# Application of the System Approach Framework to the urban beaches of Barcelona


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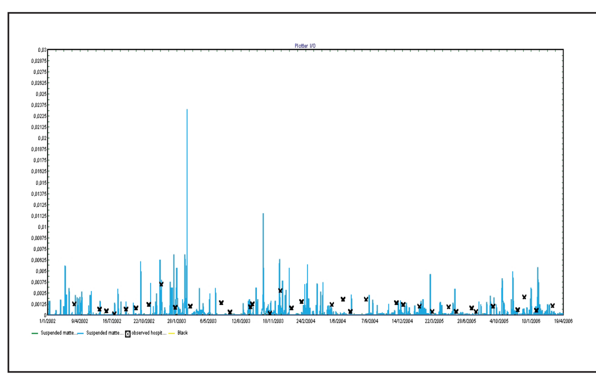
SPICOSA

## 1. Introduction

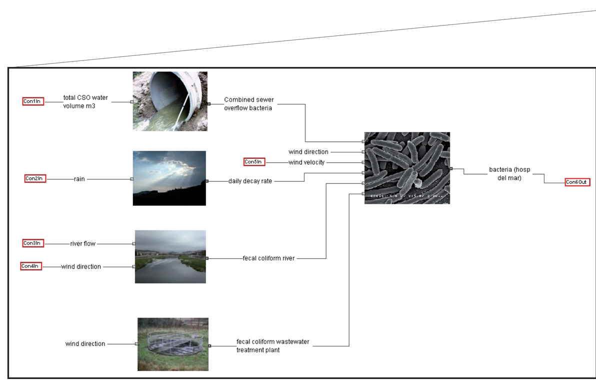
Under the EU FP6 funded project SPICOSA, the Systems Approach Framework (SAF) was applied to the coastal zone of Barcelona. Following stakeholder deliberations, there followed an investigation into the effect of changes in water quality on the aesthetic and recreational aspects of the Barcelona beaches. It is hypothesised that the majority of changes are caused by runoff, combined sewer overflow (CSO) events during storms, sediment re-suspension and transport by river. Water quality is defined in this issue as bacteria (fecal coliforms) and water clarity (suspended matter). Reduced use of the coastal water (either by regulation or personal choice) influences the beach users decision whether to stay at the beach or to leave, thus affecting the revenue received by the local businesses, and the value of the beaches in general.

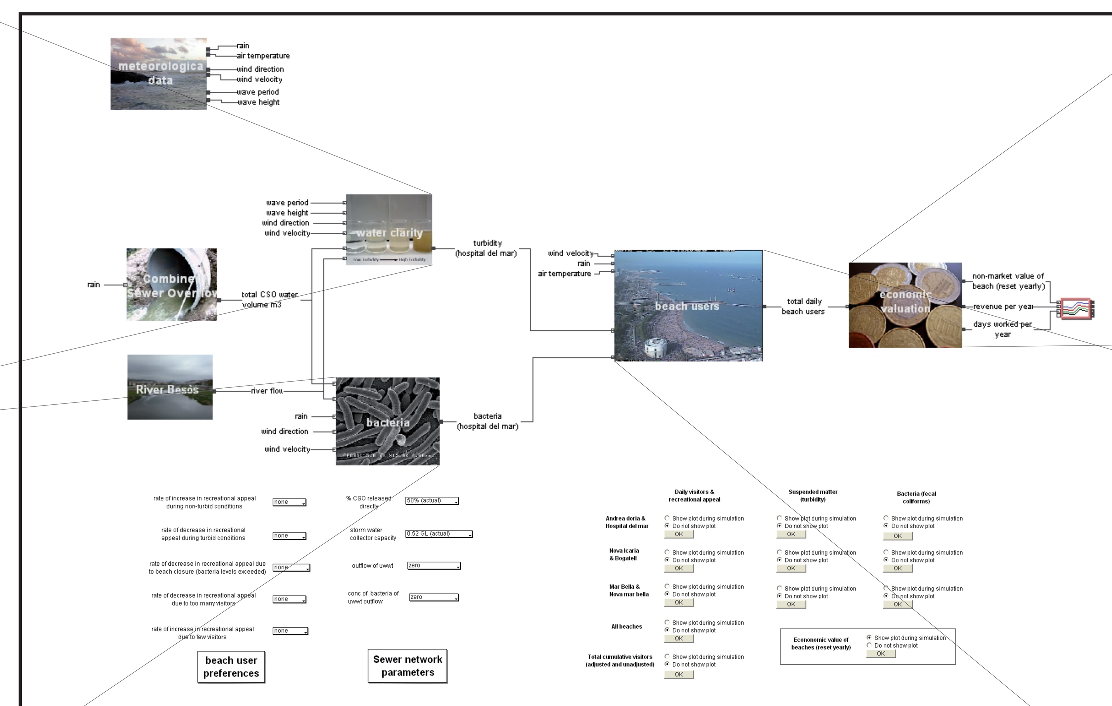
## 2. Model Formulation

The water clarity sub-model produces values which are visibly verifiable similar to the observed data. The figure shows the observed values of suspended matter at the beach of hospital del mar (black crosses) compared with the values produced by the model (blue lines).

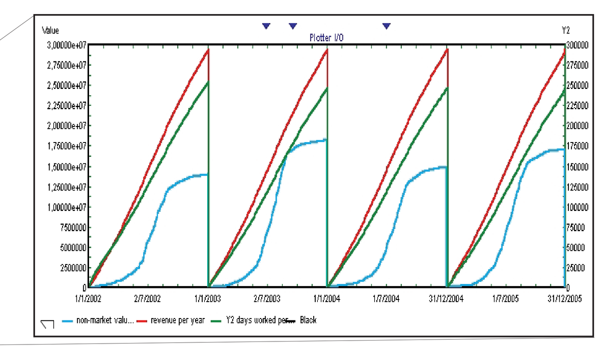


The model is constructed using various hierarchies in order to increase usability for the stakeholders. Clicking on each block opens a new sub model - this can be repeated until the user opens the "lowest" block which contains the mathematical formulation.

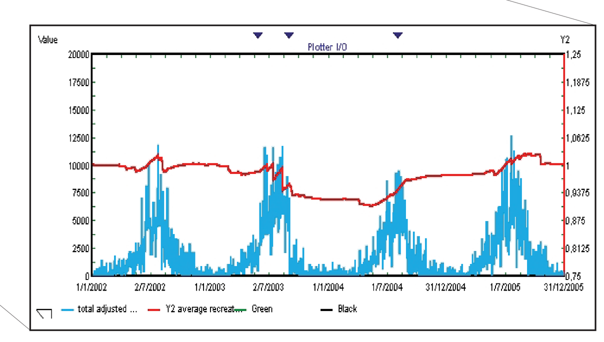




On the highest hierarchical level of the model, there is a control panel which enables the user to decide on various management options and scenarios. Similarly, the user can control which plotters appear during a simulation run.

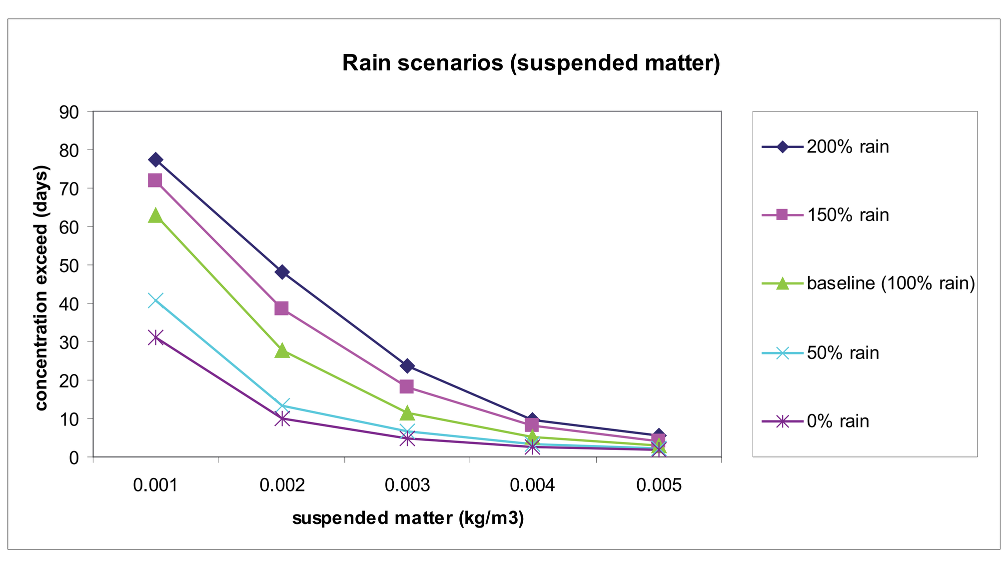


The model uses an innovative solution for evaluating economic impact by calculating both real money changes in business revenues (red, left axis) and employment (green, right axis) as well as changes in non-market value (blue, left axis) using the "travel-cost" method. The cumulative value is reset at the end of each year.

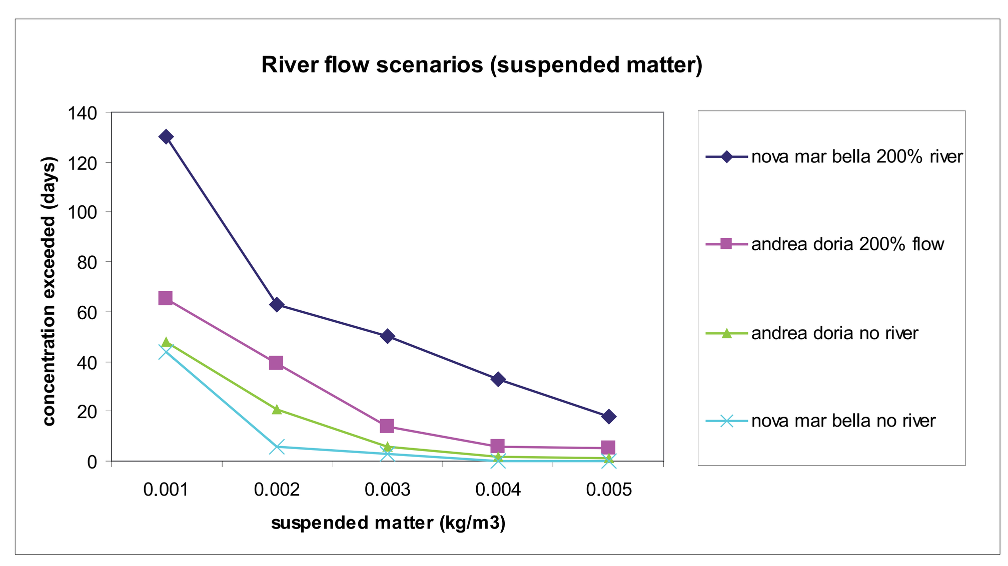


The number of daily beach users (blue, left axis) is calculated depending on meteorological and temporal factors as well as "recreational appeal" (red, right axis) which is affected by water quality and the carrying capacity of the beach.

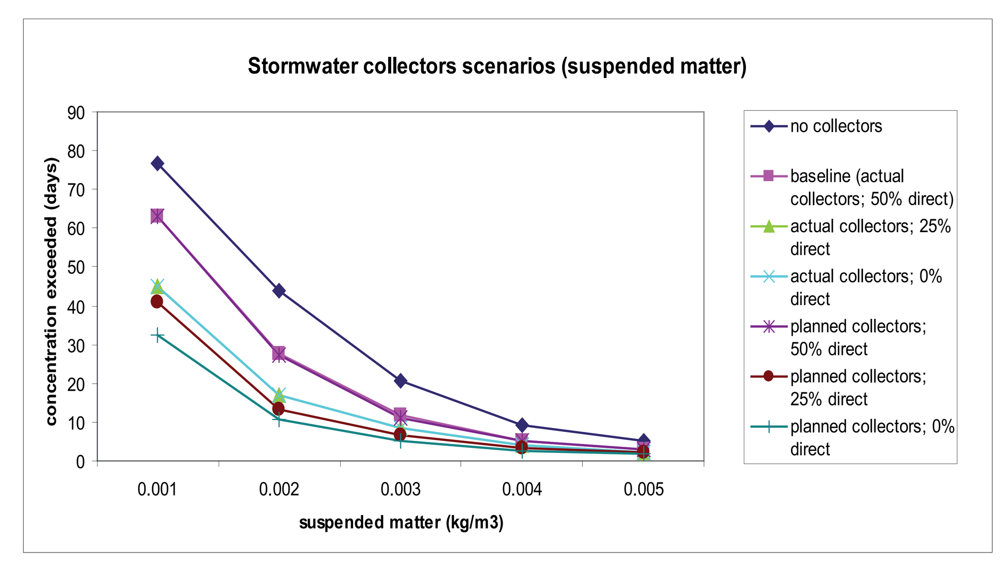
## 3. Scenarios and Model Output



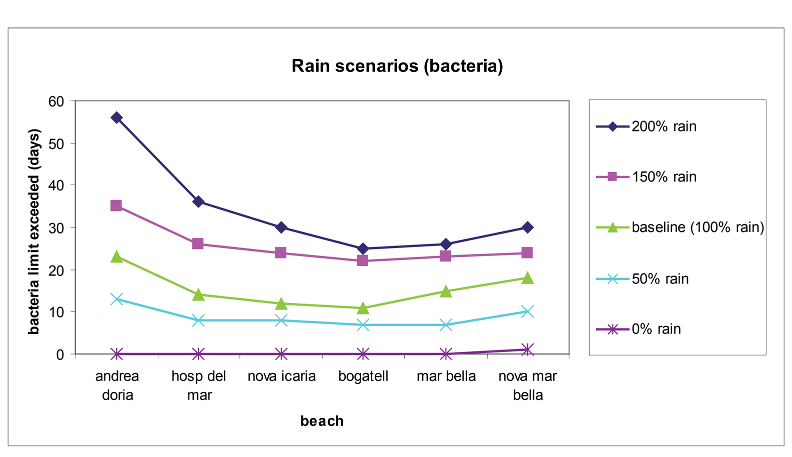

Increased rain has a greater affect on low concentrations of suspended matter than on high concentrations. Even with zero rain, days with lower concentrations of suspended matter are still fairly frequent (produced by wave re-suspension and the river).



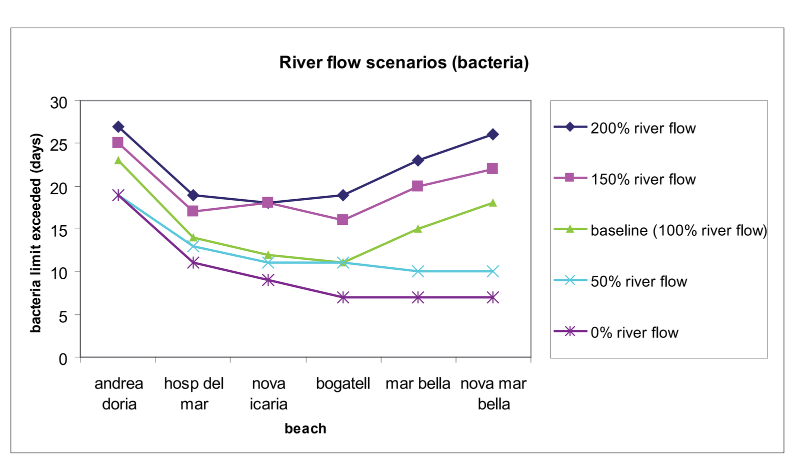

The beaches nearest to the river (nova mar bella) are affected by changes in river flow more than those furthest away (andrea doria).The two extremes of zero river flow and doubling of river flow for these two beaches are shown.



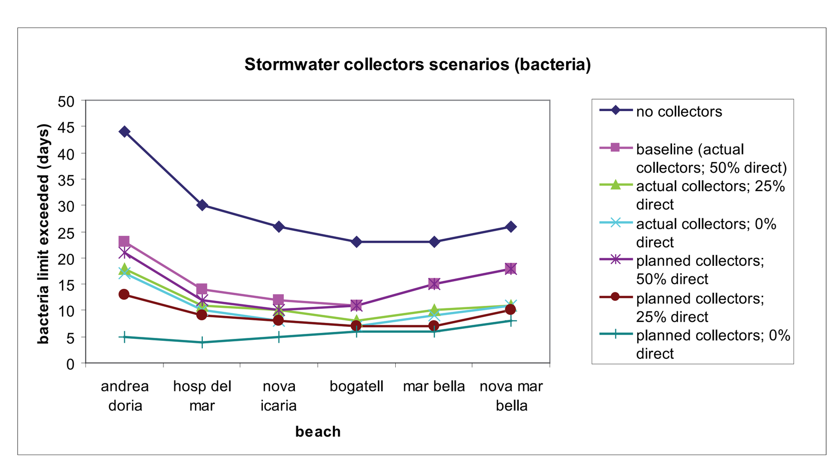

At the current percent of direct CSO release, tripling the capacity of storm water collectors will have no effect on suspended matter. The key variable is the percent of CSO directly released, and this only has a significant effect on the lower concentrations of suspended matter.



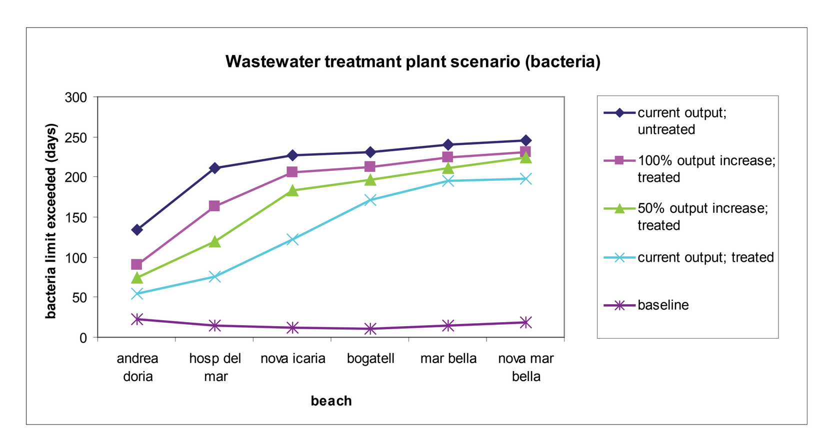

In contrast to the effect rain has on suspended matter, days in which the bacteria limit is exceeded almost disappear when there is zero precipitation. Increased rain affects each beach approximately the same, with those nearest to the river least affected.




Bacteria levels at those beaches nearest to the river (nova mar bella) are most greatly affected by changes in river flow in comparison to those furthest away (andrea doria). Even with zero river flow, there are a considerable number of days in which the bacteria limit is exceeded (caused by the CSOs).




Both the percent of CSO directly released and the capacity of storm water collectors have a shared effect in reducing days in which bacteria limits are exceeded.




Releasing the treated effluent away from the beaches (baseline) has a significant effect especially to the nearest beaches (nova mar bella). Increases in output of effluent also significantly negatively affect the water quality.

## 4. Interpretive Analysis

Analysis of the meteorological scenarios reveals that rain (and consequently combined sewer overflow events) is the key driver in the system for bacteria levels in the coastal water. Although the river does have an impact, it is minor in comparison.

Analysis of the sewerage characteristics scenarios reveals that the storm water collectors clearly can reduce both suspended matter and especially bacteria. Increasing the collector capacity will not necessarily decrease the number of days exceeding bacteria limits or high concentrations of suspended matter. A more effective policy option would be to decrease the percent of combined sewer overflow runoff that is released directly into the coastal water without being directed towards the storm water collectors.

The translation of these scenarios into changes in total beach visitors is variable due to the unknown sensitivity of beach water quality on recreational appeal. However, assuming high sensitivity over the hindcast period (2002-2005), it could result in a loss of around one million visitors a year (which equates to approximately a loss of €2.8 million using non-market valuation techniques or €37,330 in lost revenues at the local bars and restaurants). Enlarging the storm water collector capacity to the maximum possible (1.5 GL) and reducing the CSO directly released to zero would reduce the losses to a loss of 675,000 visitors a year equivalent to a loss of €1.7million (non-market value) or a loss of €22,190 in local revenues.

## 5. Final Stakeholder Deliberation

The scientific team presented the results in two stakeholder meetings. The first one took place with a reduced group of representatives and managers from the Catalan Water Agency and subsequently results were presented and discussed within a meeting of a commission in charge of coastal affairs. The main result is that our model has confirmed the expectation of certain stakeholders that the construction of further storm water collectors would have limited effects on the water quality (bacteria and water clarity) of the beaches. Policies regarding an improvement in water quality might consider the high economic costs of these infrastructures. In addition the performance of a coupled socio-economic and ecological model was noted as a positive and desirable feature of the model.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