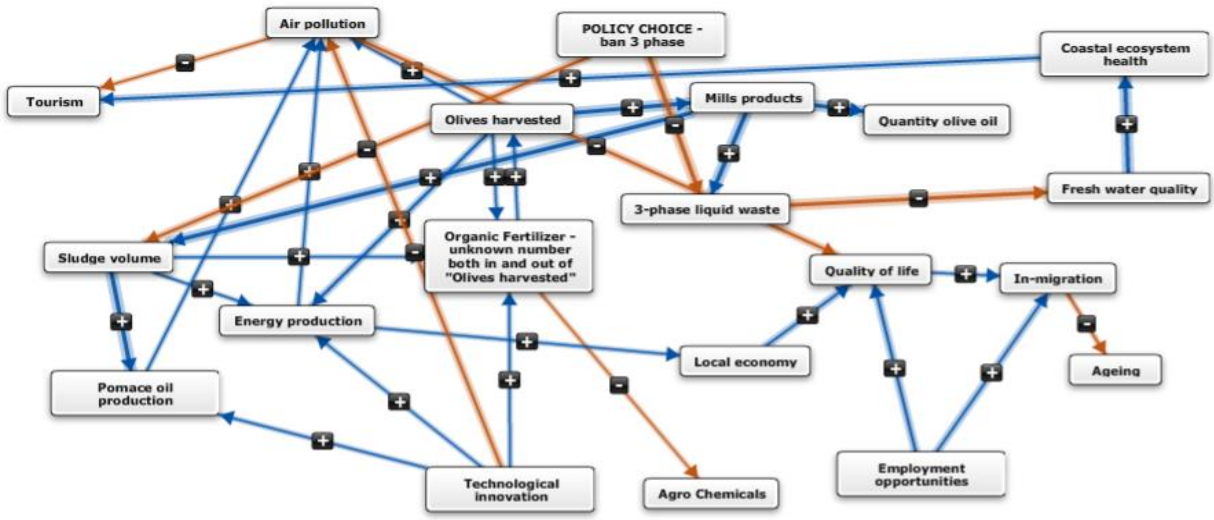

Figure 13: Fuzzy Cognitive Map of the local industry sector as it was created during the Mental Mapping seminar (January, 2019).

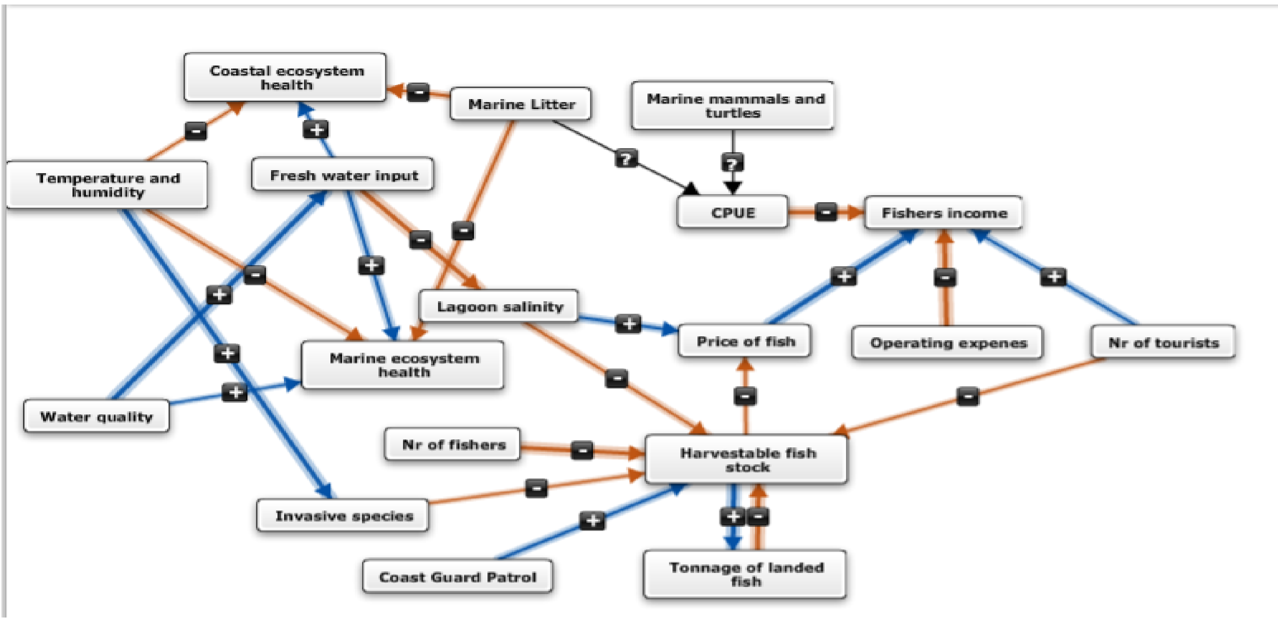

Figure 14: Fuzzy Cognitive Map of the fishing sector as it was created during the Mental Mapping seminar (January, 2019).

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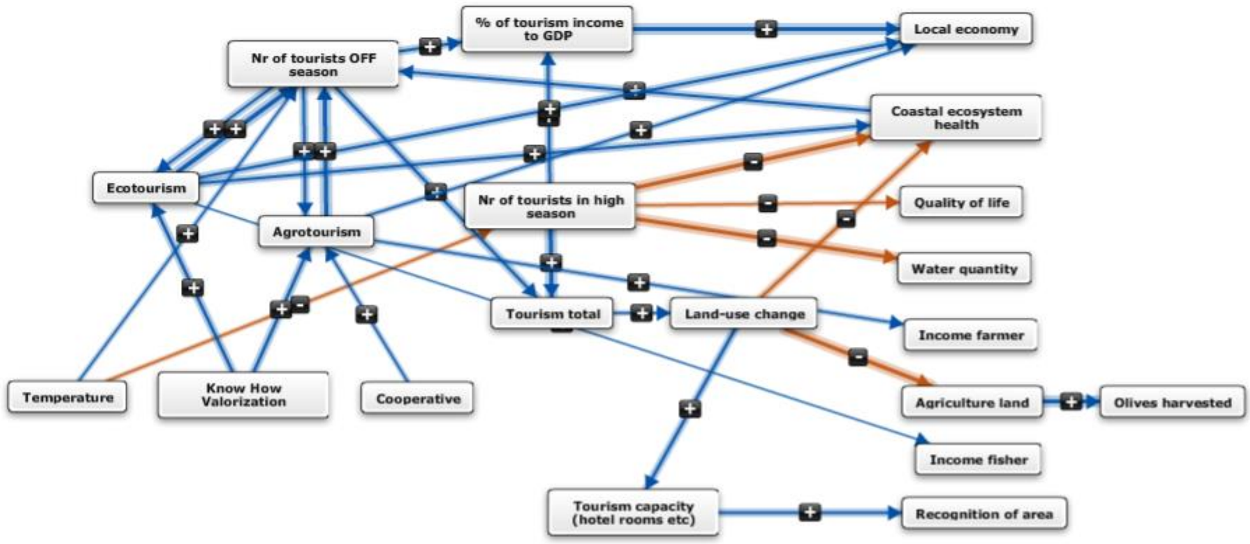

Figure 16: Fuzzy Cognitive Map of the tourism sector as it was created during the Mental Mapping seminar (January, 2019).

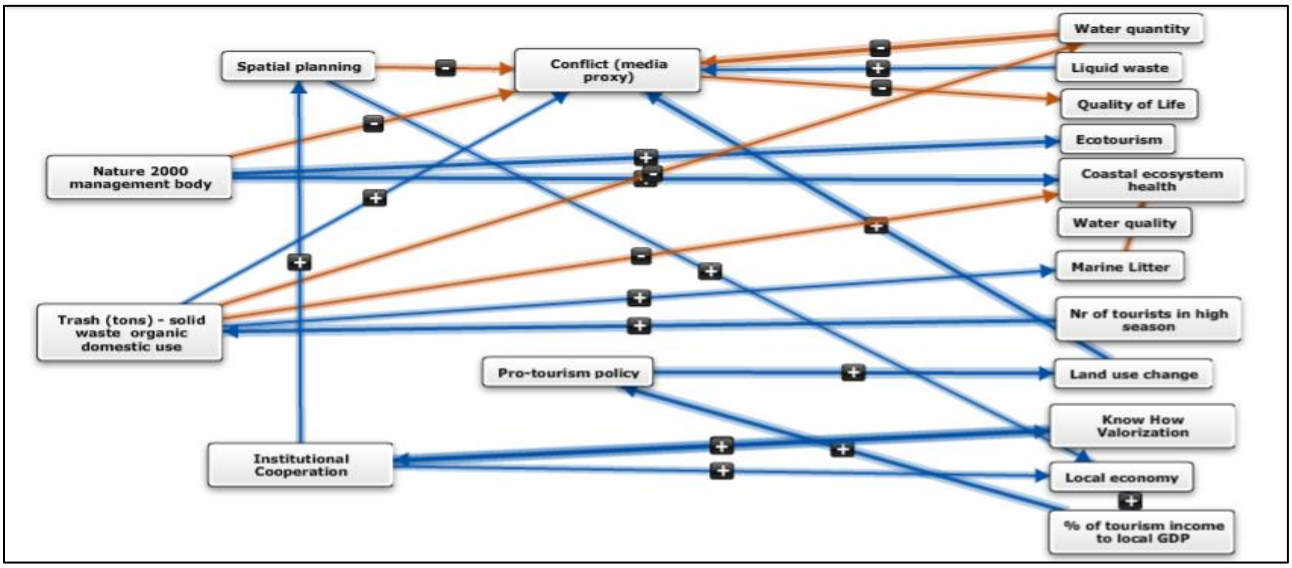

Figure 15: Fuzzy Cognitive Map of the public sector as it was created during the Mental Mapping seminar (January, 2019).

Prior to the MAL, the initial FCMs created during the Mental Mapping Seminar were further processed by the Greek team. This resulted in reintroducing some of the previously omitted variables, re-thinking of connections and their strengths (plus/minus values), as well as omitting or changing again some variables that did not correspond well in the local conditions (eg harvestable fish stock was divided into two variables: Marine fish stock and Lagoon fish stock). Furthermore, the team decided to present five instead of six FCMs. The basic economic sectors (agricultural, local industry, fishing and tourism) were kept but instead of presenting FCMs of the public sector and the institutions/NGOs, we decided to introduce the Nature/Environment sector by combining the description of both workshops. By doing this, we managed to keep the variables which could

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make sense to all stakeholders and take out details linked to administration and basic research which were discussed extensively during the sectoral workshops. This change was well accepted by the MAL participants.

Below we present the FCMs which were discussed with the participants at the workshop. The colors of the boxes in the FCM diagrams are to identify whether the variables are:

- **Transmitters** are shown in red: these are variables with outgoing connections only (i.e. exogenous system drivers and policy/business decisions).
- **Receivers** are shown in green: these are variables with ingoing connections only (i.e. business and policy indicators)
- **Central variables** are shown in yellow: These are ordinary variables with high centrality gradient
- **Ordinary variables** are shown in white: these are all variables that are neither a transmitter nor a receiver.

The agricultural sector included 33 variables out of which 6 were transmitters (Cooperative Membership, Temperature, Aging, Agricultural land Cover, Irrigation network, taxation); 3 were receivers (Employment opportunities, olive oil production, atmospheric pollution). The most central variables were Know How, Olive oil price, agricultural production (olive fruit tonnage), producers income).

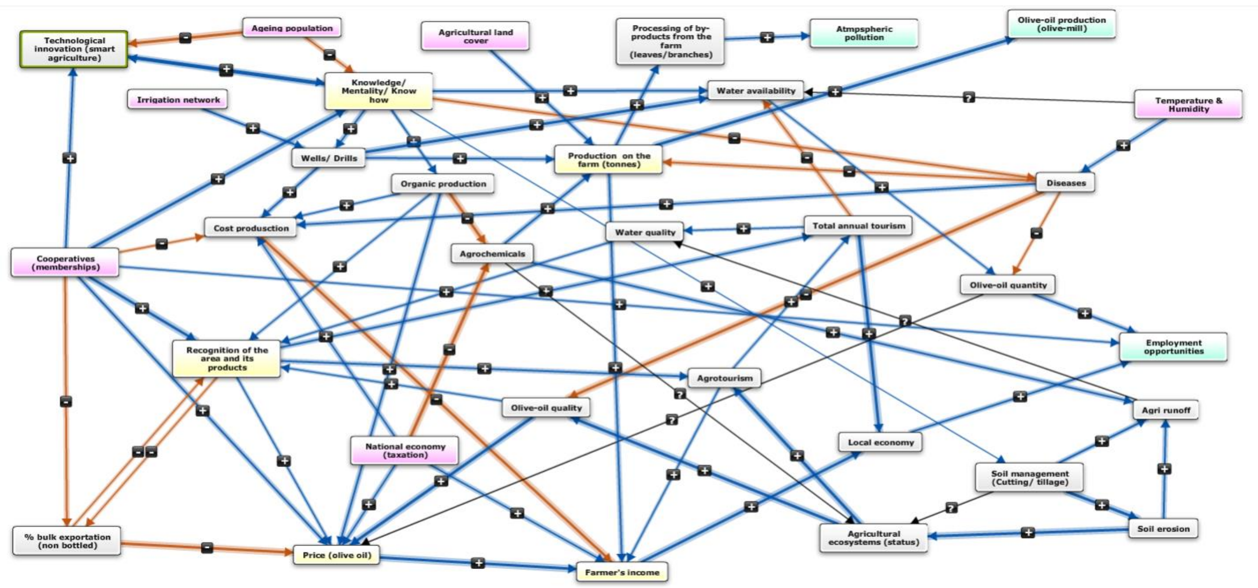

Figure 17: Fuzzy Cognitive Map of the agricultural sector that was used during the MAL workshop (June, 2019).

The olive mill sector (local industry) include 20 variables in total out of which 2 were transmitters (Technological inovation and policy decissions), 2 receivers (tourism, and Quality of Life). The most central variables were Olive fruit production (tones), the olive mill by products, and the 3 phase processing waste water).

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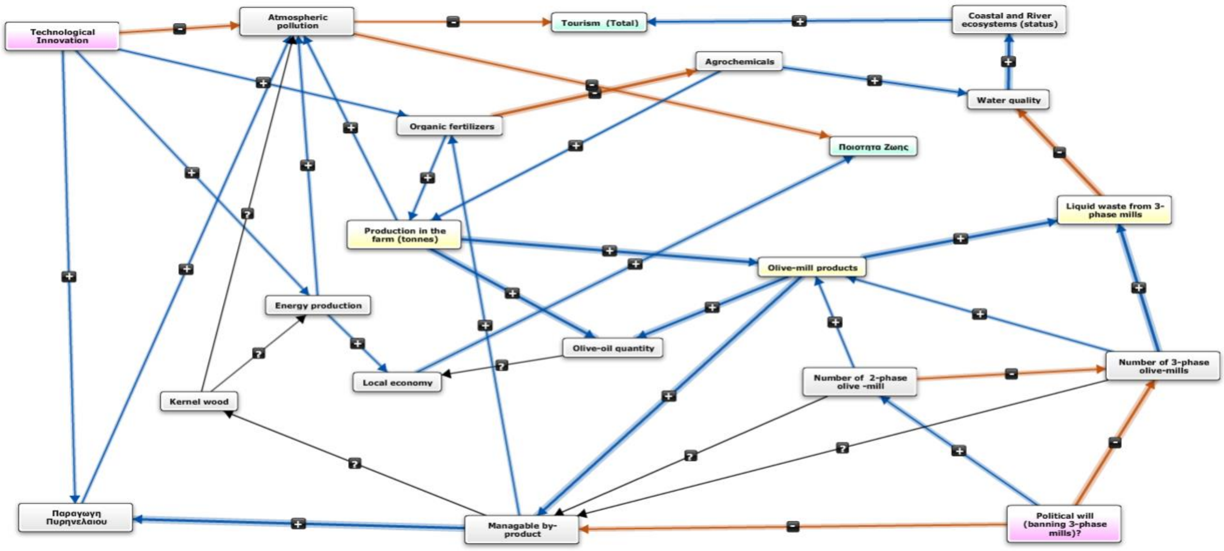

Figure 18: Fuzzy Cognitive Map of the olive - mills sector that was used during the MAL workshop (June, 2019).

The fishing sector included 21 variables of which 7 transmitters (Surface water quality, ground water quantity, Temperature and humidity, Coast Guard Patrols, Number of fishers, Summer tourism, functional costs, marine mammals and turtles) and 1 receiver (Local economy). Whereas the most central variables were fishers income, lagoon and marine harvested stock, surface water intrusion in the lagoon)

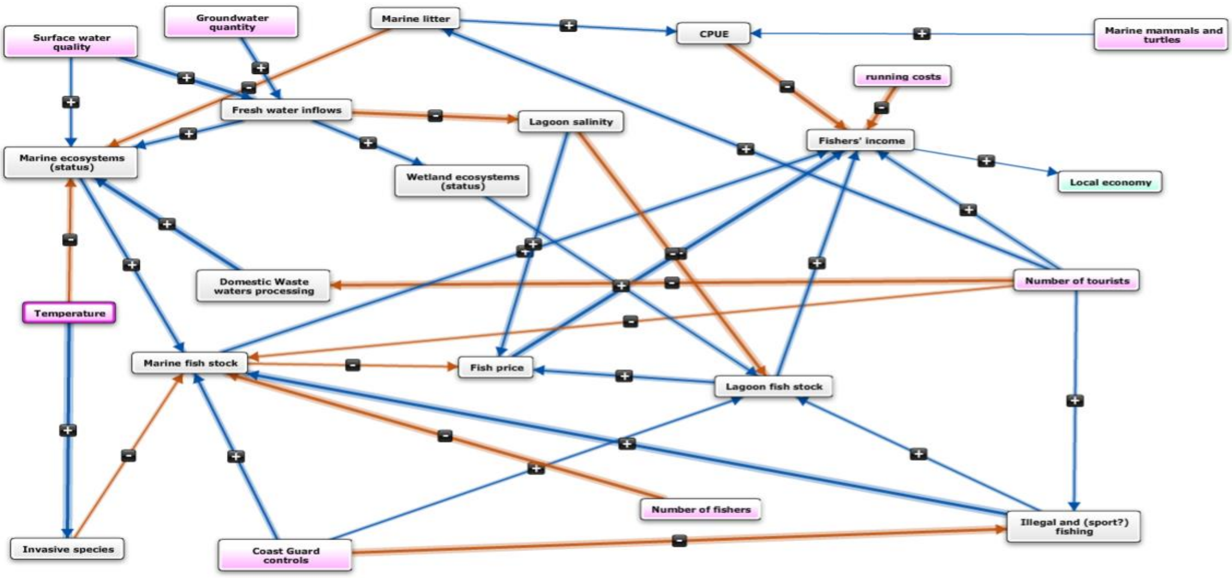

Figure 19: Fuzzy Cognitive Map of the fishing sector that was used during the MAL workshop (June, 2019).

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The tourism sector included 37 variables, of which 9 were transmitters (Waste management, atmospheric temperature, Willingness to cooperate, policy changes, Know how, Employment opportunities, agricultural runoff, Irrigation, Protected Area management effectiveness), 4 were receivers, (Waste water treatment effectiveness, Quality of life, Coastal Ecosystem Quality, Agricultural land cover). Seven variables were identified as being central and these were: Summer tourism, Thematic tourism, Ecotourism, Recognition of area, land use changes, total number of tourists

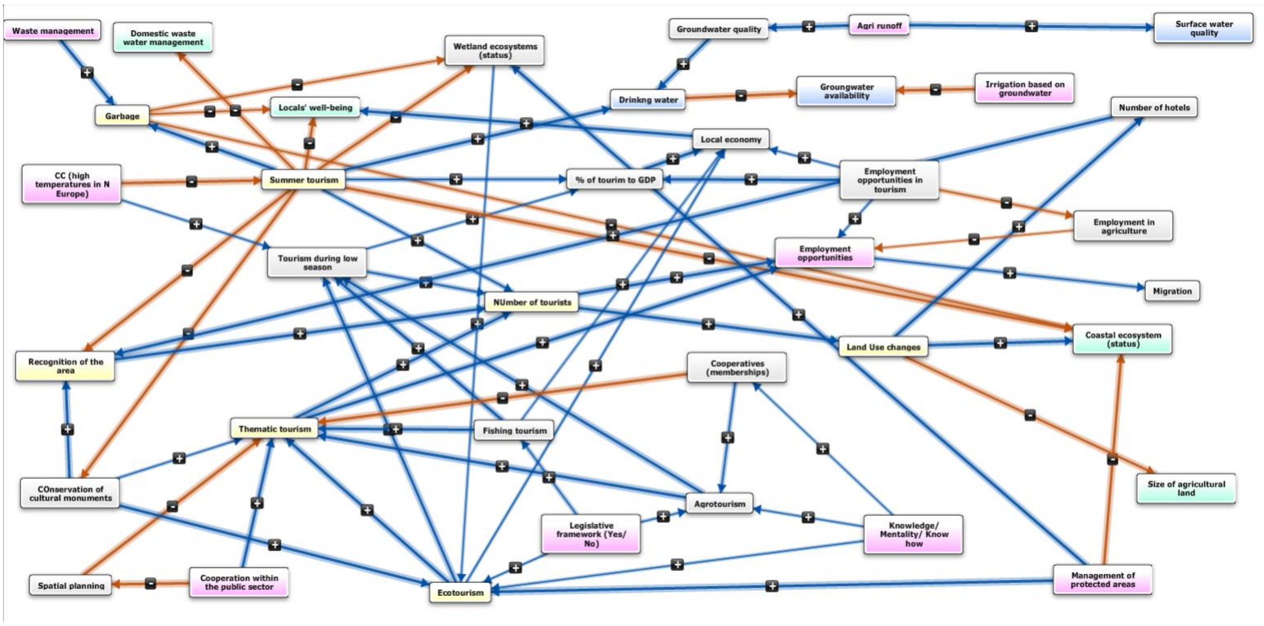

Figure 20: Fuzzy Cognitive Map of the tourism sector that was used during the MAL workshop (June, 2019).

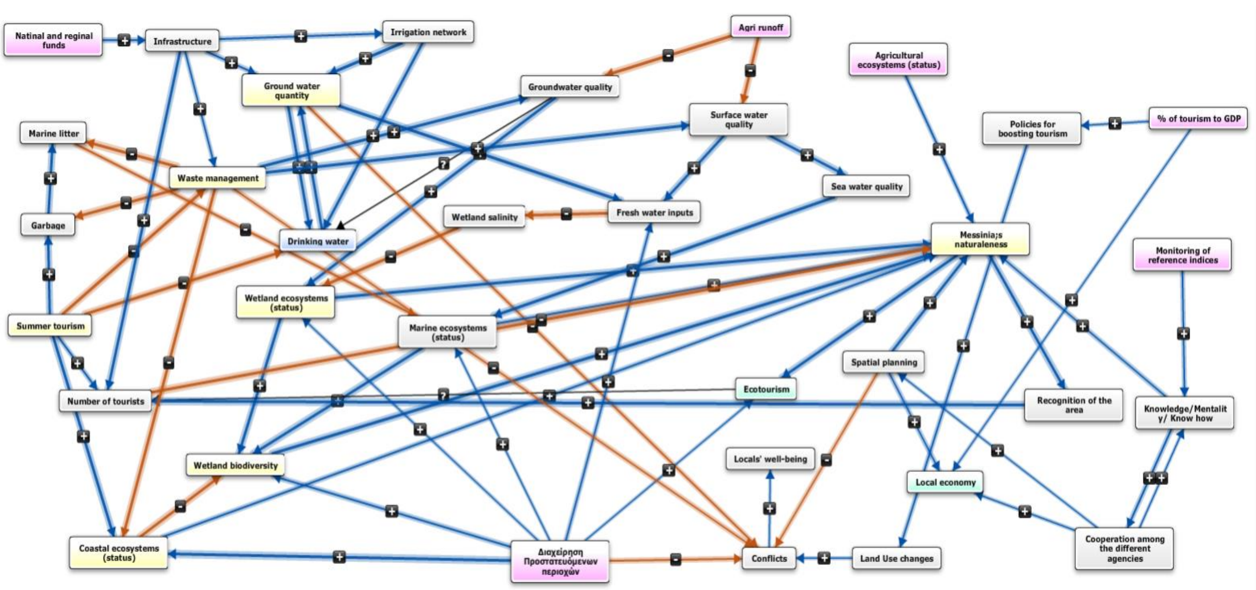

Figure 21: Fuzzy Cognitive Map of the environment sector that was used during the MAL workshop (June, 2019).

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5.1.4 Multi-Actor Workshop

The Multi-Actor Workshop was held was co-organised by HCMR and NEO/SU and was held at NEO premises in Messinia on June 26, 2019.

Table 1: Overview of participants´ affiliation – South West Messina (Eastern Mediterranean Region)

Sector linked to	**Participants linked to**	**Number of participants at MAL**
Agriculture	Olive-oil producers (2) and agronomists (1)	3
Local Industry	Olive- and pomace-mill extraction and management of by-products	1
Fishing	Fishing both in transitional and coastal waters	0
Tourism	Hotels (1), local enterprise (restaurants, gift shops), outdoor activities	2
Administration/ local authorities	Municipalities, regional government (4), water management, forestry (1), archaeology	5
Institutions/NGOs	SU (1), HCMR (4), local universities and foundations (2), NGOs for nature conservation (1)	8

5.1.4.1 Theme and structure of MAL

In total 19 participants attended the meeting representing the six sectors of the sectoral workshops organised between June and October 2018. Participants were selected based on the input of the previous workshops. In order to get a more or less equal participation of each sector 2-4 representatives from each sector were invited to attend. However, due to unforseen circumstances some of the invited participants even though the had initially accepted the invitation did not attend. This resulted in the absence of the fisheries sector. However, one of the participants (representing the local university) has long experience and ties in the fisheries sector (they run a family business), and some HCMR researchers (working on fish management), and researchers working closely with local fishers, represented the fishing sector. The facilitators, though from the same institution as some of the stakeholders, were not considered stakeholders in this context but facilitators only. The stakeholders from HCMR were not affiliated with the COASTAL project, but had the relevant expertise.

The workshop was separated in 3 different sessions. The first session, which was a general overview and presentation of results, was facilitated by the organisers form NEO and HCMR, and in the next two sessions they facilitated the re-examining and the connections and mental maps as well as produced scenarios.

During the first session the organisers presented to all the participants:

- A quick overview of each of the sectoral Vensim diagrams and presentation of the basic results of the different sectoral workshops as well as the process come to condensed Vensim diagrams
- The condensed combined causal loop diagram in steps (from land to sea), emphasizing on how different activities inland may affect coastal activities, and vice-versa.
- Explanation of the modelling steps the COASTAL project has taken so far
- Presentation of the FCMS focusing on the most important results of the workflow
- Two scenarios and how through them we can understand the changes caused to the system when a variable is altered

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Figure 22: Presentation of the condensed combined causal lood diagram during the MAL workshop (June, 2019).

During the break large printouts of each FCM were posted on the wall and after the break the participants returned to the room in groups and they were asked to validate the produced FCMs

The stakeholders:

- Corrected the diagrams: adding missing variables and links, wrong links, etc. In general few things were changed by the stakeholders;
- Suggested weights for the connections between variables were also discussed. In general, most of the weights suggested by the participants followed the weights previously suggested by the experts. However, in a few cases the participants suggested that some of the connections were stronger or weaker than the researcher's estimations
- The participants were asked to focus mainly on the diagram which linked to their sector, but they were also invited to suggest changes to the other diagrams as well.

This exercise was followed by a third session focusing in vision. Initially participants were given a small piece of paper so that they can each provide their own vision. And after this they were split in 3 groups from where they had the time to discuss their ideas and come up with a common vision.

5.1.5 Analysis of the outcomes and conclusions

The MAL workshop provided an excellent opportunity for common discussions between scientists and stakeholders. The way they were organised, created a "secure" space for stakeholders to openly express their opinions since during the whole process scientists were left at the side, acting mainly as facilitators. Furthermore, having scientists as facilitators it secured that the outcomes of the discussions were closer to

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reality, since sometimes stakeholders overlooked issues linked to their activities, which were brought up by the facilitators adding to a more holistic approach.

A general outcome from the MAL discussions was the fact that the majority of the participants were well aware of the impacts by their activities (e.g. water contamination by pests and fertilizers used in the farms; pressure on water resources by agriculture and tourism; over-fishing), and could identify possible solutions to mitigate these impacts. However, for the Greek case study at least, it felt like they lack the energy and the passion needed to make these changes. This could be due to the lack of vision, to the lack of trust, or the fact that they tend to depend on others to make the first step and then follow if this is successful.

However, among the participants we could identify those who could envision a different future proposing changes which could create win-win interactions with the other sectors. A way forward would be to bring together these ideas, enrich them with robust data (wherever possible), and focus on creating an example based on the vision of these stakeholders. This would take time and there is a need for more meetings to refine such a vision, curve the angles among the stakeholders, start creating a better understanding and get a wider acceptance.

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5.2 Belgian Coastal Zone (North Sea)

5.2.1 Executive summary

The multi-actor workshop was organised by VITO and was held at the VLM location in Bruges on May 23, 2019. In total 18 participants attended the meeting, representing the six sectors of the sector workshops organised between September and December 2018. An important objective of the multi-actor work shop (at least for the Belgian MAL) was to validate the polished versions of the causal loop diagrams, both for the sectors and the combined land-sea system, and assign the fuzzy weights if possible.

- The multi-actor workshop was organised in two sessions including a validation of the causal-loop diagram for the land-sea system, consisting of: (1) summary of main conclusions, (2) presentation of polished causal loop diagram for each sector, (3) presentation of combined causal loop diagram, (4) clarification of follow-up trajectory towards systems modeling and use of fuzzy cognitive maps, (5) break-out sessions to verify causal dependencies and set weights (importance and polarity in range -1 to +1) for each interaction in the diagram
- Break-out sessions to formulate visions on the future coastal-rural innovation in support of WP3 (Business & Policy Support) and WP5 Scenarios and Transition Pathways). The break-outs were followed by a plenary presentation of the visions.

The contributions of the participants were very useful in fine tuning the combined causal loop diagram for the land-sea system and identifying the main opportunities for land-sea synergy, as well as the priorities for the systems modelling (WP4).

5.2.2 Background

Limited water resources and decreasing surface water quality has put pressure on the traditional activities in the rural hinterland. Increased salination is another challenge especially for traditional agriculture. However, this may also offer an opportunity for alternative forms of agriculture or aquaculture in these areas. Based on the expertise and infrastructure of coastal tourism, developing sustainable rural and/or agro-tourism can provide additional income for the hinterland. Economic and environmental opportunities are found, for example, in sectoral restructuring and modernisation, improved integration in the rural food chain with diversification, changes in farming practices and new business opportunities.

For the coastal zone, similarly, Blue Growth and offshore energy production offer new opportunities for employment and port development, while marine spatial planning faces the challenge of combining multiple competing functions that feed back to the mainland and in particular the coastal zone. A new, six-year Marine Spatial Plan[6] has been prepared by the Federal Government, using feedback from coastal and marine stakeholders and will be in force in 2020.

5.2.3 Mental Mapping Seminar

SINTEF Ocean visited the Belgian partners on 14 and 15 January 2019. During this two-day workshop four Belgian team members (from VITO and GREENBRIDGE) worked with three SINTEF team member to condense the mind maps resulting from the sector workshops. The VITO team had already prepared this meeting by correcting and simplifying the mind maps where possible beforehand (i.e. removing inconsistencies and duplications, improving the graphics and checking variable labels)

[6] https://www.health.belgium.be/en/public-consultation-maritime-spatial-plan-belgian-part-north-sea-2020-2026

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During the meeting a large number of variables were omitted from the original diagrams. It was attempted to standardize the principles behind the different parts of the diagram, e.g. by introducing correct and well-labeled stock variables (i.e. variables measurable on at least an ordinal scale and being able to increase or decrease). The most important changes included:

- Deleting smaller sidesteps that were not integrated in the rest of the system
- Simplifying some of the existing feedback loops
- Renaming variables in order to ensure clarity and avoid ambiguous names
- Where applicable: renaming variables or redefining them so that they could serve in multiple feedback loops or could connect between sectors
- Merging feedback loops that occurred multiple times

Where work first focused on the sectoral diagrams (see deliverable D3), the different sectors were then recombined in order to create a causal loop diagram for the Belgian coastal-rural system. This overall system was then further simplified were possible, by merging variables and deleting variables that occurred multiple times. The final result of the mental mapping seminar is shown in Figure 23.

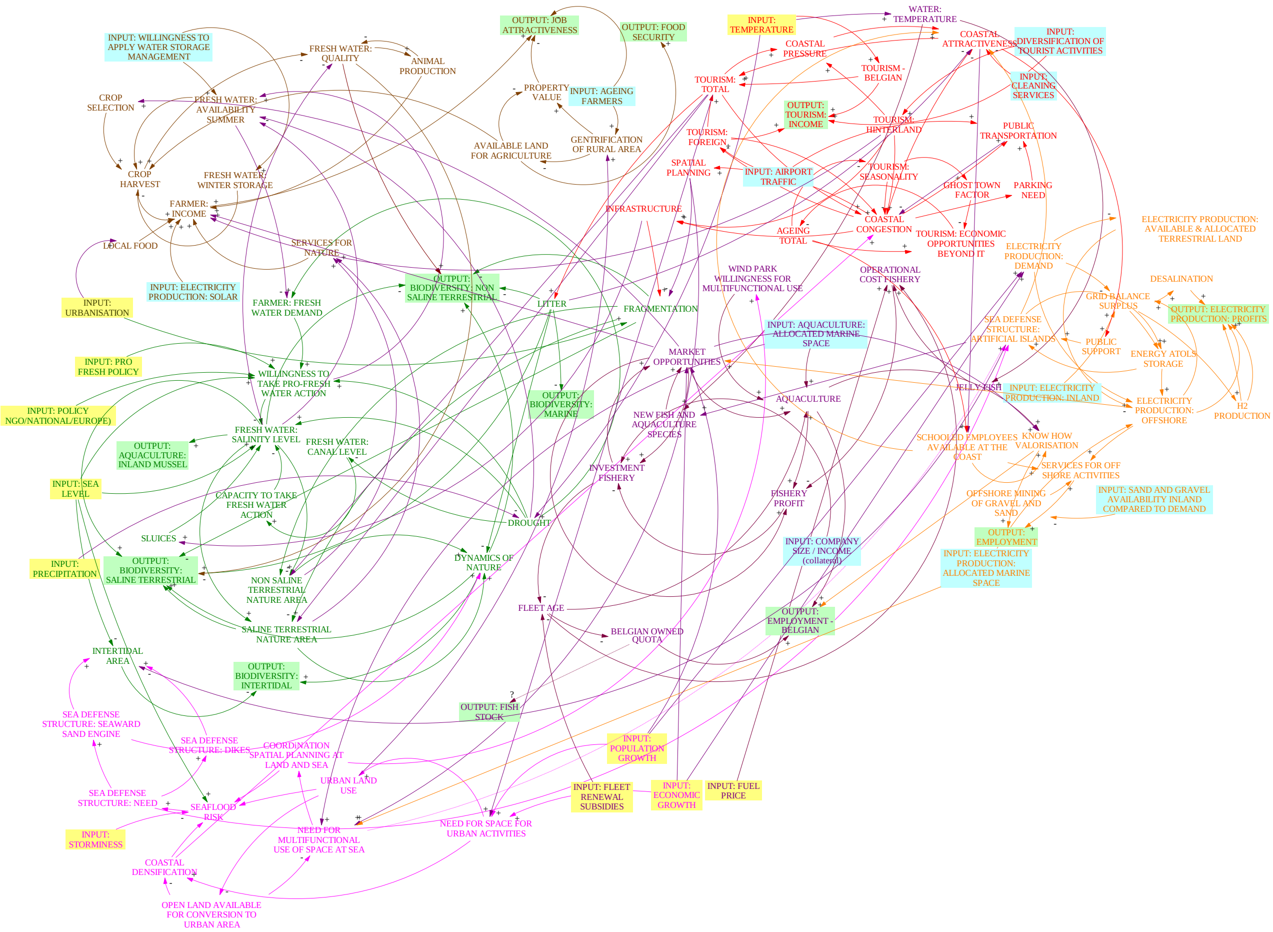

Figure 23: Causal loop diagram for the land-sea system resulting from the mental mapping seminar retaining 107 variables (January,, 2019).

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5.2.3.1 Condensing the mind maps for the sectors

At this point the causal loop diagram consisted of 107 variables. In comparison, for the original sectoral diagrams the total number of variables was around 940 (155 for Nature, 165 for Spatial Planning, 185 for Tourism, 175 for Fisheries & Aquaculture, 150 for Agriculture and 110 for Blue Industry) . Compared to the original mind maps resulting from the sector workshops, several minor ‘sidesteps’ were deleted for each sector. These are parts of the diagram that are not influencing the rest of the system dynamics, and do not relate to important model outputs. Other major changes were made by introducing a uniform system logic throughout the diagrams that included redefining variables and their connections: this was done by introducing each time the same types of stocks and stock flows. In general, the original diagrams represented well the systemic relationships between variables but contained limited stock variables: redefining variables in a uniform way could resolve this and provide a better basis for the quantified stock-flow modelling (WP4). In the original diagrams the sign (plus or minus) of the relationships were defined by the participating stakeholders. Those signs were verified and corrected where necessary (although this was not very often necessary). Corrections were especially necessary in cases where the logic of the sign was complicated or due to variable definition counterintuitive. Clear variables names also helped here.

In the end, the condensed causal loop diagrams contained only those stock variables that were necessary (Figure 24). During the condensation process, we took (where possible) into account whether a variable could be quantified and whether data would be available.

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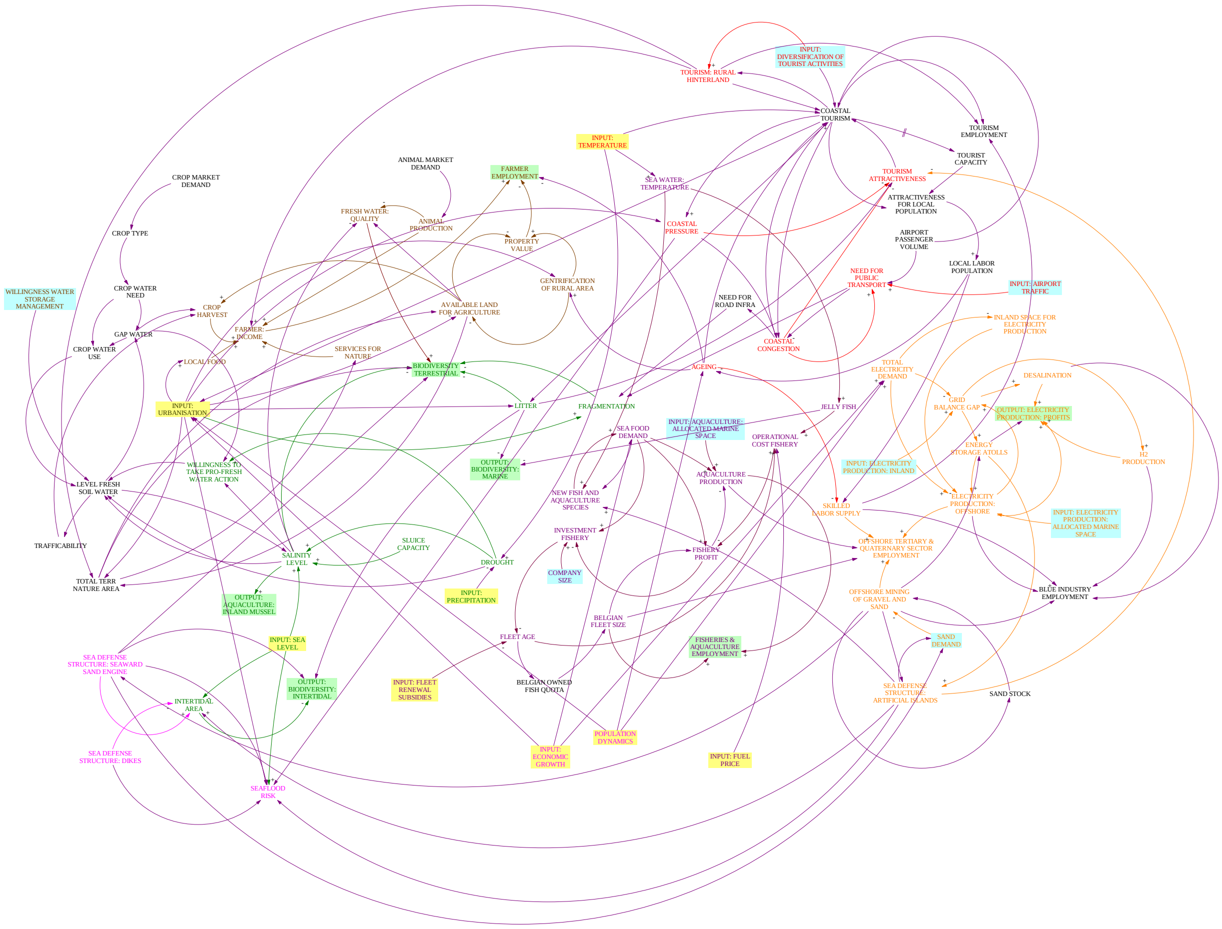

Figure 24: Causal loop diagram for the total land-sea system after further condensation retaining 87 variables (February, 2019). Variables in boxes refer to exogenous system drivers (yellow), policy and business decisions or interventions in the system (blue) or

5.2.3.2 Combined causal loop diagram for the land-sea system

After a general introduction the participants of the multi-actor workshop were first confronted with cleaned up versions of the causal loop diagrams for the individual sectors, clearly indicating the feedback loops, suggestions for stock variables and interactions with other sectors (Figure 25 - Figure 30).

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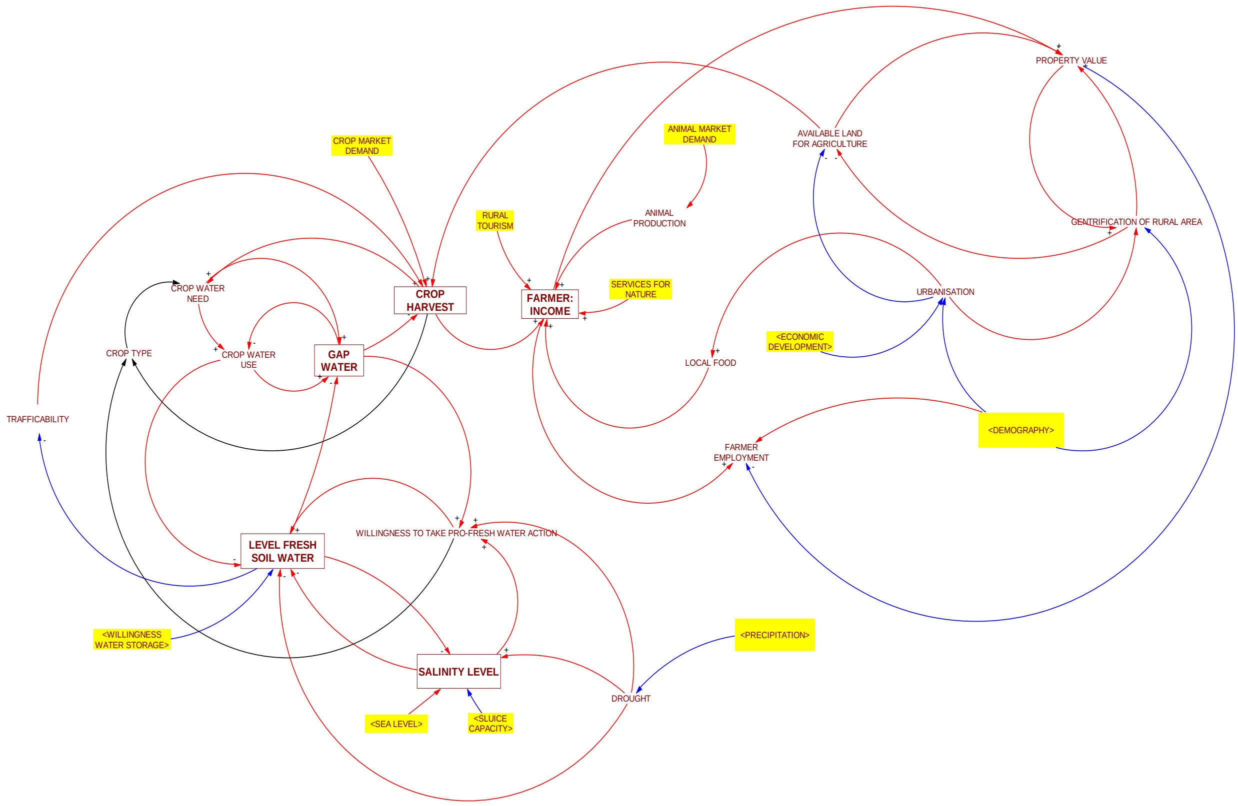

Figure 25: Causal loop diagram for agriculture with feedback, stock variables and interactions with other sectors (May, 2019).

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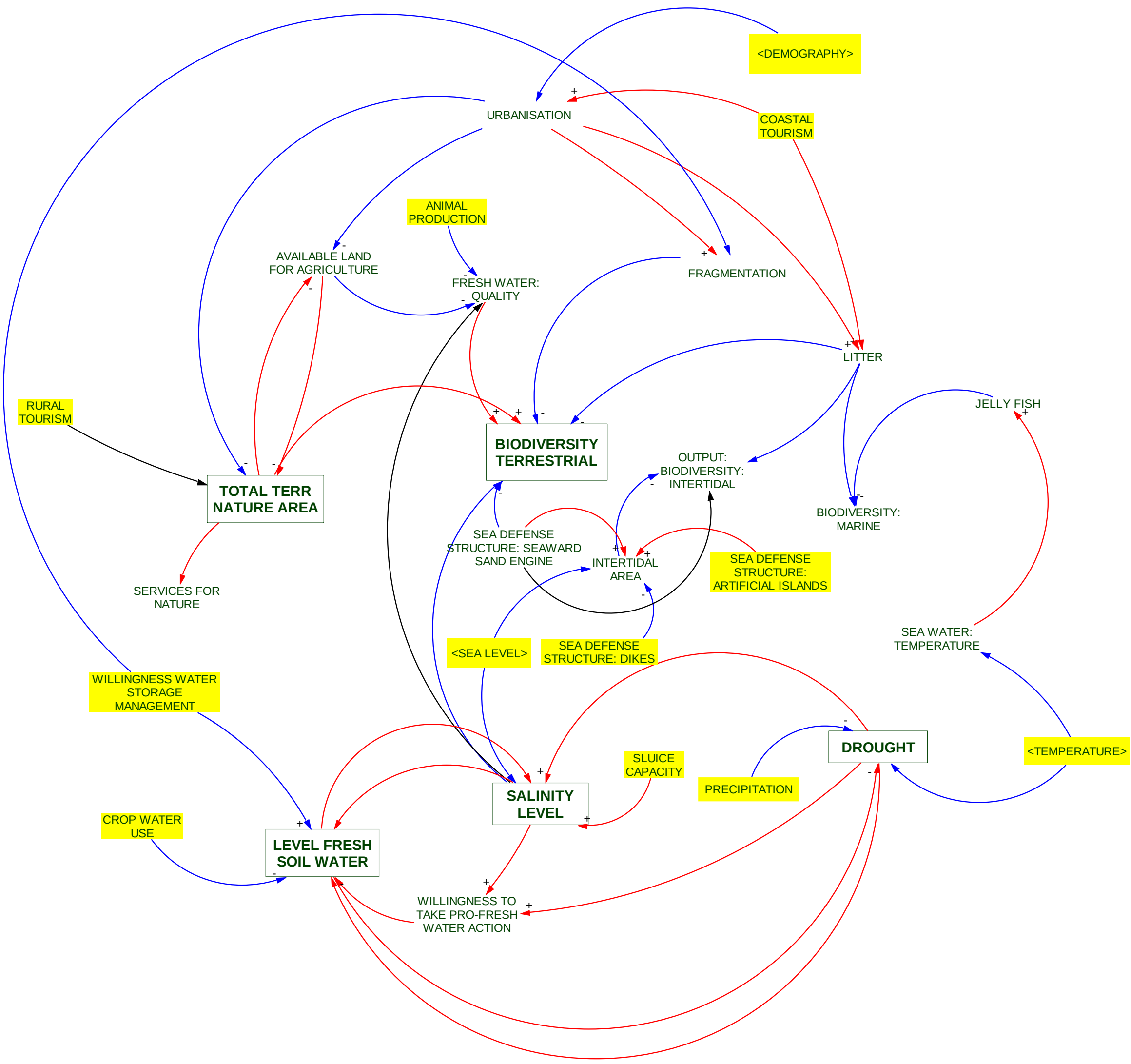

Figure 26: Causal loop diagram for nature with feedback, stock variables and interactions with other sectors (May, 2019).

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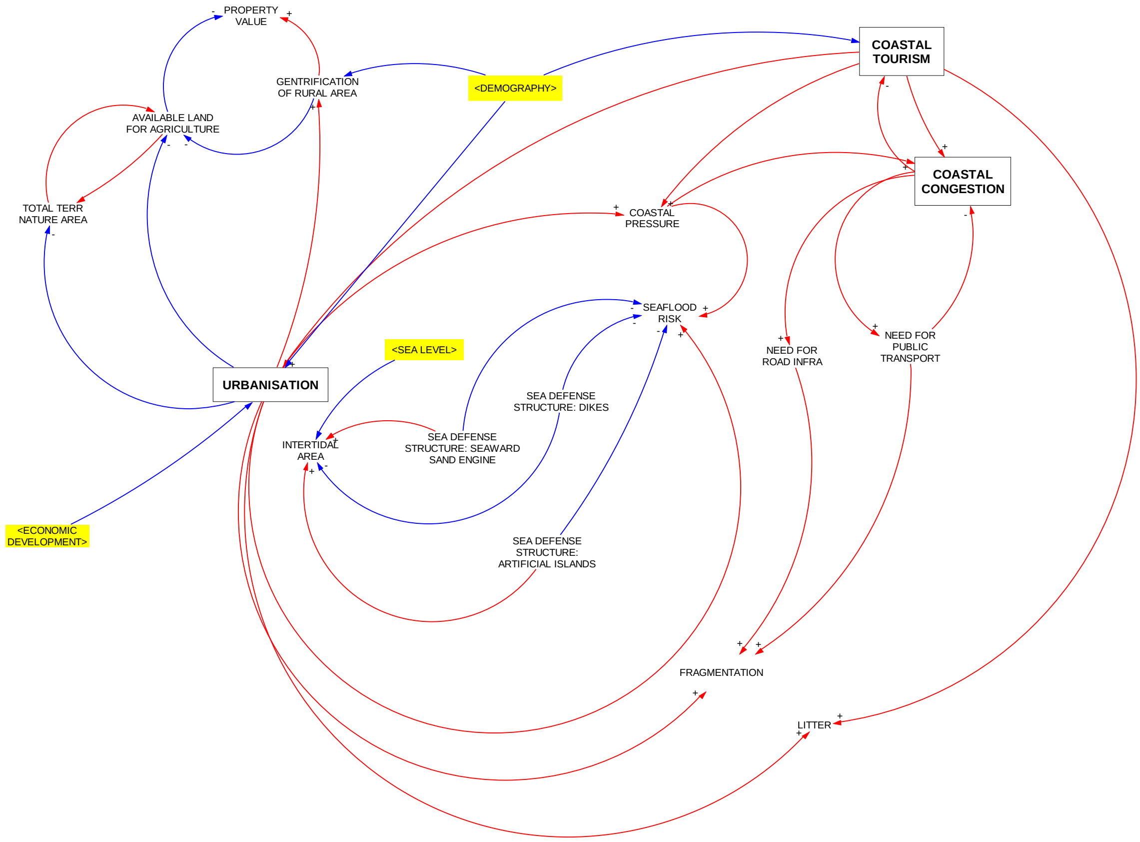

Figure 27: Causal loop diagram for spatial planning with feedback, stock variables and interactions with other sectors (May, 2019).

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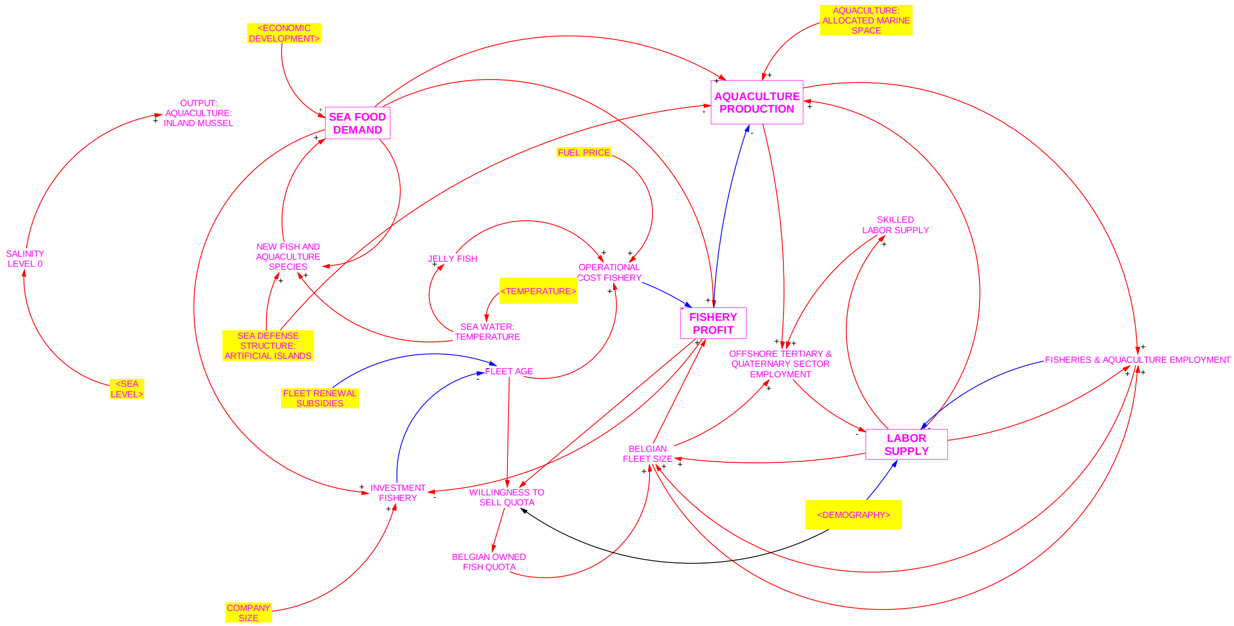

Figure 28: Causal loop diagram for fisheries and aquaculture with feedback, stock variables and interactions with other sectors (May, 2019).

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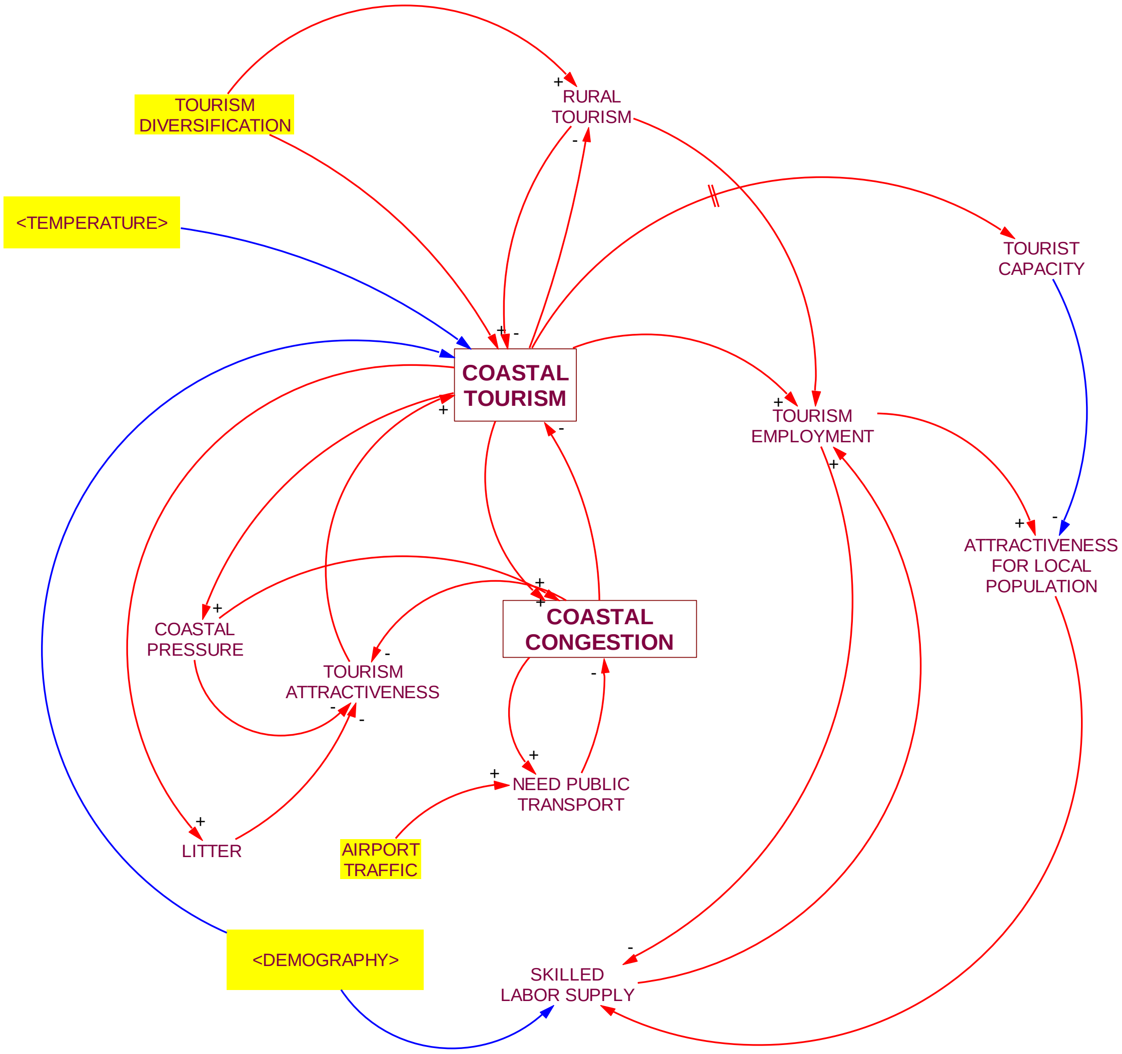

Figure 29: Causal loop diagram for tourism with feedback, stock variables and interactions with other sectors (May, 2019).

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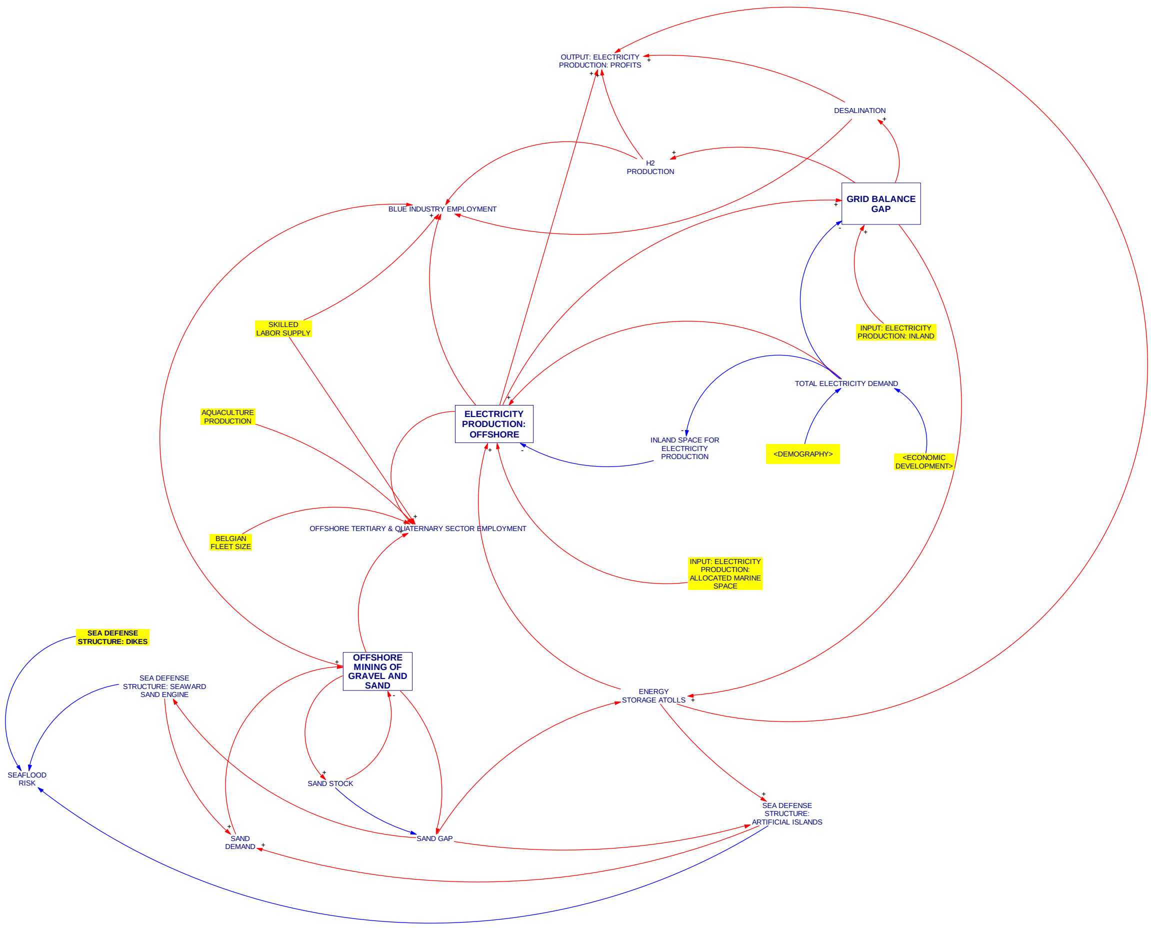

Figure 30: Causal loop diagram for blue industry with feedback, stock variables and interactions with other sectors (May, 2019).

5.2.3.3 Combined causal loop diagram

To determine the sectoral diagrams into a combined diagram the variables and variable loops that are shared by two or more sectors were determined. In addition, suggested choices for the stock variables were given. The most important shared variables (feedback loops observed in the causal loop diagram) were:

- **Water**: quantity and quality of fresh water, salinity problems, related actions. These were shared by the sectors nature, agriculture and spatial planning.
- New types of **sea defense structures**, and especially new islands and sand engine. These variables were shared by nature, blue industry, spatial planning, aquaculture and tourism. That these variables are shared by so many sectors is indicative for the multifunctional use of the variables.
- **Congestion** and related variables such as those related to densification and urbanization, transport, … were shared between tourism and spatial planning. Through **coastal attractiveness** and the related availability of (schooled) workforce, there are again links with tourism, blue industry, spatial planning and fisheries and aquaculture.
- Need for **multifunctional use of space at sea** links back to blue industry, aquaculture and fisheries and spatial planning.
- **Litter** was shared between nature and tourism.

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- **Gentrification of the rural area** was shared between spatial planning and agriculture.

Next the causal loop diagram for the total system was presented to the participants.

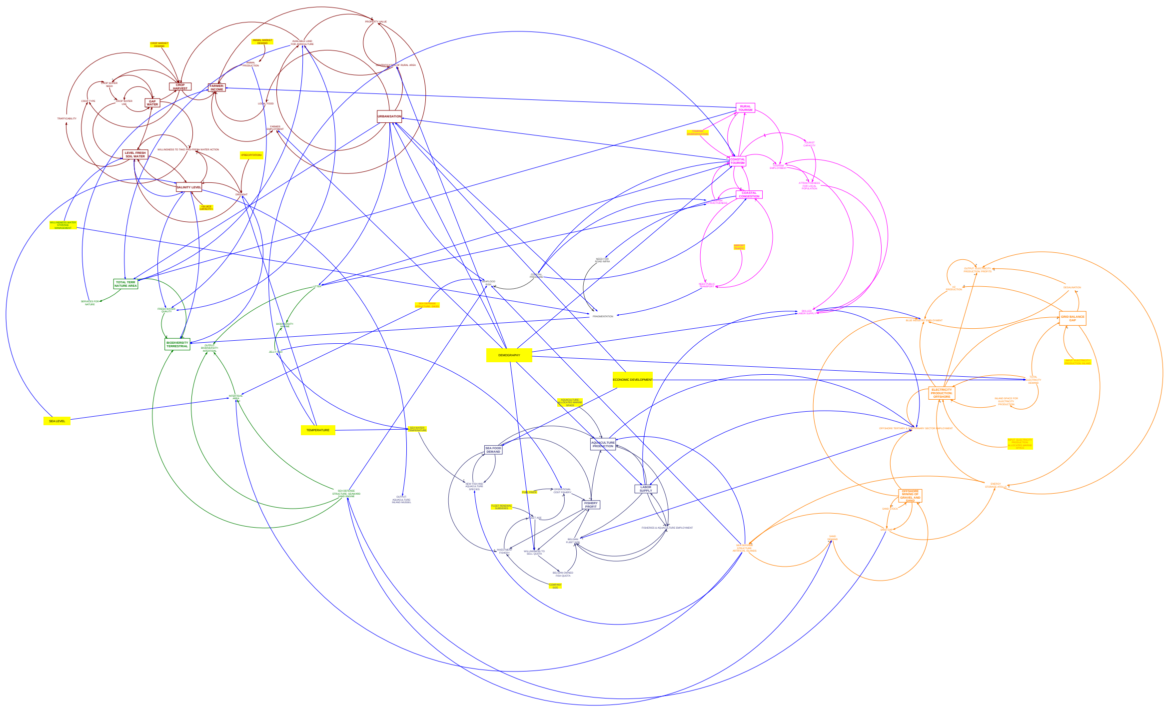

Figure 31: Combined causal loop diagram indicating the interactions within and between the six sectors and suggested stock variables (boxes), presented first during the multi-actor workshop (May, 2019).

5.2.3.4 Fuzzy Cognitive Maps

The causal loop diagrams were then translated into Fuzzy Cognitive Maps (De Kok et al., 2009; Gray et al., 2015; Kosko, 1986; Tiller et al., 2016; Tiller et al., 2017) by assigning weights for the interactions in the range -1 to +1. In the break-out during the multi-actor workshop FCMs were developed by assigning a weight indicating both the significance and polarity (-1 to +1 with 0.25 increments) to the relations connecting the variables. This was done at the level of the sectoral condensed causal loop diagrams. The weights were based on (1) the input of the stakeholders during the sector workshops (Tiller and Richards, 2018) in which they already indicated which relations were strong; (2) an expert judgement from our multi-disciplinary team that has extended experience in environmental and social processes in the Belgian coastal region. The participants had to familiarize themselves with the process of assigning weights, but in the end weights in the range (-1.0, -0.75, …, +1.0) could be set for the majority of the connections. In some cased turned out to be difficult to assign fractional weights, hence the majority of the weights were set to the value -1, 0 or +1 by the participants. The project team verified and completed the weights after the meeting.

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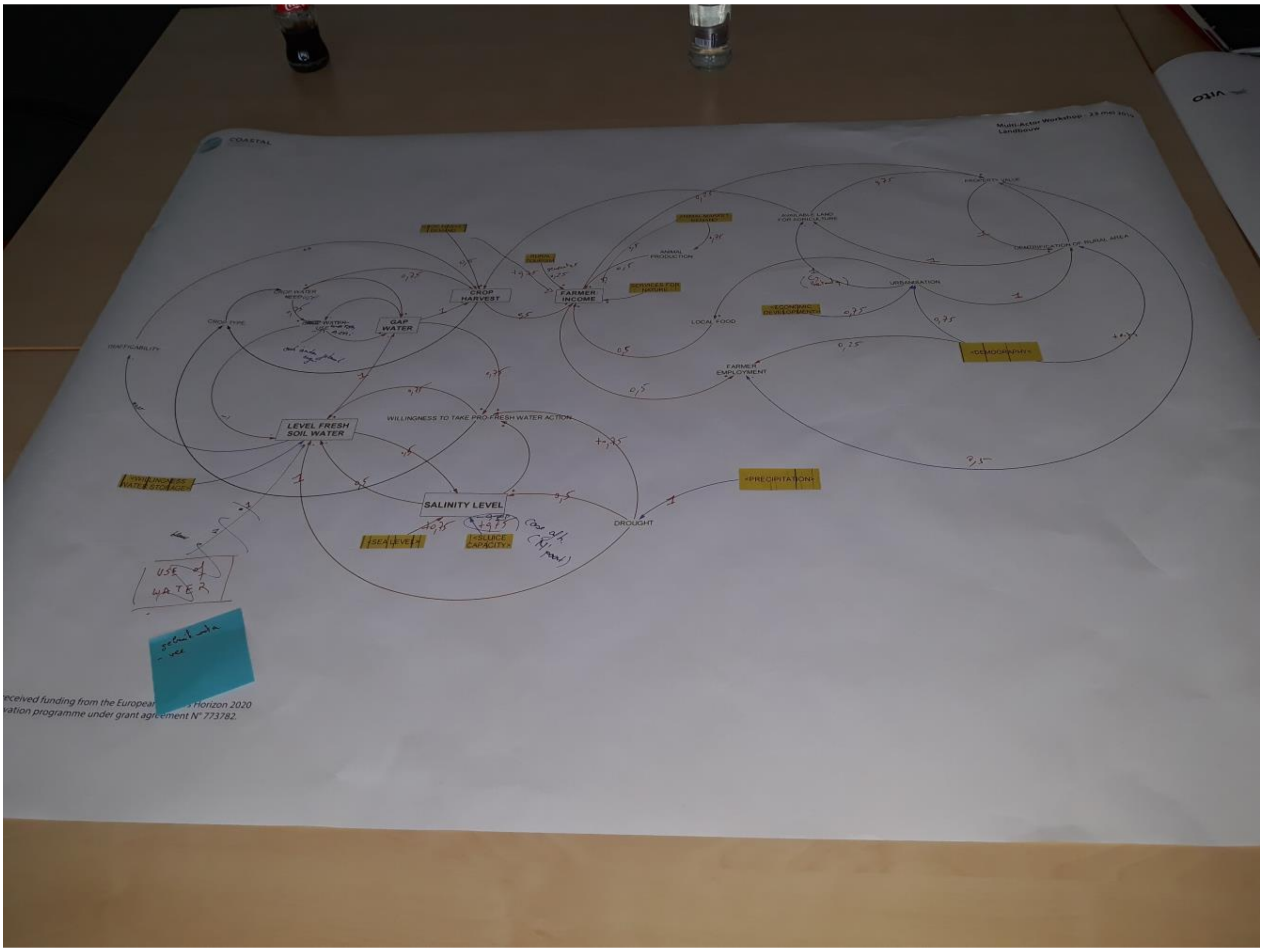

Figure 32 Fuzzy cognitive map for ***agriculture*** *with weights and polarity added by the participants (May, 2019).*

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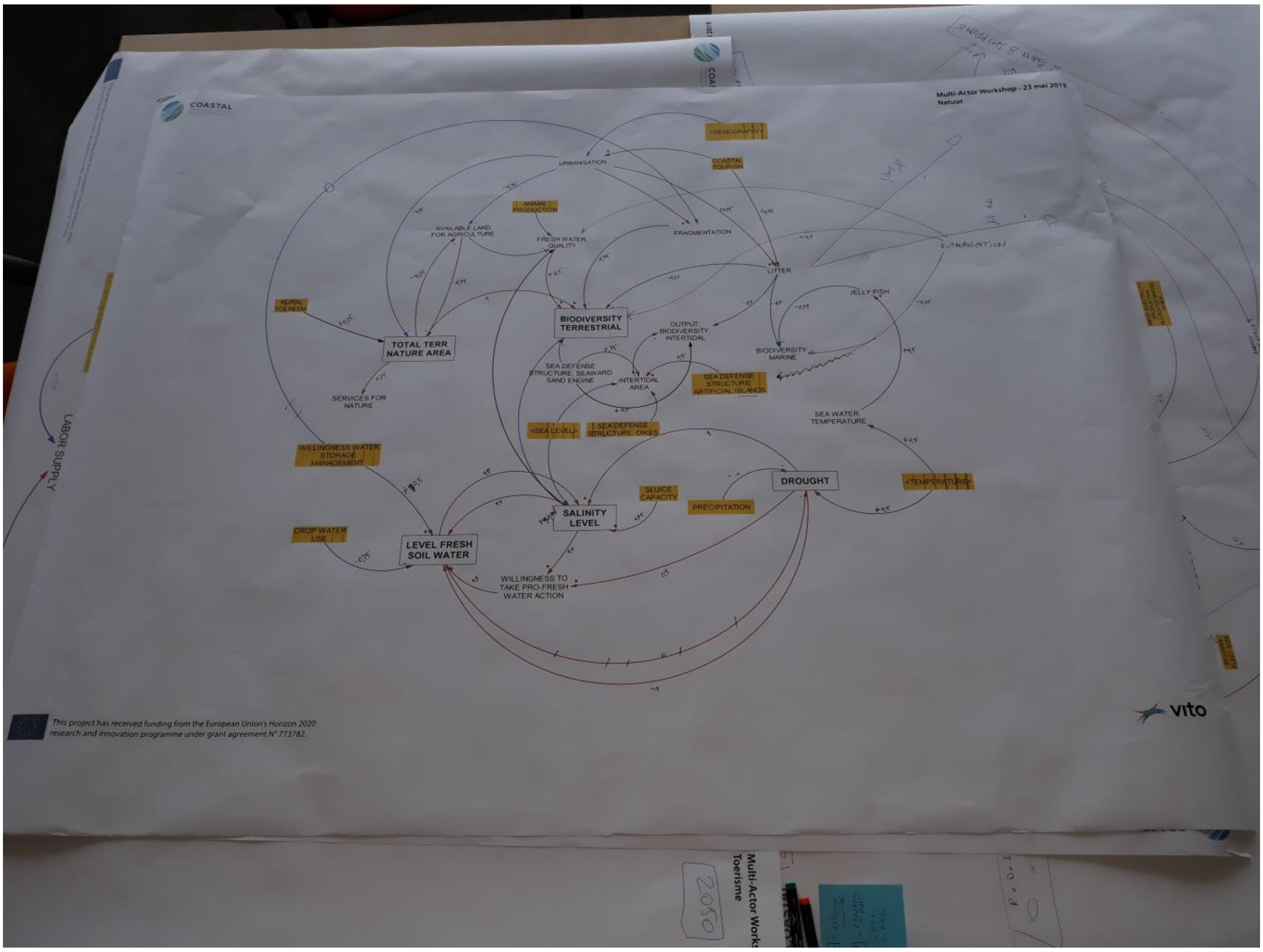

*Figure 33 Fuzzy cognitive map for **nature** with weights and polarity added by the participants (May, 2019).*

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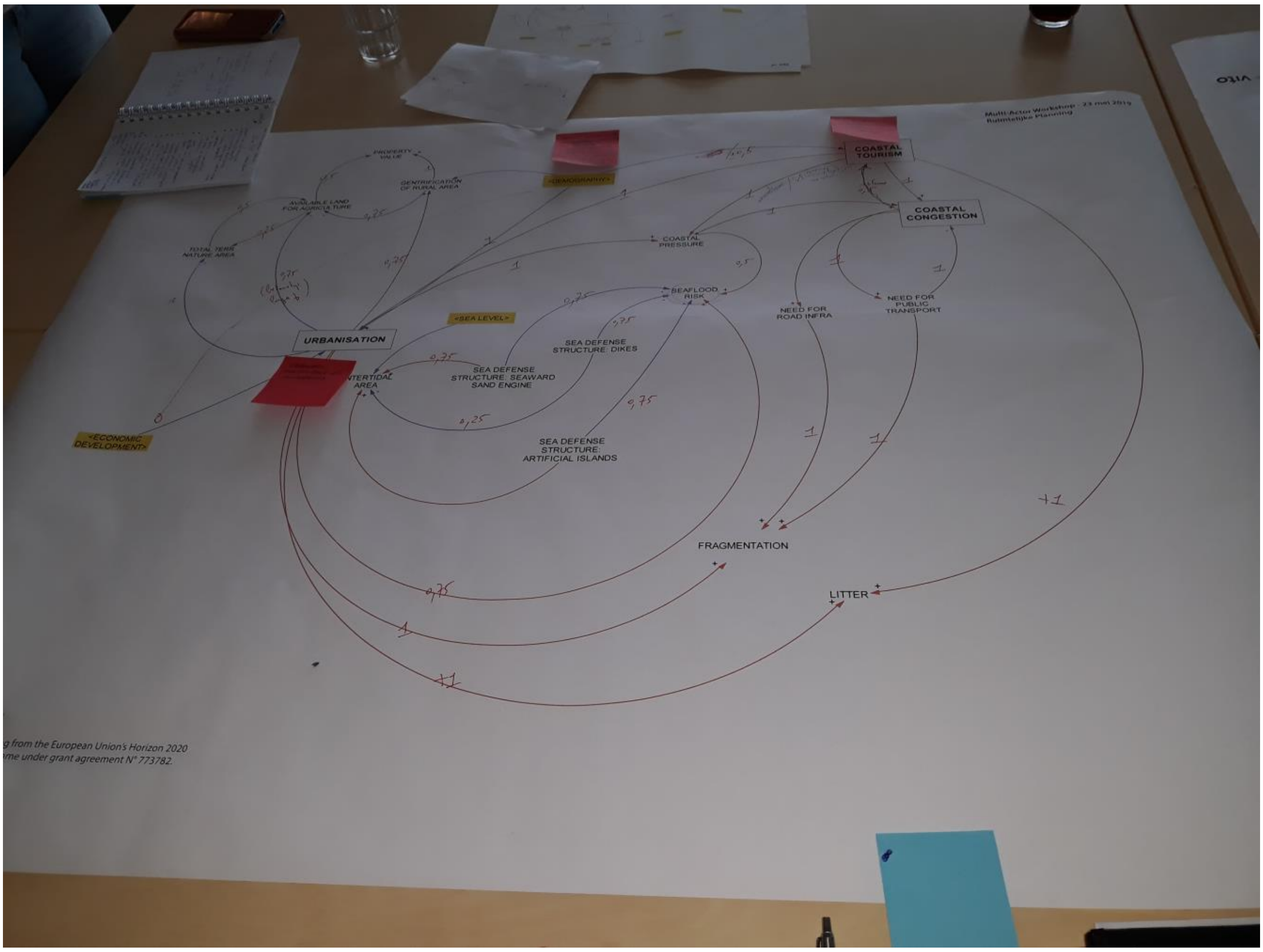

*Figure 34 Fuzzy cognitive map for **spatial planning** with weights and polarity added by the participants (May, 2019).*

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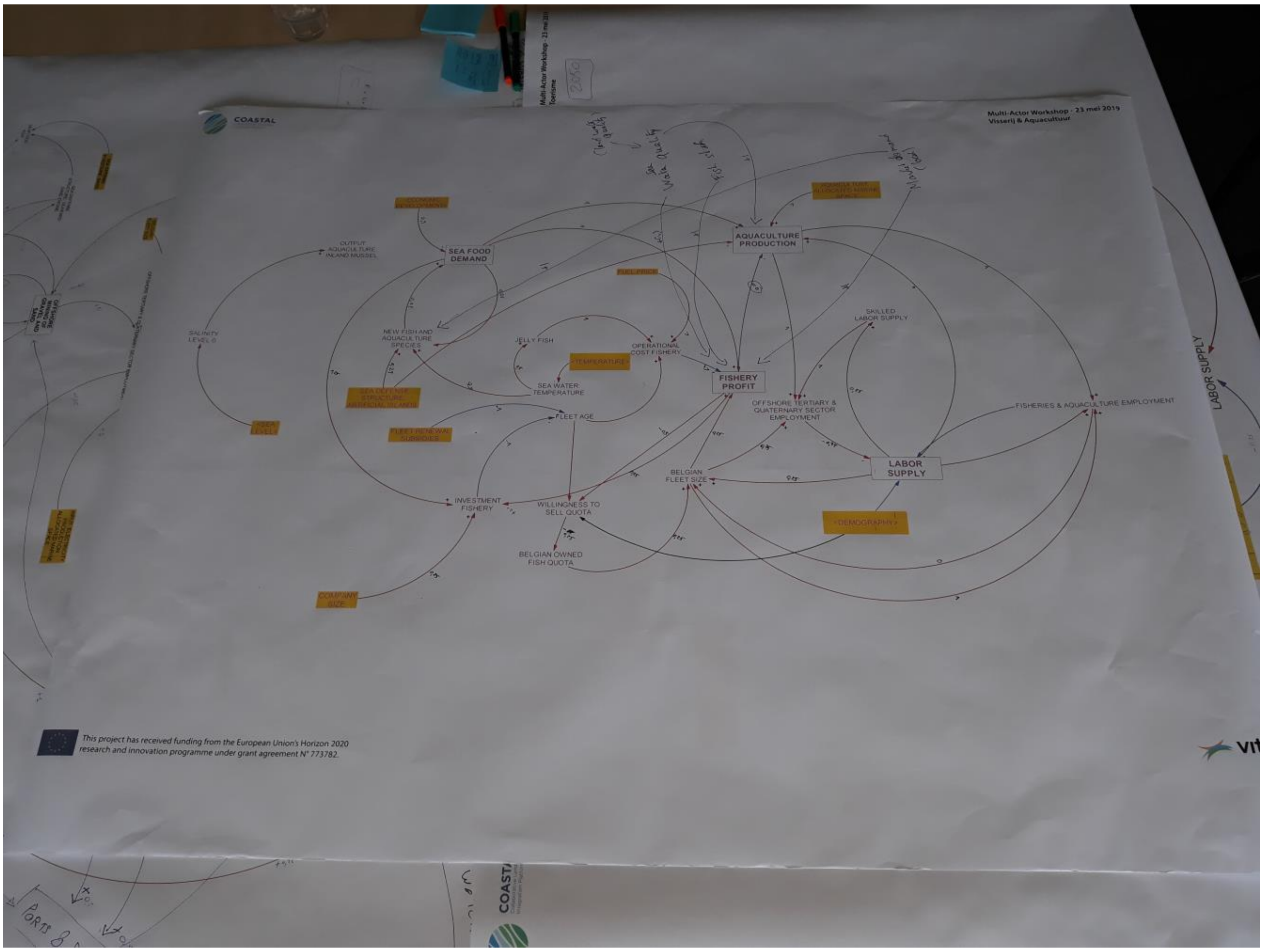

Figure 35 Fuzzy cognitive map for ***fisheries and aquaculture*** *with weights and polarity added by the participants (May, 2019).*

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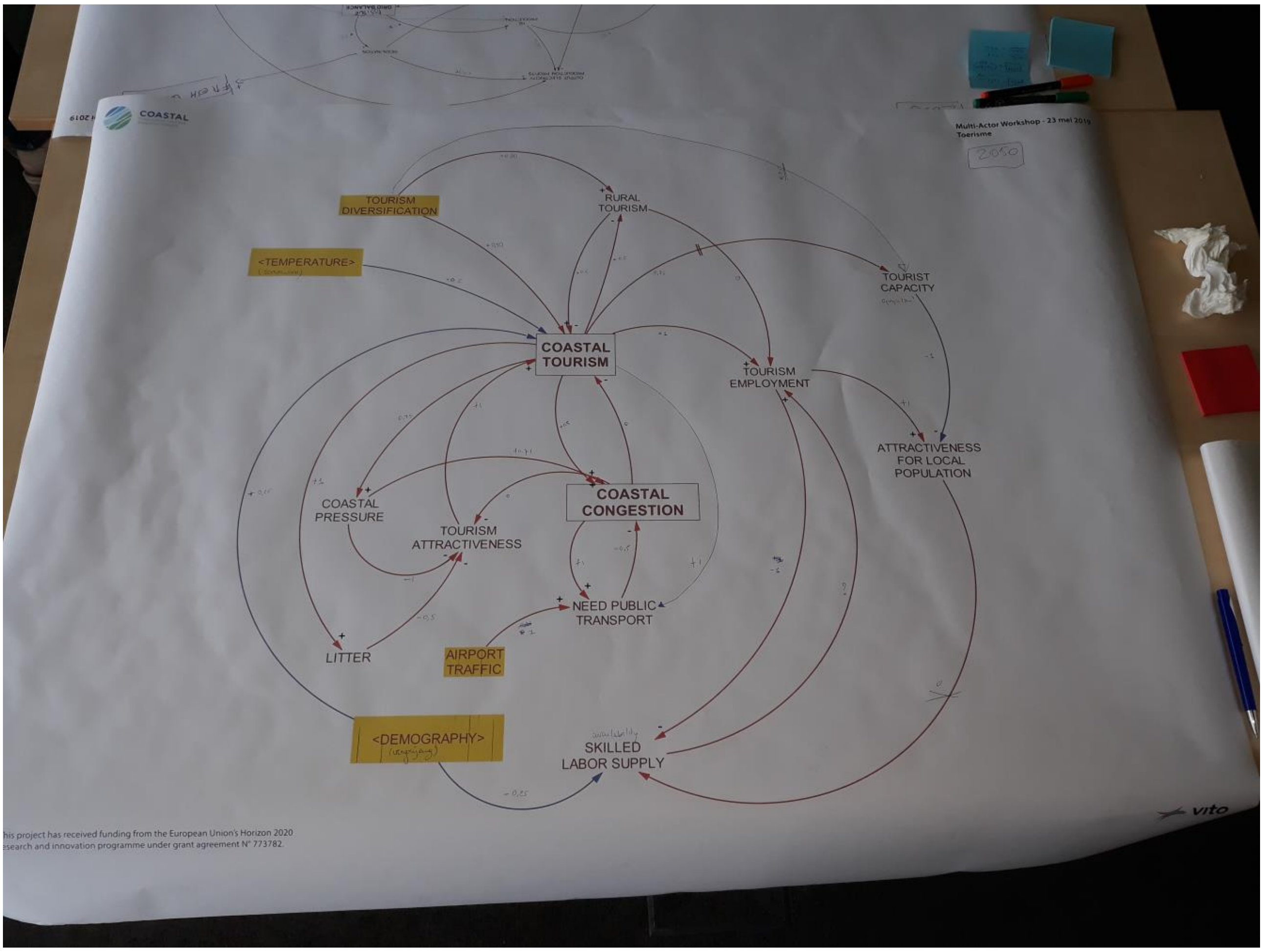

*Figure 36 Fuzzy cognitive map for **tourism** with weights and polarity added by the participants (May, 2019).*

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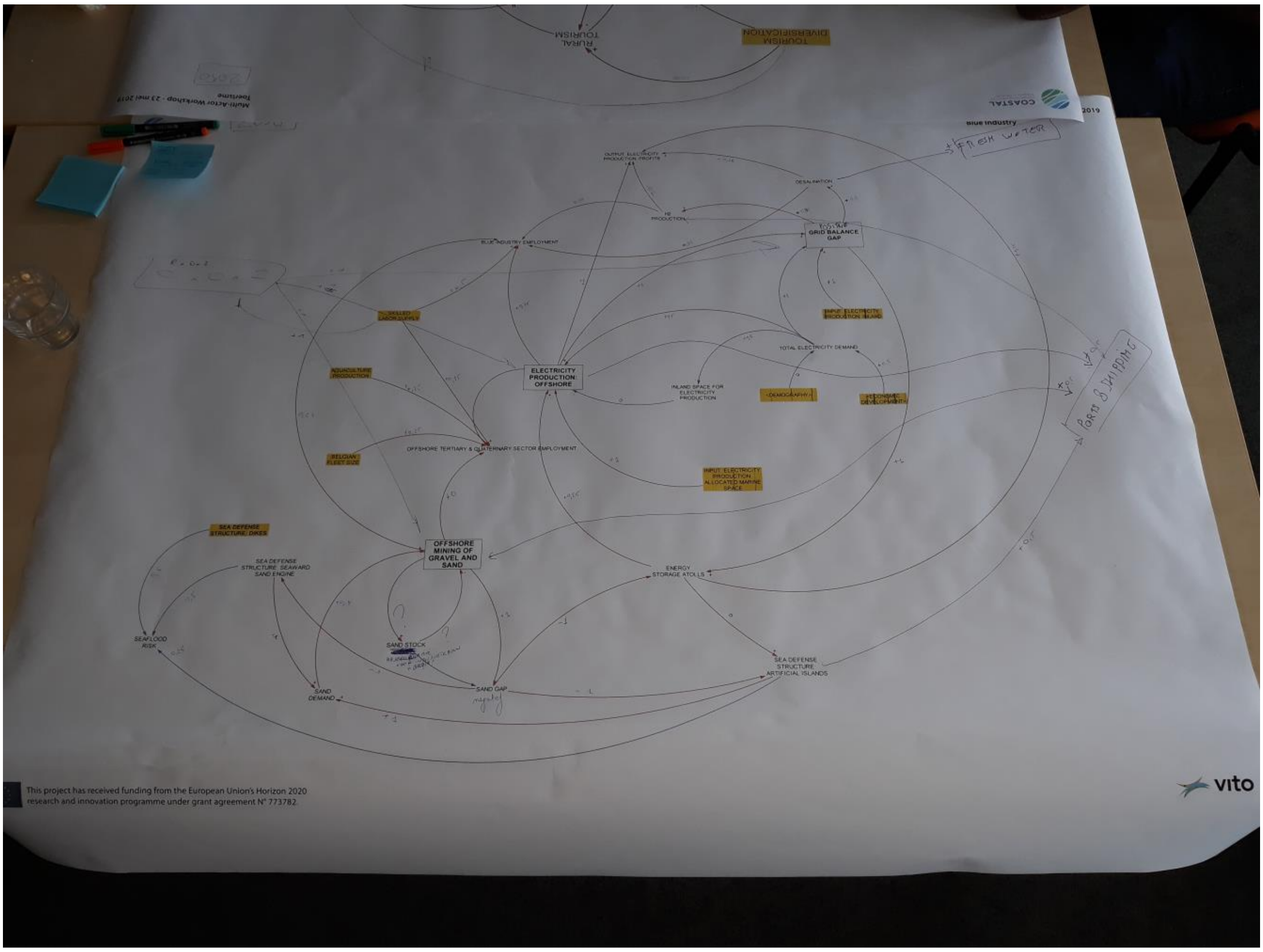

Figure 37 Fuzzy cognitive map for ***blue industry*** *with weights and polarity added by the participants (May, 2019).*

5.2.3.5 Scenario Analysis

Prior to the multi-actor workshop, several FCM scenarios had already been developed to demonstrate the potential usefulness of FCMs. The scenario examples showed how key variables and/or input variables can be varied over time and the impacts on other variables compared to a business as usual scenario (BAU).

The scenario analysis was used to gain insight in the influence variables have on other variables. This exercise was then repeated for the FCM that combines all the sectors – as many links are in common between sectors. Scenarios that are relevant in a policy context were selected that relate to important societal challenges (e.g. climate shift, gentrification) and important policy decisions that will have to be taken in the next decade (e.g. energy production and creation of offshore islands).

The first scenario focusses on **sea level rise** (Figure 38). Results indicate the strongest positive relationship with salinity level, willingness to take pro fresh water action and inland mussel aquaculture; and the strongest negative relationship with intertidal biodiversity, intertidal area and terrestrial biodiversity.

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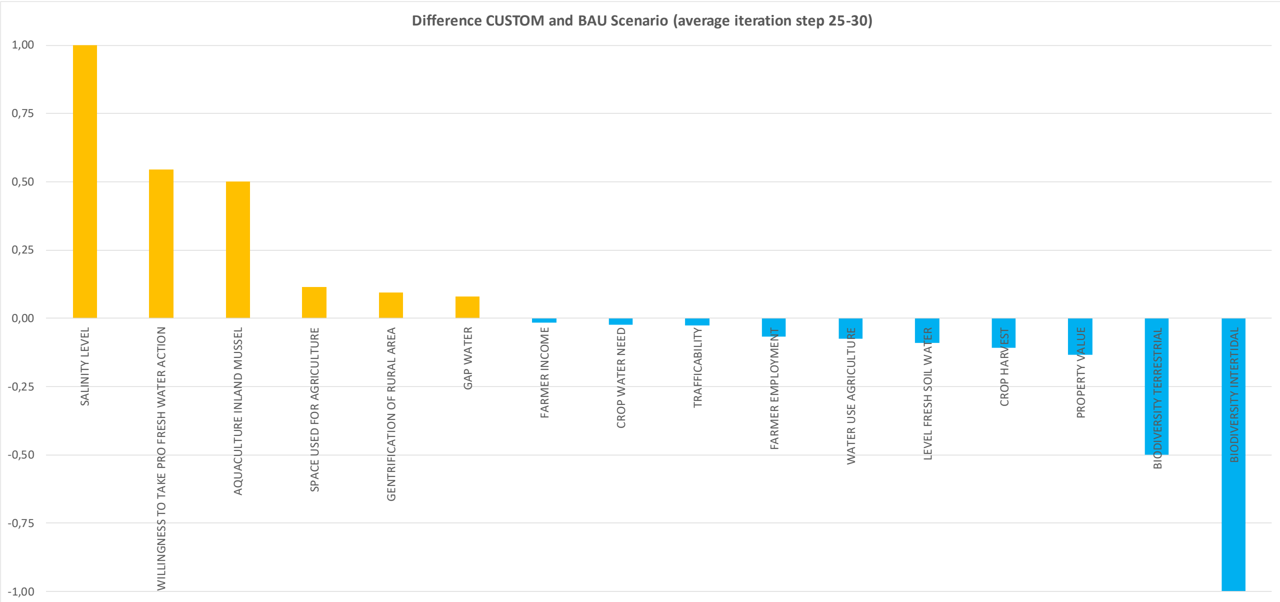

Figure 38 FCM scenario for sea-level rise, showing the impact on variables with a difference, compared to the Business-As-Usual scenario.

A second scenario focusses on a **decrease in precipitation** (Figure 39). This decrease has the strongest positive influence on drought, salinity level, willingness to take pro fresh water action; and a less important positive influence on inland mussel aquaculture, water gap and space used for agriculture. The strongest negative impact can be found on level fresh soil water, water use by agriculture; and to a lesser extent the property value.

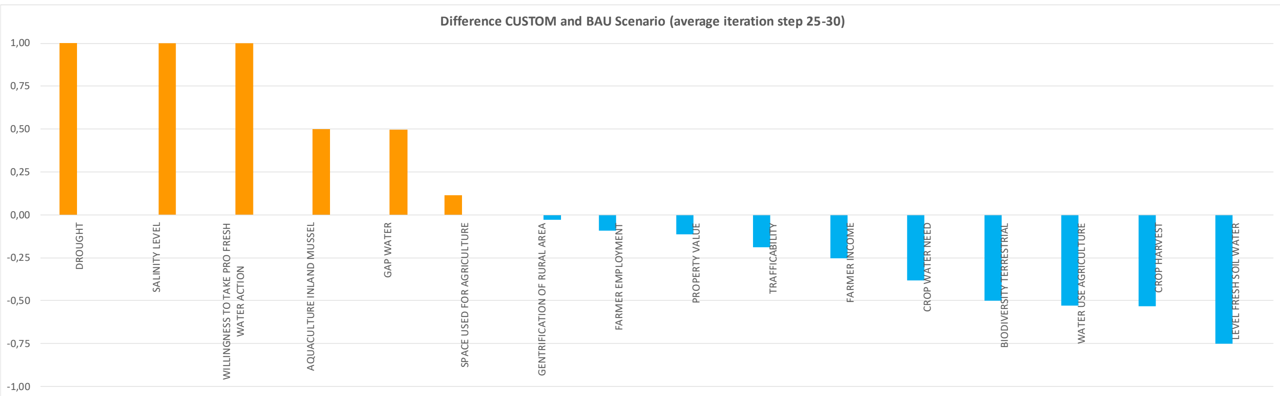

Figure 39 FCM scenario for decrease in precipitation, showing the impact on variables with a difference, compared to the Business-As-Usual scenario.

The third scenario increases the marine space allocated to aquaculture (Figure 40). This has the strongest positive effect on aquaculture production, fisheries and aquaculture employment and offshore tertiary and quaternary sector employment; and the strongest negative impact (but these impacts are limited) on skilled labor supply, attractiveness for local population and tourism employment.

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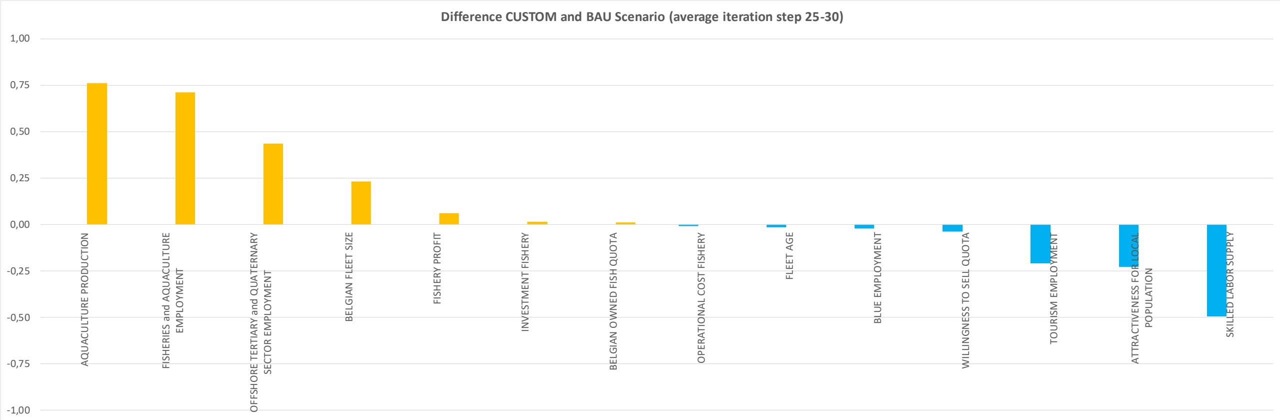

Figure 40 FCM scenario for marine space allocated to aquaculture, showing the impact on variables with a difference, compared to the Business-As-Usual scenario.

The fourth scenario increases the “**sea defence structure: islands**” variable (Figure 41). Due to its strong connectivity many variables are influenced. Most important positive influenced variables: intertidal area, intertidal biodiversity, electricity production profits, ports and shipping, sand demand, H2 production, …; most important negative: sea flood risk (meaning the risk decreases), attractiveness for local population, sand engine as sea defence structure, skilled labour supply, tourism employment etc.

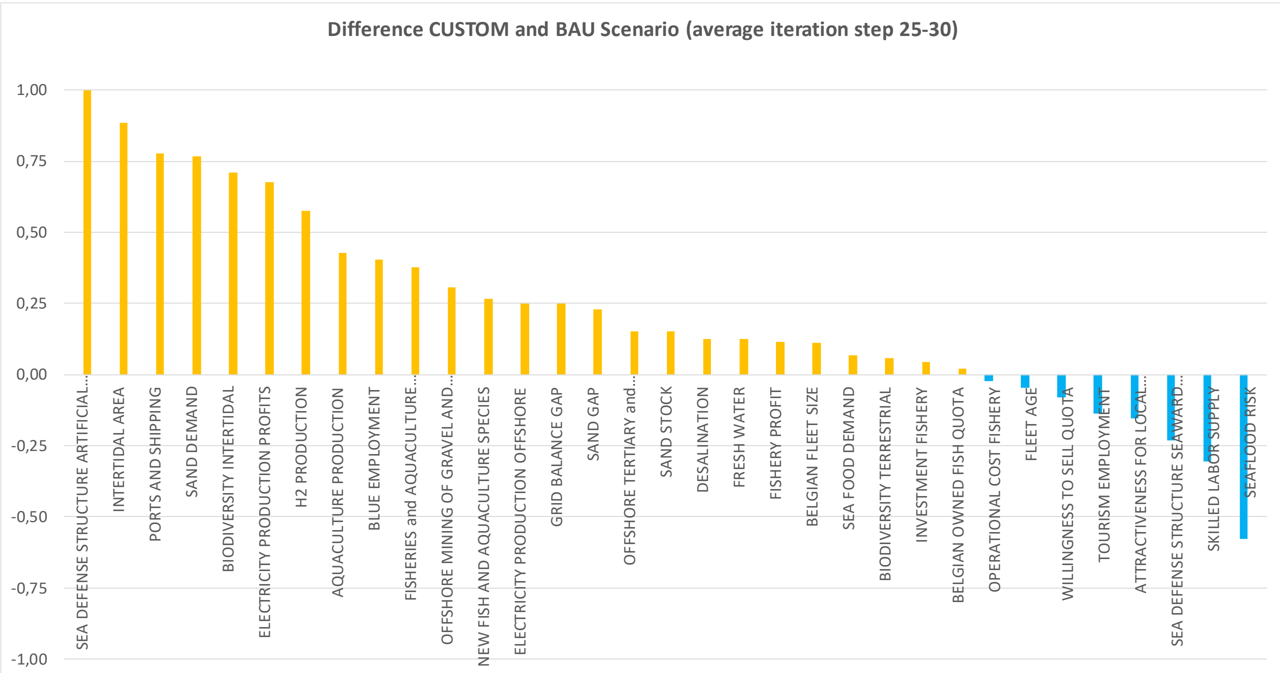

Figure 41 FCM scenario for sea-defense structures: islands, showing the impact on variables with a difference, compared to the Business-As-Usual scenario.

The fifth scenario increases **offshore energy production** (Figure 42). This has the strongest positive impact on energy production profits, grid balance gap and H2 production, and less strong impacts on blue employment and ports and shipping. Negative impact are in comparison much less important, and are strongest on skilled labor supply and employment in fisheries and aquaculture and the offshore tertiary and quaternary sector.

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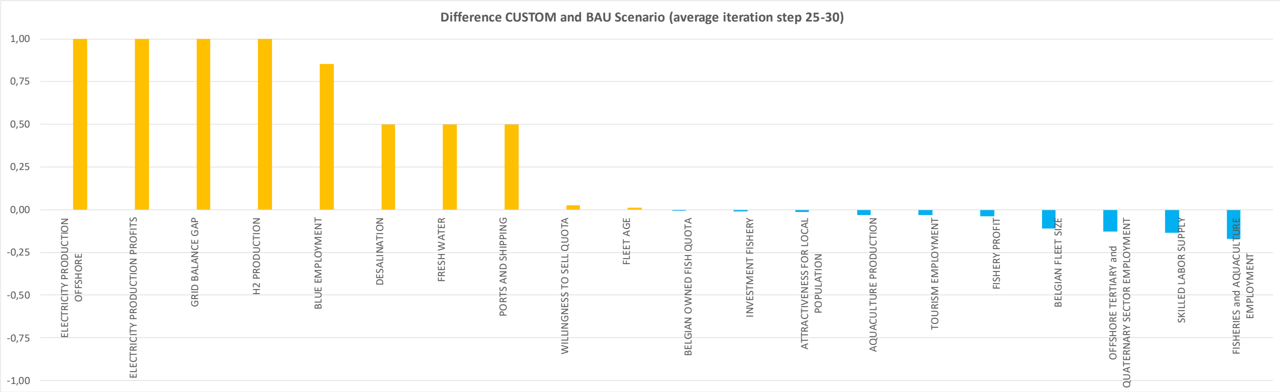

Figure 42 FCM scenario for offshore energy production, showing the impact on variables with a difference, compared to the Business-As-Usual scenario.

The final scenario is focused on an increase in **gentrification** of the rural area (such as the change of farming land into private owned land for horsekeeping, accompanied by a strong price increase of the land). The only variable affected positively (as compared to the BAU scenario) is the gentrification of rural area itself (Figure 43).. However, multiple negative impacts (differences) can be observed, the strongest being the impact on space used for agriculture and, less strong, the impact on crop harvest, property value, crop water need, farmer income and water use.

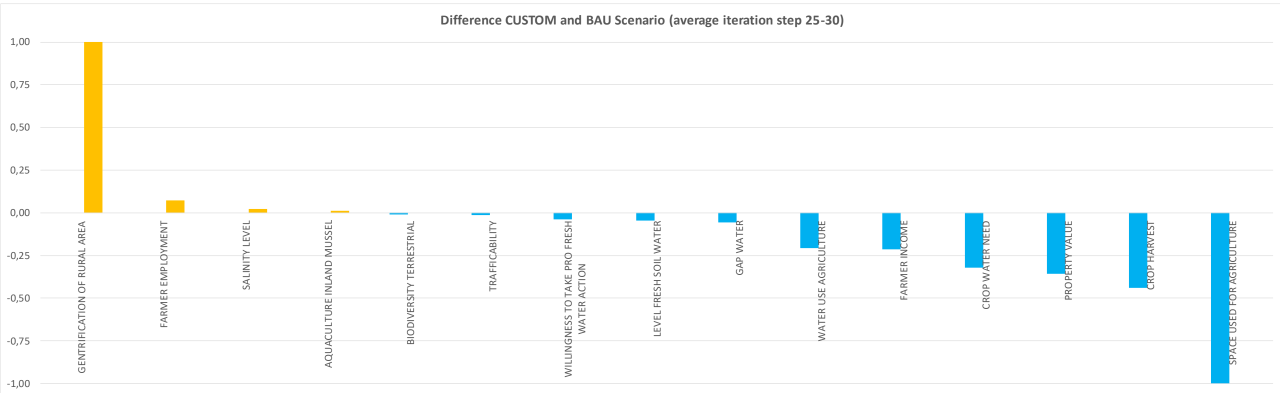

Figure 43 FCM scenario for gentrification, showing the impact on variables with a difference, compared to the Business-As-Usual scenario.

The results of these six scenarios tell us especially something about the connectiveness between variables. They assume a linear relationship and depend largely on the chosen values of the connection in the FCM. The variable value have no physical meaning. When taking into account those limitations, it is clear that the FCM cannot quantify the variations in variables, but its use should be limited to providing insight in relationships between those variables.

5.2.4 Multi-Actor Workshop

The Multi-Actor Workshop was held on May 23rd in Brugge, Belgium.

Table 2: Overview of participants´ affiliation: Belgian Coastal Zone (North Sea)

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Sector linked to	Participants linked to	Number of participants at the workshop
Agriculture, spatial planning	Regional government: regional development	1
General	Research institutions (general)	5
General	Government: marine economic interests	1
Spatial planning	Spatial planning consultancy	1
Nature	Regional government nature reserves	1
Spatial planning	Regional government – spatial planning	1
Blue Industry	Regional government – R&D Blue Industry	1
Agriculture	Agriculture research institutions	1
Agriculture	Regional government – rural development	2
Blue Industry	Local government – harbour	1
Fisheries and aq.	Fishery and aquaculture company	1
Blue Industry	Incubator	2

5.2.4.1 Theme and structure of the multi-actor workshop

Participants were selected based on the input of the previous workshops and in order to get a more or less equal participation of each sector. It proved to be difficult to find private sector stakeholders to attend, also because of many last minute cancelations.

The workshop started with a presentation that covered:

- Presentation of the results of the different sectoral workshops, and the process to come to condensed vensim diagrams and FCM; focus on the most important results of this work
- A quick overview of each of the sectoral Vensim diagrams
- Explanation of the modelling steps the COASTAL project plans to take
- Three scenarios and how they learn us which variables are influence when another variable is changed

This was followed by a first break out session. During this sessions participants were divided over three groups representing two sectors each (agriculture and tourism; blue industry and planning; aquaculture and fisheries and nature). Each participant joined the group of the sector he/she represents. These groups then discussed the condensed vensim diagrams of their two sectors:

- Correct the diagrams: missing variables and links, wrong links, In general few things were changed by the stakeholders: only one variable was added (R&D&I funding for blue industry) and a few connections were deleted (each of them have a very low FCM weight – indicating that also our experts estimated these relationships were not significant).
- Suggest weights for the connections between variables (similar to the FCM as described above: weights from -1 to 1 with 0.25 increments). In general the weights

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suggested by the participants followed the weights previously suggested by the experts. In a few cases the participants estimated higher weights, and this was especially true for their personal topics of expertise.

This exercise was followed by a second break out session focussed on scenarios. In this second session participants were mixed in three groups (ensuring a division of sectors over the groups) and each group had to work out a scenario on their vision of the future, with as main questions: “which things do you want to change to solve the problems for your sector”.

The three scenarios that were worked out by the groups were:

1. Southern North Sea Metropolitan Region: a scenario that focused on policy defragmentation by upscaling of policy domains to a larger geographical unit (Southern North Sea) that covers regions several contemporally countries. In this vision also land and sea policy would be connected in one policy level.
2. A second scenario focused on broad innovation over several sectors, in which those different sectors would find synergies. Innovation investments would lead to such things as energy transition desalination, new costal defenses, innovative aquaculture, …. In the vision of the participants this scenario required more (government) funding for innovation at sea, collaboration between different (research) sectors and industries, and a change of the mindset.
3. In a third scenario focus was on the coastal identity. This identity would bring together the different marine and rural coastal stakeholders, to invest in smart operations and R&D. The new coastal identity would mean a branding based on quality, authenticity, sustainability, aesthetics and traceability. Main thresholds to achieve this are fragmentation, lack of funding, and spatial planning.

Interesting to mention is that there was no dispute between the coastal and rural participants concerning the priorities for addressing problems and opportunities. All participants had an open mind and welcomed the exercise. Less clear, however, to them is how the outcomes of the workshop will be used as the project progresses and what the practical usefulness will be.

5.2.5 Analysis of the outcomes and conclusions

As stated above, the multi-actor workshop resulted in limited changes in the causal loop diagrams. Some links that were given the lowest possible weight in the previous round by the experts (weights of -0.25 or 0.25) were removed by the stakeholders as they were considered not important. Nevertheless, the deleted links were mentioned by stakeholders in the sectoral workshops. This shows how stakeholders in such workshops often increase the importance of their specific subtopics, while the multi-actor workshop allowed to gain a broader system picture. At the same time there was also some discussion during this multi-actor workshop from stakeholders that wanted to introduce their specific subtopic in the diagram – this is for instance why R&D&I (Research, Development and Innovation) funding in the blue industry was added as an important variable. These observations show how stakeholders try to insert their specific interests in the diagrams.

All weights in each FCM were carefully verified for any inconsistencies such as an incorrect polarity or weak instead of strong weights. Additional testing of the sensitivity of results for the FCM weights pointed to considerable sensitivity in some cases, depending on the role of the interaction in the total system. Nevertheless, it was decided to work with the weights as indicated by the participants of the multi-actor workshop.

Due to the quantitative nature of FCMs different metrics can be derived to analyse the structure on role of variables. In order to gain on their significance we calculated the centrality for the variables in the FCM (Table

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3). The centrality is defined as the sum of the absolute values of the weights for all in- and outgoing connections (Harary et al., 1965; Özesmi & Özesmi, 2004; Papageorgiou & Kontogianni, 2012, De Kok et al., 2019).

The results indicate that urbanization is the most central variable, followed by coastal tourism and artificial islands as sea defense structures. The most central variables are all important focus points of the discussion during the sectoral workshops. Furthermore, these variables are indicative for the priorities for the stock-flow modelling.

Table 3: Top-ranking central variables for the combined Belgian Coastal zone FCM diagram

1	urbanisation
2	coastal tourism
3	sea defense structure: artificial islands
4	electricity production offshore
5	skilled labor supply
6	level fresh soil water
7	grid balance gap
8	aquaculture production
9	salinity level
10	coastal congestion

Follow up
After the multi-actor workshop the causal loop diagram was verified a final time to identify remaining inconsistencies and improve the layout of the diagram. This version was distributed to the participants a few weeks after the meeting (Figure 44).

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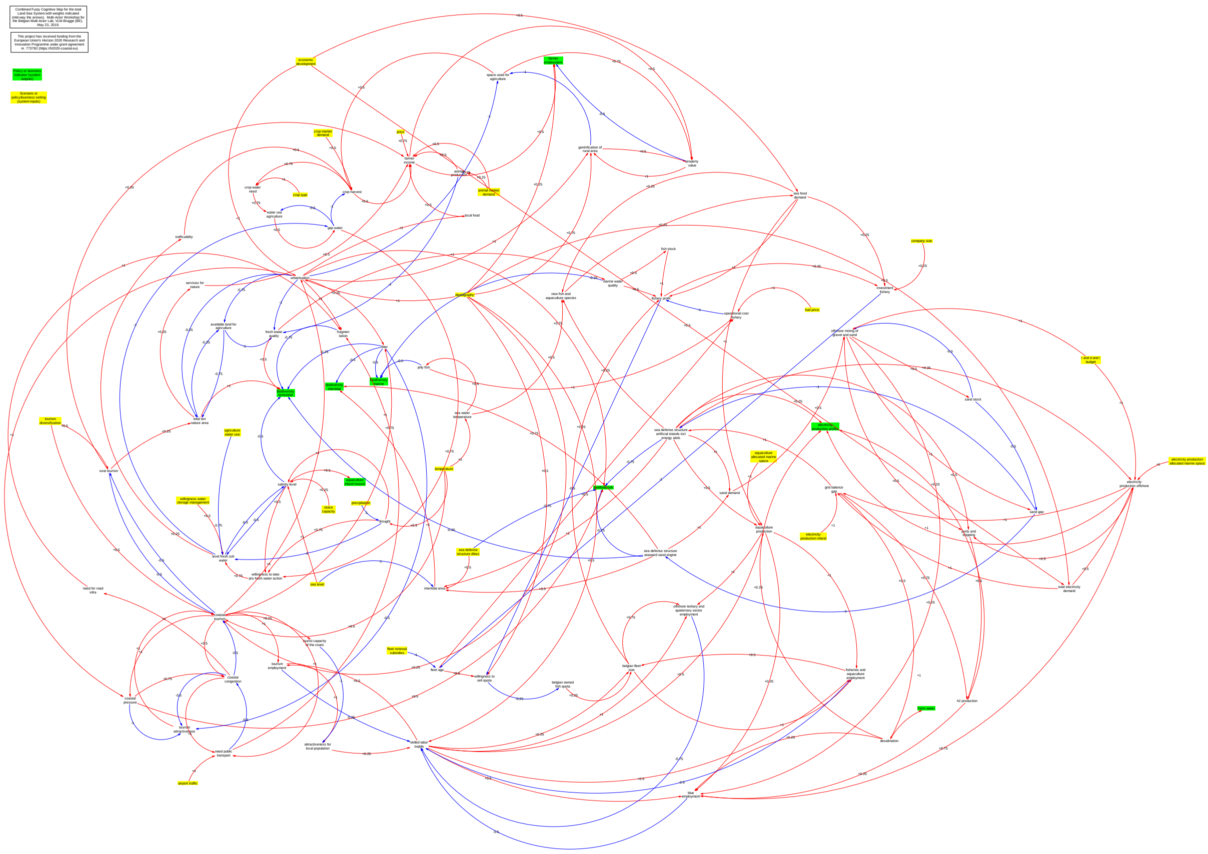

Figure 44 Polished version of the causal loop diagram, distributed to the workshop participants after the meeting (June, 2019). Positive (same direction) and negative (opposite direction) interactions are indicated in red and blue.

The contributions of the multi-actor workshop are the following:

- a polished causal loop diagram is now available, it integrates the coastal and rural variables and their interactions
- the feedback mechanisms, potentially underlying, the problems discussed, have been identified
- a platform of coastal and rural actors is available for discussion, knowledge exchange, and end-user feedback on the methodology and outcomes of the COASTAL project
- the outcomes of the workshop can be used to set the priorities for the stock-flow modelling; the first aim is to develop transparent examples addressing real-world problems, thereby demonstrating the added value of the quantification. The first priorities are: pressure on space, water scarcity and quality, and offshore renewable energy production and need for energy storage

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5.3 Sweden - Norrström/Baltic Sea

The Baltic Sea is one of the world's largest brackish water bodies, with a land catchment area about four times larger than the sea surface area. In the Swedish part of the Baltic catchment, the Norrström drainage basin and its adjacent and surrounding coastal zones is a key area with a large human population. It includes the Swedish capital of Stockholm as well as agricultural and industrial activities, contributes considerable nutrient loading to the Baltic Sea, and suffers from eutrophication and harmful algae blooms resulting from such loads also in the archipelago and coastal waters. International agreements and environmental regulations put in place since decades still have not managed to sufficiently decrease the nutrient loads from land and combat the severe eutrophication, hypoxia and algae bloom problems in the coastal and marine waters of the Baltic Sea. How to achieve sufficient management and mitigation of the nutrient loads in the short and long term, under changing human pressures and hydro-climatic conditions, is a key problem to address for the sustainable development of this coastal zone and its rural and urban hinterland areas, as for the entire catchment and coastal region of the whole Baltic Sea. Furthermore, also other environmental and social challenges need to be addressed and met for achieving sustainable development in this coastal region, such as maintaining ecosystem services and enhancing human wellbeing under multiple regional changes and change drivers.

Figure 45: The Baltic Sea and its catchment area with the Norrström drainage basin outlined in yellow.

The previously held sector workshops in MAL3 reflected on these key challenges and associated management difficulties as complex mind maps which were simplified by Stockholm University (SU) as the lead partner for MAL3. Unifying the simplified mind maps then resulted in a causal loop diagram (CLD), including 31 variables, 160 causality interactions among them, and 567 feedback loops for the MAL3 land-sea system. Based on the developed CLD, a fuzzy cognitive map (FCM) was created through assigning reasonable weights in the range of [-1, +1] to the connections according to the strength and importance of variable interactions. The developed FCM provided the possibility of defining scenarios for assessing the feedback mechanisms in the system.

The results of analysis were shared with stakeholders through a MAL workshop on 2nd of September 2019 at SU to be able to include their additional inputs on the developed CLD and FCM. This workshop also initiated the coastal-rural further exchanges of knowledge and experiences where stakeholders from both land- and sea-based sectors discussed the implications of the FCM-based scenarios and jointly developed future narratives for sustainable rural and coastal development in MAL3.

The key outcomes of the MAL workshop and scenario analysis in MAL3 can be summarized as:

- Although, each sector workshop had a specific theme and involved stakeholders from the relevant sectors, in addition to theme-sector-specific aspects, the discussions covered the joint issues/ priorities/solutions among all sectors who are affecting the land-sea system and at the same time being affected by environmental and socio-economic changes in the system. This was reflected in the co-created mind maps, as they had common word elements/connections.

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- Among all variables in the CLD, freshwater and coastal water quality are highly affected within the system since they are central aspects in the CLD with many connections to other variables.
- The envisioned future for the Norrström/Baltic Sea case according to stakeholder perspectives covered the three pillars of the sustainability, as: (i) Social aspects: Healthy and accessible sea and coast for everyone combined with a common level of knowledge on impacts of people's lifestyle on the Baltic environment; (ii) Economic aspects: International cooperation for creating/supporting finance flow across countries promoting competitive investments on regional projects, as well as national supports for creating a circulated economy; and (iii) Environmental aspects: A common framework for water quality measurement among all sectors as well as a common regulation for mitigating nutrient emissions to the sea as a long-term goal.

5.3.1 Background

The Baltic Sea is one of the world's largest brackish water areas, with a land catchment area about four times larger than the sea surface area. The catchment area is inhabited by around 85 million people, and various activities of this population on land and sea influence the Baltic Sea ecosystem status (Gren and Destouni, 2012). The water exchange between the Baltic Sea and the North Sea is limited, leading to that nutrients and other substances carried to the coast by the water discharges (runoff) from the land catchment largely accumulate in the Baltic Sea. Such land-based nutrient and pollutant inputs to the sea, together with pressures from human activities at the sea itself, cause eutrophication, pollution, marine littering, habitat loss and other types of disturbances, such as underwater sounds, over-fishing, and introduction and spreading of alien species in the Baltic Sea (HELCOM, 2017). In the Swedish part of the Baltic catchment, the Norrström drainage basin and its adjacent and surrounding coastal zones (MAL3 in COASTAL) is a key area with a large human population. This area includes the Swedish capital of Stockholm as well as agricultural and industrial activities, contributing a relatively large nutrient loading to the Baltic Sea, while also suffering from eutrophication and harmful algae blooms occurring in the own local archipelago and coastal waters. As in other places around the Baltic Sea (and the world), also here the human population and its land and water uses (Darracq et al., 2005), as well as the regional climate (Bring et al., 2015a) have changed and will continue to change over time, and these changes affect directly the nutrient loading to the sea (Bring et al., 2015b) as well as biodiversity and ecosystem services on land (Elmhagen et al., 2015).

International agreements and environmental regulations put in place since decades still have not managed to sufficiently decrease the nutrient loads from land (Destouni et al., 2017) and combat the severe eutrophication, hypoxia and harmful algae bloom problems in the coastal and marine waters of the Baltic Sea (The Guardian, 2018). There are several combined reasons that need to be addressed and solved for overcoming the great difficulties in managing and decreasing the nutrient loads from land to sea. These include uncertainties about actual biogeophysical system behaviour (Destouni et al., 2017; Levi et al., 2018) combined with social fairness issues (Gren and Destouni, 2012; Chen et al., 2019) and still remaining: i) major gaps in relevant environmental monitoring (Hannerz and Destouni, 2006; Destouni et al., 2017), and ii) dominant nutrient legacies from historic-to-present human activities, with unclear sector responsibility for the difficult (if not practically impossible) mitigation of their considerable contributions to current nutrient loads (Destouni and Jarsjö, 2018). How to achieve sufficient nutrient load management and mitigation in the short and long term, under changing human pressures and hydro-climatic conditions, is a key problem to address in MAL3 for the sustainable development of the Norrström coastal region and its rural and urban hinterland areas, as for the entire catchment and coastal region of the whole Baltic Sea. Furthermore, also other environmental and social challenges need to be addressed and met for achieving sustainable development in this coastal region, such as maintaining ecosystem services (Goldenberg et al., 2017) and enhancing human wellbeing (Goldenberg et al., 2018) under the multiple regional changes and change drivers.

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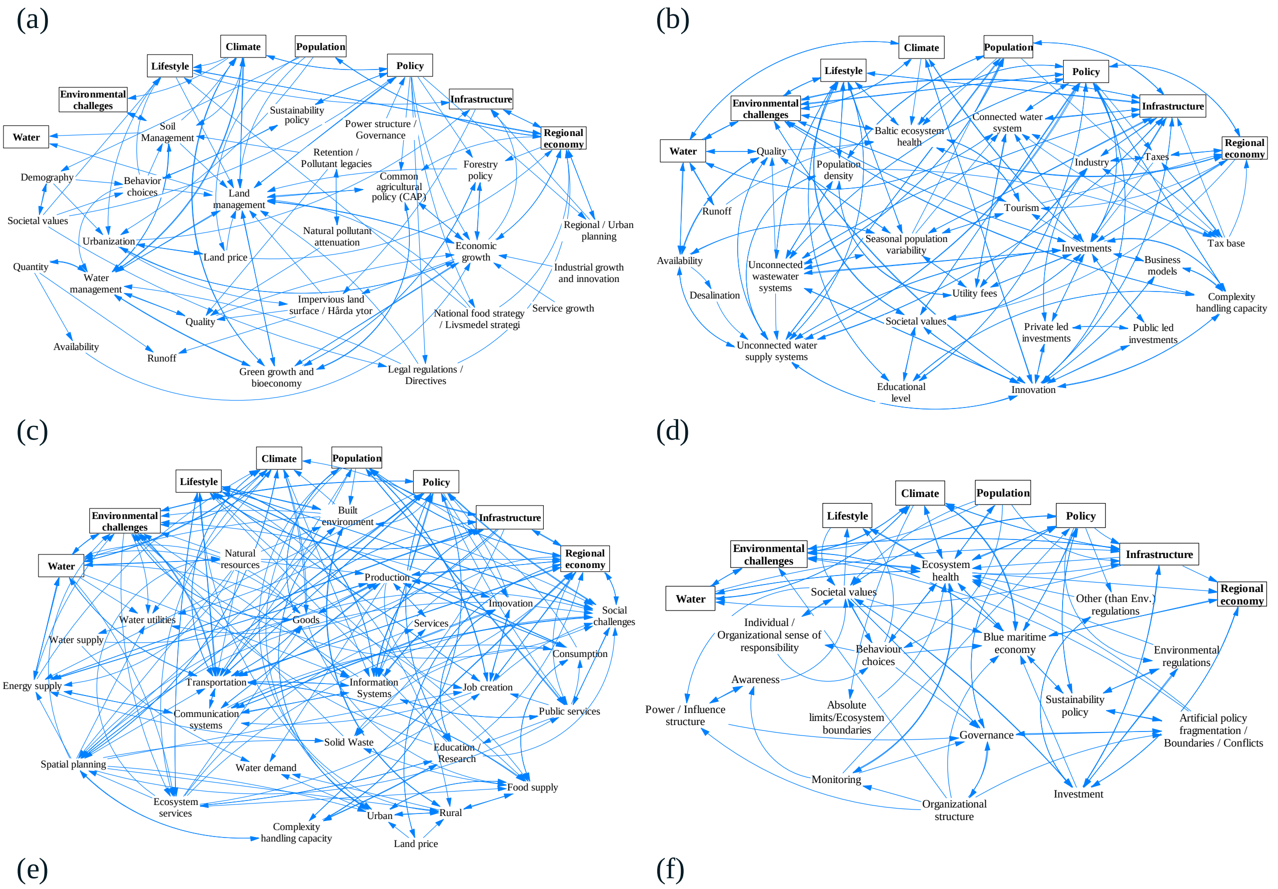
5.3.2 Mental Mapping Seminar

Instead of having the mental mapping seminar for the Swedish case, the Stockholm University (SU) team as the lead partner for MAL3 and the WP1 leader from SINTEF Ocean had a Skype meeting on 4th of June 2019 where the whole process of simplification and unification of the mind maps and developing the causal loop diagram (CLD) and fuzzy cognitive map (FCM) by the SU team were discussed and the results were confirmed by the WP1 leader.

5.3.2.1 Condensed Vensim Diagrams

The six sector workshops held in October 2018 for MAL3 resulted in complex mind maps as shown. This figure indicates more complex system understanding of the stakeholders that have land perspectives than those that have sea/coastal perspectives. These mind maps were simplified to be able to analyze and reflect on the key issues/priorities based on stakeholder perspectives from land, coastal, and sea sectors in MAL3. The simplification process aimed at condensing the complex mind maps by combining the word elements and replacing them by quantifiable/measurable variables.



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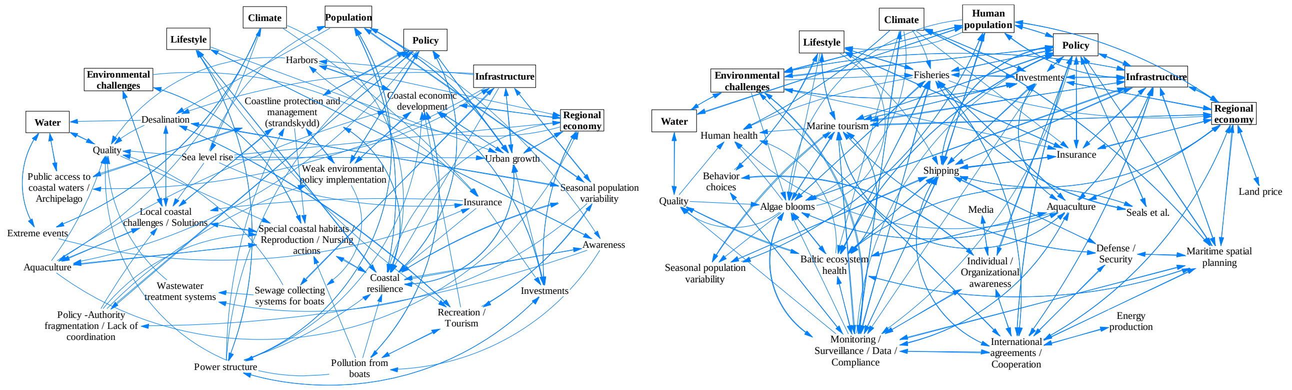

Figure 46. Original Vensim representations of the co-created mind maps for MAL3 in: (a) SW1- Green growth and terrestrial-freshwater ecosystems; (b) SW2- Industry, water-wastewater and solid waste infrastructure, and innovation; (c) SW3- Urban-rural communities and land spatial planning; (d) SW4- Blue growth and coastal-marine ecosystems; (e) SW5- Coastal tourism, recreation, harbors, and other coastal activities; and (f) SW6- Marine tourism, fisheries, marine spatial planning and other marine activities.

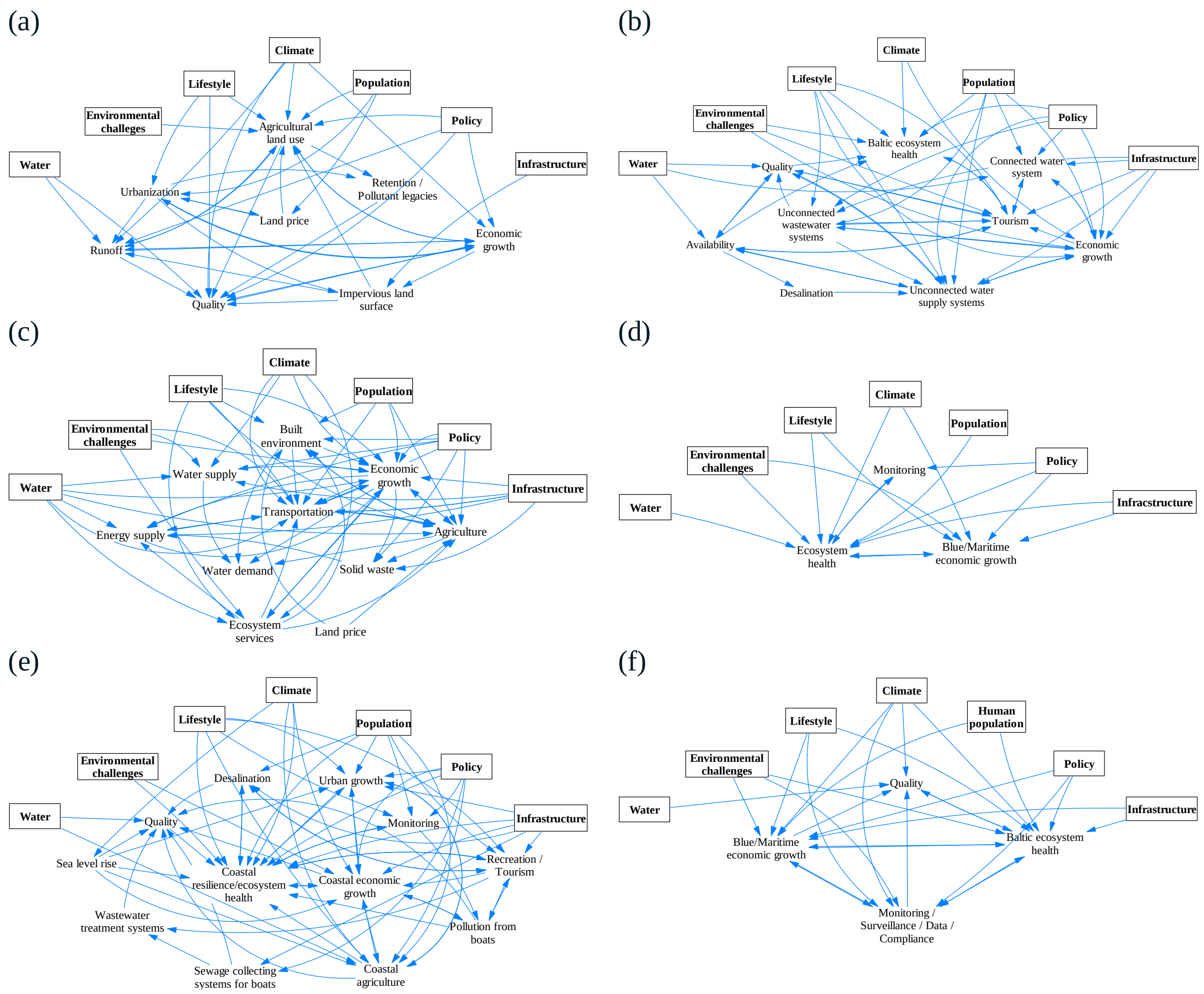

Figure 47. Simplified and condensed Vensim representations of the co-created mind maps for MAL3 in: (a) SW1- Green growth and terrestrial-freshwater ecosystems; (b) SW2- Industry, water-wastewater and solid waste

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infrastructure, and innovation; (c) SW3- Urban-rural communities and land spatial planning; (d) SW4- Blue growth and coastal-marine ecosystems; (e) SW5- Coastal tourism, recreation, harbors, and other coastal activities; and (f) SW6- Marine tourism, fisheries, marine spatial planning and other marine activities.

5.3.2.2 Combined Vensim – Regional Causal Loop Diagram for Norrström/Baltic Sea

The simplified mind maps were unified by combining similar variables repeated in the mind maps as well as identifying cause-effect and feedback loops in the whole system, which resulted in a unified CLD. In this diagram, variables/connections are shown with different colors associated with different sector workshops. In combining variables from different mind maps, the data/model inventory developed for MAL3 in WP2 was considered for selecting representative variables.

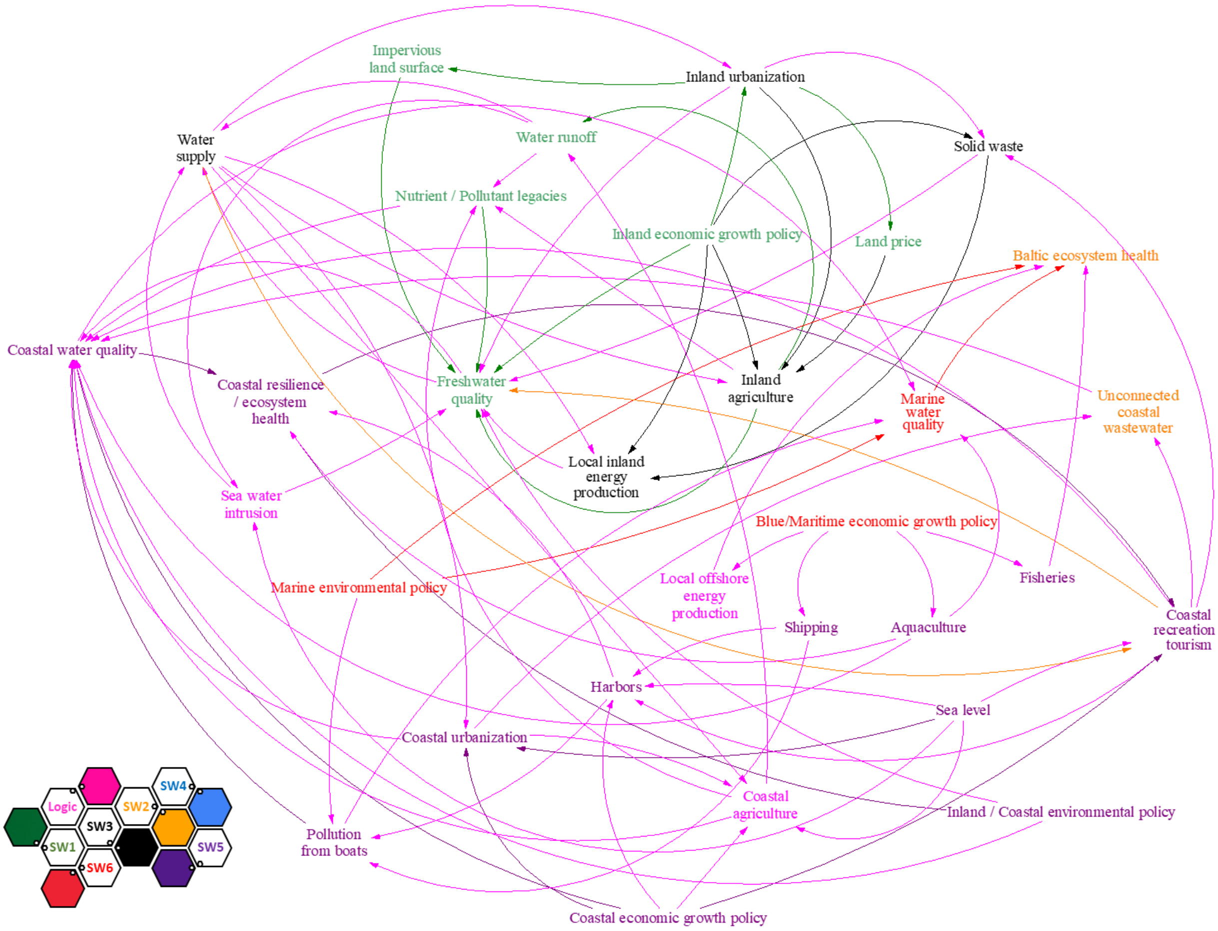

Figure 48. Unified Vensim representation of the regional CLD for MAL3. The variables/connections are assigned different colors associated with different sector workshops (variables/connections in light purple are added to make the diagram more logical).

5.3.2.3 Fuzzy Cognitive Maps

For a semi-quantitative analysis of the developed CLD, all interactions among variables were assigned a weight in the range of [-1, +1] to be able to quantify the impacts of those interactions on variables, leading to a FCM for MAL3. Negative weights show reverse interactions between variables while positive weights show consistent interactions. Also, higher absolute values for weights are assigned to stronger interactions and vice

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versa. The weight for the connections was determined based on comparing the strength and significance of the connections. The developed FCM was later used for defining scenarios based on different sets of weights to analyze behaviour and feedback mechanisms of the system.

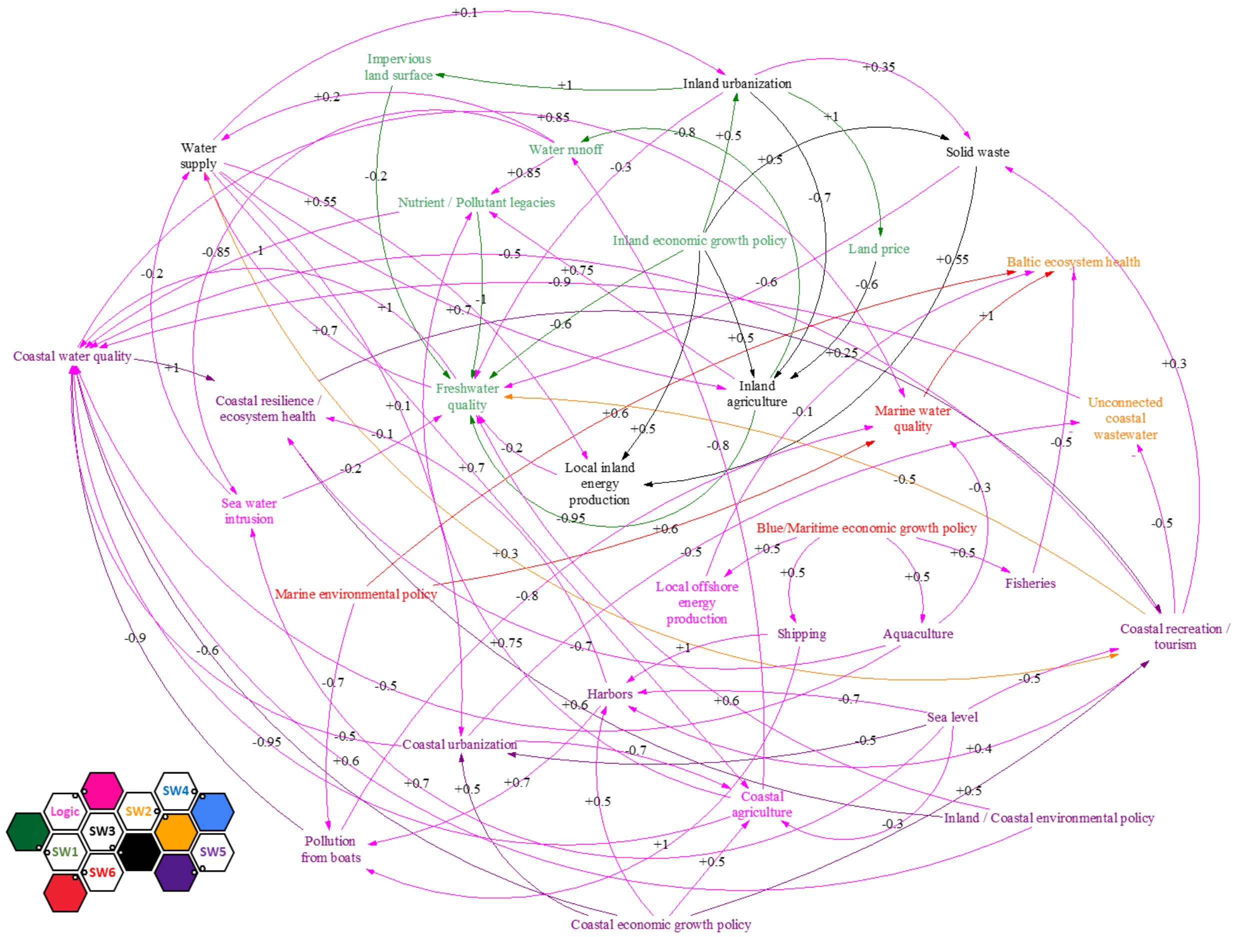

Figure 49. FCM for MAL3. The variables/connections are assigned different colors associated with different sector workshops (variables/connections in light purple are added to make the diagram more logical).

5.3.2.4 Scenarios

The developed CLD for MAL3 was analyzed according to a number of FCM-based scenarios defined based on the following key variables:

- Inland urbanization
- Coastal urbanization
- Water runoff
- Sea level
- Nutrient/pollutant legacies
- Water supply
- Inland/Coastal environmental policy
- Marine environmental policy
- Inland economic growth policy
- Coastal economic growth policy
- Blue/Maritime economic growth policy

These variables cover different aspects of land spatial planning, climate change, biophysical system behaviour, and environmental and economic policies in the land-coast-sea system of MAL3. By forcing each key variable to change (increase from the state of 0.5 to 1, decrease from 0.5 to 0, and be constant at 0.5) and accordingly modifying the set of weights for the connections in each scenario, the state (changing in the range of [0, 1])

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and change pattern of other variables were compared with a base scenario (in which none of the variables were forced to change) over 100 iterations. While these scenarios were run, the other variables all started with the average state of 0.5 and ended up with different states as the system reaches to its equilibrium under each scenario.

In total, 109 scenarios including the base scenario were analyzed in MAL3 according to the key variables and their components. The results of these scenarios showed that variables related to water quality, such as freshwater and coastal water quality, are highly affected in the system (even in the based scenario without any intentional change in variables) since they have many connections in the CLD as the central variables. Here, the results of three scenarios are presented for forcing: (i) sea level; (ii) coastal urbanization; and (iii) inland economic growth policy to increase and decrease, since scenarios of forcing them to be constant resulted in minor changes/impacts on variables. The developed set of weights for the base scenario was used for the sea level and coastal urbanization scenarios. However, the scenario based on inland economic growth policy was aimed at policies focusing on inland agriculture as one of the main features of inland economy. Thus, the set of weights presented was modified and used for this scenario, reflecting the highest importance for inland agriculture compared to other features of inland economic growth policy.

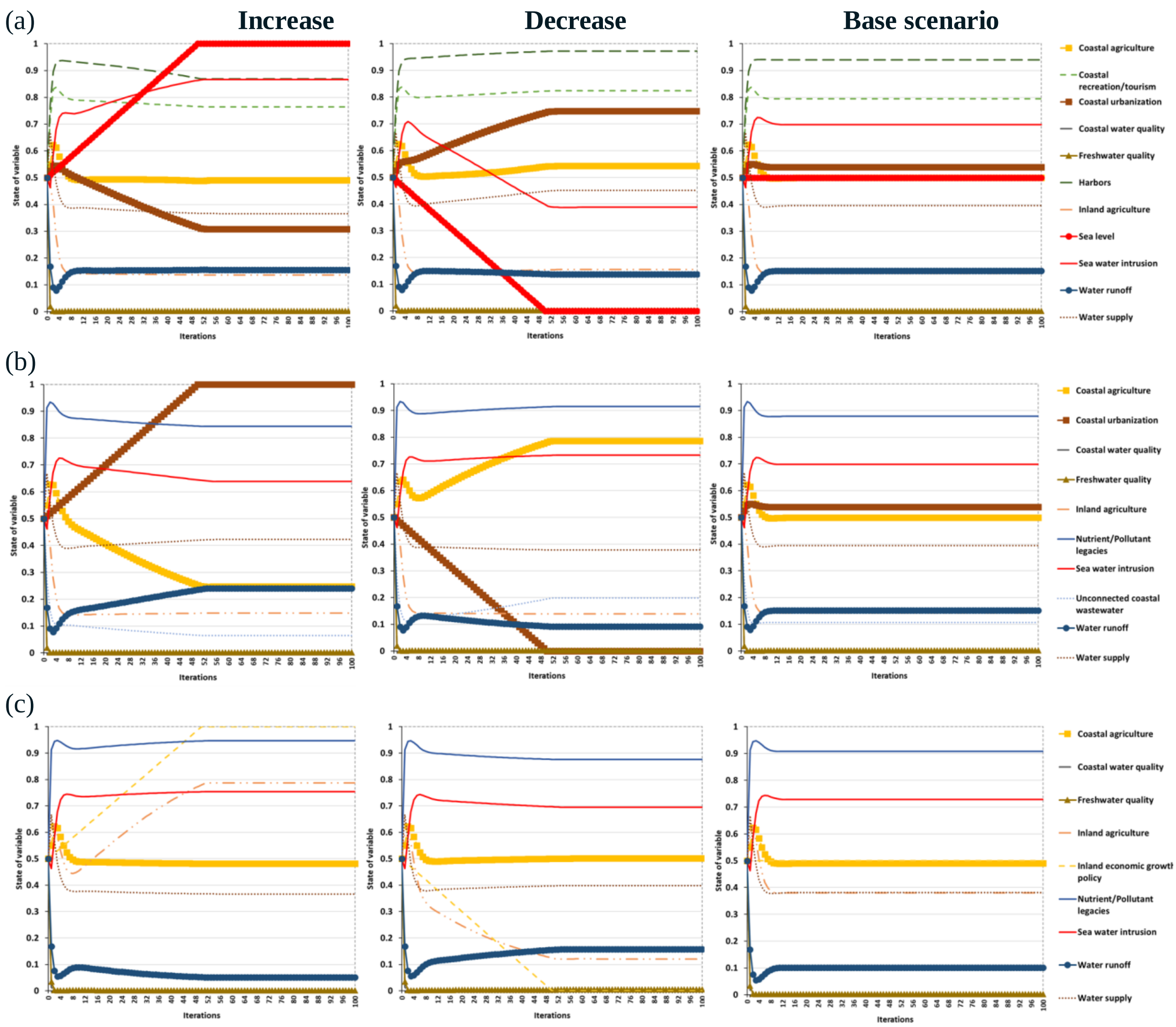

Figure 50. (a) Sea level scenario; (b) Coastal urbanization scenario; and (c) Inland economic growth policy scenario (focusing on inland agriculture). In each row, the left and middle graphs show the change pattern of relevant

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variables due to forcing the key variable to increase and decrease, respectively. The right graph shows the change pattern of the same relevant variables in the base scenario.

We see logical interactions between variables in the developed CLD for MAL3. For instance, increase in sea level has caused coastal urbanization, harbors, and coastal resilience/ecosystem health end up with lower states than their states in the base scenario, possibly due to flooding in the coastal region. Also, decrease in coastal urbanization has led to higher state for coastal agriculture (due to possibly more land availability) and accordingly lower state for water runoff and hence higher state for sea water intrusion compared to their state in the base scenario. Changes in inland economic growth policy related to inland agriculture have significantly affected water runoff rather than freshwater quality, since the latter has already had the lowest state in the base scenario within the system.

5.3.3 Multi-Actor Workshop

The first round of Multi-Actor Workshop (MAL) workshops in MAL3 was organized and hosted by SU on 2nd of September 2019 for three hours. A number of stakeholders who participated in the previous sector workshops in MAL3 were invited for further communication of the results of CLD development and scenario analysis in the Norrström/Baltic Sea case. The invitation process was coordinated directly by SU through which information about the project and the case area (the MAL/project flyers) as well as objectives of the MAL workshop were disseminated. In total, the MAL workshop in MAL3 involved 18 participants from different sectors as listed below.

Table 4:Overview of participants´ affiliation: Norrström/Baltic Sea

Sector linked to	**Participants linked to**	**Number of participants at MAL**
Green growth (Agriculture)	The Swedish National Farmers' Association (LRF) focusing on land, forest, garden and the rural environment developments	1
Blue growth, Governmental agencies and authorities	The Swedish agency for Marine and Water Management (Hav) focusing on marine and freshwater environment management, and the National Resource Institute Finland (LUKE) working on sustainable development/use of resources promoting bio-based businesses	2
Municipalities	Water center for innovation-Campus Roslagen (CRAB) responsible for water and wastewater management in the coastal municipalities	2
Administrations/ Local authorities	Stockholm Vatten Och Avfall responsible for water, wastewater, and waste management on the land	2
NGOs and ICT organizations	Stockholm environment Institute (SEI) working on solutions for environmental challenges based on connecting science and policy, and Global Utmaning (GLOB) working on sustainable development in social, economic and climate terms	4
Institutions/ Universities	Stockholm University (SU), Royal Institute of Technology (KTH), Satakunta University of Applied Sciences (SAMK), and Royal Swedish Academy of Engineering Sciences (IVA) working on various socio-economic and environmental aspects on land, in coast, and at sea	7

5.3.3.1 Theme and structure of MAL

The MAL workshop in MAL3 was planned in two parts. The first part was started with reviewing the activities carried out in MAL3 as part of the COASTAL project, presenting the results of mind mapping exercise as CLD and FCM, and working with a dynamic platform developed in Tableau (https://www.tableau.com/) by SU for better understanding the scenario results by stakeholders. The goal was to assess whether stakeholders'

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understating of the system was reflected in the developed CLD. The participants discussed variables, connections and the weights on the FCM according to the scenario results in Tableau.

The second part of the workshop was focused on creating future narratives for MAL3. Participants were divided into three groups involving representatives from different sectors to discuss and envision future narratives for sustainable rural and coastal development in MAL3. Each group then reported back the created storylines about future of the coastal area in MAL3 as the conclusion of its group work. Their ideas were combined to build a complete image of the ideal future in MAL3 from stakeholder perspectives.

5.3.4 Analysis of the outcomes and conclusions

In the original mind maps developed during the sector workshops, most of the word elements were related to policy and regional economy as the two main drivers of system changes in MAL3, while few word elements were related to climate and population as the two drivers that may assumed by stakeholders not controllable by the components of the system. Although, each sector workshop had a specific theme and involved stakeholders from the relevant sectors, in addition to theme-sector-specific aspects, the discussions also covered the joint issues/priorities/solutions among all sectors who are affecting the land-sea system and at the same time being affected by environmental and socio-economic changes within the system. This was reflected in the co-created mind maps, as they included common word elements/connections.

Different scenarios defined and analyzed in MAL3 indicated that the developed CLD is a good representative of the main variables and interactions within the system. Participating stakeholders in the MAL workshop discussed the results of some scenarios and together portrayed the following visionary image for the Norrström/Baltic Sea from a regional perspective including all aspects of sustainability:

“The Baltic coastal region is everyone’s accessible playground. This creates the incentives of developing and preserving healthy sea and coasts, combined with a good level of general well-being for people living around the coasts, not only in the big beneficiaries of the Baltic Sea (Finland and Sweden) but also in all the surrounding countries. All the Baltic Sea states work together following a problem-based approach and supporting/developing the finance flow across countries. A new HELCOM is developed, incorporating and considering all three environmental, social and economic aspects of the sustainable development. This new HELCOM has successfully initiated naming and faming programs to promote competition among all beneficiaries in terms of their investments on effective projects and programs. At the local level, people’s behavior and lifestyle is changed to achieve a level of common knowledge/realization of their roles and impacts within the complex system of the Baltic Sea environment. Green growth sectors expand, leading to high self-sufficiency in food and less transportation, without intensifying the impacts on water quality. A common framework for water quality measurement and its indicators is developed and agreed upon by all sectors on land and at sea. Also, all sectors follow a common regulation to minimize and mitigate nutrient and pollutant emissions as a long-term goal. For this, policies and investments are focused on the upstream, creating market-based innovations that regulates the amount and the type of pollution each sector can/is allowed to emit to the downstream. This is also supported by building new infrastructures based on new technologies (such as parallel systems of stormwater collection for groundwater recharge), and developing circulated economy among sectors.”

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5.4 Romania - Danube's Mouths - Black Sea

5.4.1 Executive summary

The Romanian case study covers the South Eastern Romania's rural area and Danube Mouths - Black Sea coastal zone. Due to the semi-enclosed location and size of the contributing catchment area, the Black Sea is vulnerable to anthropogenic pressures and pollution sources. Even today Black Sea is still under pressure from excess nutrients and contaminants due to emissions from agriculture, tourism, industry and urbanization in the Danube basin. The increased rates of eutrophication, pollution and bioaccumulation affect both the biodiversity and fishing sectors. Mass tourism is also an important growth sector for the Black Sea and eco-tourism is becoming more important in the region. Within COASTAL, local actors and experts from the Danube Delta and Black Sea coastal zone participated in collaborative exercises to analyse problems, the underlying causes, propose and discuss solutions, and validate and interpret the impacts of simulated business and policy decisions. Six interactive workshops were organized in autumn 2018, focusing on Blue Growth (industry, transport and administration); Tourism; Fishing and Aquaculture; Rural Development of Danube's Delta region; Agriculture, cross-compliance and ecosystems services; Rural tourism, recreation and others rural activities attended by local stakeholders. Qualitative and quantitative techniques were combined in this co-creation process supported by graphical tools to gain in-depth understanding of the systemic transitions underlying the land-sea interactions in each specific domain. Generally, the main findings of the workshops were related to policies and underdevelopment. It was evidenced the excessive bureaucracy and authorities directly linked to lack of communication and the limitations of the local authorities and communities. Despite of many strategies, the area needs improvement and sustainable development involving infrastructure, social protection, health and education. Further, on 5 September 2019, the National Institute for Marine Research and Development "Grigore Antipa" Constanta, Romania (NIMRD) hosted a MAL meeting for the Danube's Mouths - Black Sea Case Study, with the participation of partners from the Research Institute for Agriculture Economy and Rural Development (ICEADR), Local Activity Group Danube Delta (GAL DD) and Local Activity Group Central Dobrogea (GAL DC). The meeting was attended by local actors, representing municipalities, research institutions/academia, authorities, entrepreneurs and civil society, who all contributed to develop future narratives about the development of the region. There were two working groups and the main development directions identified in the area were eco-tourism, aquaculture (for the coastal and delta communities) and integrated agriculture (for inland rural areas).

5.4.2 Background

The Black Sea has special natural features due to its semi-enclosed location and catchment area five times higher than its surface. Therefore, it is vulnerable to anthropogenic pressures and pollution sources (BSC, 2008). Until the '60s, the Western part of the Black Sea was known as an example of natural eutrophic ecosystem due to the permanent Danube's nutrients input (Gomoiu, 1981). Further, with anthropogenic activities enhancement, increased use of fertilizers, wastewater discharges, detergents, etc., the nutrients regime has undergone significant changes. These changes were related to the Danube's nutrients input that increased significantly (Mee & Topping, 1999; Cociaşu et al., 2008) and led to alterations in the Black Sea ecosystem. Mismanagement of nutrients in the Danube Basin has led to severe ecological problems: the deterioration of groundwater resources and the eutrophication of rivers, lakes and especially the Black Sea. The Black Sea eutrophication effects appeared soon: the transparency decreasing, higher quantities of organic matter decomposition and oxygen depletion (Gomoiu, 1992) and bottom waters became seasonally hypoxic or even anoxic (ICPDR – ICBS, 1999) transforming the North Western part of the Black Sea into a highly eutrophic one (Zaitsev in Mee, 1999). These problems were directly related to social and economic issues (e.g. drinking water supply, tourism and fishery as affected sectors; agriculture, nutrition, industry and wastewater management as drivers) (ICPDR, 2005). In the early 90s, have found decreasing nutrients input resulted in the first recovery signs (Gomoiu, 1992). Today the Black Sea catchment is still under pressure from excess nutrients and contaminants due to emissions from agriculture, tourism, industry and urbanization in the Danube basin. Approximately 65% of the Romanian coastline is in the Danube Delta Biosphere Reserve and subject

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to tourism regulations, resulting in conflicts between nature conservation and economic development. Failing to resolve these conflicts has social, economic and political impacts which calls for urgent co-creation actions among all the stakeholders involved (Golumbeanu & Nicolaev, 2015).

5.4.3 Mental Mapping Seminar

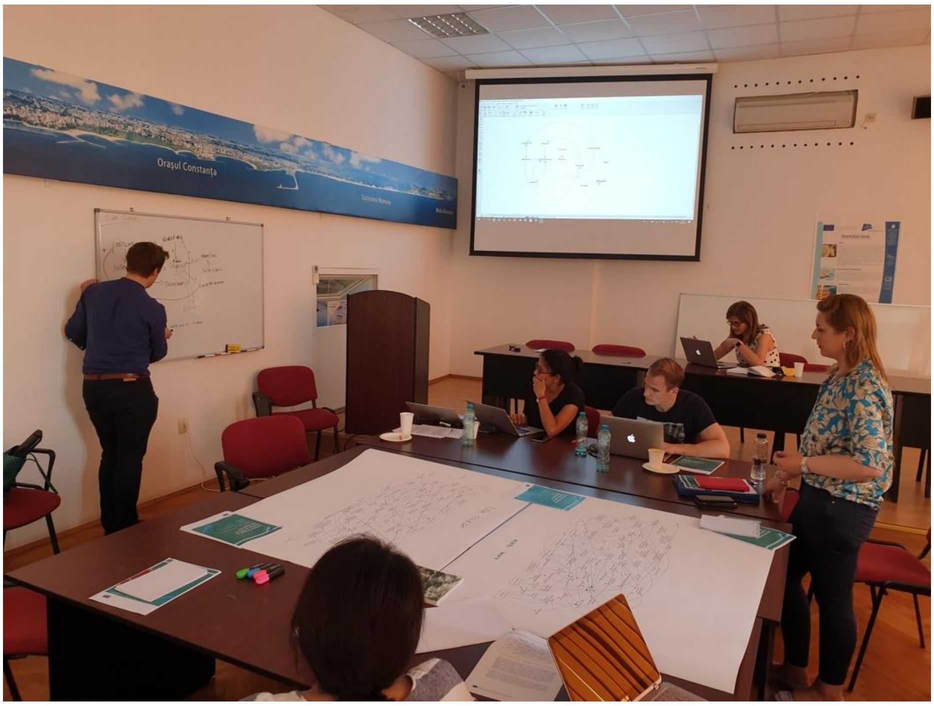

Figure 51: Mental mapping seminar – NIMRD, Constanta, Romania – 12-14 June 2019

SINTEF Ocean visited the Romanian partners, at Constanta, during 12-14 June 2019. For two and half days a group of 15 participants from SINTEF, NIMRD and ICEADR discussed about the six stakeholders' meetings and CLDs, respectively. We printout all the workshop mental maps on A0 paper and discussed about each of the workshops completed (Blue Growth (industry, transport and administration); Tourism; Fishing and Aquaculture; Rural Development of Danube's Delta region; Agriculture, cross-compliance and ecosystems services; Rural tourism, recreation and others rural activities). We reviewed each CLD, merged synonym variables and refined them. Generally, it was evidenced the excessive bureaucracy and authorities directly linked to lack of communication and the limitations of the local authorities and communities. Despite of many strategies, the area needs improvement and sustainable development involving infrastructure, social protection, health and education.

5.4.3.1 Condensed Vensim Diagrams

The following are the vensim diagrams based on the work done at the seminar with SINTEF. The first is the original version post sectoral workshop, and the second is that condensed version where variables were reduced to those that are most relevant, including being combined with others. They are in the following order: 1) Blue Growth; 2) Tourism; 3) Fishing & Aquaculture; 4) Rural Development; 5) Agriculture; and 6) Rural tourism. We combined variables when possible and come up with new ones that better represent a group of variables considering data sources, or proxys for data, for each variable decided on in the process. Simultaneously with the whiteboard, we make the Vensim representations – putting in + (plus) or – (minus) on the arrows from one variable to the next.

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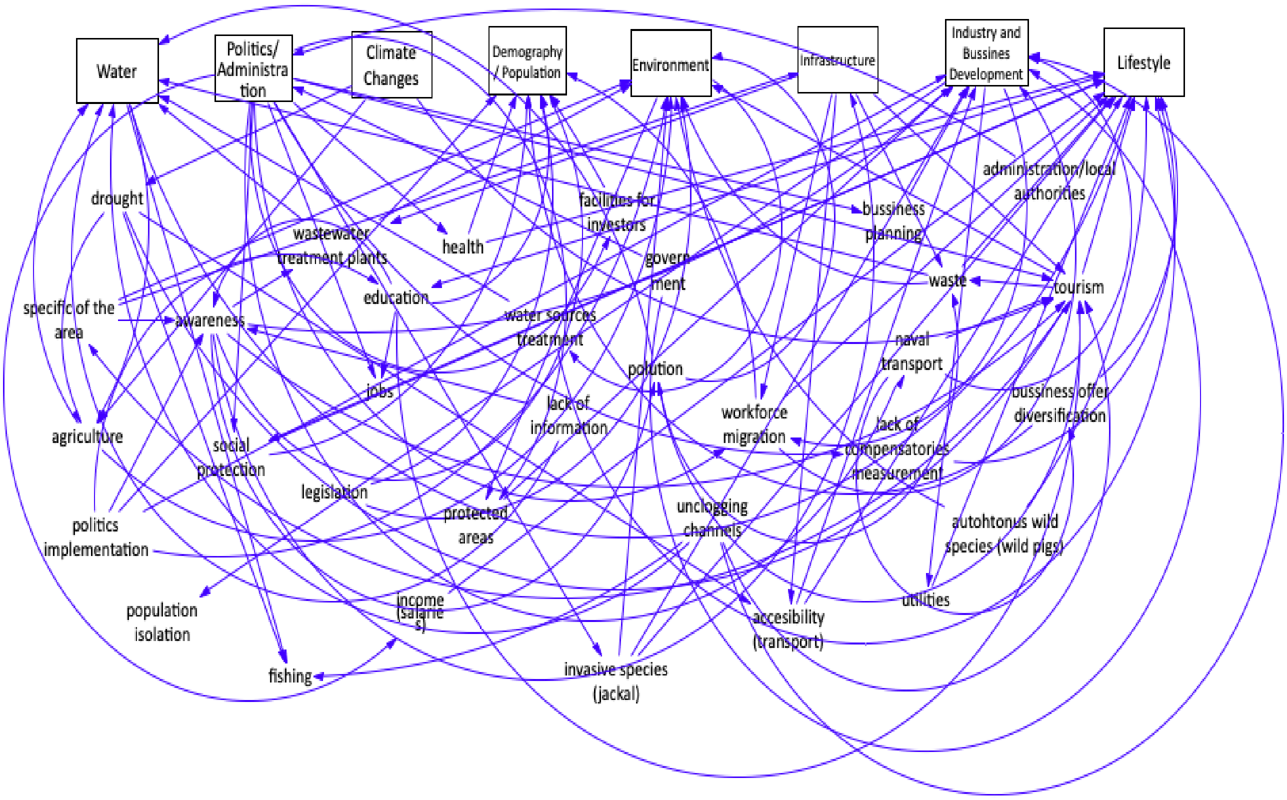

Figure 52: Blue Growth CLD before mental mapping seminar

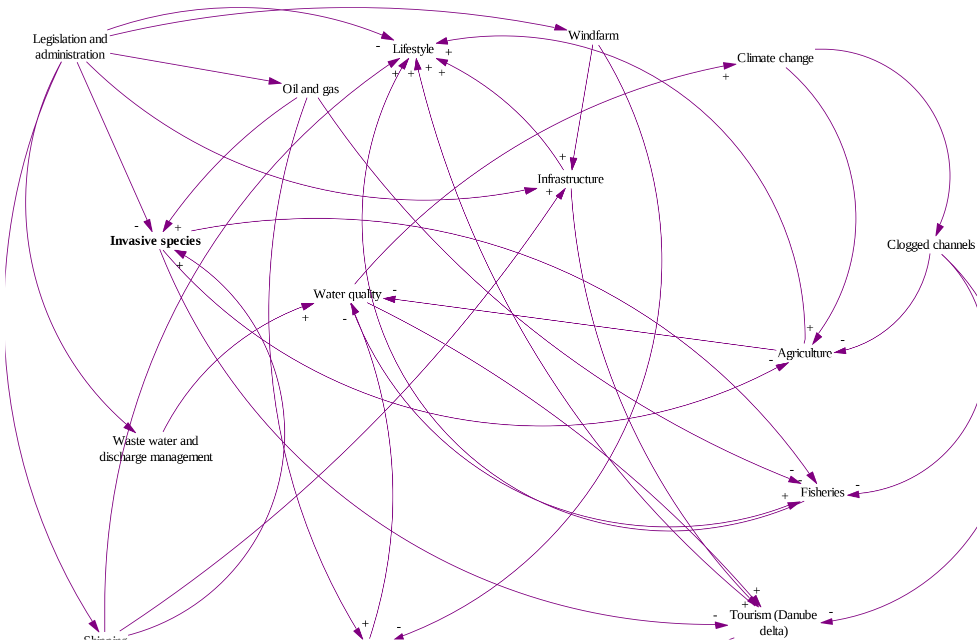

Figure 53: Blue Growth CLD after mental mapping seminar

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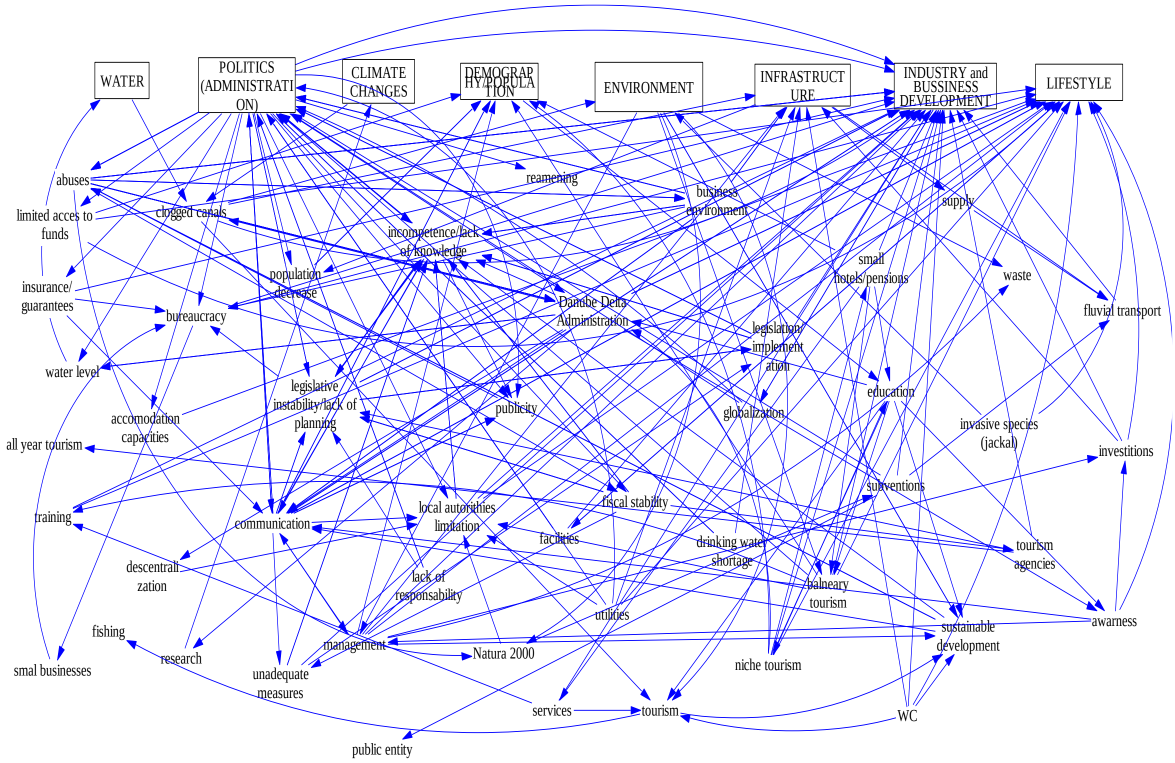

Figure 55: Tourism coastal CLD before mental mapping seminar

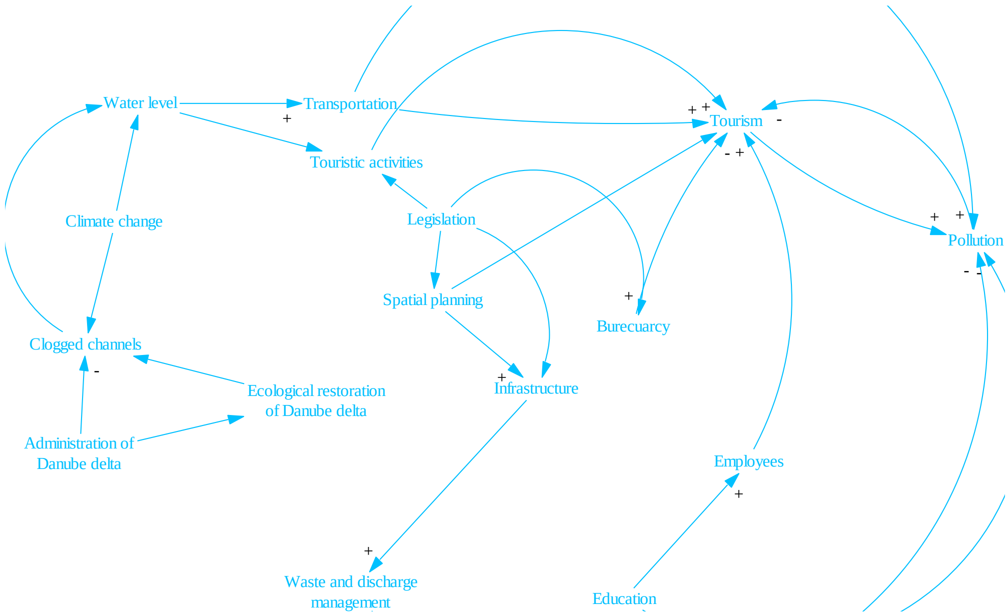

Figure 54; Tourism coastal CLD after mental mapping seminar

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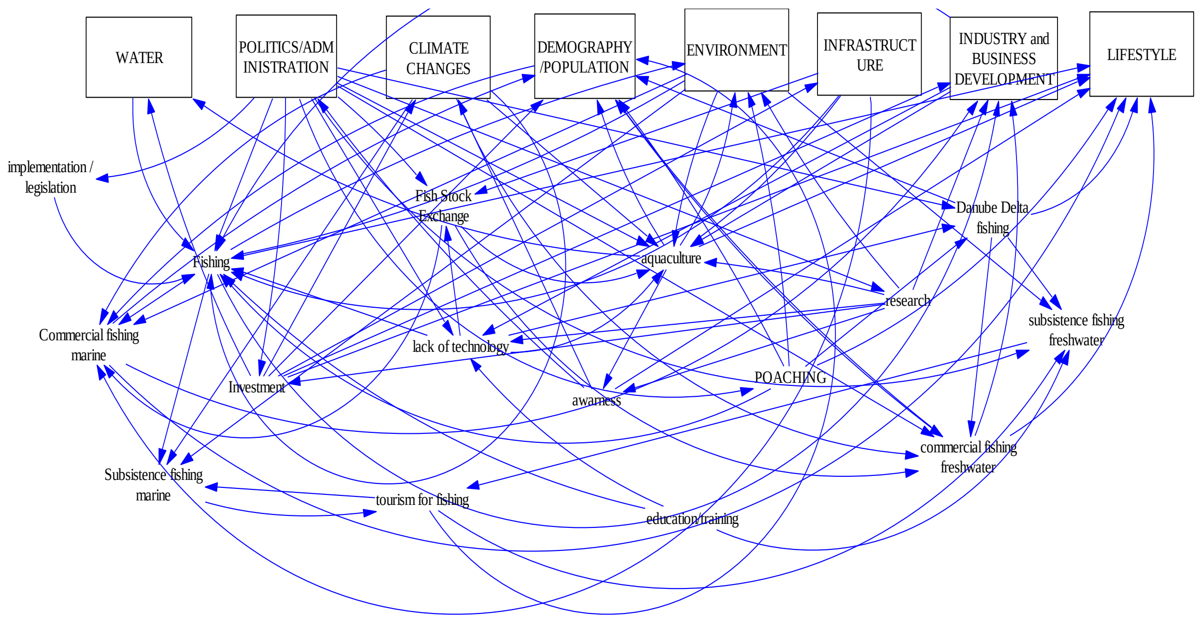

Figure 56: Fishing and Aquaculture CLD before mental mapping seminar

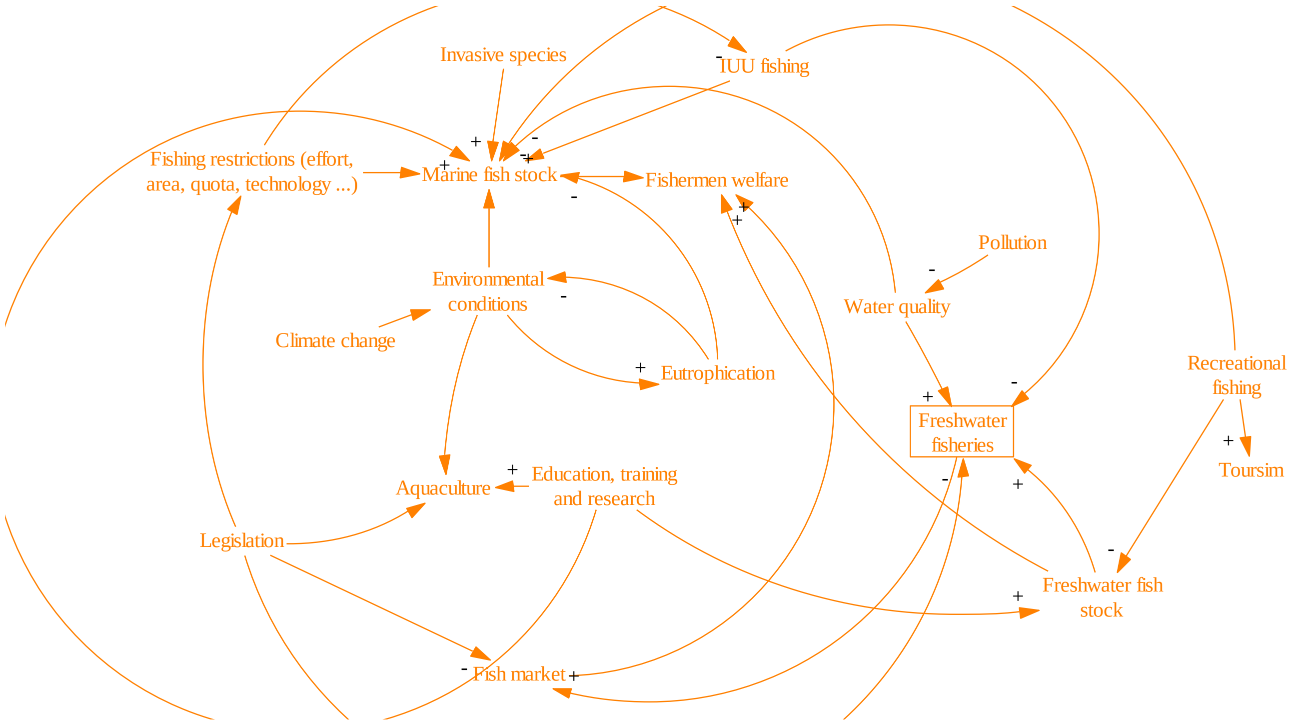

Figure 57: Fishing and Aquaculture CLD after mental mapping seminar

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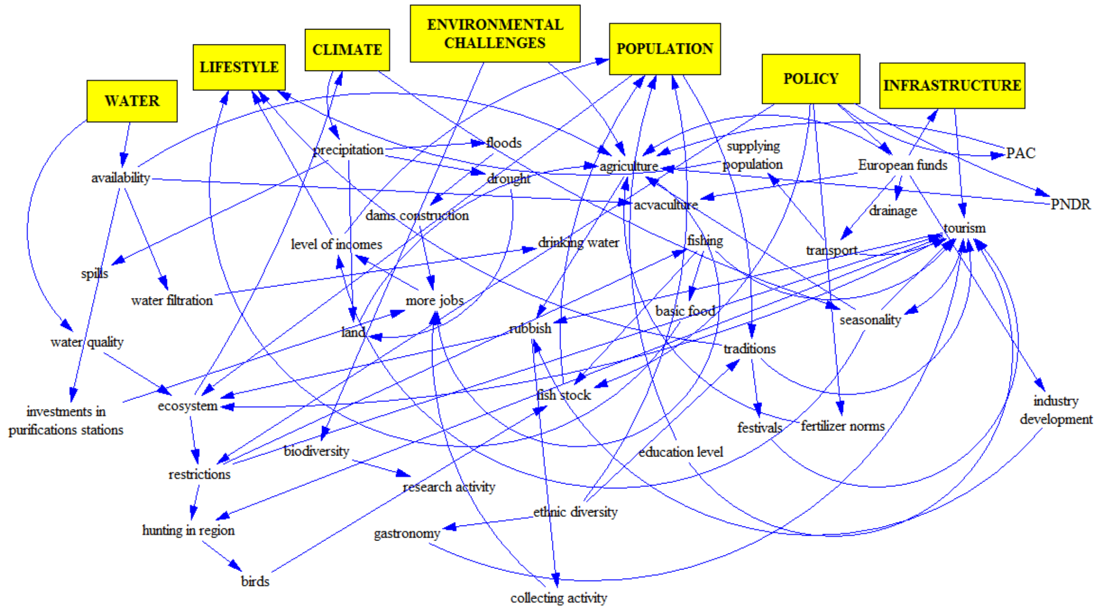

Figure 59: Rural Development of Danube's Delta region CLD before mental mapping seminar

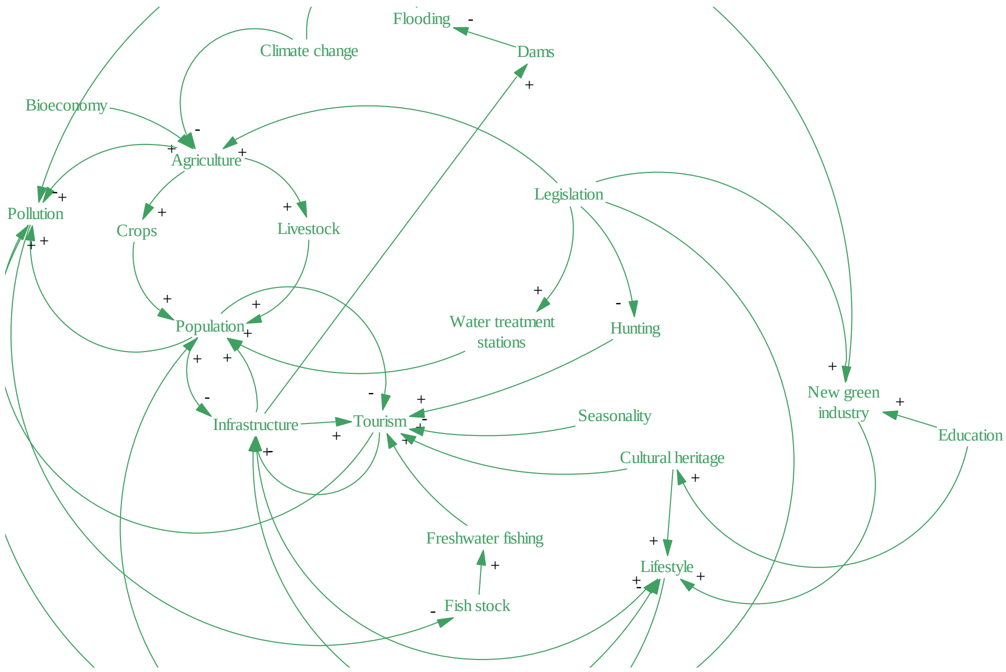

Figure 58: Rural Development of Danube's Delta region CLD after mental mapping seminar

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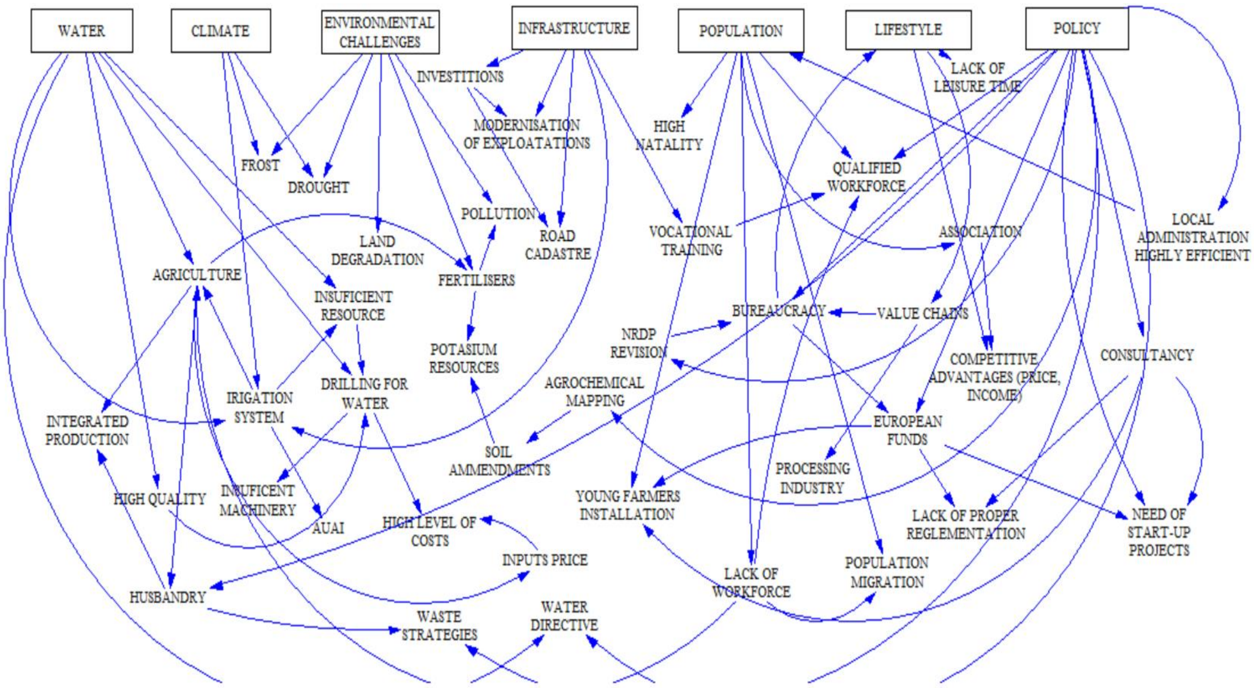

Figure 61: Agriculture, cross-compliance and ecosystems services CLD before mental mapping seminar

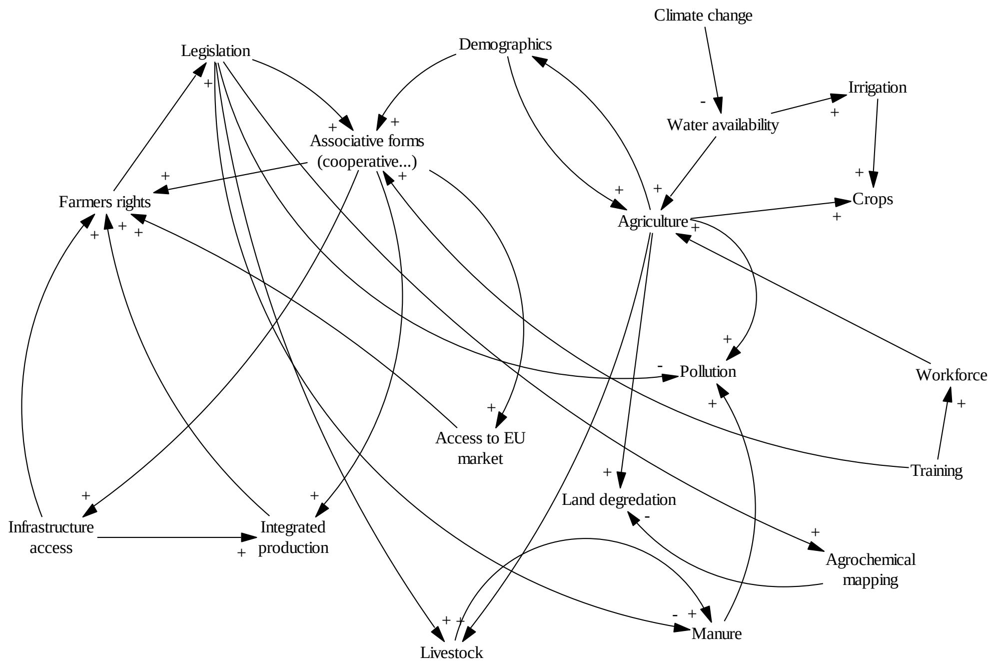

Figure 60: Agriculture, cross-compliance and ecosystems services CLD after mental mapping seminar

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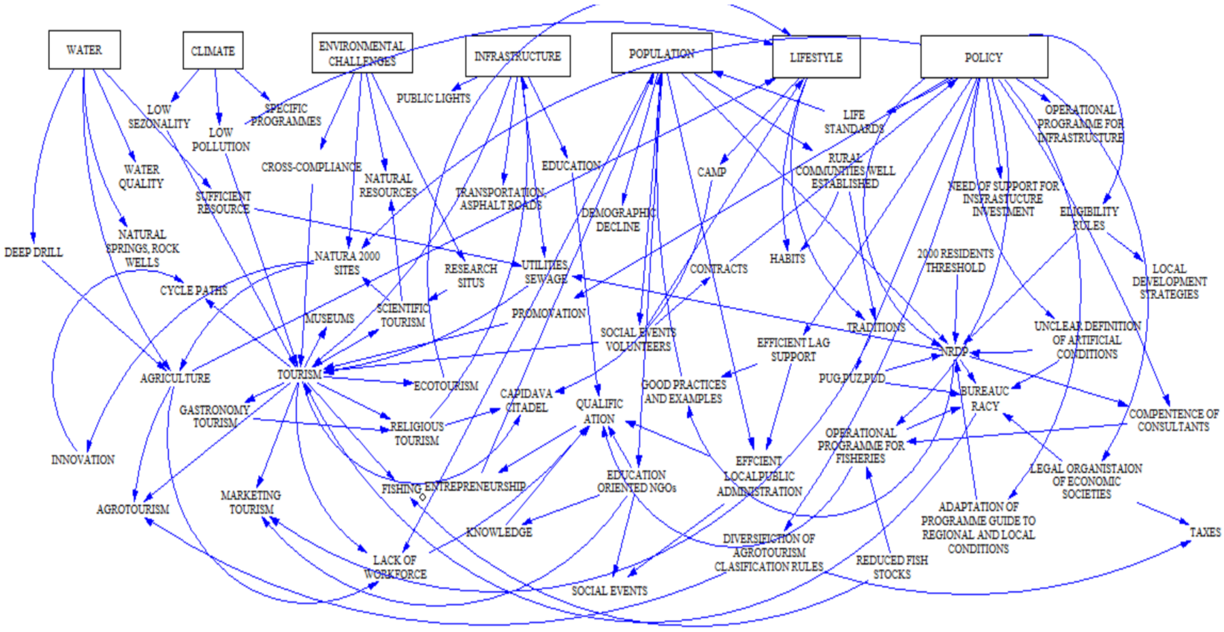

Figure 63: Rural tourism, recreation and others rural activities CLD before mental mapping seminar

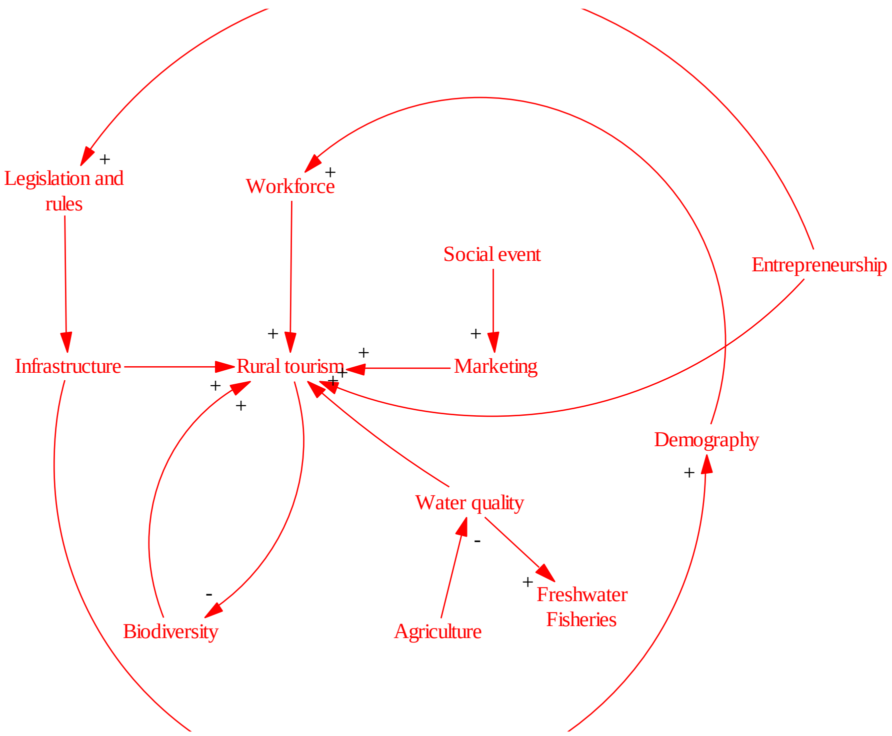

Figure 62: Rural tourism, recreation and others rural activities CLD after mental mapping seminar

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As we combined variables and came up with new ones that better represent a group of variables considering data sources for each variable decided on in the process, we simultaneously made the graphic Vensim representations – putting in + (plus) or – (minus) on the arrows from one variable to the next. Finally, we considered only 40% (N=101) from initial variables (N=249).

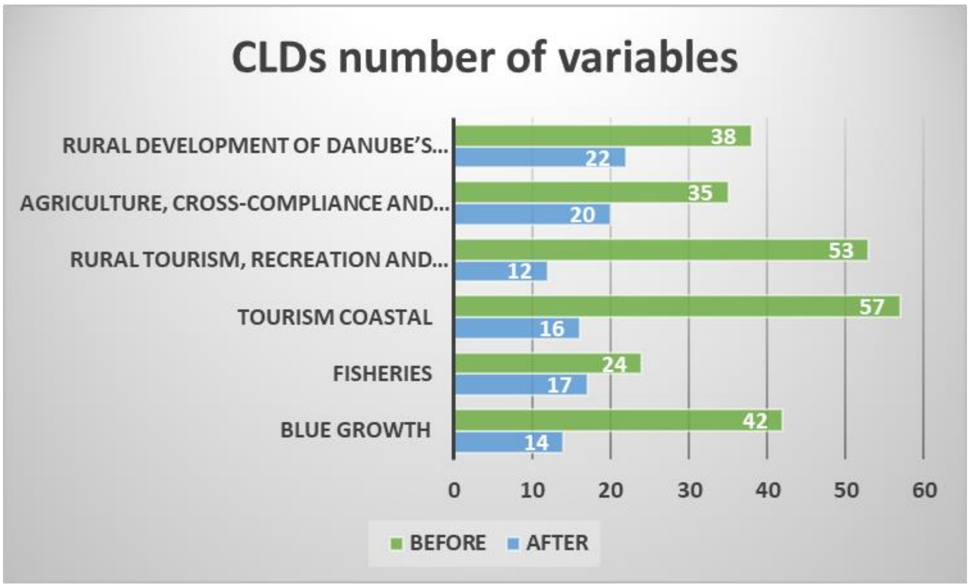

Figure 64: Number of variables per Casual Loop Diagram (CLD) developed in six stakeholder's meetings (before) and combined during the mental mapping seminar (after), Romania

The most significant adjustment was observed for Tourism. Thus, for *Rural tourism*, *recreation and others rural activities* many of the initial variables had included the trend or status in the original name (e.g. low, lack of, need of support, well established, sufficient, decline, threshold, good, efficient, competent, unclear,

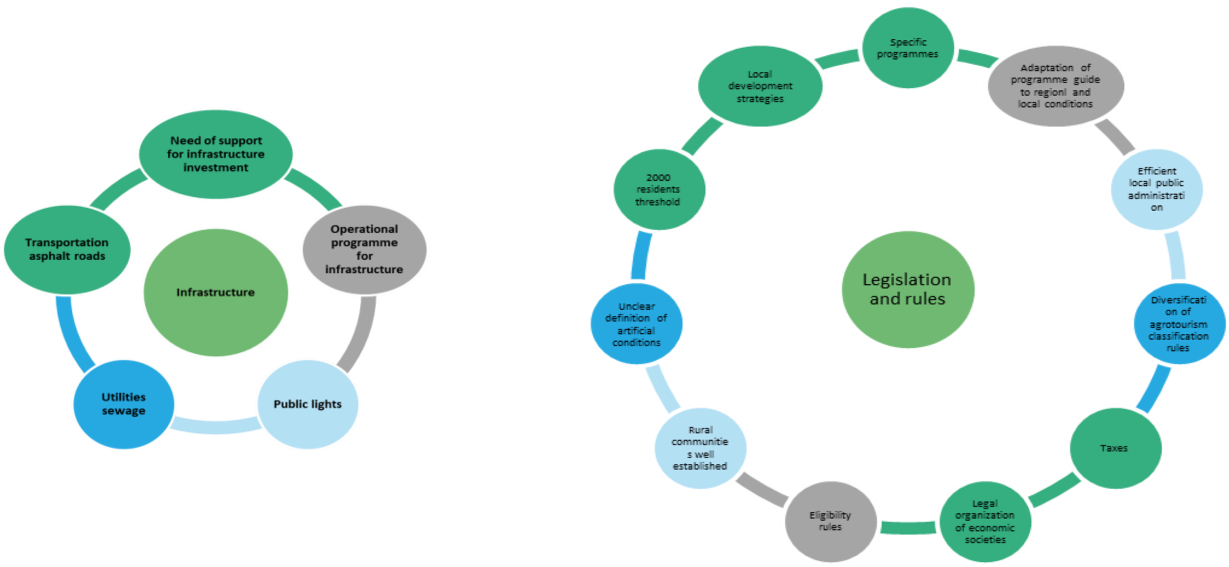

Figure 65: – Grouped variables for Rural tourism, recreation and others rural activities workshop

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reduced). Accordingly, variables with same meaning were grouped (e.g. five into Infrastructure and 11 into Legislation and rules).

For *Tourism* (coastal) were also summarized seven variables for Bureaucracy and nine for Legislation. The six sector workshops and respectively CLDs provided a more detailed analysis of the problems and priorities of the study region. All the different sectors were aware of the links among the different economic activities, and were able to discuss opportunities, obstacles as well as identify interactions with other sectors and the Black Sea. A general conclusion outlined that governance and excessive bureaucracy are disturbing the business (planning, facilities for investors (lack of), lack of compensatory measures, tourism, infrastructure) and social areas (health, incomes, protection, jobs), moving away from real problems like the conflict between Marine Protected Areas (and restrictive measures) and the exploitation of resources or the Danube Delta's clogged canals and invasive species (jackal).

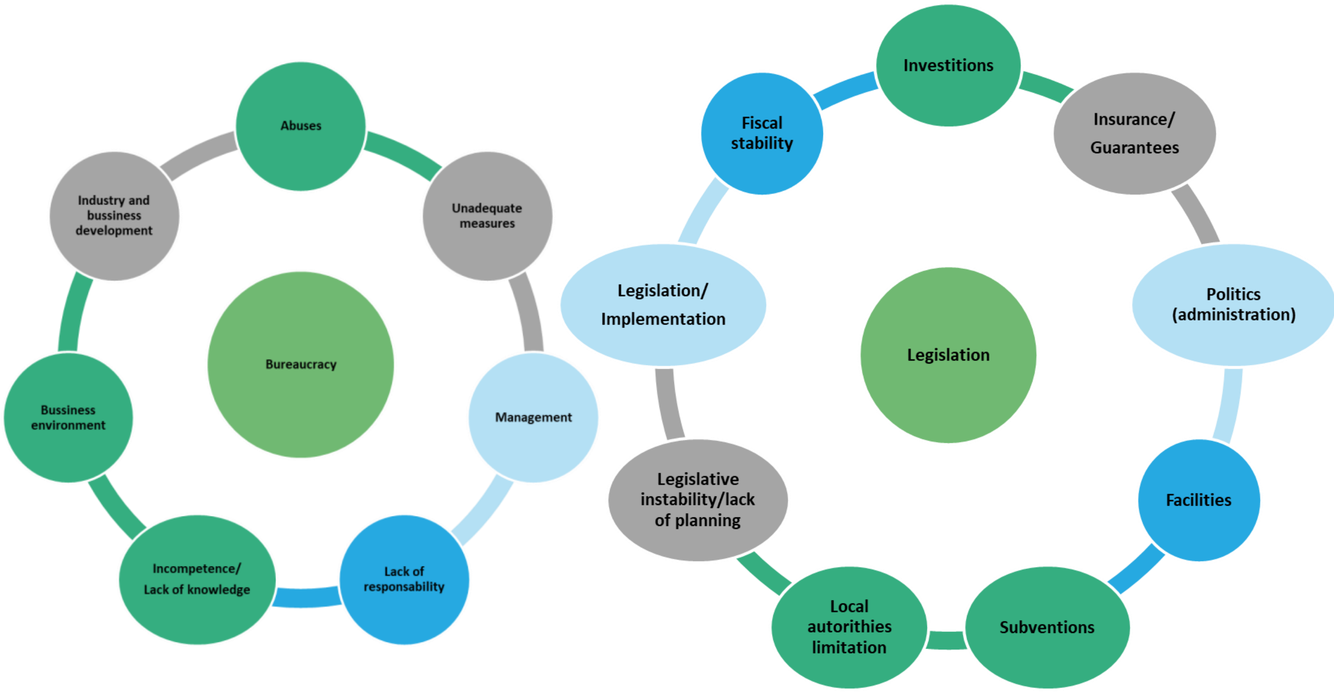

Figure 66: Grouped variables for Tourism (coastal) workshop

The combined diagram includes elements and arrows (causal links) linking the variables together including a sign (either + or −) on each link. These signs have the following meanings:

1. A causal link from one variable A to another B is positive (+) if either (a) A adds to B or (b) a change in A produces a change in B in the same direction.
2. A causal link from one variable A to another B is negative (−) if either (a) A subtracts from B or (b) a change in A produces a change in B in the opposite direction.

Thus, every link in the diagram represent what we believed to be causal relationships between the variables meaning that one variable has a direct effect on another considering short term effects, long term effects, unintended consequences and possible associations. Putting the sign, we took into consideration existing evidence, or consensus amongst us and awareness of our own assumptions.

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Combined CLD shows how the variables are interconnected and the loops are created and analyse their dominance in our case. At this moment, with 60 variables and tens of thousands of loops it is clear that our minds can't process and interpret the system dynamic and any decision taken without modelling is a subject of hazard.

5.4.3.2 Combined Vensim – Regional Mental Map for Danube Mouth (Black Sea)

Finally, the variables in Vensim were combined for all six CLDs by cutting and pasting first model two into model one (the new versions) with different colors. We drew arrows between models, with those that link the variables from one to the other. A full regional model of land-sea perceptions where all variables ideally either have existing data available or at least proxys thereof was made (Fig.5.4.3.2.1). This is the basis for the later SD modelling – but this is also what was presented to the MAL.

Joint variables are outlined by Legislation, Infrastructure, Pollution, Climate Change, Tourism, Fisheries and Agriculture, each found in five CLDs and describing thus the study case main issues.

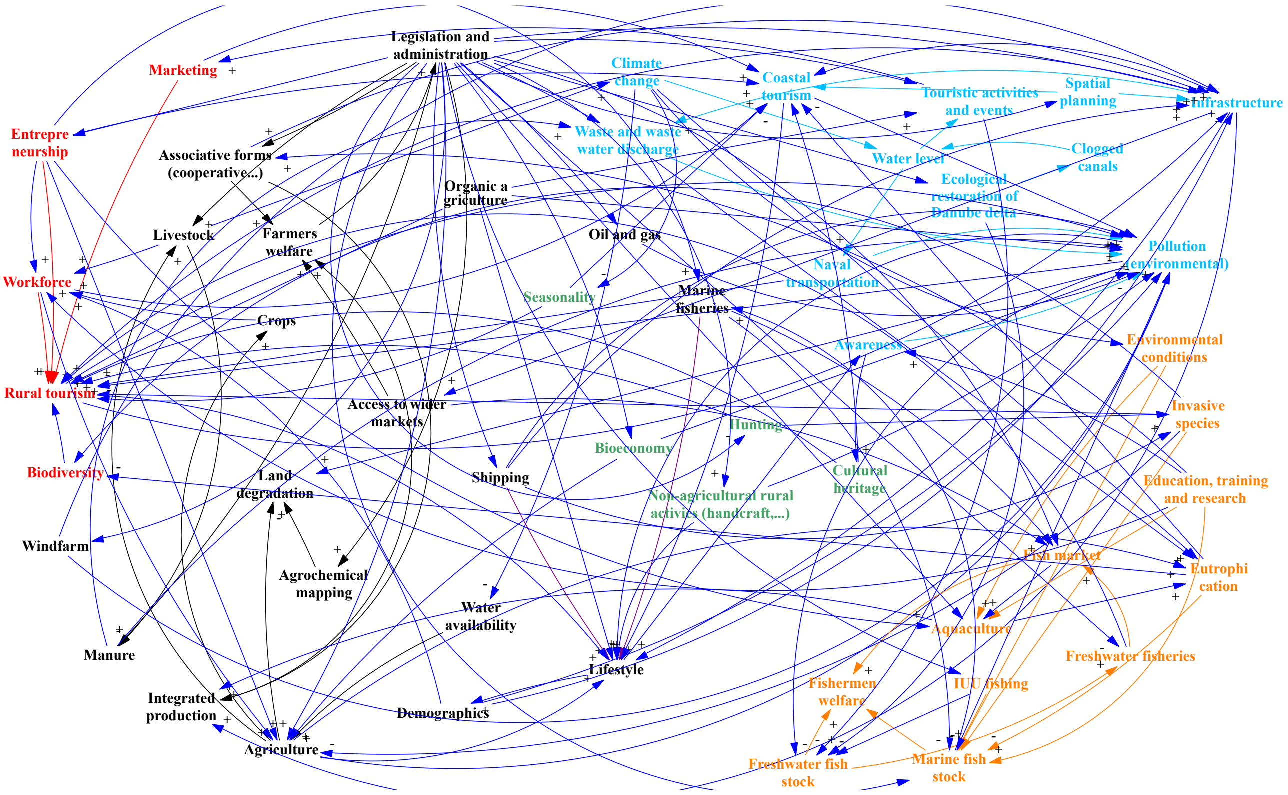

Figure 67: Merged CLD – Romania, 12-14 June 2019

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5.4.3.3 Fuzzy Cognitive Maps

The design of a fuzzy cognitive map (FCM) is a process that heavily relies on the input from experts and/or stakeholders (Hobbs et al., 2002). Thus, after six stakeholder meetings were developed CLDs and FCMs for each. After the experts meeting in June 2019 were merged into one complex CLD and FCM developed to support our group decision-making, allowing to collaboratively represent and test the assumptions about system in "real time", based on a simple, semi-quantitative model and scenarios. Our FCM is the graphical representation of the knowledge about the Danube's mouths – Black Sea coast system and is made up of 60 variables, with density=0.049 and the variable „legislation and administration" being most central (22.5). Centrality is the most important measure for map complexity and is the summation of variable's indegree and outdegree (Bougon et al., 1977; Eden et al., 1992) which shows how connected the variable is to other variables and what the cumulative strength of these connections (N=173) is. According to the FCM there are connections, seven drivers (independent variables) – entrepreneurship, education, training and research, recreational fishing, awareness, seasonality, administration of Danube Delta, and bioeconomy, three receivers (dependent variables) – fishermen welfare, flooding, and land degradation and 50 ordinary variables (Fig.5.4.3.3.1).

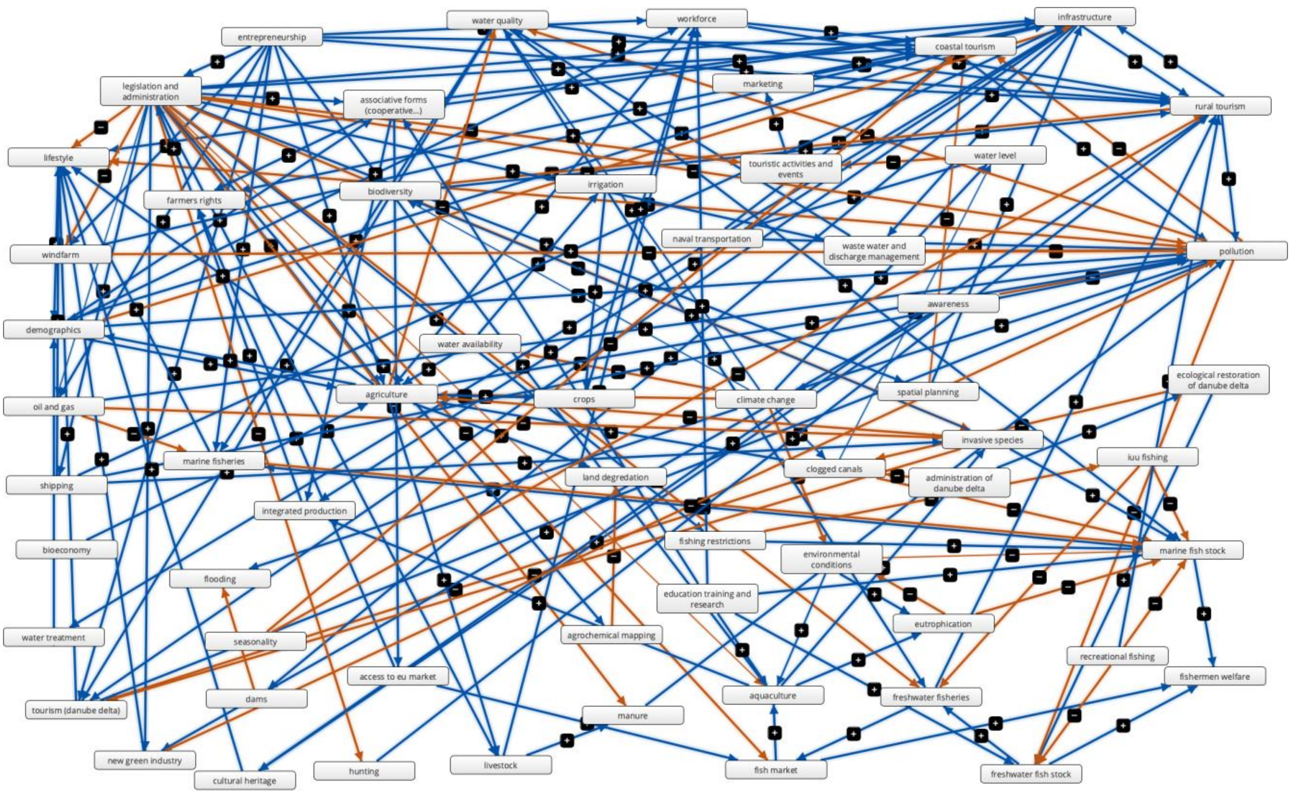

Figure 68: FCM – Romania – based on merged Vensim

Centrality is the absolute value of either overall influence in the model (all + and – relationships indicated, for entire model) and indicates (a) the total influence (positive and negative) to be in the system (Kosko 1986a). The higher the value, the greater is the importance of all concepts or the individual weight of a concept in the overall model. Overall, „Legislation and administration" is the most central (22.5) and had a strong effect on the other variables (outdegree of 20.5) and was affected by an indegree of only 2.0 being involved in more than 20000 loops. Other important variables with high centrality were pollution, agriculture and infrastructure. Because of the high complexity of the FCM, during the mental mapping seminar we didn't add weights (-1..+1). Analysing each FCM we found different centralities, drivers and receivers for each sector.

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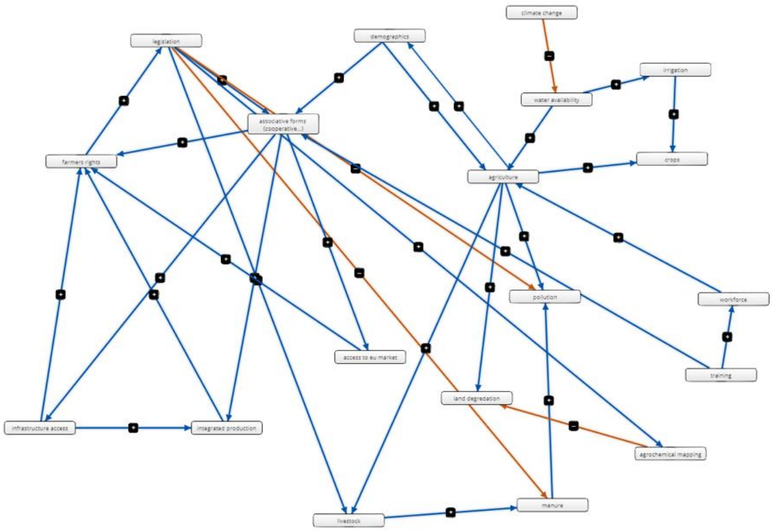

Figure 69: FCM for Agriculture, cross-compliance and ecosystem services - 31 connections, 2 drivers – training and climate change, 3 receivers – pollution, crops and land degradation. Centrality – agriculture, associative forms and legislation

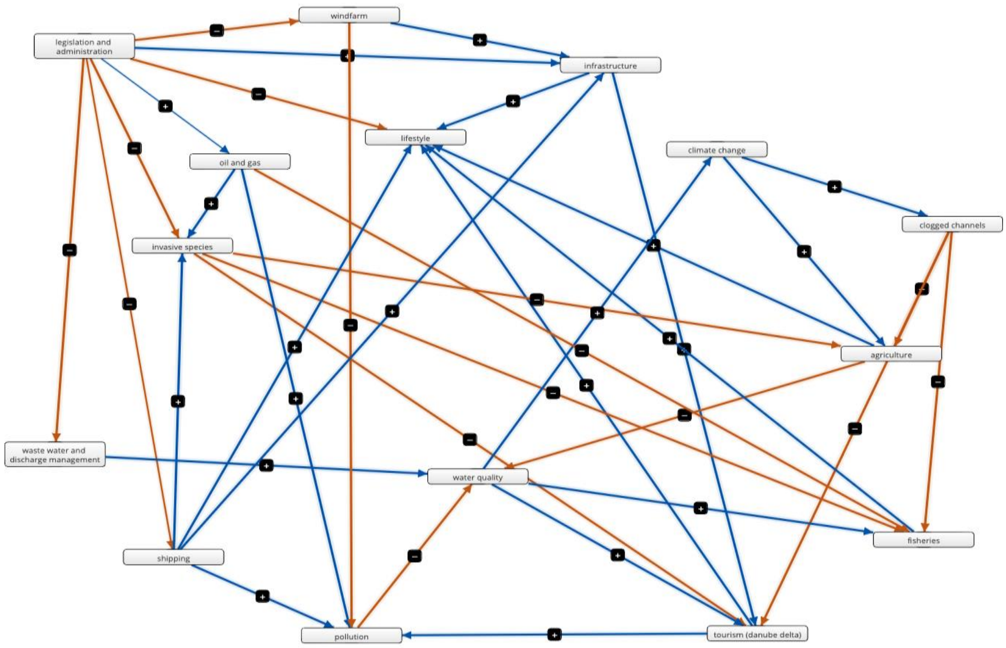

Figure 70: FCM for Blue growth - 36 connections, main driver – legislation, receiver- lifestyle. Centrality – water quality, invasive species, tourism, lifestyle

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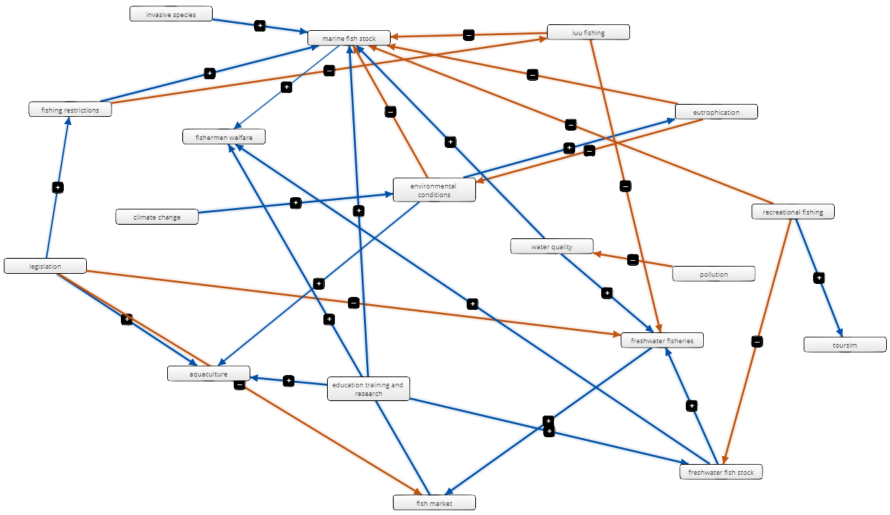

Figure 72: FCM Fishery – 29 connections, main driver – legislation, 3 receivers – most important - aquaculture and fishermen welfare. Centrality - marine fish stock.

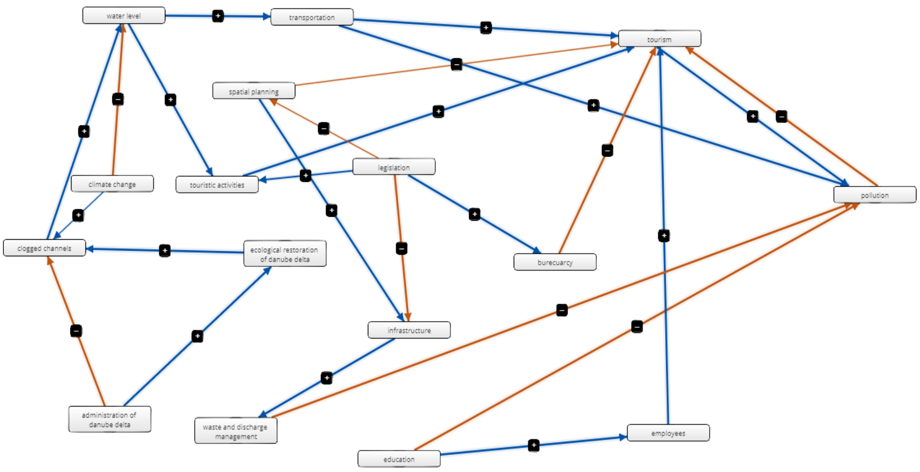

Figure 71: FCM Tourism (coastal) - 25 connections, main driver - legislation and no receivers. Centrality - tourism, pollution and water level.

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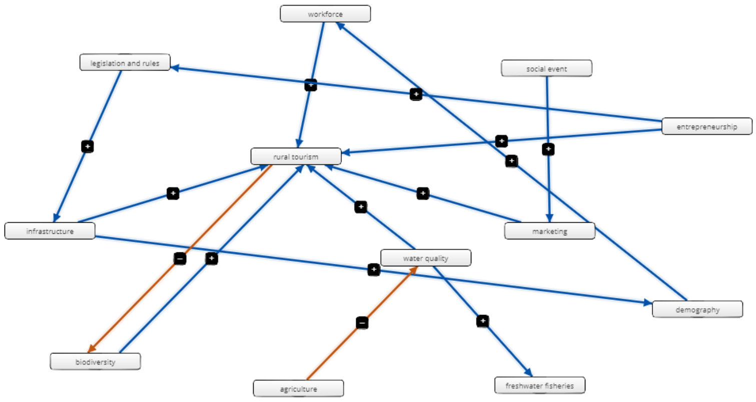

Figure 74: FCM Tourism rural-14 connections, main driver – entrepreneurship; one receiver-freshwater fisheries. Centrality - water quality and infrastructure

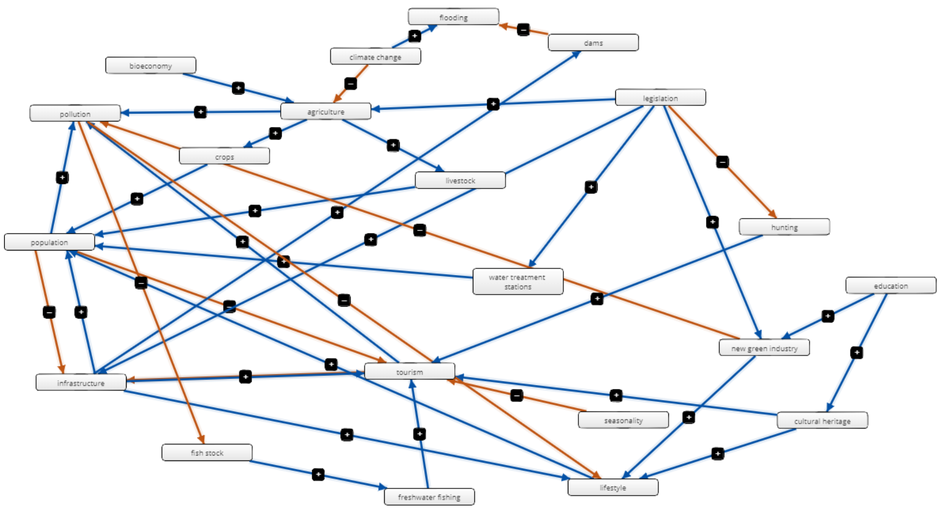

Figure 73: FCM Rural development - 37 connections, main driver – legislation, one receiver - flooding. Centrality - population, tourism and infrastructure.

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5.4.3.4 Scenarios

Participants to MAL developed future scenarios during the multi actor workshops based on results from previous workshops and the simplification process for the Danube's Mouths – Black sea case as follows:

Group 1

The main discussion topic for future development of the Danube Delta and Black Sea coastal area is tourism (generating 90% of the GDP). As fisheries are declining, most of the Danube Delta population is employed in touristic activities. A green friendly tourism should be approached, by promoting electric transportation and clean technologies (e.g. waste-water treatment). Another key-point is preserving the specificity of the zone with regards to traditions, folklore, gastronomy (during summer 2019 were approved by the Sanitary Veterinary Directorate the operation of *Local Gastronomy Points*). Households can function as guesthouses, offering accommodation and catering services, in an authentic traditional environment. Another development direction was promoting of different types of tourism activities - sophisticated travelers following belletristic itineraries, routes based on ancient ruins (Greek, Roman) or following literary/cultural routes: multicultural cemetery of Sulina, Lighthouse of Sulina, the houses of the old owners, 2 wrecks very well preserved. One of the mayors of the villages on the Danube delta upstream envisaged the village as a mini port for cruises on the Danube and tourists are following the neighbouring wine rand archaeological routes. Agriculture practices in the area should change from large land-owners to smaller surfaces cultivated by locals (pre-emption rights) and the resulting products should be used for their livelihood, marketed in local pensions/hotels, and only the surplus (if any) marketed elsewhere.

Group 2

The discussions focused on three main directions, namely aquaculture, tourism and agriculture. The envisaged development of marine aquaculture in the future foresees the legal settlement of the water body concession issue and the implementation of the shellfish areas sanitary-veterinary classification for safe human consumption. For fish farming, on land recirculating aquaculture systems (RAS) are the solution. In a long-term time frame, four shellfish farms, one cage fish farm in open sea and two RAS fish farms on land are desired. Another potential development direction could be the capitalization of chlorophyll from micro and macroalgae. With regards to tourism development, the trend of passing from classic tourism to eco-tourism is clear. The Danube Delta, a rather expensive destination, will be visited especially by foreign tourists whom seek beautiful landscapes and nature, birdwatching, local traditions. For inland rural areas, the future relies on integrated agriculture, namely each community should focus on a complete production: from cereals, animal farming, processing units, in order to deliver finite products. Moreover, lower interest rates for credits and more subsidies are desirable, together with adapting to novel technologies (smart irrigation systems).

5.4.4 Multi-Actor Workshop

The Multi-Actor Workshop was held on 5th September 2019, at the National Institute for Marine Research and Development "Grigore Antipa", Constanta (NIMRD) with the participation of partners from the Research Institute for Agriculture Economy and Rural Development (ICEADR), Local Activity Group Danube Delta (GAL DD), Local Activity Group Central Dobrogea (GAL DC). The meeting was also attended by local actors, representing municipalities, research institutions/academia, authorities, entrepreneurs and civil society. We had participants linked to Research in Agriculture, Water quality and Fisheries sectors coming from different institutes and universities with expertise in those sectors (Table 5).

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Table 5: Overview of participants´ affiliation – Danube's Mouths (Black Sea)

Sector linked to	Participants linked to	Number of participants at MAL
Agriculture and rural development	Research, Academics, LAGs	8
Black Sea water quality	Research, NGO	4
Fisheries and Aquaculture	National Fishery Authority, Entrepreneurs, Research	6
Tourism	Entrepreneurs (Danube Delta)	2
Administration	Village's mayors	2

5.4.4.1 Theme and structure of MAL

The workshop was organized into three parts. For the introductory one, we presented the summary of COASTAL project and the results so far, including Romania's stakeholder meetings CLDs and the merged CLD. It was also presented a model for the Black Sea coastal waters quality considering nutrients (N and P) and chlorophyll *a* concentrations. The model took into consideration some main variables resulting from the participatory process.

In the second part the participants were asked to write down, anonymously, their vision regarding the development of the study case area is. Then they were divided in two working groups, with their expertise evenly distributed and were being asked to discuss scenarios for how our area (Danube's Mouths-Black Sea) will look like in the future. Most of the participants agree to be informed and participate to another MAL (maybe in spring 2020) because they considered the method provides outcome to understand complexity, links, and take decision based on our model. Finally, in the third part of the MAL were discussed the future scenarios as were concluded by the two groups and correlations with the 60 variables found in merged CLD and FCM.

Figure 75: Photos from the MultiActorLab – Constanta, Romania – 5th of September 2019

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5.4.5 Analysis of the outcomes and conclusions

The Danube's Mouths – Black Sea coastal zone represents a special study case because of the natural beauty of the buffer unique area, Danube Delta. Like the entire country, the area was strongly suffering from communism period but also the transition to a new society. Nowadays, 30 years after the revolution and 12 years as European Member State, the impact of legislation and administration expressed as too many, unharmonized legislation and bureaucracy, overlapped with corruption and a demographic decline brought the region in a state which is not desirable as BAU scenario.

All COASTAL meetings (with stakeholders, mental mapping seminar and MultiActorLab) conclusions were in line with the 2030 vision for Danube Delta[7] *"An attractive area – with precious biodiversity and vibrant, small/medium scale (artisanal and modern) agriculture and business - where people live in harmony with nature; integrating economies of tourism, farming and fishery; and supported by urban service centers"*. But the project wants to bring the theory into reality and simulate different options through models and scenarios and to help the decision makers to use the best policies for the area's sustainable development. Thus, based on conclusions so far, we will focus on tourism – as the main option of the coastal area and delta, fisheries, agriculture and rural development as the main sectors of interest. Considering also the improvement of coastal water's quality we'll combine submodels developed with all CLDs and FCMs information for the nominated sectors. Accordingly, we started to collect data for identified variables. This process is still ongoing and could end-up with some changes both for variables, signs or weights.
Few type of data collected are:

- Agricultural branch production by sectors, ownership form, macroregions, development regions and counties - new series (2001-2017).
- Area under irrigation command and agricultural area irrigated, by land use, macroregions, development regions and counties (1997-2018).
- Drainage area, open canals, by land use, macroregions, development regions and counties (1997-2018).
- Land fund area by usage, ownership form, macroregions, development region and counties (1990-2014).
- Park of tractors and of main agricultural machinery in agriculture (end of year) by ownership form, macroregions, development regions and counties (1990-2017)
- Production from aquaculture excluding hatcheries and nurseries (2008-2017)
- Area cultivated with main crops by ownership form, macroregions, development regions and counties (1990-2017)
- Area of the vineyards in bearing by ownership form, macroregions, development regions and counties (1990-2017)
- Crop production by main crop, ownership form, macroregions, development regions and counties (1990-2017)
- Fruit production by fruit species, ownership form, macroregions, development regions and counties (1990-2017)
- Museums and public collections, by counties and localities (2005-2017)
- Mean age of usually resident population by sex, urban/ rural area, macroregions, development regions and counties, at July 1st (2012-2017)

[7] https://www.mdrap.ro/userfiles/delta_dunarii/draft_Danube_Delta_Strategy.pdf

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- Natural increase of the population, by urban/ rural area, macroregions, development regions and counties (1990-2017)
- Permanent resident population, by age group and age, sex, urban/ rural area, macroregions, development regions and counties, at January 1st (1992-2019)
- Rate of natural increase of the usual resident population, by urban/ rural area, macroregions, development regions and counties (2012-2017)
- Staying overnight in the establishments of touristic reception by type of tourists, macroregions, development regions and counties (1990-2018)
- Existing touristic accommodation capacity by type of establishment, counties and localities (1990-2018)

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5.5 France - Charente River Basin (Atlantic Region)

5.5.1 Executive summary

The territory of the MAL4 consists of the Charente River watershed (10 000 km²) and its coastal zone (Mer des Pertuis charentais) ; it is located in the South West of France, in the northern part of the "New Aquitaine" region (Figure 27). The multi-actor workshop was organized by Irstea and the site partners CRANA and FRAB. It was held on the 21st of May 2019, at the Corderie royale at Rochefort close to the Charente river mouth. Twenty four stakeholders selected on the basis of their previous participation to the six sectorial workshops and of their interest for the coastal project attended the inter-sectorial workshop. The rural sector was slightly over-represented. The multi-actor workshop was organized in three exercises carried out by three inter-sectorial sub-groups of stakeholders. The goals were: (i) to simplify and validate the global polished Mind Map by selecting about 15 variables considered as the most relevant to the land-sea system, (ii) to assign weights to the links between variables in each sectorial FCM map, focusing on the variables selected in the previous exercise, (iii) to rank the scenarios that emerged during the six sectorial workshops, and possibly suggest new ones if necessary. The most central variables in the final map of the land-sea system are important focus points of the discussion during the sectoral workshops and reflect the concerns of stakeholders regarding the future of water resources and of the main economic activities on the area, agriculture (land), shellfish farming and tourism (sea). The modelling of several scenarios was for a first indication of the interdependencies inside the land sea system but the outcomes are strongly linked to the weights assigned to the links of the mental maps.

5.5.2 Background

The Charente River watershed (10 000 km²) and its coastal zone (Mer des Pertuis) are located in the South West of France, in the northern part of the "New Aquitaine" region. Summer tourism, agriculture, and shellfish farming are highly developed economic activities. The Nouvelle Aquitaine region is at the forefront in France for tourism and agriculture and in Europe for shellfish farming. The increase of urban coastal population impacts strongly rural areas and protected areas in the many salt marshes or freshwater wetlands. The use of water resources is a key issue both in terms of quality (i.e. pollution by nitrate and pesticides) and quantity (impact on natural environments and availability of drinking water). Drinking water, agriculture and preservation of aquatic environments require large volumes of water, subject to the effects of climate change. The effects of water quality on coastal environment (salinity, planktonic and benthic production) receive little attention from inland stakeholders, who are more focused on concerns relating to water quantity. The impact of inland agricultural activities (cereal crops, vineyards) is felt downstream, in significant sectors for the local economy such as shellfish farming and tourism. At the same time, the two major ports in the area rely on local agricultural produce for a sizeable portion of their business. In addition, the continuous growth in the number of resident retirees and tourists in coastal zones has an important effect on land prices and demand for products and services. All of these issues mean that any significant change in land use and/or sector activities will impact employment in a number of coastal and rural sectors.

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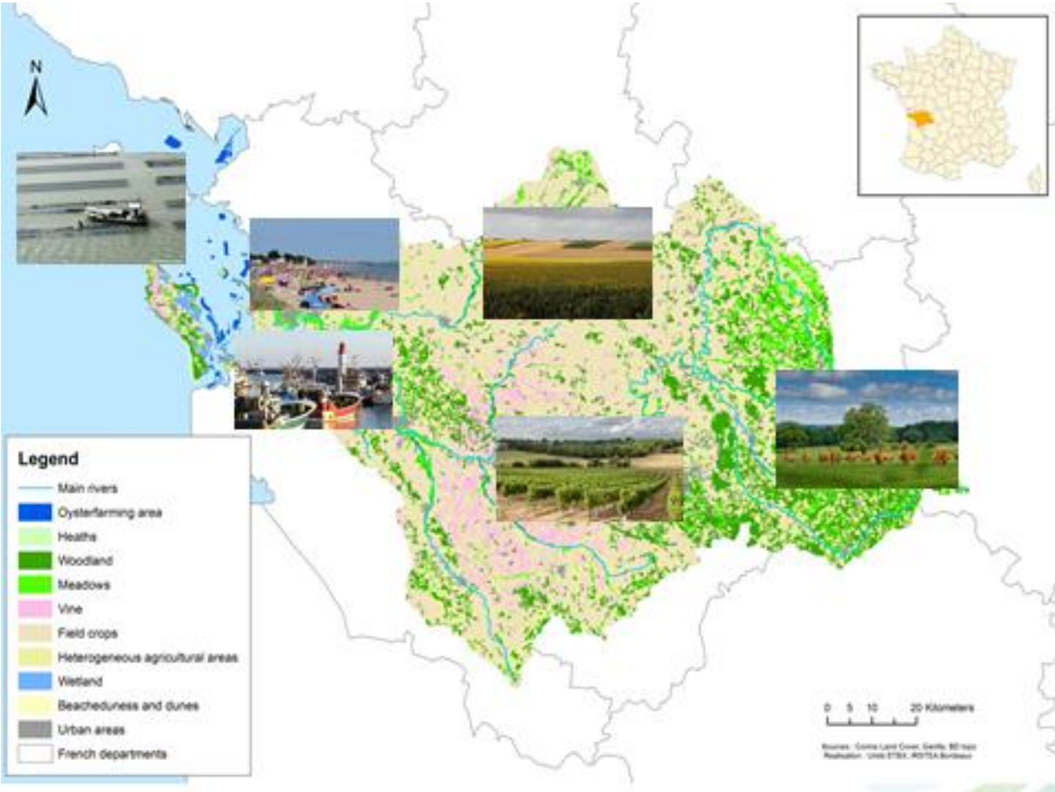
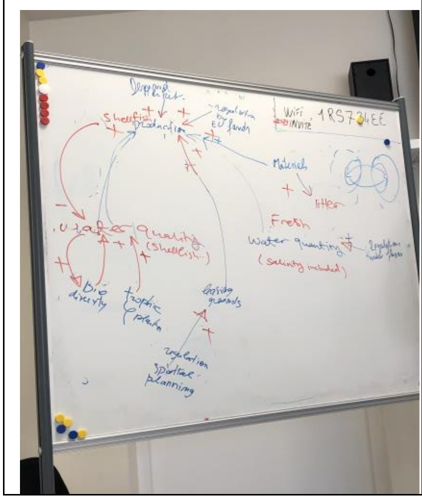


Figure 76: Map of the MAL4 site (SW France)

5.5.3 Mental Mapping Seminar

SINTEF Ocean visited the French partner IRSTEA from February 27 to March 01, 2019. Three persons from IRSTEA and two persons from SINTEF Ocean attended the workshop (Figure 77). It was decided to work out the simplification problem starting from sectorial mind maps built out during the sectorial workshops with rural and coastal stakeholders.



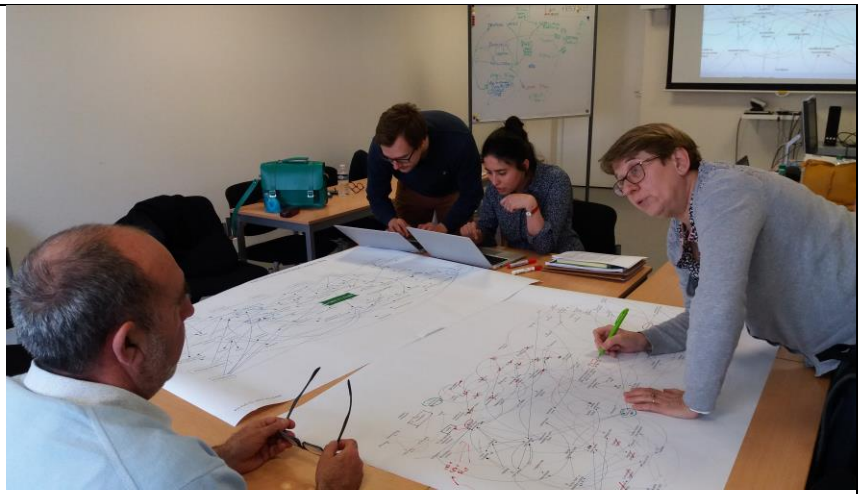


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Figure 77: SINTEF visited IRSTEA to discuss the simplification process

The sectorial mind maps built during the sectorial workshops were indeed quite complicated with several simplifications needed in order to merge these maps to create a global map of the land-sea system.

At the end of the sectoral workshops (November 2018), the total number of variables proposed by the stakeholders was, distributed as follows:

Table 6: Number of variables proposed post sectoral workshops

Environmental Policies	63
Agriculture and agro-industry	52
Shellfish farming, aquaculture and fisheries	85
Water sector	61
Ports Infrastructure	85
Coastal and rural tourism	56

A semantic analyse was performed for each individual workshop, as well as all workshops together. 402 terms (drivers not included) were collected from the co-created mental maps. From the 402 terms collected, we created a final lexicon of 350 different terms by eliminating strict duplicates (exactly the same wing). The term "water quality" was used in 5 of the 6 workshops. The terms 'population increase', 'biodiversity', 'climate change', 'population change', 'export', 'quantity of water' were used in 4 workshops. The terms "Short circuit", "field crops", "tourism", "viticulture" were mentioned in 3 workshops. 23 terms were quoted twice.The simplification process was carried out by gradually phasing out redundant variables or merging similar ones on sectorial mind maps. Some variables and associated links were abandoned because they were considered as less important for land-sea dynamics and/or very difficult to model (for instance, information of the public and its consequences). Simplified maps were then merged one by one using common variables to link the sectorial model in order to achieve the global simplified map of the whole system. An example of a simplified map merging shellfish farming and policies is provided in Figure 78

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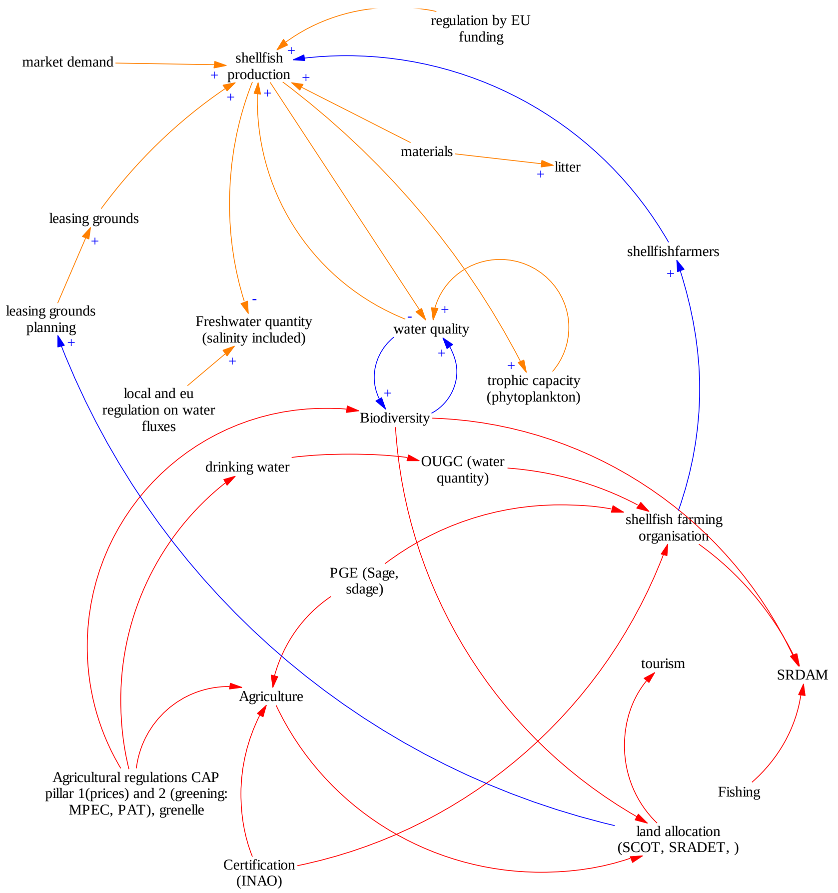

Figure 78: Example of simplified map merging shellfish farming and policies – March 2019

5.5.3.1 Condensed Vensim Diagrams

The sector mind maps simplified during the workshop with SINTEF resulting in the causal loop diagrams are presented and commented in the figures below. The stock flow diagrams will be defined further. This matter will be discussed in two workshops with a limited set of stakeholders and dedicated for one to the rural areas and for the other to the coastal zone. These restricted inter sectoral workshops will be attended by both rural and coastal stakeholders and will be held at the end of October and early November 2019.

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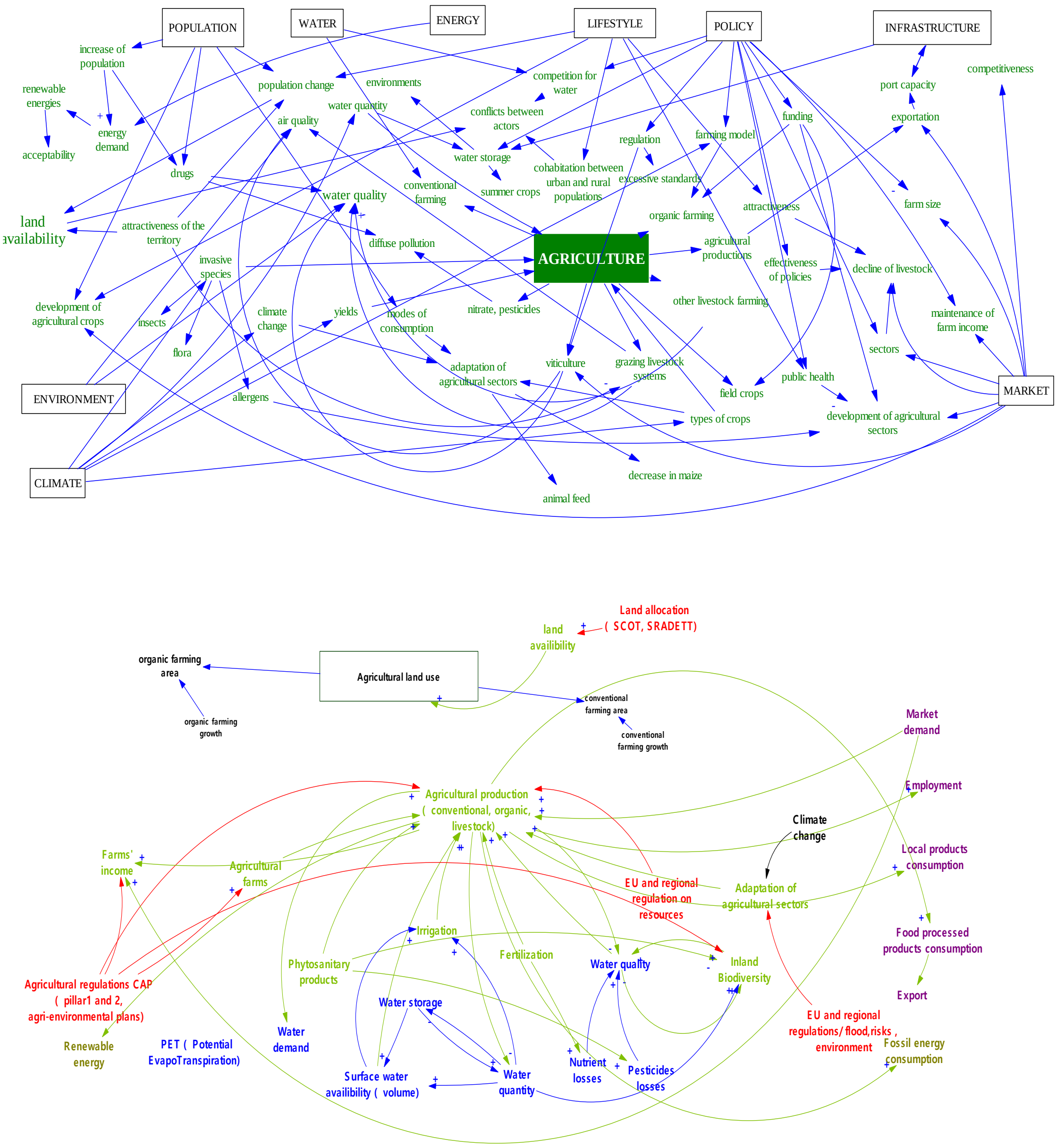

Figure 79: Agriculture/Agroindustry mind maps: original mind maps at the end of the workshops (top) and simplified maps (bottom)

Some drivers were renamed, e.g. “Market” as “market demand”, in order to precise the meaning that stakeholders assigned to the term. Some concepts have dropped, such as the problems of cohabitation between farmers and "new rural people". In the simplified map. Organic farming, conventional farming and livestock variables were merged in global variable entitled “agricultural production” Major concepts like farms income, CAP and agricultural policies, adaptation of agricultural sectors, employment, market demand, and irrigation were kept in the simplified map. Two major issues,

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“access to water resources” and “land availability”, emerged along with the need for an adaptation of agricultural systems and the importance of policies for this highly regulated sector.

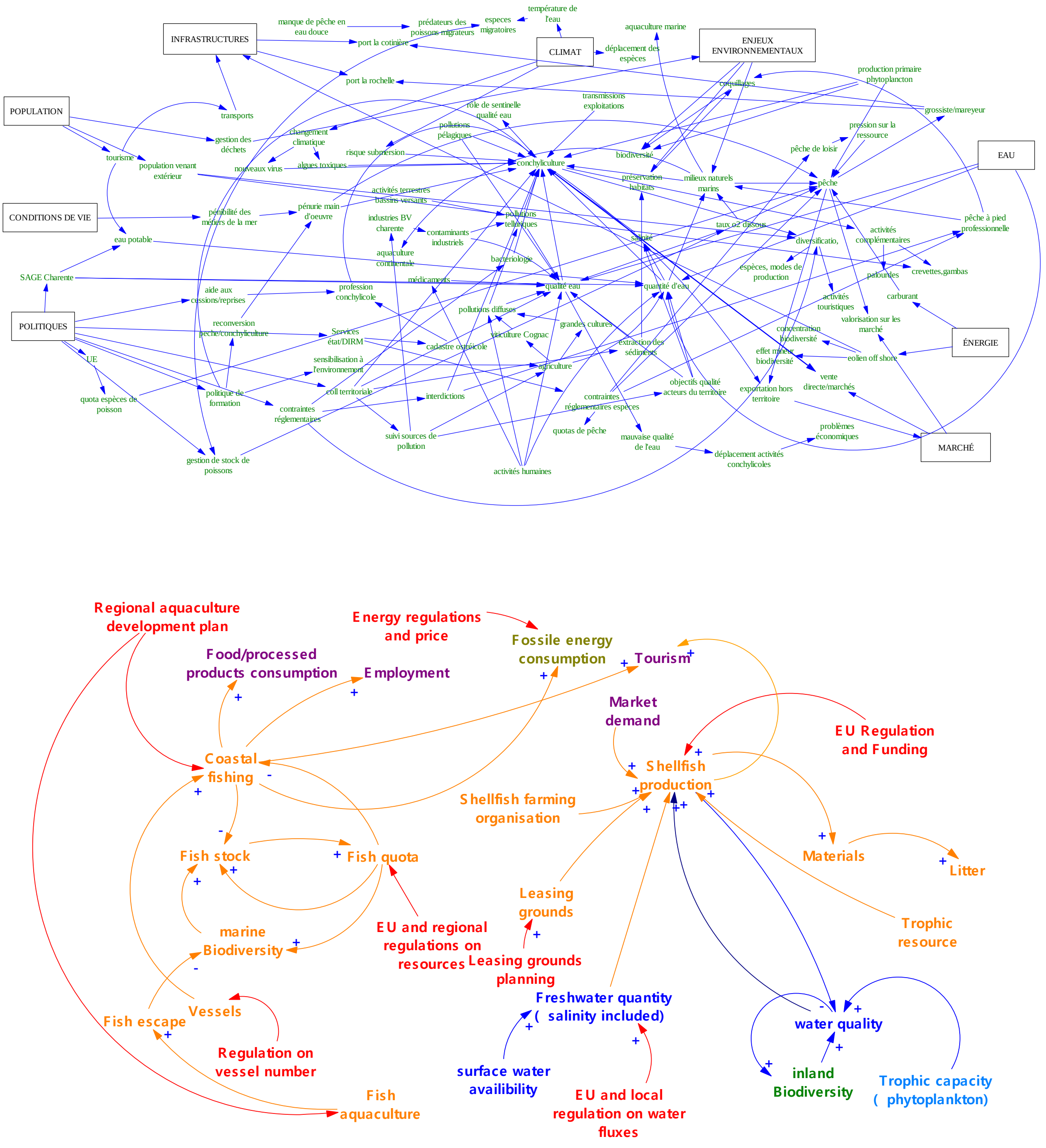

Figure 80: Shellfish farming mind maps (original top simplified bottom)

The importance of regulations for shellfish production was highlighted (7 links from the driver Policy in the original map). Specific variables were created for each kind of regulation. The water issue pops up also from the global map with variables defined as availability of water, quantity and quality on shellfish production. Interdependencies with other activities are highlighted through a range of variables : water quality, freshwater quantity and salinity induced, marine biodiversity, food industry and tourism.

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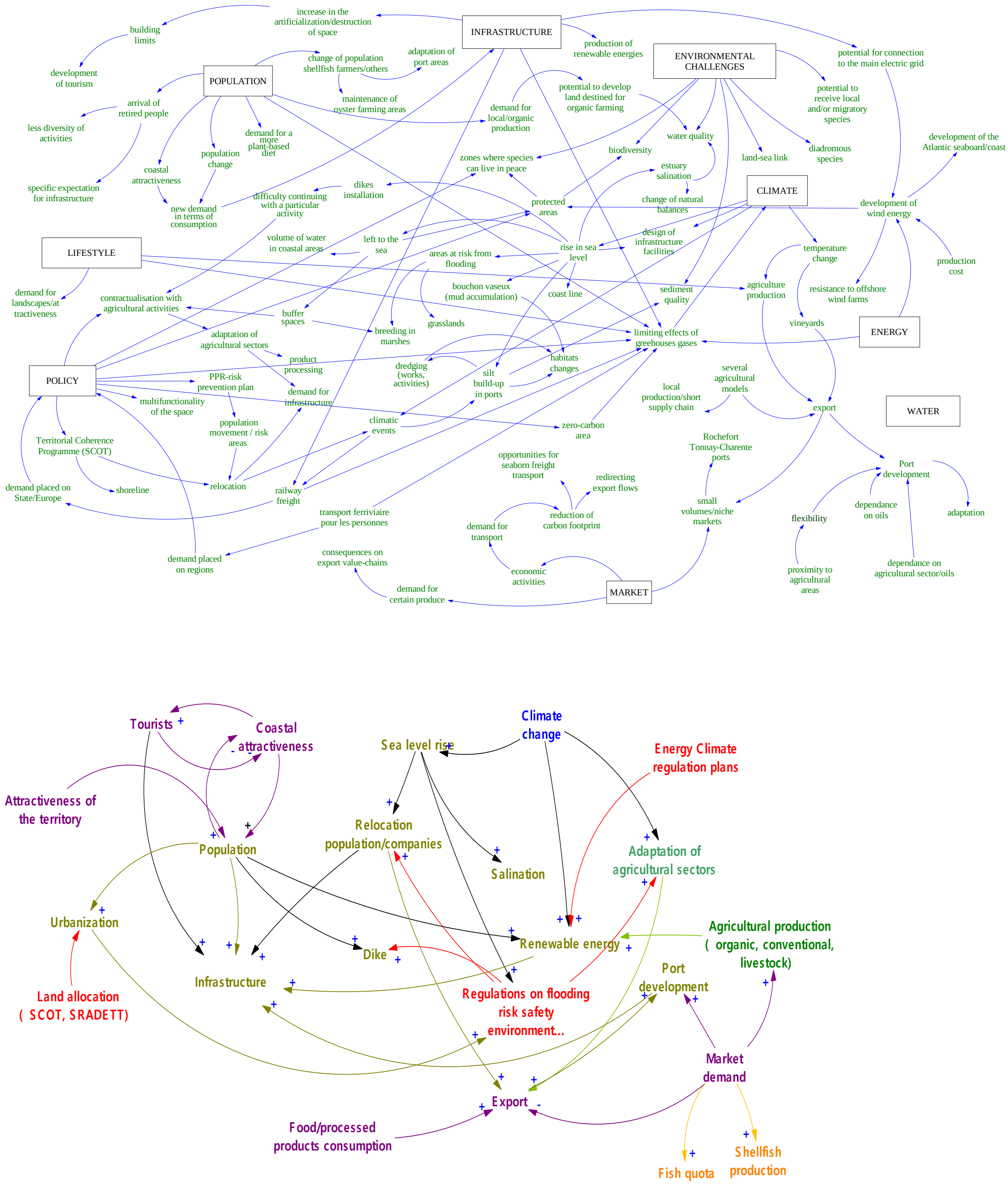

Figure 81: Port & Infrastructure mind maps (original top - simplified bottom)

The main drivers brought out for this sector were policy, climate change and environmental challenges. For policy, the drivers appear more specifically in the relevant regulation variables on the simplified map. Environmental issues are expressed by variables related to energy transition. Because the sectoral workshop was dealing with the subject of infrastructure, the driver "population" has also

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many links with other variables on the original map. In the simplified map, this issue has been translated in more synthetic variables encompassing the variables proposed by stakeholders. The development of ports is linked to the adaptation of agricultural sectors. The competition for space on the coastal zone between urbanisation, population, tourism, agriculture and indirectly natural areas is highlighted through a range of variables.

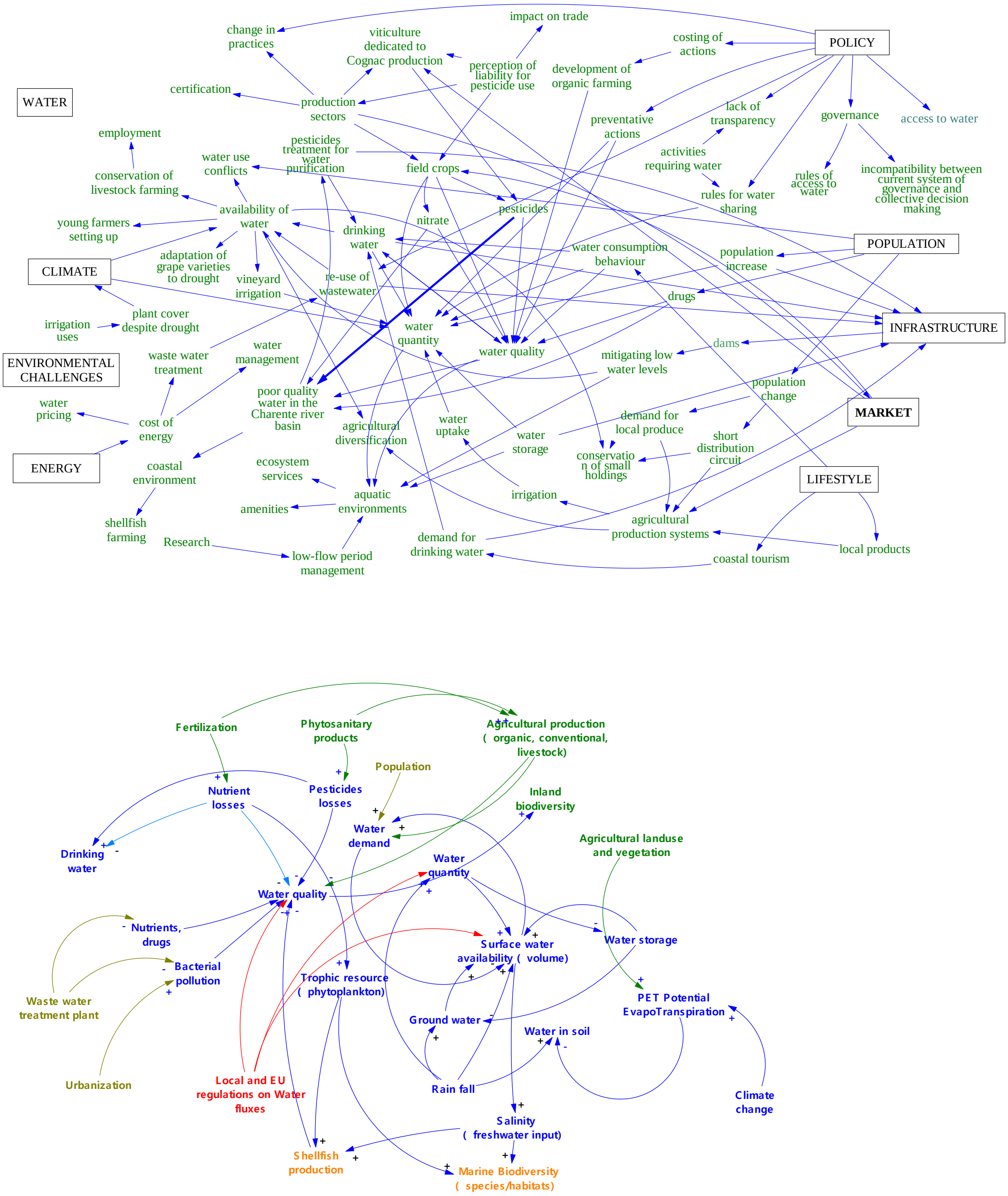

Figure 82: Water sector mind maps (original top - simplified bottom)

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Water is a central theme for the MAL4 case study because there is a strong concern regarding the use of water in the next future and because many of the main activity sectors relay on water availability and water quality. This issue can be easily noticed on the original mind map where all drivers have an impact on the water sector. The drivers "Infrastructure" and "policies" were the main drivers used in the sectoral mental map. However, the driver "Policy" is reinforced in the simplified map. On the causal loop diagram, the variables concerning the water sector appear to be central and related to the variables around agriculture and environment as well as with shellfish farming and the variables related to population. The simplified map reflects all the variables that stakeholders put forward during the first round of sectoral workshops.

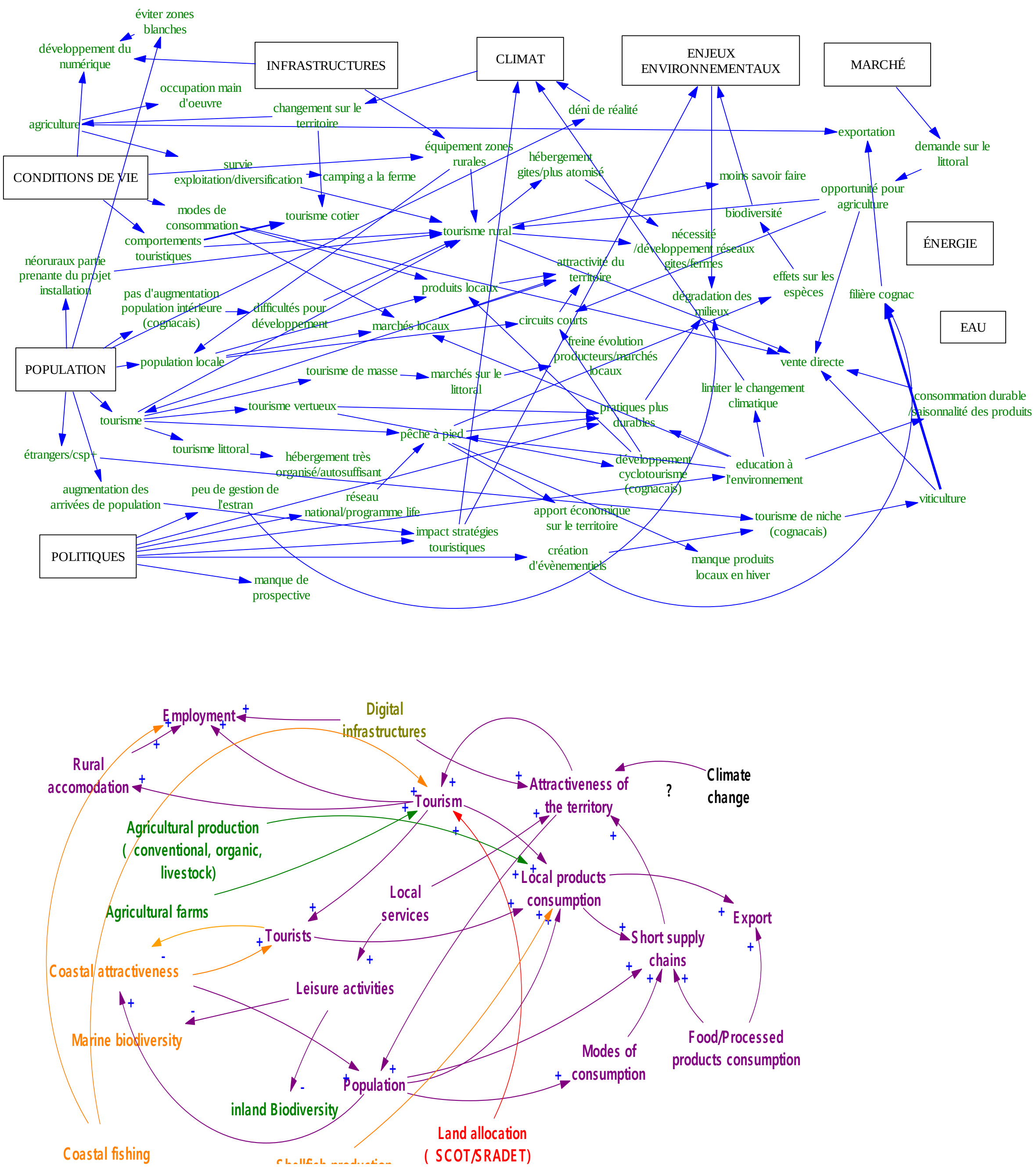

Figure 83: Tourism sector mind maps (original top - simplified bottom)

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The tourism sector is a key activity in particular with regard to the coastal tourism. Tourism is massively coastal while rural tourism is considered niche tourism. Links with many drivers have been proposed by stakeholders during the sectorial workshop, those related to policy and population appearing as the most important. In causal Loop diagrams, the most important regulation appears to be the land allocation which reflects the competition for space. Tourism is strongly dependent on the quality of the environment, the coastal attractiveness and linked to the development of local services and short supply chains.

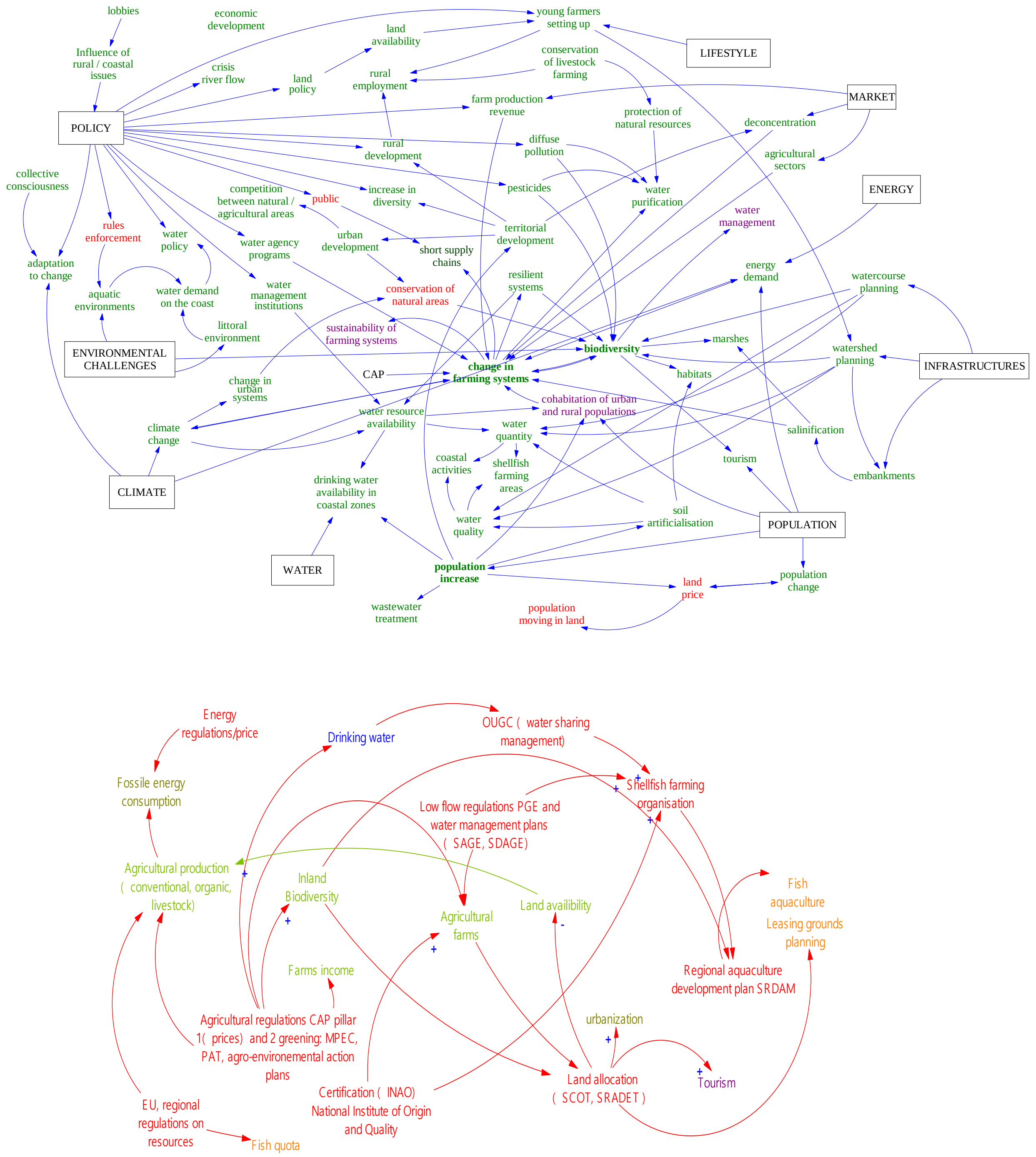

Figure 84: Public Policies sector mind maps (original top -- simplified bottom)

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Agriculture, shellfish farming and tourism are the main economic activities on the area: they are highly regulated and interdependent. Therefore, in the original sector mind map pertaining to public policies, policy is interconnected with almost all the other sectors of the system. Many variables relate to the scope of the regulation to which it refers. They were consequently merged to finally get the specific regulation variable itself. The simplified map takes into account the regulations applying to agriculture, shellfish productions, fisheries, land allocation, water management and the environment. The Causal Loop Diagram shows how these regulations impact the all land-sea system.

After final adjustments (redundancies, coherence…) on simplified sector mind maps, we came back to our site partners (CRANA and FRAB) to finally shape the Global Causal Loop Diagram of the MAL4 system (Figure 85). This diagram was further used for concertation with stakeholders during the inter-sectoral workshop (see paragraph 5.4.4).

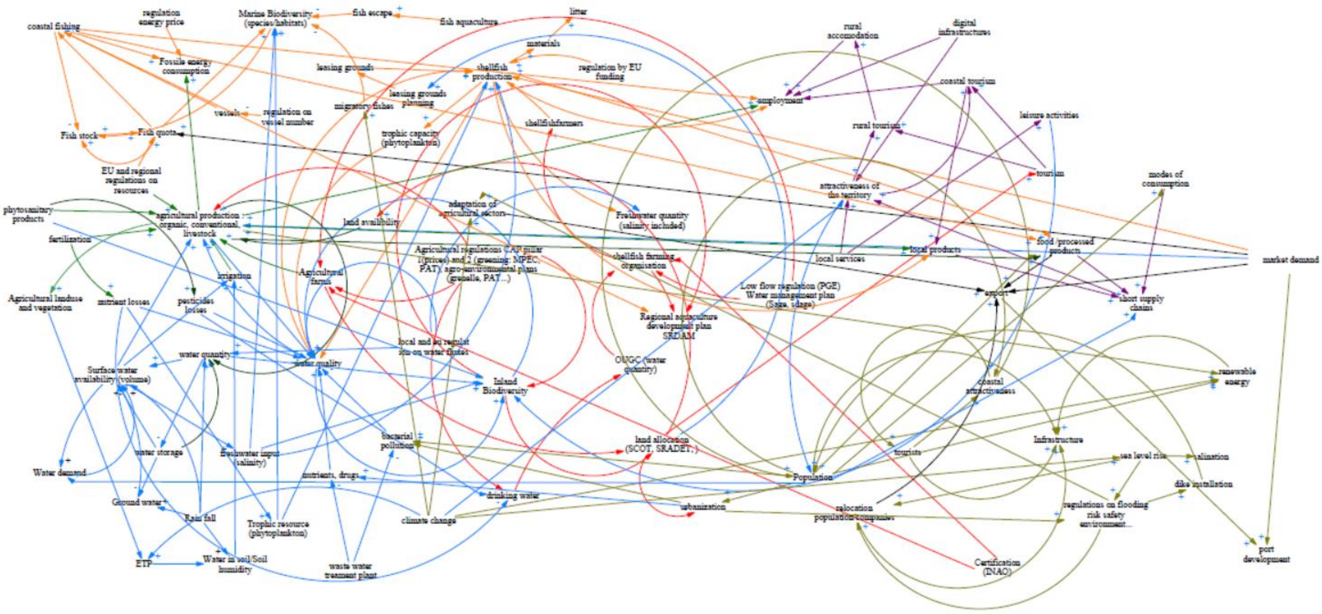

Figure 85. Final causal Loop Diagram of the MAL4 system – March 2019

In parallel, we developed a French-English glossary describing all the variables used in the global Causal Loop Diagram. Definitions of variables were later added to explain briefly what must be understood behind the terms e.g. surface water availability, water demand, water quality, etc. An example of the glossary (for the water demand) is provided below.

Table 7 : An example of the glossary

Variable (French)	Variable (translated in English)	Explanation (Fr and En)
Demande en eau	Water demand	The demand for water often refers to removal from surface waters or groundwater. In the coastal zone, demand for freshwater is measured by salinity. The requested salinity can be estimated by volume or flow of freshwater in the estuary. The demand for water is related to an

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		economic or domestic use and claimed by an institution. The water sharing is managed by local organizations.

With arrows between variables were indicated the causal relationships between variables and drivers on the sector mind maps. These links were discussed during the sectorial workshop with stakeholders. When we focused on the proper representation of the rural-coastal system by polishing minds maps, we added +or – signs at the arrows indicating that the effect is positively or negatively related to the cause.

The way of the links decided by the MAL4 team were afterwards validated during the multi sectorial workshop. We decided to provide blind maps without the way chosen in order to let stakeholders free of their own choice. Positive (reinforcing) and negative (balancing) feedbacks were brought to light during the polishing of the sector mind maps. Some examples of renforcing and balancing loops are presented in the Figure 86 below.

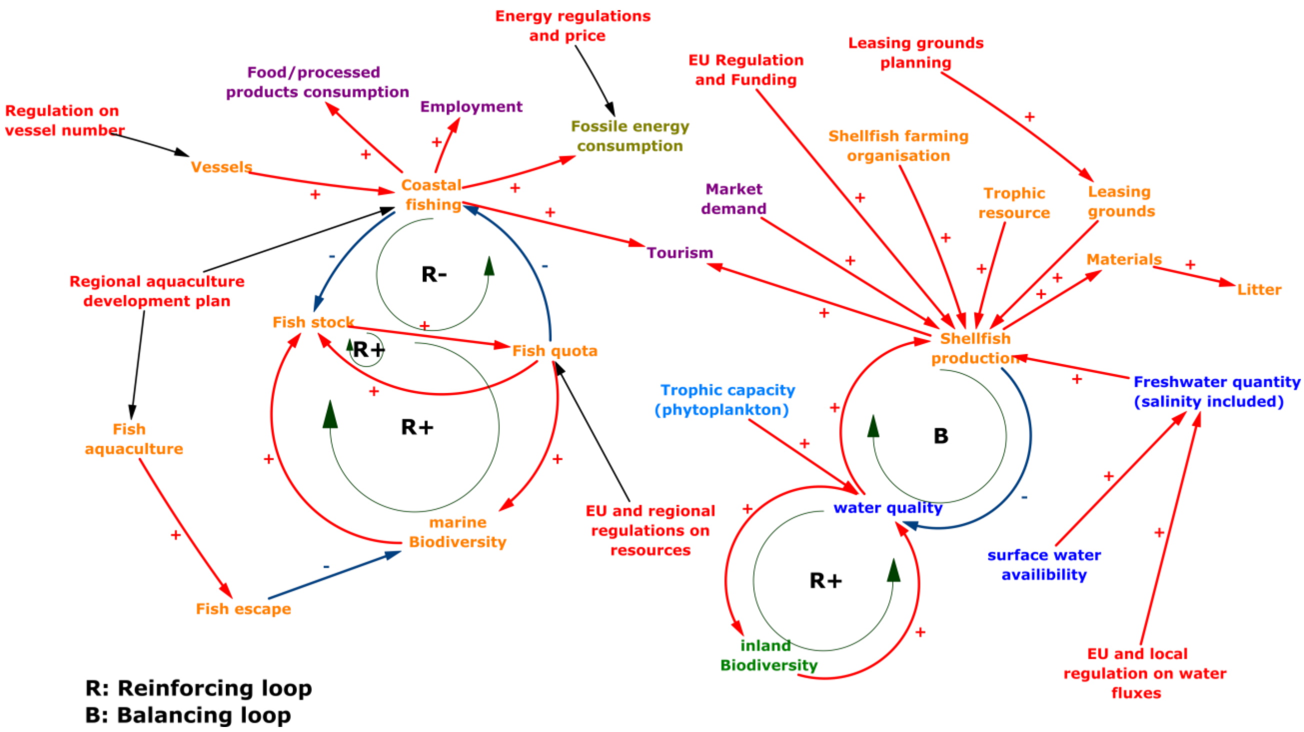

Figure 86. Some examples of causal loop diagrams

5.5.3.2 Combined causal loop diagram for the Charente Land sea system

The final global causal loop diagram was obtained from the six simplified mind maps built during the inter sectoral-actor workshop (see stakeholders 'groups in Figure 87) and the simplification achieved afterwards by the MAL4 team. Many variables used in the different workshops were similar or referred to the same notion. They were then merged and/or renames differentl-

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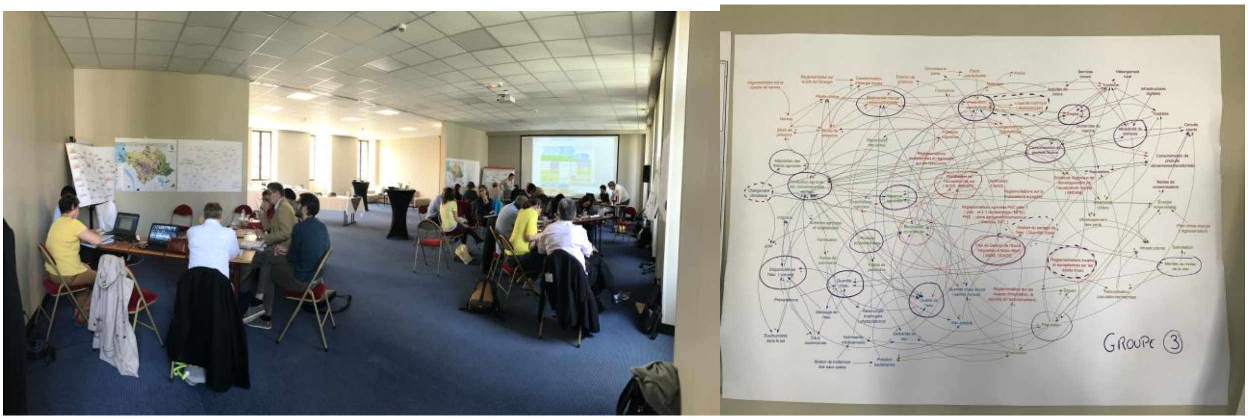

Figure 87. Three sub-groups of stakeholders worked on the mental maps

5.5.3.3 Fuzzy Cognitive Maps

Component and processes that stakeholders believed as essential in the functioning of the Charente case study Land-Sea systems and key relationships between these components were defined though the sector mind maps. They were afterwards highlighted thanks to the causal loop diagrams. Polarity of interactions was assigned by the scientific team to links within the Causal Loop Diagrams characterizing the relationships with fuzzy cognitive-based qualitative values. One exercise of the multi sectorial workshop was then to confirm with stakeholders the assignment of the positive or negative influence between components and then to characterize the relationship by converting qualitative values into semi-quantitative values ranging between -1 and +1.
To cope with the time allocated for the exercise and to allow exchanges on the models, each group had to work only on two sectors (group 1: agriculture and agro-industry/public policies– group 2: water/ shellfish farming, aquaculture and fisheries – group 3: tourism/port, infrastructure, energy).

Links between variable were treated one by one. To facilitate the decision-making process, and to translate qualitative scores of “low”, “medium” or “high” into fuzzy cognitive-based qualitative values, each participants had to vote for each link, using cards translating the sense of low (+or-), medium (++ or --) and high (+++ or ---).

+++ ++ + ? --- -- -

The final score was the score assigned by the majority. Scores decided by stakeholders were further translated by the MAL4 team into FCM values of 0, 0.25, 0.5, 0.75 and 1 respectively with negative relationships encoded as the inverse of the positive relationships.

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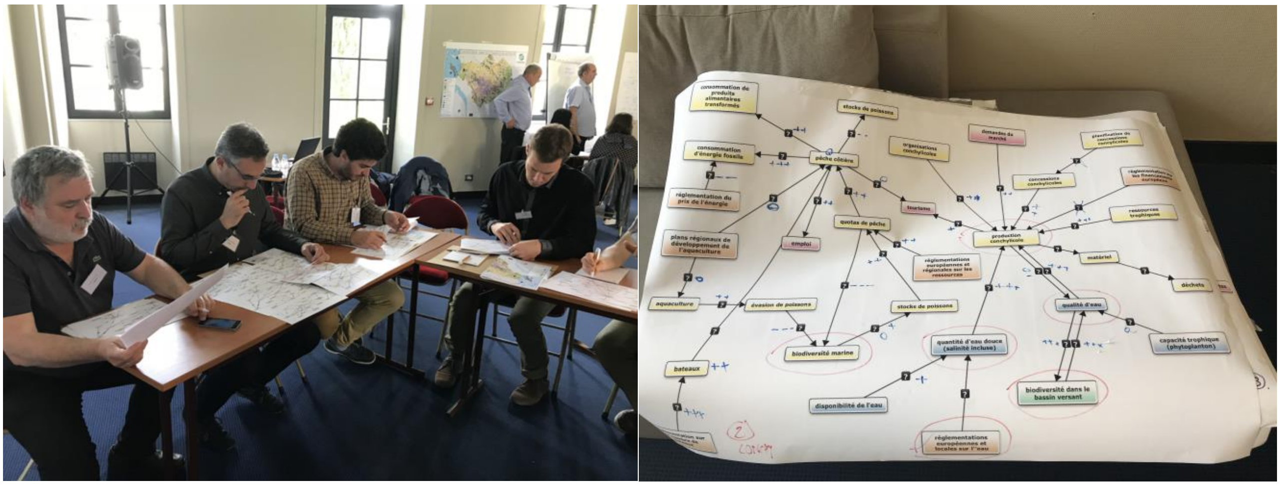

Figure 88: .Two sub-groups of stakeholders working on the FCM maps

5.5.3.4 Scenarios

Scenarios were thereafter performed to determine how the system might react to plausible changes to socio-economic or ecological components within the system. Scenarios were first proposed by stakeholders during the sectoral workshops and then formalized by the MAL4 team. These scenarios (see Table 8) served as a basis for discussion with consideration if a scenario was desirable or likely to happen. The themes of scenarios were then ranked on the basis of the number of times they were designated by the participants. Top ranking scenarios are mainly related to the rural zone and that may be explained by the stakeholders attending the workshop. Another possible explanation may be the importance that stakeholders give to the evolution of agriculture as a critical issue with respect to the preservation of water resources and to the future development of other economic activities.

Table 8: Scenario rank based on the number of time they were mentioned

Scenarios	Total times mentioned
Sustainable agriculture and farming industries	10
Impact of climate change	10
Water Storage	10
Development of organic farming	9
Renewed public policies (climate change)	8
Concentration of population in urban areas and big farms in rural zones	6
Mosaic of landscapes and activities, preservation of the environment	6
Education et public information	5
Public policy for a better management of coastal wetlands	5
Increase pressure on land	5
Public policy to develop sustainable tourism	4
De-carbonatation of the territory to reduce environmental footprint	3
Decrease of farming activity, especially livestock systems and consequences	3
Maintaining present farming systems. Preservation of breeding	3
Development of solar and offshore wind power energies	3

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Increased population in coastal areas	2
Development of sustainable shellfish farming	2
Development of a biomass energy sector	2
Evolution of the anthropic pressure	2
Adaptation of infrastructure linked to sea level rise.	1
Changes in wine practices	1
Digital development and associated infrastructures	1

After the inter-sectoral workshop, five scenarios were retained by the MAL4 team for scenario analysis using Mental Modeller software. The selection was made on the basis of the importance the stakeholders gave to scenarios and the relevance for the land-sea system. These five scenarios are the followings:

1. Increased population in coastal areas (most likely to happen)
2. Sustainable agriculture and farming industries (most desirable)
3. Water storage (most likely to happen)
4. Decrease of the anthropic pressure (most desirable)
5. Development of sustainable shellfish farming (specific to Charente River basin)

To model scenario, formalization of the scenarios was carried out by identifying variables that cause the scenario, and define the evolution of other variables.

Thus for example, the scenario “increased population in coastal areas” is generated by a sharp increase of the population. The evolution attributed to the variable was +0.9. This course of action was carried out for the five scenarios. To control sensitivity of the scores on the result, scenarios were run 3 times, with an average value and positive and negative deviation of 0.1 (named min and max) around this value (cf.Table 9).

At first, Conventional, Organic and Livestock agriculture production were considered separately for Agricultural production. Because of the too high number of links between variable leading systematically to programme crash, the three types of agricultural production were merged in order to carry out scenarios analyses. Outcomes of the modelling of scenarios were analysed by comparing results with what may be intuitively expected by expert opinion. Results are presented in figures below (Figure 89 to Figure 93).

Table 9: Summary of the FCM values used for each scenario

		Values of variable evolution for scenarios														
Variable	Type	Increased population in coastal areas			Sustainable agriculture and farming industries			Water storage			Decrease of the anthropic pressure			Development of sustainable shellfish farming		
		min	av	max	min	av	max	min	av	max	min	ave	Max	min	av	max
Agicultural production conventional, organic, livestock					+0.4	+0.5	+0.6	+0.5	+0.6	+0.7	-0.01	-0.1	-0.2			
Phytosanitary products, nutrients	Driver				-0.2	-0.3	-0.4									
Farm income	Receiver															
Inland biodiversity																

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Agricultural farms					+0.1	+0.2	+0.3									
Adaptation of agricultural sectors	Receiver															
Water storage								+0.7	+0.8	+0.9						
Water quantity																
Water quality																
Surface water availability (volume)																
Water demand					-0.2	-0.3	-0.4									
Domestic water pollution					-0.1	-0.2	-0.3									
Climate change	Driver															
Attractiveness of the territory																
Tourism								+0.2	+0.3	+0.4	-0.2	-0.3	-0.4			
Short supply chains					+0.4	+0.5	+0.6				+0.01	+0.1	+0.2	+0.01	+0.1	+0.2
Modes of consumption																
Market demand	Driver				+0,1	+0.2	+0.3									
Employment	Receiver															
Export																
Local products consumption					+0,05	+0.15	+0.25				+0.01	+0.1	+0.2	+0.01	+0.1	+0.2
Local and EU regulation on water fluxes	Driver				+0,1	+0.2	+0.3	+0.01	+0.1	+0.2	+0.2	+0.3	+0.4			
Agricultural regulation CAP etc...	Driver				+0,1	+0.2	+0.3				+0.01	+0.1	+0.2			
Land allocation (SCOT, SRADET)					+0,01	+ 0.1	+0.2				+0.1	+0.2	+0.3			
Low flow regulation (PGE), water management plan (SAGE, SDAGE)	Driver										+0.01	+0.1	+0.2			
Land availability								-0.01	-0.1	-0.2	+0.1	+0.2	+0.3			
Marine biodiversity	Receiver															
Shellfish production																
Trophic capacity														+0.2	+0.3	+0.4
Coastal fishing	Driver															
Population		+0.8	+0.9	+1				+0.2	+0.3	+0.4	-0,4					
Urbanization																

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Port development											-0,1					
Infrastructure	Receiver															
Sea level																
Industry	Driver										-0,1					

The first scenario deals with the Increase of the population in coastal areas. Differences of 0.1 in outcomes were not considered to be significant. The increase of population has the strongest positive influence on the amount of infrastructure, which is also the most sensitive variable with water demand and urbanization. Negatives outcomes -although very limited- affect variables such as surface water availability and agricultural production

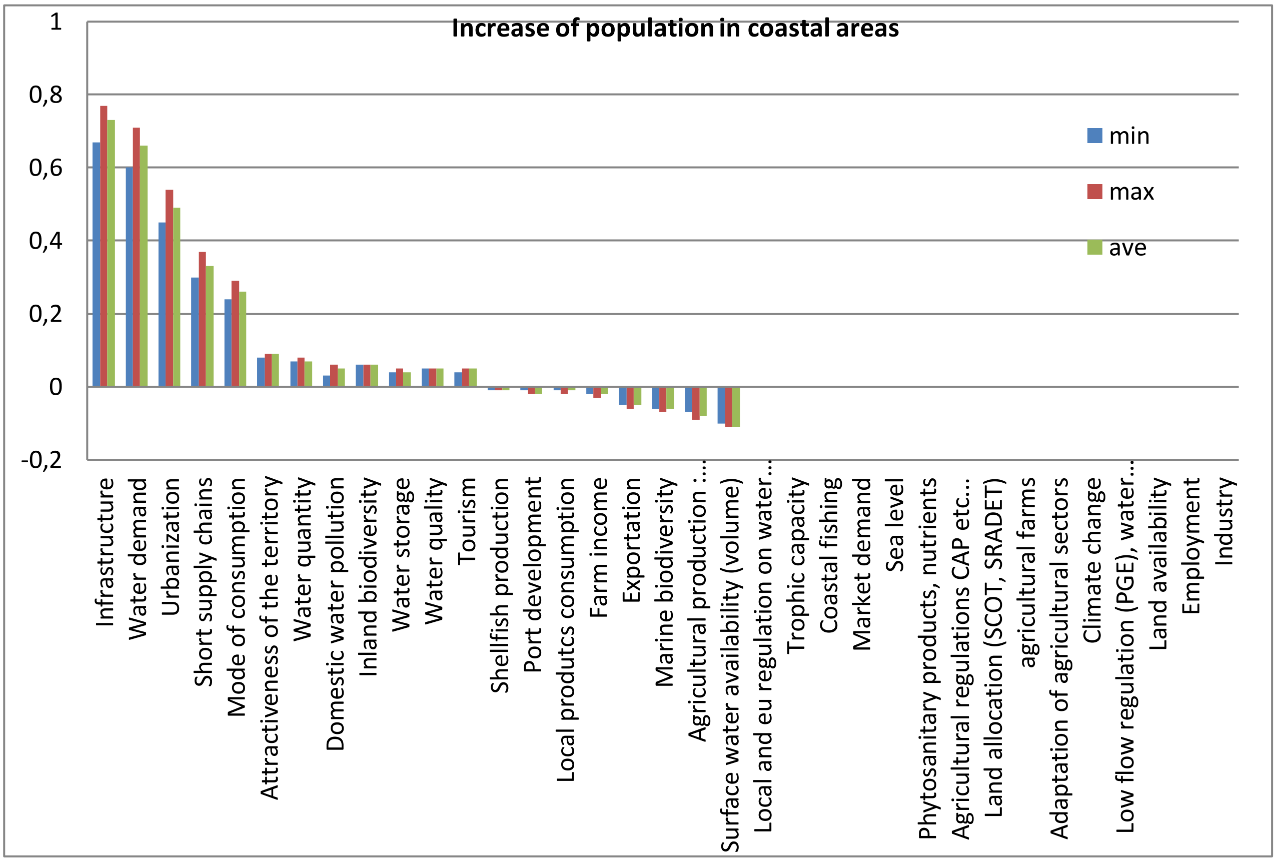

Figure 89: Outcomes for the scenario Increase of population in coastal areas. Variables without values are not affected.

The second scenario focuses on the Development of Sustainable Agriculture and Farming industries. Relative change of system variables affects mainly the employment, the water quality, the biodiversity and the shellfish production. These variables refer to sustainability of the system. Other variables are impacted positively: export and subsequently port development and infrastructure and also farm income. Negative change of water quantity seems counter intuitive (if sustainable agriculture) but might be explained by the merging of all types of agriculture in one variable (agricultural production). Water storage seems pegged with water quantity, the decrease of one variable implying a similar decrease in water quantity and availability. Variables without values are not affected.

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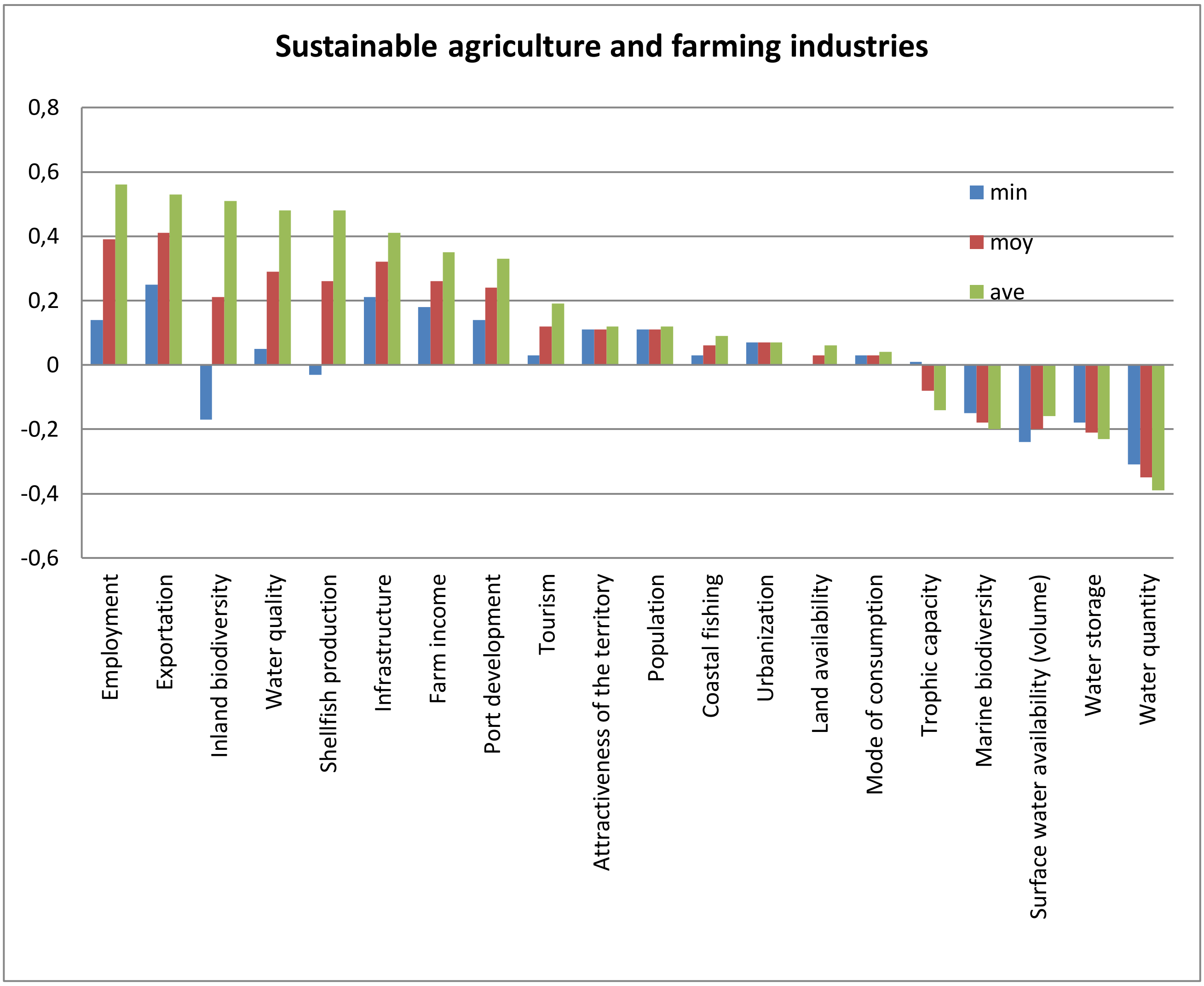

Figure 90: Outcomes for the scenario Sustainable agriculture and Farming industries. Only affected variables are represented.

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Next scenario focuses on the *creation of Water Storage infrastructure*. An increase of water quantity and availability is expected from this scenario. Results show however the relationship between water demand and water availability. The building of Water storage infrastructure increases water availability that increases in turn water demand. With climate change and greater constraints on water resource, such outcomes require further discussion with stakeholders. Some stakeholders think that water storage could be a solution to issues around water quantity. This opinion is controversial because other stakeholders think this solution discards the large water circle. It is also interesting to note that most of the variables are positively impacted, revealing the importance of the water issue for this case study. Negative changes of some system variables are not considered to be significant.

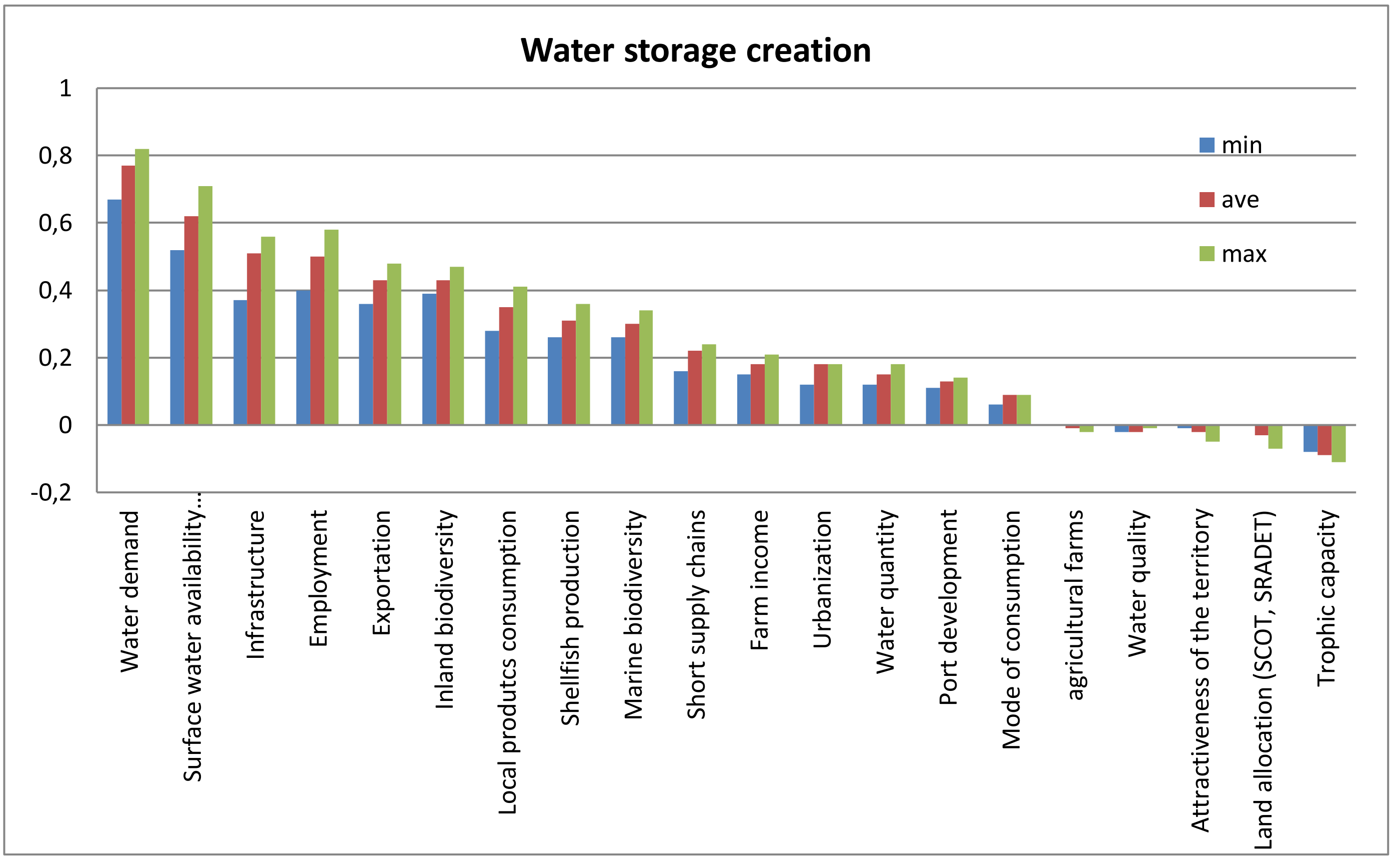

Figure 91 Outcomes for the scenario Water storage creation (only affected variables are represented).

The fourth scenario focuses on the *Decrease of the anthropic pressure* for a sustainable development of the land-sea system. As could be expected, the scenario output shows a positive impact on natural resources such as biodiversity, water quality, water availability and shellfish production. The decrease in infrastructure, water demand and urbanization is an unsurprisingly consequence of the decrease in anthropic pressure.

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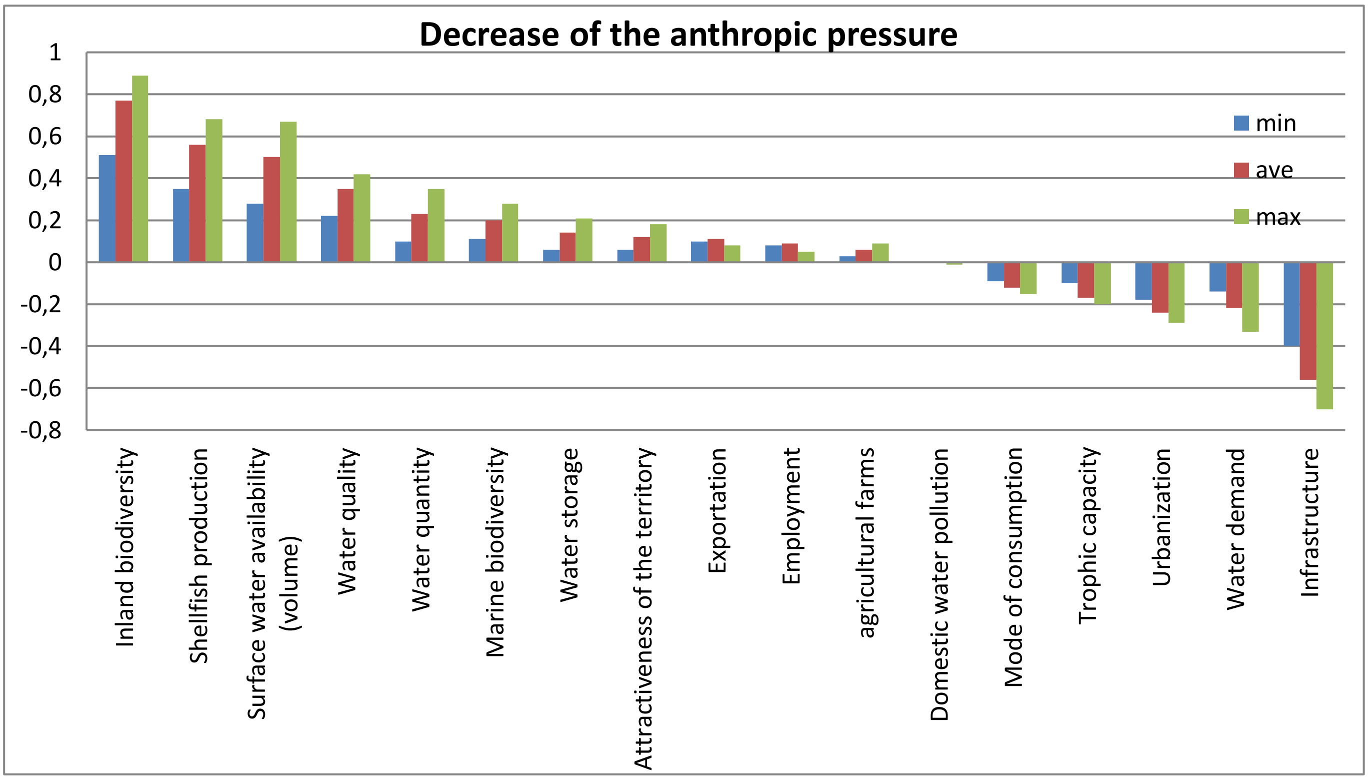

Figure 92: Outcomes for the scenario Drecrease of anthropic pressure (only affected variables are represented).

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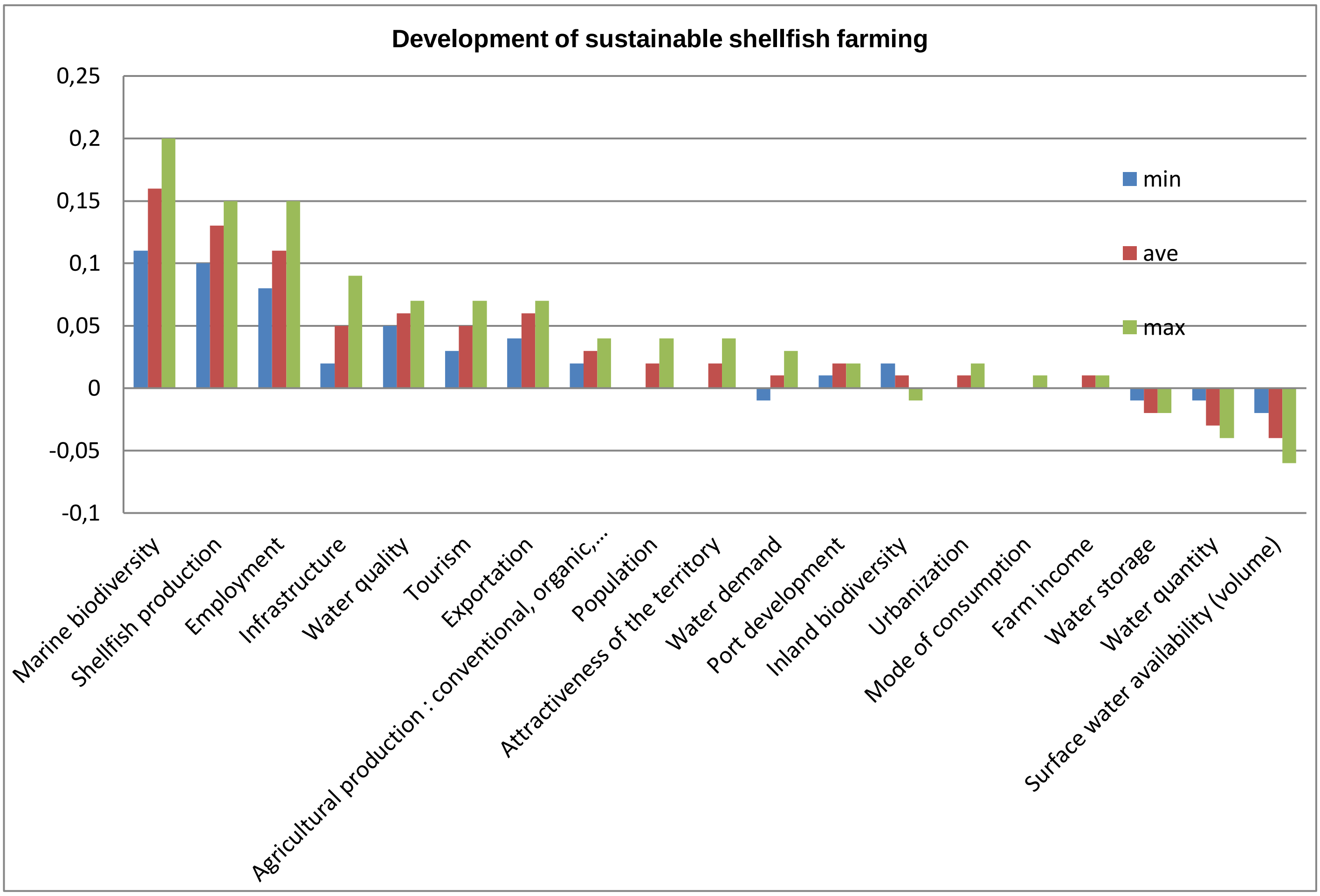

Figure 93: Outcomes for the scenario Development of Sustainable Shellfish Farming (only affected variables are represented).

A sustainable shellfish production impacts positively and unsurprisingly the marine biodiversity, the shellfish production itself and the employment. Tourism, infrastructure and water quality are also positively impacted: this outcome can be explained by an increase in the coastal attractiveness.

This exercise is interesting for stakeholders because they can see the interdependencies inside the land sea system but the outcomes are strongly linked to the weights assigned to the links of the mental maps.

The analyses of Mental Modeler outputs provide a first indication on the interdependencies of components of the land-sea system, useful for stakeholders. However and this could be expected:

- The outcomes strongly depend on the weights allocated for each link by stakeholders,
- Relationships between components can't be translated by a simple link,
- Some variables (for instance, agricultural production) need to be split into more relevant variables (organic farming, intensive farming),
- Outputs are very sensitive to slight changes of weights,

All this issues will be discussed in the next scheduled multi-actor meetings.

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5.5.4 Multi-Actor Workshop

5.5.4.1 Theme and structure of MAL

Twentyfour stakeholders selected on the basis of their previous participation to sectoral workshops attended the inter-sectoral workshop. It was more difficult to gather coastal actors and consequently the rural sector was slightly over-represented.

The seminar was split into 4 sessions over the morning and ended with a buffet.

The objective of the first session was to recall the challenges and methodology of the COASTAL project: The presentation covered the following topics: (i)a reminder of the objectives of COASTAL, (ii)the main purposes of the Multi-Actor Workshop, (iii)the outcomes of the previous sectorial workshops, (iv)the sharing of simplified maps for each sector and of the global mind map built after the SINTEF seminar and from the collective work of the MAL4 team, resulting from the merger of all the sector maps, (v) and finally the scenarios progressively formalized.

After the presentation, participants were divided into three smaller groups representing at least three sectors each. In this section, the three groups had to work on three separated exercises.

The first one focused on the identification of the key variables in order to simplify the global map: Each group had to select around 15 variables that they considered as the most relevant for coastal and rural interactions. Participants were working on the global mind map displayed on the wall, with a facilitator from the MAL4 team circling the variables chosen by participants. They were given individual maps and a list of variables to help their understanding of the simplified model. Depending on the group, a discussion or a vote were used to reach a consensus. The global map modified by each group was used in the next exercise. The three results were further analyzed by the MAL4 team to provide the final simplified map.

The objective of the second exercise was the weights estimation for the links between variables. To cope with the time allocated for the exercise and allow fruitful exchanges on the models, each group had to work only on two sectors.

The last exercise aimed at clarifying the scenarios developed during the sectorial workshops, and formalized by the scientific team and if necessary to propose new scenarios. Stakeholders worked individually to select six scenarios that are "*the most likely to happen"*, six scenarios that "*they want the most to happen"*, and suggest if needed "*new scenarios"*. This exercise was carried out by each participant, individually.

The Multi-Actor Workshop was held on the 21st of May 2019, at the Corderie royale at Rochefort close to the Charente river mouth, France .

Table 10 : Overview of participants´ affiliation - Charente River Basin (Atlantic Region)

Sector they represent	Participants linked to	Number of participants at MAL
Agriculture and agro-industry	Regional government – rural development	7
Agriculture and agro-industry	Agricultural cooperative	1
Water	Public institution - water management	3
Water	Regional government – water management	1
Water	Mixed economy company – water management	1

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Shellfish, aquaculture and fisheries	Departmental Government – Sea and Coastal management	1
Shellfish, aquaculture and fisheries	Public education and vocational centre – shellfish farming	1
Shellfish, aquaculture and fisheries / tourism	Regional government – shellfish farming	1
Shellfish, aquaculture and fisheries	Consulting agency	1
Public policies	Public institution – coastal protection an management	2
Public policies	Public institution – rural policy	1
Tourism	Rural tourism	1
Water	Wine company - Research and development	1
Port, infrastructure, energy	Regional government	1
General	Research institution	8

5.5.5 Analysis of the outcomes and conclusions

5.5.5.1 Simplification of the global map with stakeholders

The first exercise (see paragraph 5.5.4.1) helped to decrease of the number of variables by more than half. 36 variables remained from the 86 initial variables. Each group selected a different number of variables to keep (28, 12 and 16 variables depending on the group). However, 32 remaining variables on 36 were chosen by at least 2 groups. The Figure 94 shows the variables selected by one or several groups, with the sector specified.

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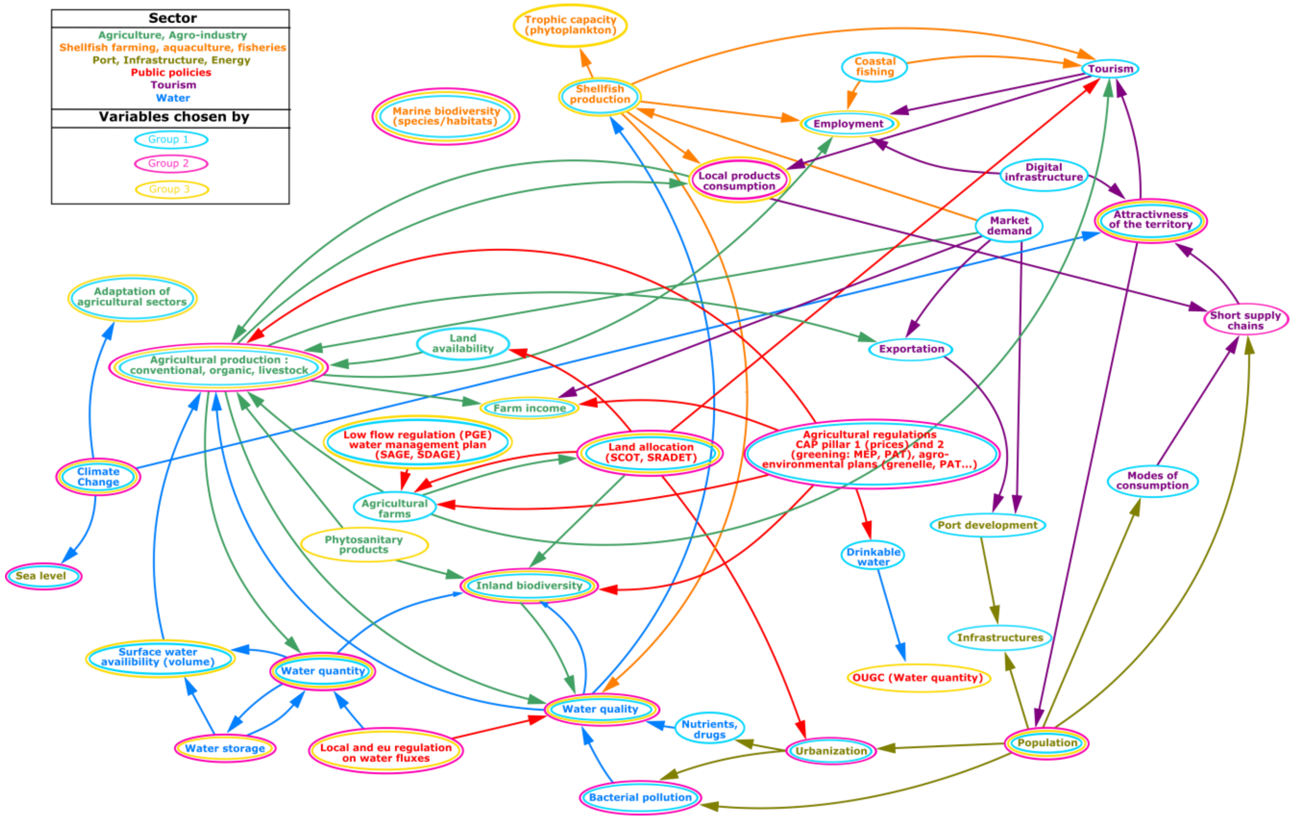

Figure 94: Synthesis of the selection of the variables by groups 1,2,3 among the element of the global mind map of MAL4

5.5.5.2 Completing the FCM maps

For the second exercise, the weights set by the Mal4 team were first removed on the Mental modeler maps to avoid influence on participants' votes (see paragraph 5.4.4). This procedure was quite long, and in regard to the allocated time, only the links between the key variables chosen in the first exercise were evaluated.
Several changes were achieved by participants, removing or merging connected variables.
The global map presented below (Figure 95) is the result of the work carried out by stakeholders and was used for the scenario modeling with Mental Modeler.

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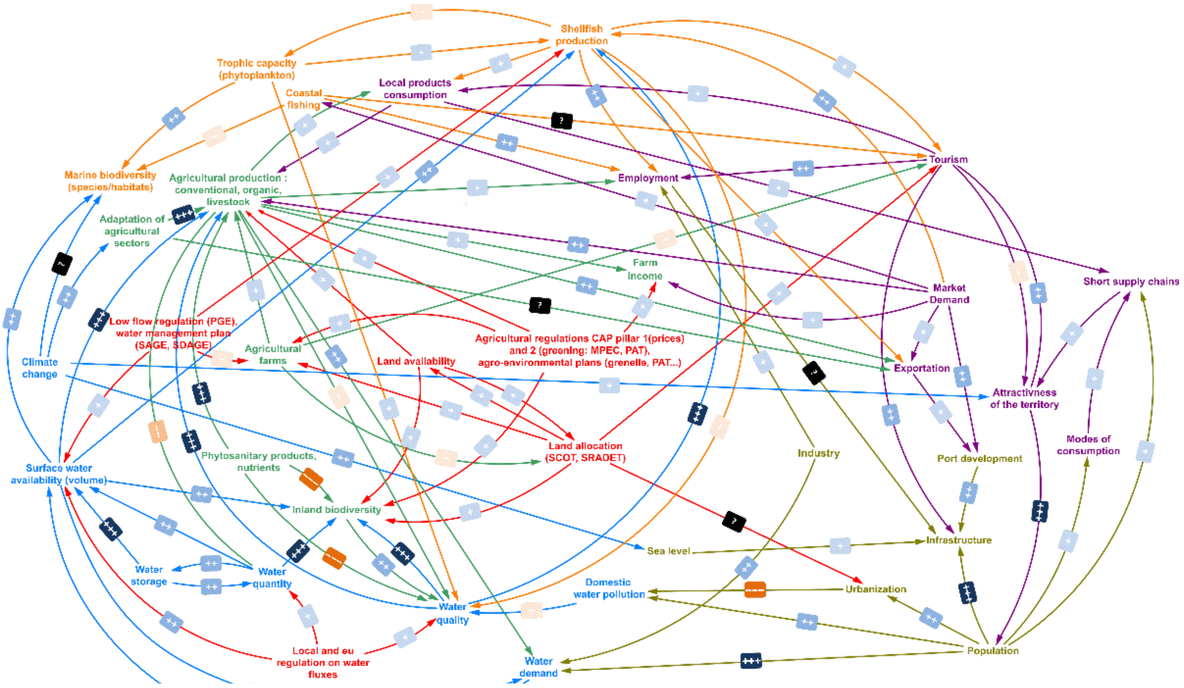

Figure 95 : Synthesis of exercises 1 and 2, after verification, analysis and additions of FCM by MAL4

The centrality of the variable can be derived by the model and enhance the most important elements The results of the centrality ranking (Table 11) indicate that agricultural production is the most central variable, followed by surface water availability and water quality, then followed by inland biodiversity and shellfish production. The most central variables are important focus points of the discussion during the sectoral workshops and reflect the concerns of stakeholders regarding the future of water resources and of the main economic activities on the area, agriculture (rural) and shellfish farming (coastal). Furthermore, these variables will have to be taken into account for the Vensim stock-flow modelling.

Table 11: Top-ranking central variables for the combined MAL4 territory FCM diagram

Centrality rank	**Variable**
1	Agricultural production
2	Surface water availability
3	Water quality
4	Inland biodiversity
5	Shellfish production
6	Population
7	Water quantity
8	Tourism
9	Water demand
10	Phytosanitary products, nutrients

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5.5.5.3 Conclusions and perspectives

The MAL4 team intends to provide a glossary with all the variables used in the simplified global model and the "story" told by coastal and rural stakeholders, which explains the links between the variables. That interactive model could be shared on the web and could feed the discussions between stakeholders, as it will ease the understanding of the model by stakeholders who were not involved in the making of the global map. A prototype has been done on a range of variables and links, but will be completed and opened for discussion.

The multi-actor workshop allowed to simplify the global map of the land-sea system (half of the variables were merged or removed). While stakeholders in sectoral workshops focused on their very specific issues or concerns, the multi-actor workshop resulted in a broader picture of the land-sea system.

After the multi-actor workshop the causal loop diagrams were verified by the MAL4 team and several scenarios were modeled using MM software. A final version of the outcomes with explanations was sent to the participants firstly, for a feed-back of the work carried out, and secondly to prepare the next workshops where the most desirable scenarios will be detailed and discussed.

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5.6 Spain – Mar Menor Coastal Lagoon (Western Mediterranean)

5.6.1 Executive summary

The Mar Menor coastal lagoon (135 km2) is located in the Region of Murcia (SE Spain). The area is characterized by multiple environmental, social-cultural and economic interests, often competing for scarce resources, water being the most important. The Campo de Cartagena catchment draining into the Mar Menor covers an area of 1.255 km^2 and is mainly covered by intensive irrigated horticulture and tree crops, which has caused a hydrological and nutrients imbalance in the lagoon. Public administrations are not controlling that best agricultural practices optimizing water and fertilizer use are being implemented, and there is a general lack of support of touristic activities by the local and regional governments.

5.6.2 Background

The Mar Menor coastal lagoon (135 km2) is located in the Region of Murcia (SE Spain). The area is characterized by multiple environmental, social-cultural and economic interests, often competing for scarce resources, water being the most important. There is a high potential for complementarity, win-win scenarios and development of sustainable business cases based on public-private collaboration, efficient use of water, and innovative farming practices and a transition to sustainable models of tourism and agriculture. The Campo de Cartagena catchment draining into the Mar Menor covers an area of 1.255 km2 and is mainly covered by intensive irrigated horticulture and tree crops. The intensive and highly profitable irrigated agriculture depends on scarce low-quality groundwater and water from inland inter-basin water transfers. Agriculture provides labor and income to the region but forms a source of excessive nutrients and contamination into the Mar Menor coastal lagoon. The resulting poor water quality affects the ecology of the lagoon with severe implications for its potential function for tourism and fisheries.

The coastal lagoon forms part of a Specially Protected Area of Mediterranean Importance (SPAMI). The Mar Menor is one of the hotspots for tourism in the Region of Murcia, with a total number of 346,000 tourists and 1.4 million-over-night stays in 2016. Beside international visitors, the Mar Menor has an important touristic function for the regional population (1.5 million inhabitants). The availability of water for irrigation and drinking water for tourism will be further reduced under future climate conditions. As such, the Mar Menor is strongly influenced by interactions between inland agriculture on the one side, and coastal tourism and fisheries affecting natural ecological values and socioeconomic sustainability on the other side. The need to move towards sustainable modes of agriculture, fishery and tourism is increasingly recognized and recently revived strongly due to sudden increase in contamination levels resulting in a strong drop in tourism.

5.6.3 Mental Mapping Seminar

As with the Swedish partners, SINTEF Ocean did not physically meet with the Spanish partners, but rather held an online meeting with the R&D partners prior to their MAL. For this case study, diagrams coming from the sectorial workshops were simplified and homogenized in Vensim and then translated into R and merged automatically.

5.6.3.1 Condensed Vensim Diagrams

Variables representing the same concept were harmonized across sectorial diagrams, so there were no major changes in the structure of the diagrams but they became more comparable and we also slightly changed some of the variables names so that they could be eventually measured in a qualitative or quantitative way (e.g., hectares, high/medium/low, count, tons, kg/ha, EUR/kg, etc.) and allowed identification of common variables between the sectors for later merging.

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Figure 96 is a condensed diagram of the local populations sector. Positive and negative relationships are indicated with blue and red arrows, respectively. The width of the arrows represents the strength of the relationship as explained under section 5.6.3.3.

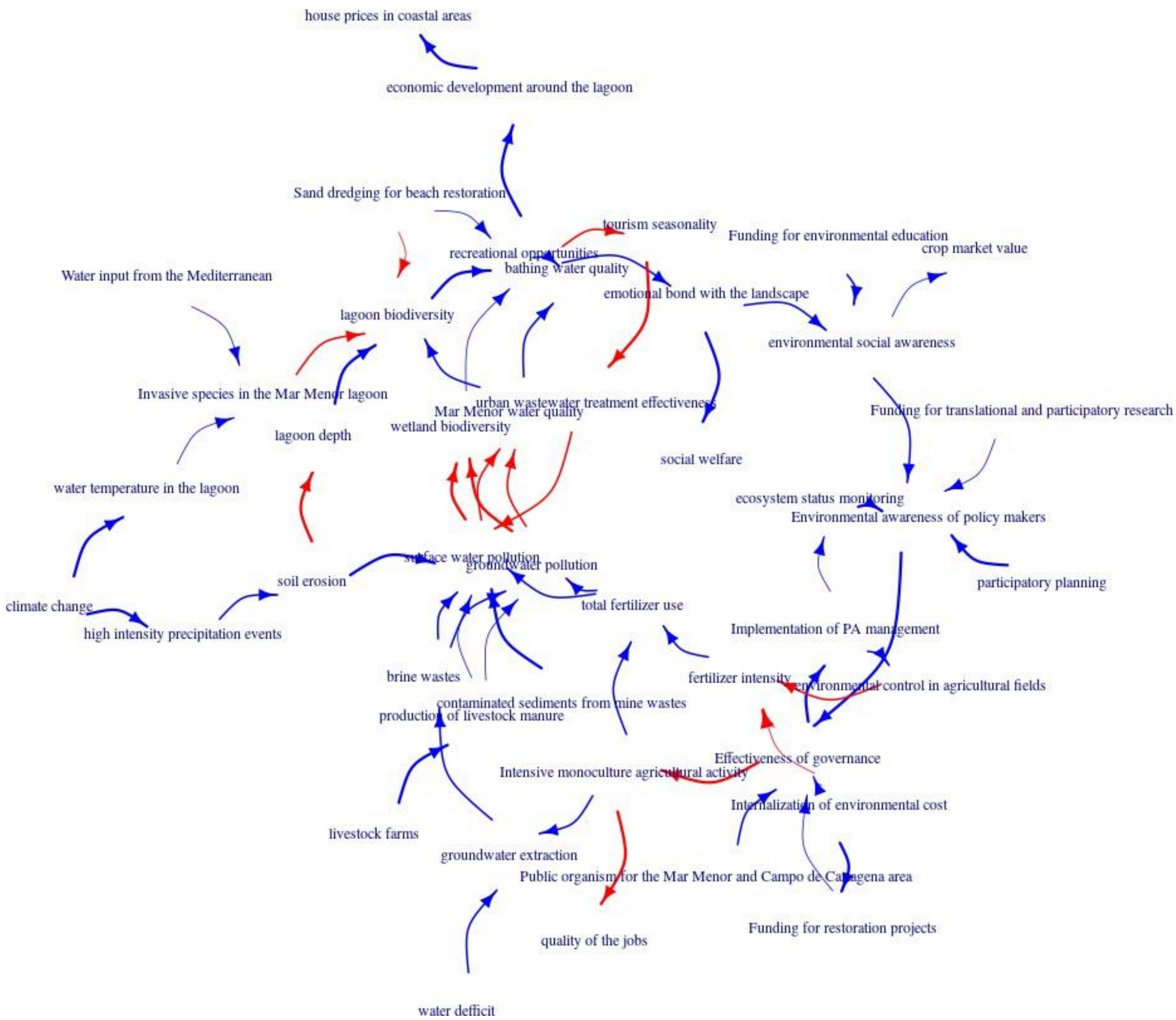

Figure 96: Condensed Diagram of the local populations sector. Positive and negative relationships are indicated with blue and red arrows, respectively. The width of the arrows represents the strength of the relationship.

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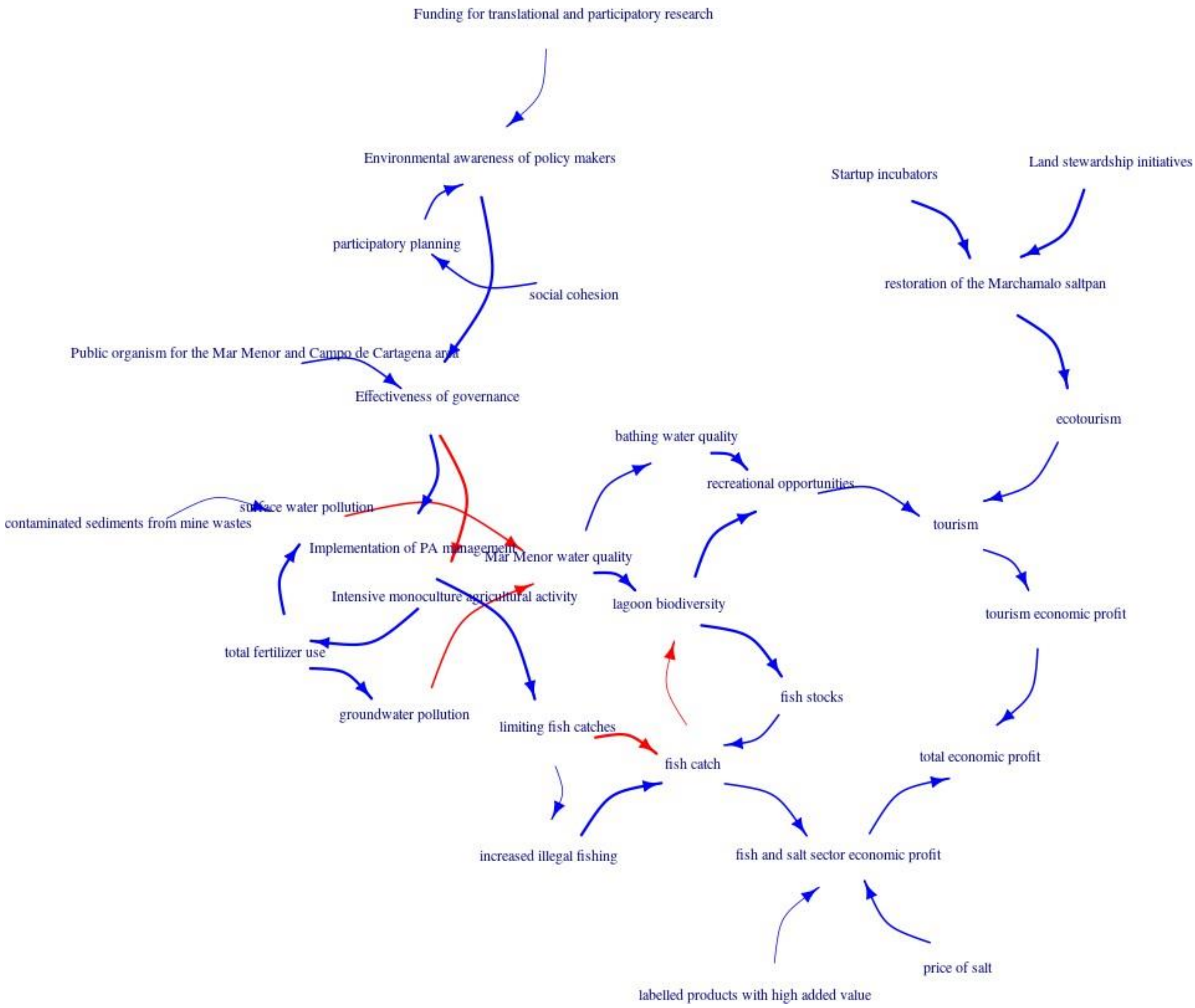

Figure 97: Condensed Diagram of the fisheries/salt pans sector. Positive and negative relationships are indicated with blue and red arrows, respectively. The width of the arrows represents the strength of the relationship.

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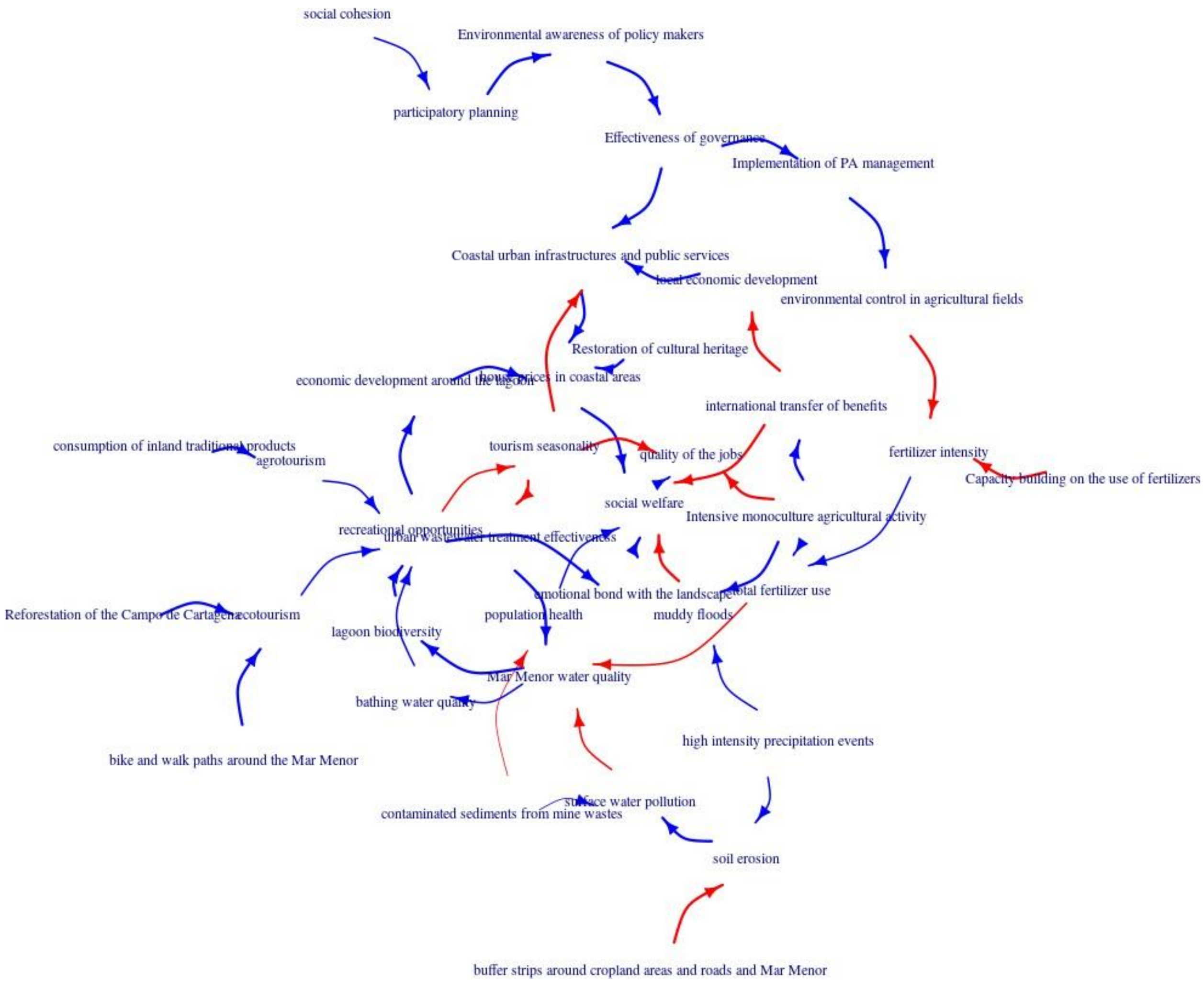

Figure 98: Condensed Diagram of the administrations sector. Positive and negative relationships are indicated with blue and red arrows, respectively. The width of the arrows represents the strength of the relationship.

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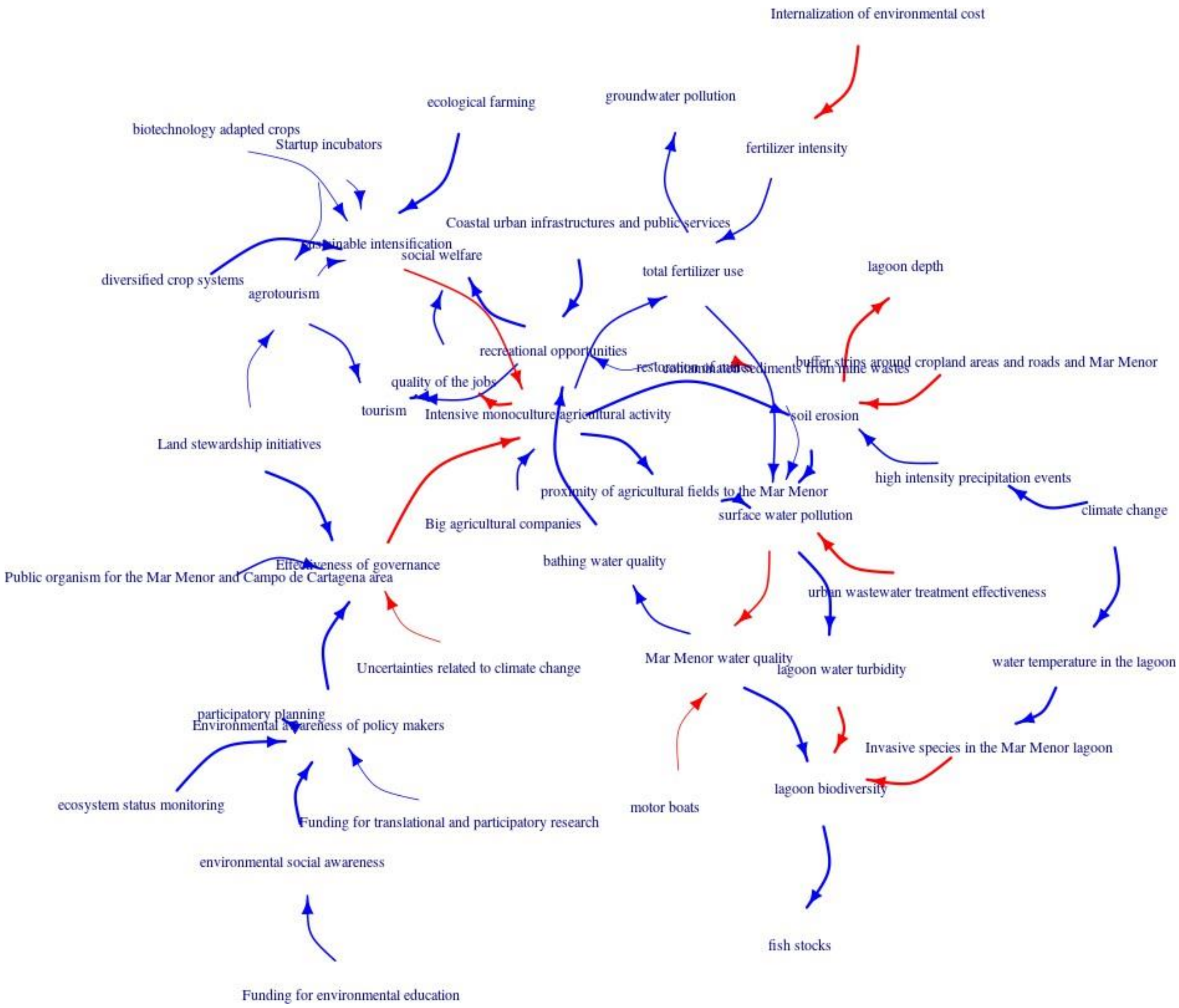

Figure 99: Condensed Diagram of the agricultural sector. Positive and negative relationships are indicated with blue and red arrows, respectively. The width of the arrows represents the strength of the relationship.

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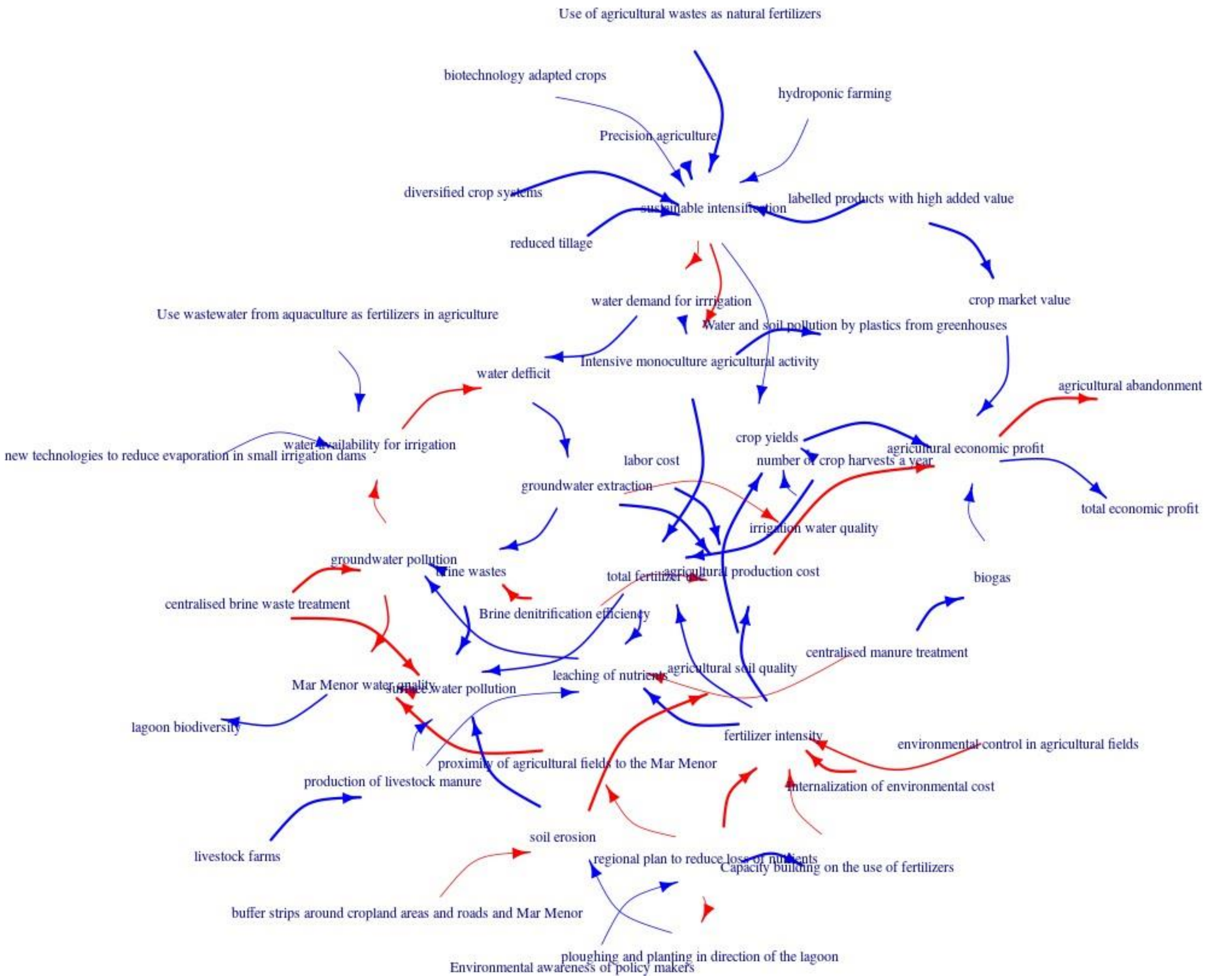

Figure 100: Condensed Diagram of the environment sector. Positive and negative relationships are indicated with blue and red arrows, respectively. The width of the arrows represents the strength of the relationship.

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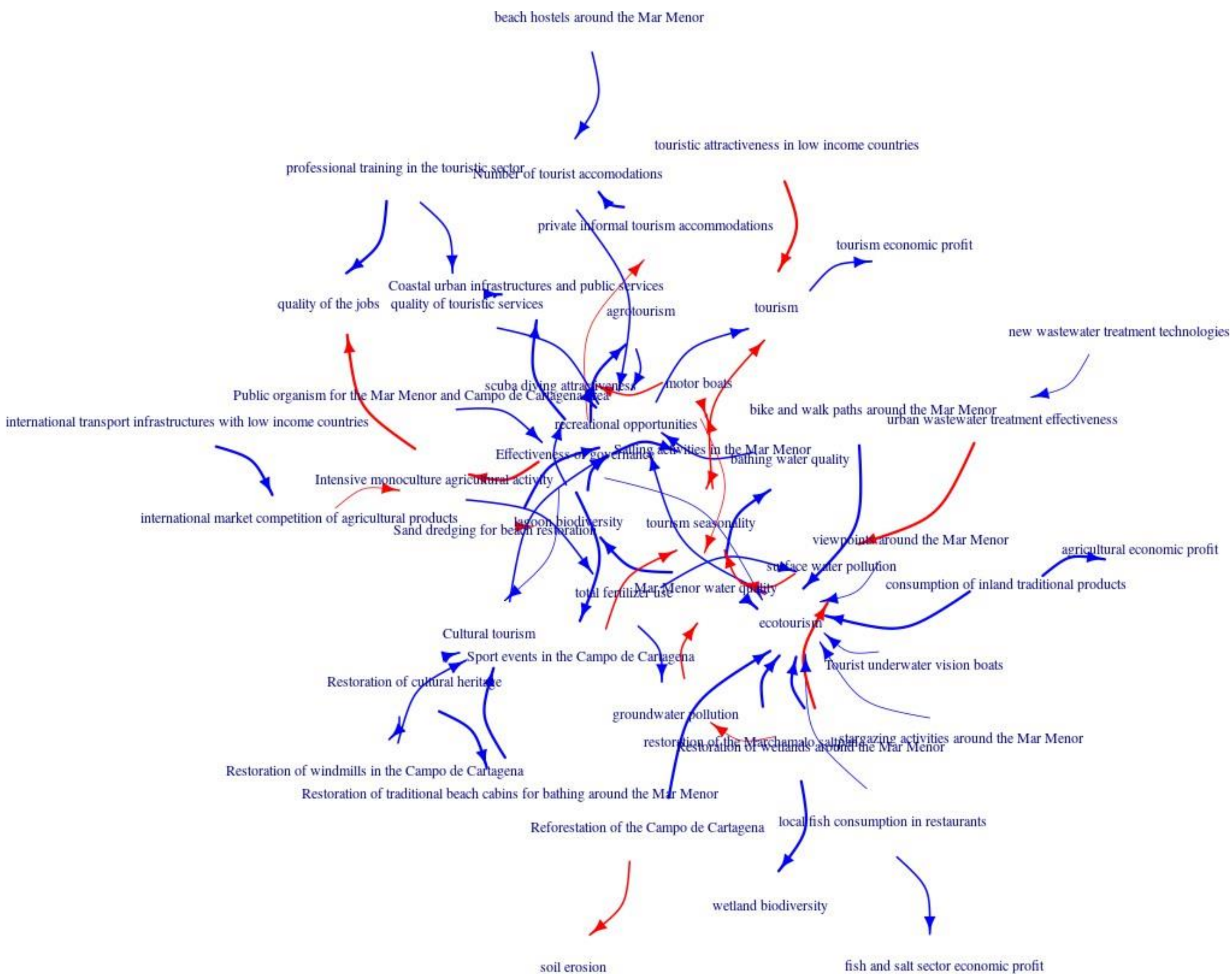

Figure 101: Condensed Diagram of the touristic sector. Positive and negative relationships are indicated with blue and red arrows, respectively. The width of the arrows represents the strength of the relationship.

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5.6.3.2 Combined diagram – Regional Mental Map for Mar Menor Coastal Lagoon (Western Mediterranean)

By combining the sectorial diagrams, variables and relationships were merged, and hence more feedback loops were present, representing a more comprehensive and consensual diagram, which is more appropriate for integrated studies.

Table 12: Number of variables and relationships in the sectorial versus de combined diagram

Sector	Variables / Relationships	Unique variables
Environment	44 / 60	2
Agriculture	49 / 67	23
Administrations	45 / 54	5
Fishermen/Salt pans	30 / 35	4
Tourism	49 / 69	20
Local populations	37 / 48	4
Combined	125 / 219	-

A total of 125 variables and 219 relationships were obtained in the combined diagram.

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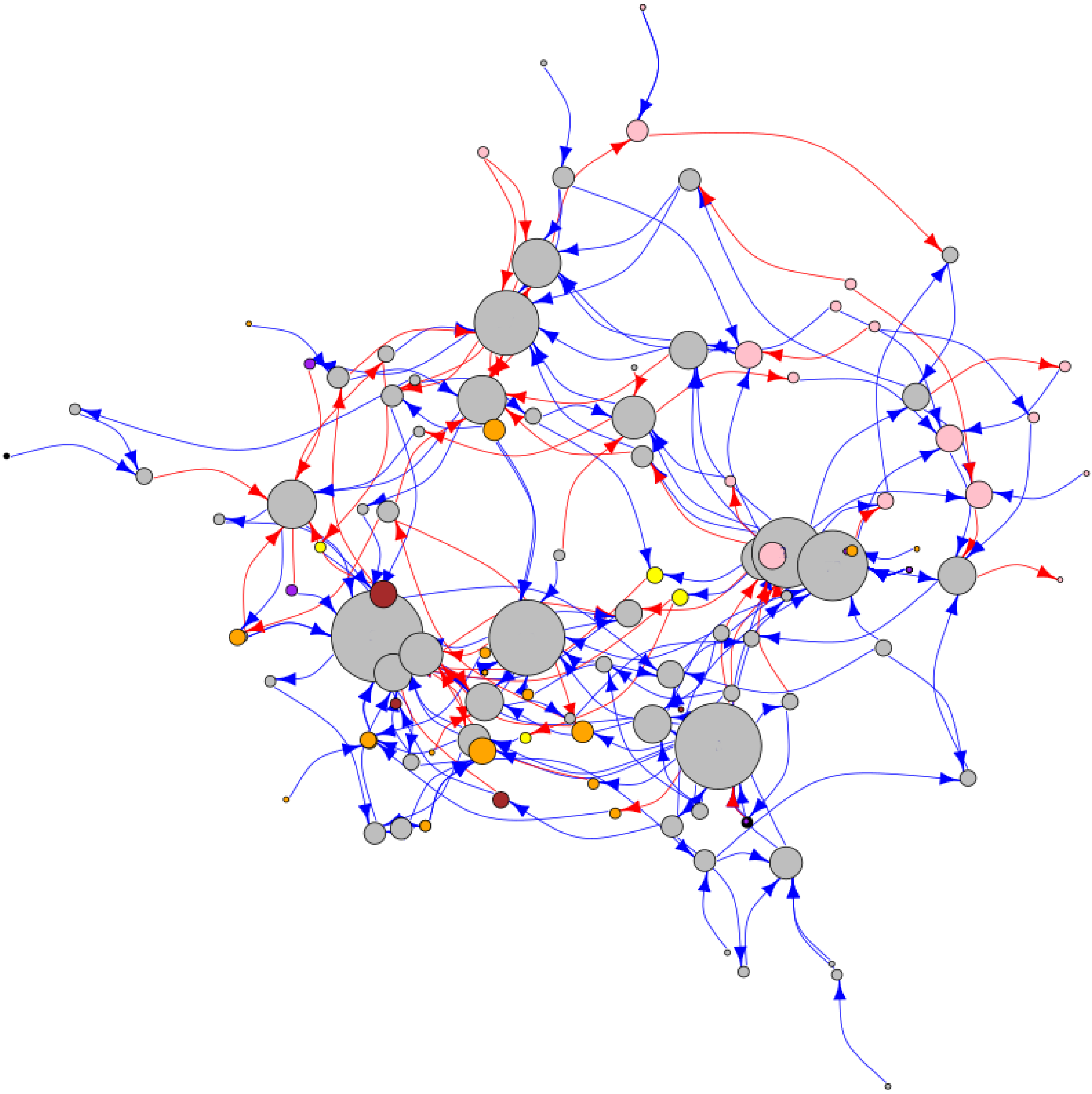

Figure 102: Combined Diagram of relationships and variables. Shadowed area comprises most of the variables from the agricultural sector. Variables sharing the same connections are placed closer to each other.

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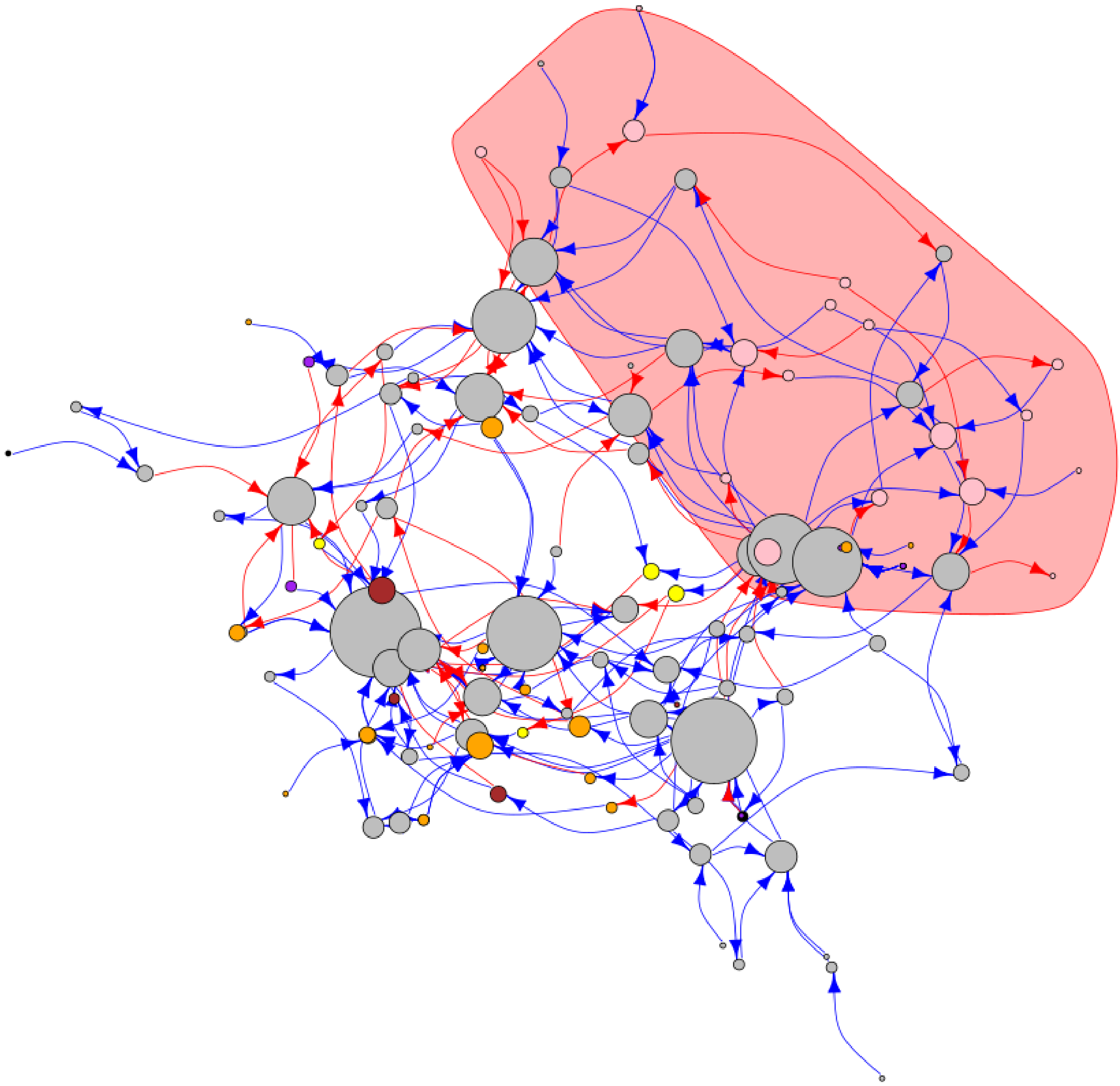

Figure 103: Combined Diagram of relationships and variables. Shadowed area comprises most of the variables from the tourist sector. Variables sharing the same connections are placed closer to each other.

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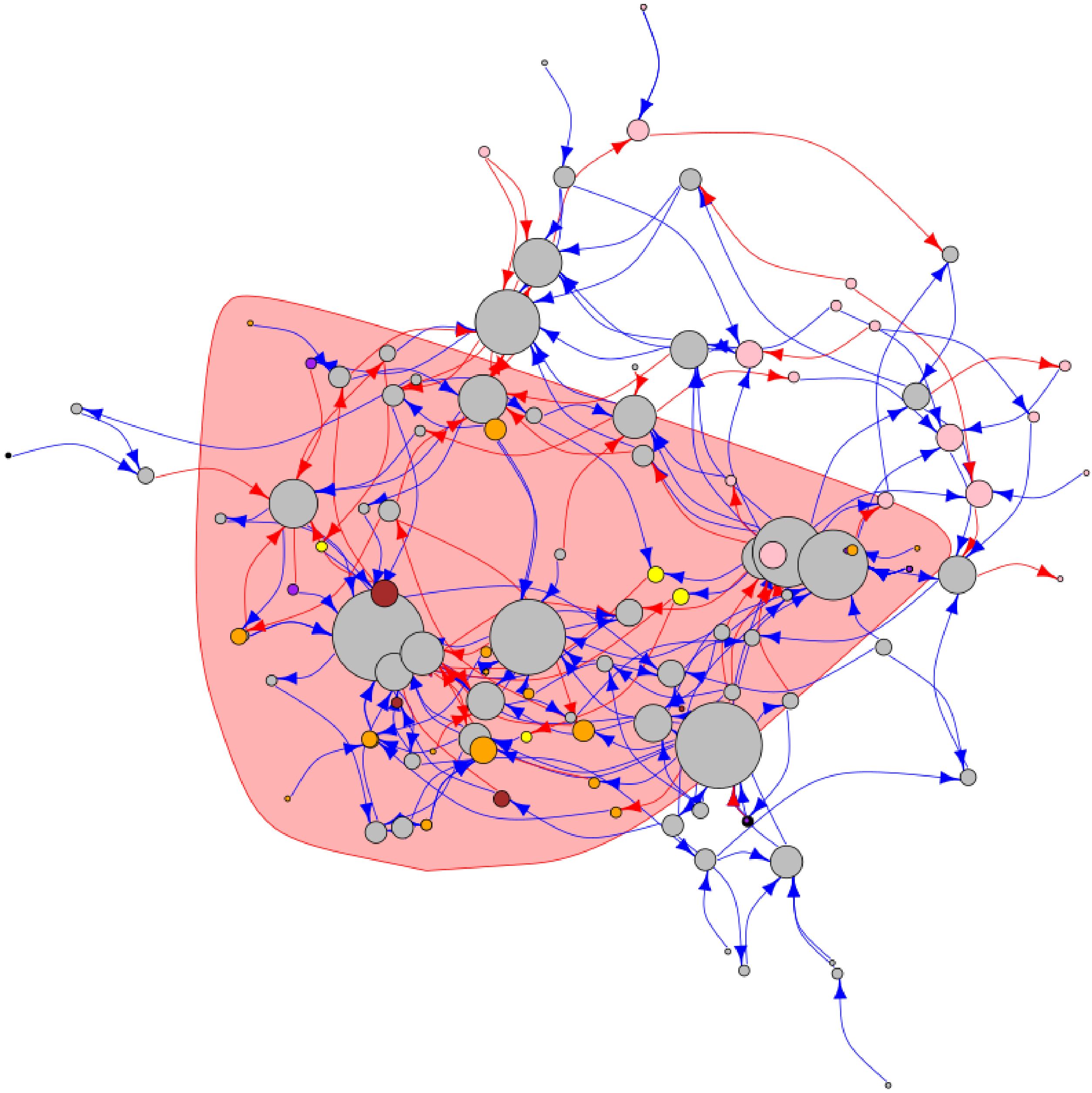

Figure 104: Combined Diagram of relationships and variables. Shadowed area comprises most of the variables from the local populations sector. Variables sharing the same connections are placed closer to each other.

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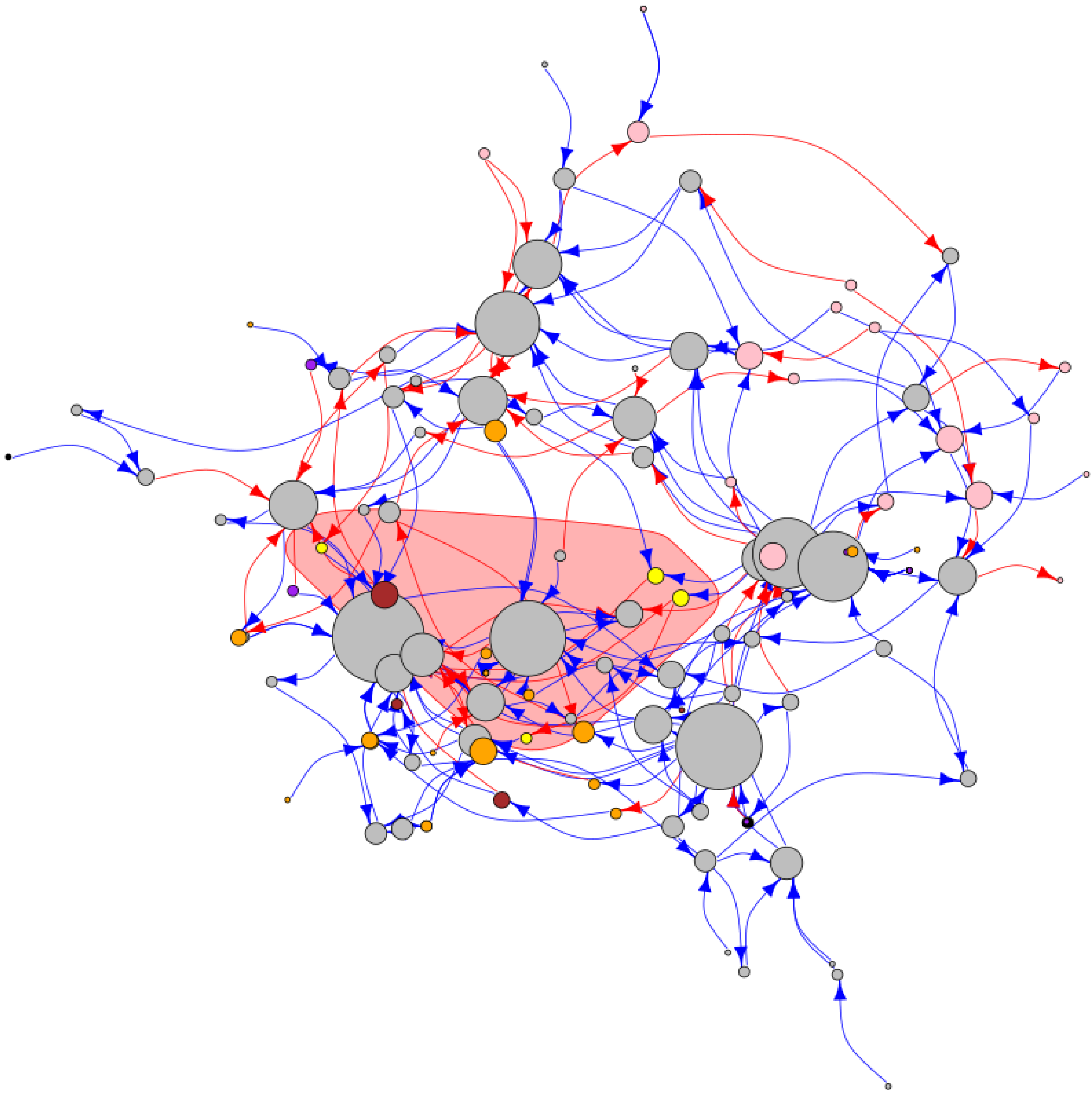

Figure 105: Combined Diagram of relationships and variables. Shadowed area comprises most of the variables from the fisheries/salt pans sector. Variables sharing the same connections are placed closer to each other.

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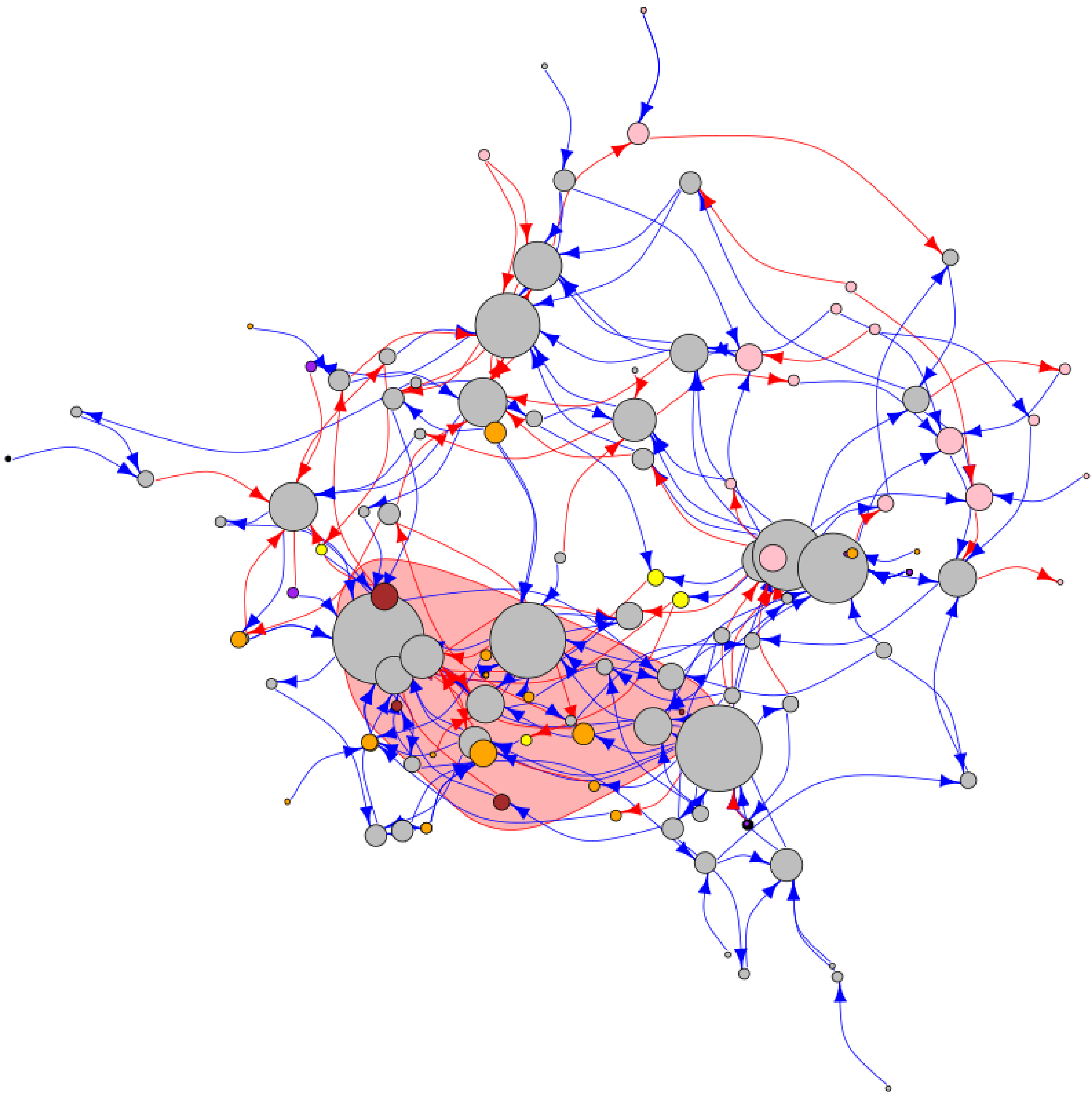

Figure 106: Combined Diagram of relationships and variables. Shadowed area comprises most of the variables from the public administrations sector. Variables sharing the same connections are placed closer to each other.

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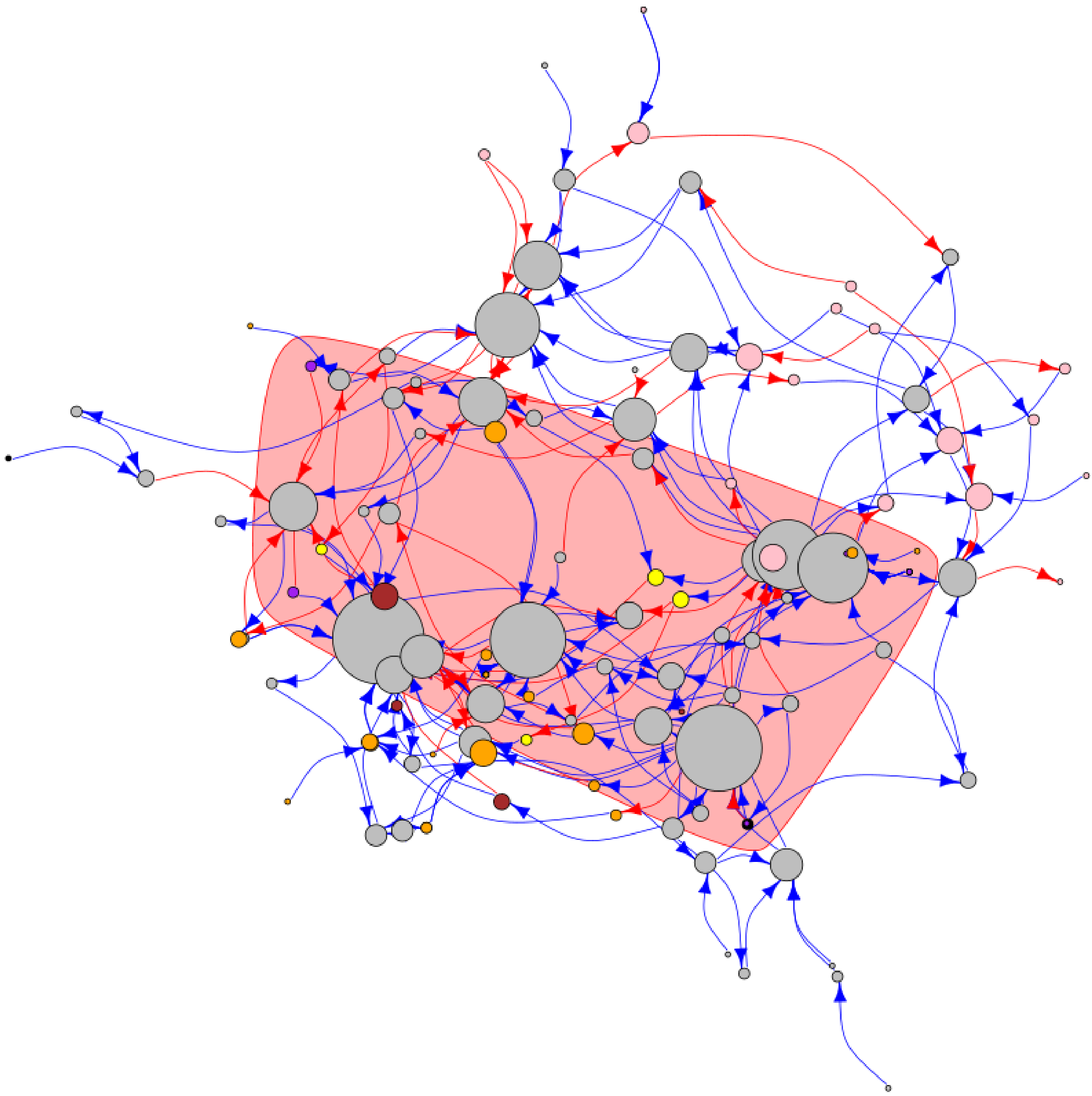

Figure 107: Combined Diagram of relationships and variables. Shadowed area comprises most of the variables from the environmental sector. Variables sharing the same connections are placed closer to each other.

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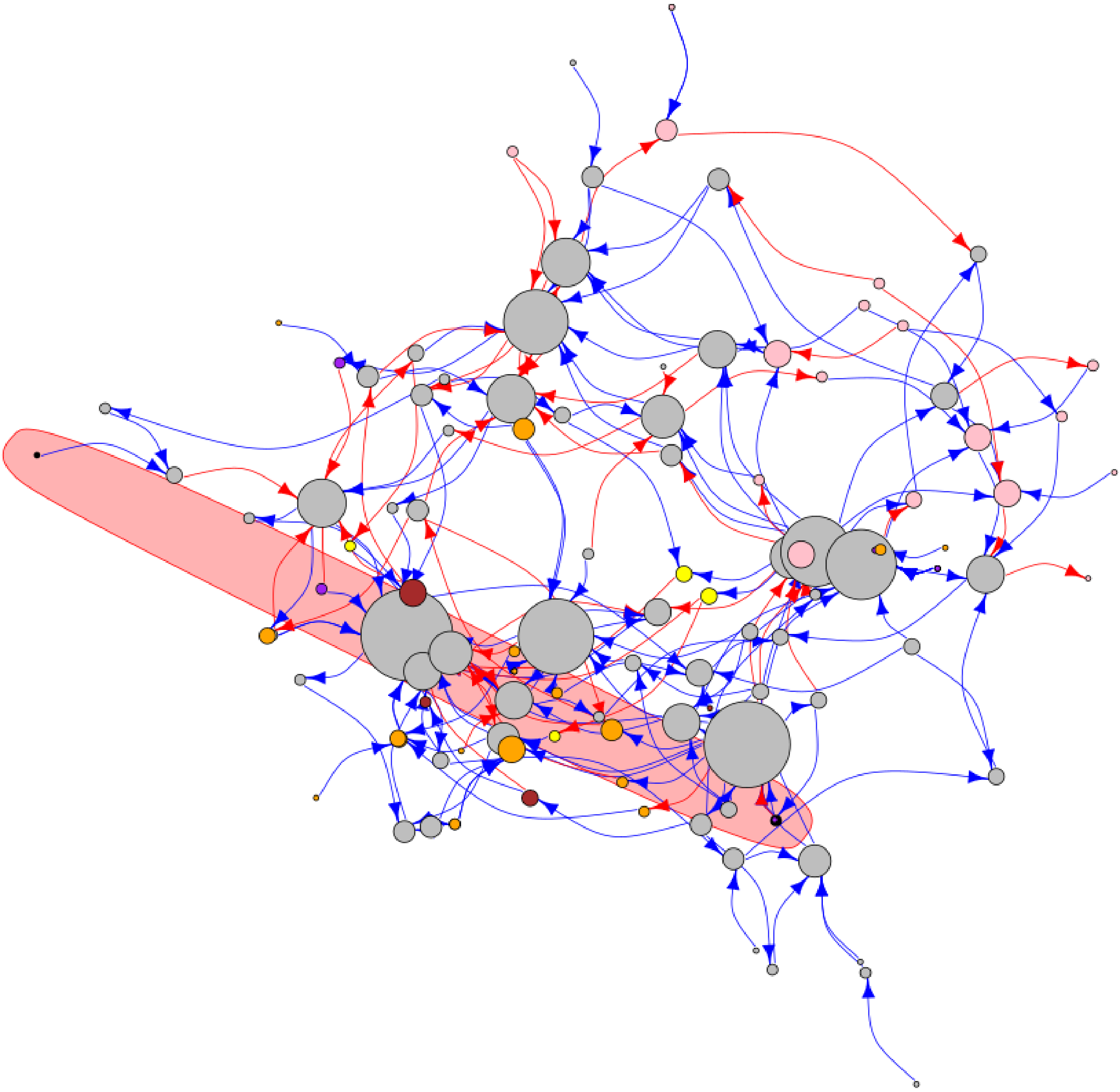

Figure 108: There were only 5 variables that were common to all sectorial diagrams, i.e. intensive monoculture farming activity, lagoon biodiversity, Mar Menor water quality, surface water pollution and total fertilizer application, which emphasizes the relevance

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5.6.3.3 Fuzzy Cognitive Maps

For each relationship between two variables, whose sign had been previously defined during the sectorial workshops, weights were added in order to describe the strength and direction (+/-) of the relationship in terms of low, medium or high, based on the perceived importance given by the participants in the sectorial workshops.

5.6.3.4 Scenarios

Scenarios were studied mainly by analysing the differences in the effect of changing the initial value of the most relevant variables compared with the BAU or 'no changes' scenario at the last iteration step, when the system was stabilized. The following bar plots show the differences in the variables that were affected by each scenario (figures x – y). Variables selected for producing scenarios were the ones having more centrality in the diagram and relating to each sector.

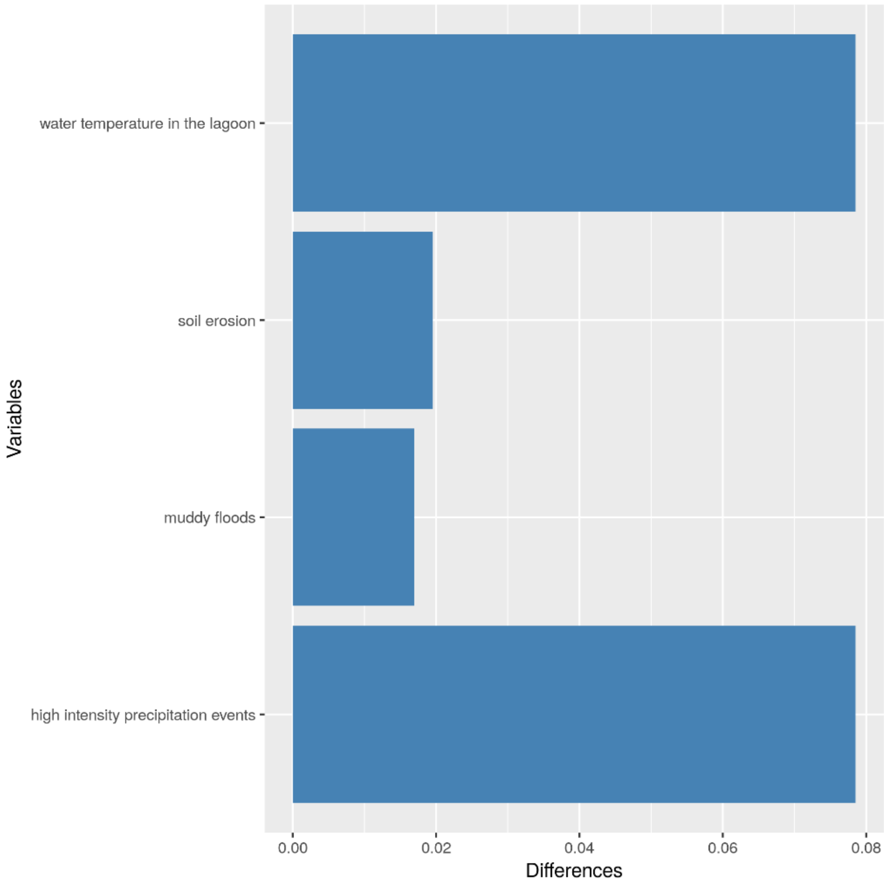

Figure 109: Differences from the BAU resulting from the 'increased climate change' scenario showing the main variables affected.

Under a more intense climate change scenario, the model predicts an increase in several biophysical variables and events, which negatively affect agriculture, populations and lagoon biodiversity.

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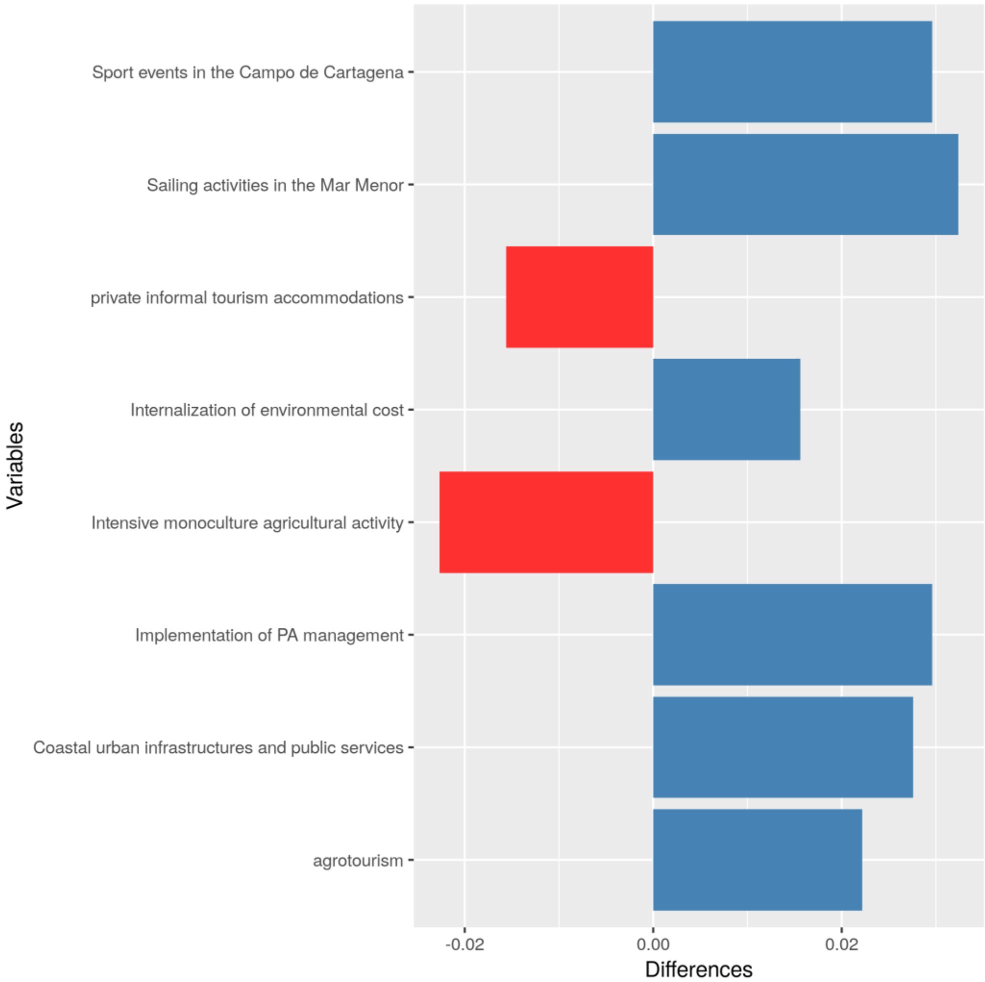

Figure 110: Differences from the BAU resulting from the 'increasing effectiveness of governance' scenario showing the main variables affected.

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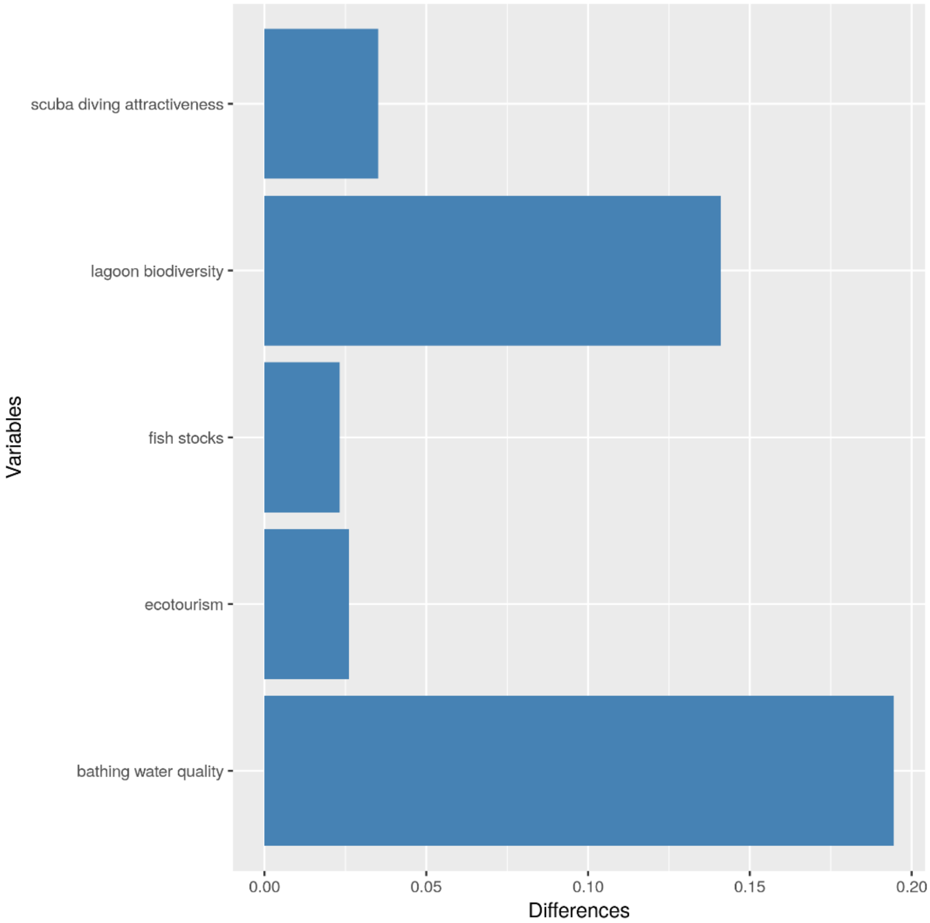

Figure 111: Differences from the BAU resulting from the 'increasing Mar Menor water quality' scenario showing the main variables affected.

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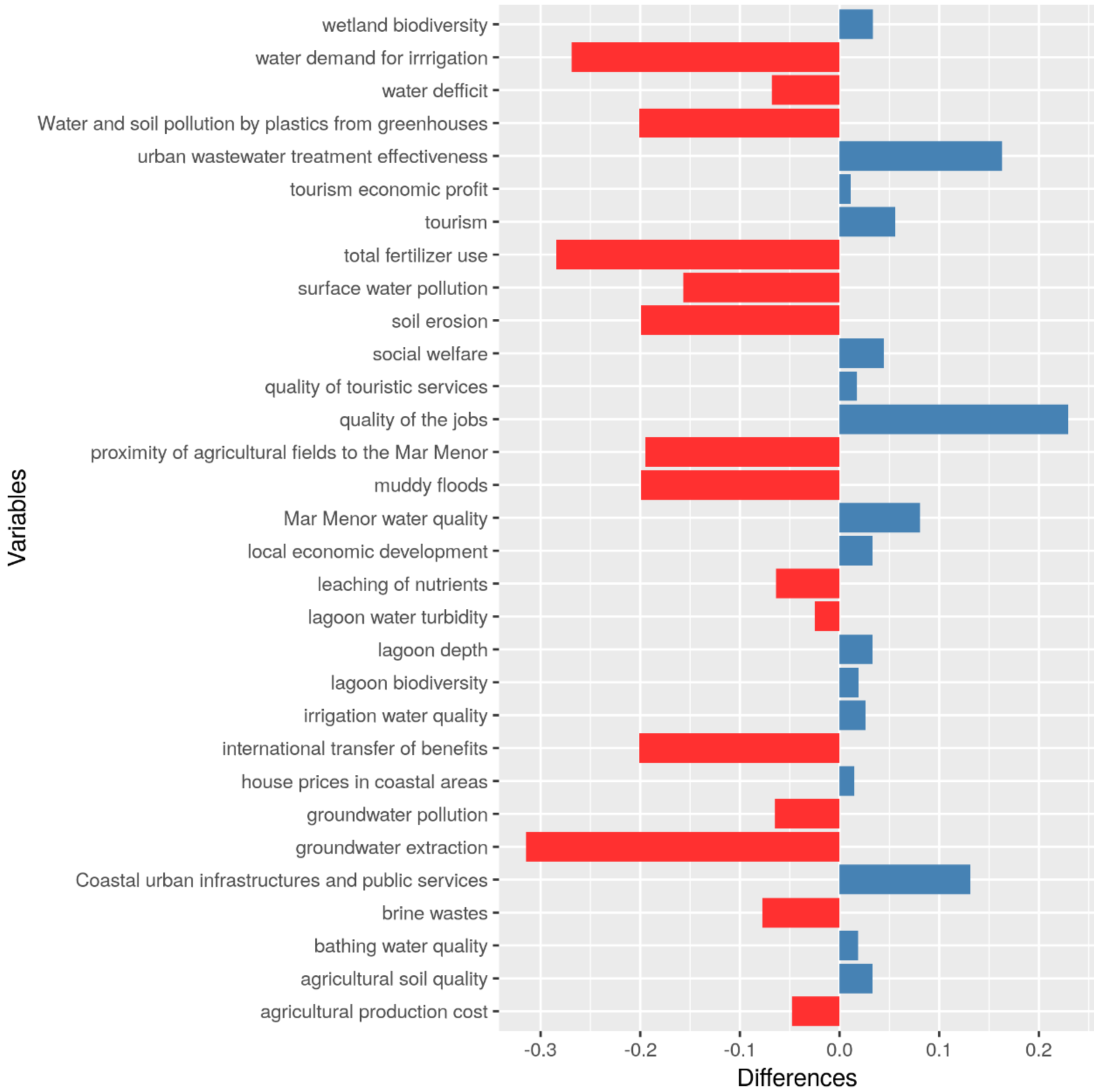

Figure 112: Differences from the BAU resulting from the 'decreasing tourism seasonality and intensive monoculture agricultural activity' scenario showing the main variables affected.

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The effect of improving Mar Menor water quality would have clear positive effects on local populations, tourism, lagoon biodiversity and fisheries. Increasing effectiveness of governance would have a positive effect on most sectors, whereas intensive agricultural activity would be reduced.

A combined scenario by changing two key variables, related to tourism and agriculture, led to numerous effects on the system, including the decrease in several unwanted variables and the increase in beneficial ones.

5.6.4 Multi-Actor Workshop

The first Multi-Actor Workshop workshop was held at the CEBAS-CSIC facilities in Murcia (Spain) on April 11th 2019 from 10 am until 2 pm. A total of 14 participants attended the workshop representing different sectors. Most participants also participated during the previous sectorial workshops.

Table 13: Overview of participants´ affiliation - Mar Menor Coastal Lagoon (Western Mediterranean)

Sector linked to	**Participants linked to**	**Number of participants at MAL**
Agriculture	Farmer associations	2
Local populations	Local associations	3
Tourism	Hotels, restaurants, nautical activities	3
Fisheries/salt pans	Salt pan activities	1
Administrations	Regional government, rural development network	3
Environment	NGO for nature conservation, University, CSIC	2

5.6.4.1 Theme and structure of MAL

The workshop started with an intro about the outcomes of the six sectorial workshops and we started showing and characterizing the combined model. We showed the first order variables that were inputs of the more central variables in the model and briefly discussed the assigned weights of the relationships in order to receive feedback from the participants. Then we discussed with them the results of the scenarios of the most central and transmitter variables, mostly by means of bar plots of differences with the BAU scenario. At the same time, the first order variables affected by the selected scenario variables were shown to the participants in order to help them understand the results of the scenarios. During a short coffee break, we gave them the full list of variables comprised in the combined model and asked each participant to select the top ten most important ones. This exercise was performed to validate the final combined causal loop diagrams and confirm the most important variables. Then, after the pause, we grouped them into 5 teams (mixing people from different sectors) and asked them to work on a common vision/proposal that would benefit their respective sectors and directly or indirectly also improve the conservation status of the Mar Menor lagoon. The proposal could consist of several different initiatives and they should try to reflect on the interactions/synergies among them as well as the resources and knowledge or institutional support needed for implementation. Finally, each team had 5-10 minutes to explain their proposal and they were openly discussed. After the workshop, we started describing a list of potential System Dynamics models to be developed during COASTAL.

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5.6.5 Analysis of the outcomes and conclusions

Through the workshop we were able to show and discuss the sectorial and combined model structure and main system interactions; show the impacts of the most important scenarios on multiple sectors; perform an individual selection of the most important variables, as well as multi-sectorial group work to identify opportunities for sustainable development. In that regard, we were able to 'validate' the combined systems map, identify the main (business) opportunities and transition pathways for sustainable development and jointly build trust and common ownership among stakeholders. There were no changes in terms of variables or the strength of the relationships proposed by the participants, probably due to the fact that participants were more interested in the main effects of scenarios on different sectors in terms of general trends, rather than on specific variables. Discussing the causal loop diagrams and results of the FCM was very helpful to guide the discussions and inspire the participants for creative system thinking.

The main scenarios discussed during the MAL workshop were in relation to many different variables, such as social welfare, ecotourism, sustainable intensification, soil erosion, governance, fish stocks, climate change, lagoon water quality, social cohesion and tourism seasonality. These variables were discussed because they played an important role in the causal loop diagram. On the other hand the main ideas to create synergies were mainly a few in relation to initiatives, such as the implementation of nature based solutions at cropland scale, including: vegetation buffers around cropland areas, conservation agricultural practices and crop diversification; the promotion of a more sustainable coastal-rural tourism, including agrotourism, and the promotion of solar energy facilities. As the main outcome of the workshop, the idea now is to build models for those ideas, individually and in combination, and try to assess their effect on different indicators, such as the total economic benefit, the relative contribution of each sector to the total economic benefit, the quality of jobs, population trends, surface and groundwater quality, lagoon water quality, landscape degradation, public services, recreation potential, fish stocks, number of tourists, total water use, the effect on climate change adaptation and mitigation or vulnerability, etc.

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6 CONCLUSIONS

This deliverable provides a detailed account with a wealth of information on the steps taken to design and improve a conceptual model of the land-sea system and final outcomes of the first round of multi-actor exchanges. These took place between March and September 2019, bringing together coastal and rural stakeholders for the first time in the project. The workshops (one for each MAL) and analyses serve multiple purposes:

- to validate the outcomes of the coastal and rural sector workshops as reported in deliverable D03 (Tiller et al., 2019) from a new, synergistic perspective
- to develop an integrated, conceptual model: a diagram of the land-sea system at a regional scale serving as architecture for the depending WPs (evidence-based systems modelling, formulation of business road maps and policy guidelines)
- to identify the reinforcing and balancing feedback mechanisms underlying the problems and affecting the opportunities for improved land-sea synergy, as reported by the stakeholders
- to define and/or validate the significance of the land-sea interactions in the diagram, expressed with weights in a Fuzzy Cognitive Map (FCM)
- to challenge the stakeholders to formulate scenarios aimed at regional development and improved land-sea synergy, taking into consideration potential opportunities and obstacles

The outcomes are used as starting point for evidence-based systems modelling (Figure 2) and a useful platform for exchanges between coastal and rural actors has been created.

Earlier all MALs completed their six sector workshops, with a representative balance of coastal and rural stakeholders (Tiller et al., 2019) as planned. The selection of participants to these sector workshops proved to be a good starting point for the multi-actor workshops. The main reason for organizing thematic, sector-based workshops prior to the multi-actor exchanges was to avoid difficult, counter-productive disputes which could hamper the discussions and "open-mindness" in the first phase of the project. Contrary to the expectations, none of the MALs reported problems for their combined multi-actor workshops, where stakeholders with different and sometimes conflicting objectives (such as agriculture and environmental protection) were brought together. Instead, open discussions were reported, and the participants appreciated the use of graphical tools and systemic analyses supporting their discussions.

Preparing for the multi-actor workshops the WP1 lead partner interacted with the research partners (VITO, HCMR, SU, IRSTEA, INCDM, ICEADR and CSIC) in a "mental mapping seminar" to discuss the outcomes of the sector workshops and design an integrated Fuzzy Cognitive Map or FCM (Kosko, 1986; Kok, 2009; Gray, 2015; Tiller et al., 2016; Tiller et al., 2017) with weighted land-sea interactions for each MAL. The weights (usually in the range between -1 and +1) define the polarity and importance of each land-sea interaction and allow for scenario analysis (Kok, 2009). Useful metrics for the role of variables in the diagrams were derived with the FCMs for several of the MALs and have been reported in this document. The outcomes were used during the plenary introductions preceding the multi-actor workshops. The partners facilitating the workshops received general guidelines on the methodology and clear instructions on how to organize their workshop. A general recommendation, which proved to be useful, was to focus on the practical implications of the analyses with scenarios rather than methodological technicalities. In addition to the scenarios prepared with the FCMs, the participants were challenged to define their own scenarios: future narratives focusing on improved regional development and land-sea synergy. These are extremely useful and based on the expertise of the stakeholders who came up with practical recommendations, taking into consideration ongoing plans and developments in the regions.

The interactive design, polishing and improvement of the merged CLDs for the land-sea system proved to be a challenging but useful exercise. The final results are diagrams capturing the main feedback mechanisms for

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the MALs (Figure 11 and Figure 12ff; Figure 44, Figure 49, Figure 67, Figure 95, Figure 102ff). For practical and methodological reasons differences can be noticed for the MALs and interpretation of the guidelines. These pertain to differences in the complexity and thematic focus of the MALs, the way the FCMs are processed and used to set up scenarios, the presentation and the level of detail used in the diagrams, the level of detail of the narrative scenarios. Interesting differences are observed in the issues, solutions, opportunities and scenarios for the MALs. On the other hand, considerable overlap is seen in the issues affecting coastal-rural interaction as retained in the final analysis (such as water scarcity, urbanization, eutrophication or bioaccumulation and invasive species). These are an excellent starting point for the exchanges between the MALs which are planned in the coming year.

The principle of feedback and its significance for business and policy analysis was explained with examples. Assigning weights to the land-sea interactions proved less of a challenge for the workshop participants than thinking in terms of system feedback. The Belgian MAL reported technical difficulties with the interpretation of the scenario analyses based on their FCM. These were attributed to the complexity of the FCM and lack of non-linearity and time reference in an FCM. The problem was addressed by comparing final state of variables after a number of iterations (see Figure 38) to support the scenarios. Other MALs choose to support their scenarios based on the transient dynamics of the FCM (see, for example, Figure 50 and Figure 89).

The challenge for the MALs and project as a whole is now to quantify the outcomes of the multi-actor analyses evidence-based stock-flow models (De Kok et al., 2019) while keeping in consideration the priorities of the stakeholders and conclusions of the multi-actor workshops. The approach followed to achieve this will be indirect rather than direct: modelling the total system for each MAL (with 50 to 100 variables) is considered less useful and expected to result in impractical and overly complex models, with considerable data problems. Instead the partners have been asked to identify a selection of 3-5 key problems in their merged land-sea diagram. These issues will be modelled from scratch by adding time delays, systemic limits and other model relevant aspects. These were not always discussed by the stakeholders in this level of detail but are implicit to the problems and opportunities raised by them. Documented examples of operational models are distributed and discussed to harmonize the modelling process, ensure a similar level of detail and model granularity, and sufficient complementarity of the models. The second round of multi-actor workshops, planned by the end of 2020, will be supported with scenarios using these stock-flow models.

Since this next round of intersectoral workshop will be held online, or a mix of online and real life versions where possible due to the COVID-19 pandemic, one of the challenges will be to get them engaged throughout the session and keep their interest and active participation. The online format provides an additional challenge to the workshop organization and participation. Therefore, in collaboration with coordinators of WP1, WP3 and WP5, we are now designing a suitable and attractive workshop agenda and dynamics that is adjusted to an online format and that facilitates active participation and stakeholder interaction.

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7 Revisions requested after RP1 – M18

Comments from reviewers	
The deliverable only partially addresses the objectives proposed and fit the description of work.	*We agree that D04 only partially fulfils the objectives specified in Section 3, and that this is an ambigous statement in the text, which could be understood as if the deliverable did not meet its original obligations. We have clarified this text now so that the reader understands that these objectives refer to the entire work done in WP1, and it was never intended that this deliverable would fulfill them all.*
There are some weaknesses related to the methodological structure and its coherence, e.g.: the lack of simplification workshops in Spain and Sweden,	*There was no lack of simplification workshops in Spain and Sweden, and we realize we have been unclear in our explanation of this in the methodology section. We have clarified this in the text now in paragraph 2 of Section 3.1.* *Both of these case areas did their own simplification work – without the on-site workshop facilitating of the WP leader (SINTEF Ocean). Although there was no SINTEF staff present in Spain or Sweden, exactly the same methodology was used for simplification by experienced staff in these two case areas. Methods were previously instructed by SINTEF, and results were validated through another conference call with SINTEF. This did not affect the results in any way at all. In fact, given that Spain did their workshops first, a lot of lessons learned from these were applied to the on-site facilitating in the other case areas.*
FCMs during the MAL were not convincingly justified.	*Fuzzy Cognitive Maps (FCMs) are directed causal graphs with weights to indicate the polarity and significance of each interaction. This positions FCMs in between Causal Loop Diagrams and fully quantified stock-flow models – making them potentially useful tools for preparing the stock-flow modelling. Our general experience is that assigning the weights was possible and considered more useful than post-processing to derive scenarios. These scenarios could be visualized in terms of the transient dynamics or final equilibrium states obtained after a sufficient number of iterations. The scenarios were often too difficult to interpret for policy analysis. Using FCMs was offered as a methodological choice for the Multi-Actor Labs,*
The methodology for the mental models and FCM should be appropriately documented including the lessons learnt from using this methodology.	*Section 3.1 has been restructured in a more logical order and elaborated to provide a detailed, step-by-step documentation of the methodology, including the design and use of FCMs in the project.*
It is also not clear if the narrative scenarios formed part of the core methodology as not all MALs did them, as well as what were their objectives and how they feed into the next steps of the project.	*We acknowledge that we have not explained this properly in the methodology section and have added a separate section for narratives only – explaining what these are (section 3.1.1.2 Narrative analysis). In this section, we explain how we used narratives (that were developed in D1.1) in the simplification process and as a tool for developing the FCMs and scenarios in these (which all build on the narrative analysis from D1.1 and the*

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The reference to scenarios is somewhat confusing throughout the document, as sometimes these are narrative scenarios produced directly by stakeholders while others are Vensim derived scenarios.	*facilitators understanding of these workshop discussions). It is as such not part of the core methodology of worktask 1.2, but was core in D1.1 – but in this work (and most other) – all work builds on each other. We have tried to adjust the language in this deliverable to reflect this and harmonize the terminology.* *We have also cleaned the language around scenarios (which are always developed by stakeholders, via the narratives – and Vensim is also developed by the narratives via the stakeholders – so it is really all the same thing). Each of the MALs had to report on scenario analysis for cross-comparatiliby but also as this was needed for WP3 as well and we wanted to avoid stakeholder fatigue so we attempted to add in more data gathering in existing workshops.* *We also moved a section on methodology on scenarios and FCMs from the Belgian case study to the methodology section for better deliverable coherence.*
Given the differences in how the MAL workshop methodology was applied across the different case studies, it would have been useful to include the general methodological guidelines that were prepared for the MALs as an annex and clearly explain in the methodology the main deviations in each MAL.	*We added this in 3.1.1.6 and not an annex as we consider this important and it was indeed an oversight to not include it in the first version of this deliverable.*
There are some apparent contradiction or misalignment between the reported results e.g. the results of MALs and regional mental maps for the Greek case in relation to "awareness"	*We think this is a misunderstanding and fixed the sentence where we think this misunderstanding stems from. Linguistically, the sentence is correctly phrased, but the order of the variables would indicate that „lack of" belongs to „awareness" as well and not just the first variable – so we move the variables around.*
The lack of an appropriate stakeholder mapping and analysis may hinder the validity of the results, particularly given the limited stakeholders participation in some workshops.	*We added in the methodology section (section 3.1.1.5) how we selected stakeholders „Stakeholdler selection for actual MALs". This method is sufficiently explained and justified in our response in D1.1. In none of the workshops did we consider the participation to be limited. In fact, it was well sized in all cases and in line with our methodological choice.* *We also added a table in the same section where each Multi-Actor Lab reflected on the stakeholder selection process.*
This is further aggravated due to the very strong participation of research organizations in comparison to other	*All sector and multi-actor workshops were faciltated by the local research partners coordinating their Multi-Actor Labs. We realize this is not clearly understood and we chose to add a new section*

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stakeholders, as well as the unclear role of such organizations sometimes mentioned as stakeholders and other times as facilitators.	*(3.1.1.6) where we explained the general guidelines for facilitating these multi-actor workshops as it was laid out for the facilitators. It is important to understand that, like drivers, these are guidance steps. In all case, there were geographical and social and political differences – and differences in models that would be focused on – so that there would naturally be some differences as we see in comparative studies. We have also adjusted the presented results to reflect this setup. Some did go beyond these steps and added additional analyses that they found useful or particularly interesting. This did not affect the reliability or usefulness of the results of the multi-actor workshops.* *We clarified the text in the Greek case study a bit, as we could see that this „what hat are you wearing" issue could be misunderstood there in section 5.1.4.1. It now reads:* *The facilitators, though from the same institution as some of the stakeholders, were not considered stakeholders in this context but facilitators only. The stakeholders from HCMR were not affiliated with the COASTAL project, but had the relevant expertise.*
The conclusions on "lessons learned" are rather generic and lacking an appropriate level of comparative analysis, which should be reviewed. It would be useful to have a section on the lessons learn specifically from using the methodology, its potential, limitations and areas for improvement. If not in this document, then this could be done in a separate deliverable or publication.	*We are working on a methodology paper we would like to see published this year. We did add in more on this in the last section as well though.*

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