Brigham Young University
BYU ScholarsArchive

International Congress on Environmental Modelling and Software

6th International Congress on Environmental Modelling and Software - Leipzig, Germany - July 2012

Jul 1st, 12:00 AM

Building an Integrated Model for Freshwater Allocation with Local Managers in a Coastal Area

Johanna Ballé-Béganton

Denis Bailly

M. Lample

Rémi Mongruel

Jean Prou

See next page for additional authors

Follow this and additional works at: https://scholarsarchive.byu.edu/iemssconference

Ballé-Béganton, Johanna; Bailly, Denis; Lample, M.; Mongruel, Rémi; Prou, Jean; Réthoret, Harold; Bacher, Cédric; Agùndez, José A. Pérez; Vanhoutte-Brunier, Alice; and Neveu, Julien, "Building an Integrated Model for Freshwater Allocation with Local Managers in a Coastal Area" (2012). *International Congress on Environmental Modelling and Software*. 291.
https://scholarsarchive.byu.edu/iemssconference/2012/Stream-B/291

This Event is brought to you for free and open access by the Civil and Environmental Engineering at BYU ScholarsArchive. It has been accepted for inclusion in International Congress on Environmental Modelling and Software by an authorized administrator of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.

Presenter/Author Information
Johanna Ballé-Béganton, Denis Bailly, M. Lample, Rémi Mongruel, Jean Prou, Harold Réthoret, Cédric Bacher, José A. Pérez Agùndez, Alice Vanhoutte-Brunier, and Julien Neveu

This event is available at BYU ScholarsArchive: https://scholarsarchive.byu.edu/iemssconference/2012/Stream-B/291

International Environmental Modelling and Software Society (iEMSs)
2012 International Congress on Environmental Modelling and Software
Managing Resources of a Limited Planet, Sixth Biennial Meeting, Leipzig, Germany
R. Seppelt, A.A. Voinov, S. Lange, D. Bankamp (Eds.)
http://www.iemss.org/society/index.php/iemss-2012-proceedings

Building an Integrated Model for Freshwater Allocation with Local Managers in a Coastal Area

Johanna Ballé-Béganton[1], Denis Bailly[1], Michel Lample[1], Rémi Mongruel[2], Jean Prou[3], Harold Réthoret[4], Cédric Bacher[5], José A. Pérez Agùndez[2], Alice Vanhoutte-Brunier[5], Julien Neveu[6]

[1]*Université de Brest, UEB, UMR AMURE, 12 rue du Kergoat, CS 93837, 29238 Brest Cedex 3, France (Johanna.Beganton@univ-brest.fr)*
[2]*Ifremer, UMR AMURE, UEM, BP 70, F-29280 Plouzané Cedex, France*
[3]*Ifremer, Environment and Resources Laboratory, 17390 La Tremblade, France*
[4]*EPTB Fleuve Charente, 2 place Saint-Pierre, 17100 Saintes, France*
[5]*Ifremer, Coastal Dynamics Department, 29280 Plouzané, France*
[6]*Eaucéa, 67, allée Jean Jaurès, 31000 Toulouse, France*

Abstract: In the last forty years the Charente river catchment on the Atlantic coast of France has experienced recurrent low river flows in summer, attributed to the increase in irrigated areas. This situation is inconsistent with the regional plan goals of good ecological status of the watershed and conflicts with the need for freshwater input in downstream coastal waters for oyster farming in the Marennes-Oléron bay. In this application of the SPICOSA (Science and Policy Integration for Coastal System Assessment) experiment, a new participatory approach for integrated assessment with local managers is explored in order to improve the regulation of freshwater use and meet the goals of the regional management plan. An integrated model was co-constructed following the SPICOSA System Approach Framework (SAF). The model, developed with the ExtendSim software, uses an ecosystem services approach to represent the system components of resources, uses, and governance. Irrigated agriculture production and irrigation governance regulation are simulated in the watershed and their impact on the coastal waters downstream. Local managers were involved at different steps of the model construction, from the choice of the policy issue through the setting up of the conceptual model, its formulation and appraisal the choice of scenarios, and presentation of results. The knowledge exchange with local managers was crucial for modelling freshwater governance and exploring relevant policy options. The integrated view provided by the model results modified local managers' perception of the freshwater system. This paper argues that the process of co-constructing the model was an essential driver of trans-disciplinary scientific communication and stakeholder engagement, and discusses the lessons learned for further improvement of this participatory modelling SAF approach.

Keywords*:* integrated modelling; Science and Policy integration; ICZM

1 INTRODUCTION

In the last forty years the Charente river catchment on the Atlantic coast of France has experienced recurrent low river flows in summer, attributed to the increase in irrigated areas. This situation is inconsistent with the regional plan goals of good ecological status of the watershed and conflicts with the need for freshwater input in downstream coastal waters for oyster farming in the Marennes-Oléron bay. In this application of the SPICOSA (Science and Policy Integration for Coastal System Assessment) experiment, a new participatory approach for integrated assessment with local managers is explored in order to improve the regulation of freshwater use and meet the goals of the regional management plan. An integrated model was co-constructed following the SPICOSA System Approach Framework (SAF) (Hopkins et al. 2011). The model, developed with the ExtendSim software, uses an ecosystem services approach (MEA 2003) to represent the system components of resources, uses, and governance. Irrigated agriculture production and irrigation governance regulation are simulated in the watershed and their impact on the coastal waters downstream. Local managers were involved at different steps of the model construction, from the choice of the policy issue through the setting up of the conceptual model, its formulation and appraisal the choice of scenarios, and presentation of results. The knowledge exchange with local managers was crucial for modelling freshwater governance and exploring relevant policy options. The integrated view provided by the model results modified local managers' perception of the freshwater system. This paper argues that the process of co-constructing the model was an essential driver of trans-disciplinary scientific communication and stakeholder engagement, and discusses the lessons learned for further improvement of this participatory modelling SAF approach.

2 THE SPICOSA PERTUIS CHARENTAIS STUDY SITE

The Charente river catchment is a mainly rural area of 10,500 km²; 60% of its area is agricultural and there is considerable tourist activity on the coast. The Marennes-Oléron basin is the first oyster production site in France where the quality and temperature of the water allows oysters to be cultivated over a complete biological cycle, and the basin has become the main spat collection area in France. In the last forty years, a number of droughts as well as change in agricultural policy have largely modified land use in the watershed: irrigated areas have increased massively, from 38 km² in 1970 to 815 km² in 2000, 85% of which is for maize production. The frequency of low flow conditions in the Charente has increased since 1976 and has been attributed to water extraction for irrigation rather than to climate change. In this context, the Charente region is in danger of failing the EU Water Framework Directive with respect to providing drinking water for households and tourism as well as local industries and maintaining the coastal ecosystem in good ecological status (Mongruel et al. 2011).

In 2008, an ICZM study of resource use in the Pertuis Charentais area reviewed expert analyses, petitions to the Administrative Court, and press articles, and observed common concerns to do with fresh water resources, with a large number of references to irrigation issues. Despite the considerable need of fresh water for the tourist industry, the tensions and conflicts in the area are between farmers and oyster farmers (Bouba-Olga et al. 2008). Situated downstream from the catchment, the shellfish farming industry depends on freshwater input from the river to carry nutrients for oyster growth and to reduce salinity during the spawning season for spat collection. Despite the fact that the processes have been scientifically described, it is difficult for this industry to quantify the minimum amounts of fresh water it needs. The dependence of spat collection on freshwater flow is a particular topic of controversy. In 2009 the regional River Basin Management Plan (SDAGE) formulated two goals: surface waters in good ecological status and subterranean waters in good chemical condition. It established a hierarchy for quantitative management of fresh water with, in order of priority, (1) good ecological status of coastal ecosystems, (2) availability of household drinking water, and (3) maintenance of other private uses (agriculture, shellfish farming) while reducing their impacts. In 2004, a Shortage Management Plan (PGE) had already involved different regional and local institutions with the national administration to establish Target Discharge Thresholds, defined at different control points in the catchment, to be reached in four years out of five, thus avoiding the drying up of the river during the irrigation season. The management plans are implemented through four main procedures (EPTB Charente 2004):

- Irrigation is controlled through maximum yearly or seasonal authorised volumes, established by the national water police, and through orders issued by the Prefect for the reduction or banning of sub-basin irrigation whenever the river

flow falls below the Target Discharge Thresholds or Crisis Ban Thresholds at the sub-catchment monitoring station.
- When flows are very low, the Prefect can order the reduction of household freshwater consumption.
- The watershed agency, the EPTB Charente, works with the different water users and in particular with the farmers' associations to maintain river flow, and also manages the discharge of two upstream water dams used to sustain a minimum flow during droughts.
- The UNIMA canal association manages the uptake of water from the river at drinking water purification sites and the wetlands area downstream.

In 1993, a convention was signed between the farmers in the upstream sub-watershed and the EPTB Charente to organise the management of irrigation uptake in exchange for water releases from the reservoir-dams built in 1989 and managed by the EPTB Charente. In accordance with this convention, the management of irrigation uptake is collaborative in the upstream sub-watersheds of the Charente and much less constrained downstream (Figure 1). The political debate now focuses on the modification of the "authorised volumes of water" for each type of consumption and on the improvement of the rules which restrict supply during periods of water shortage.

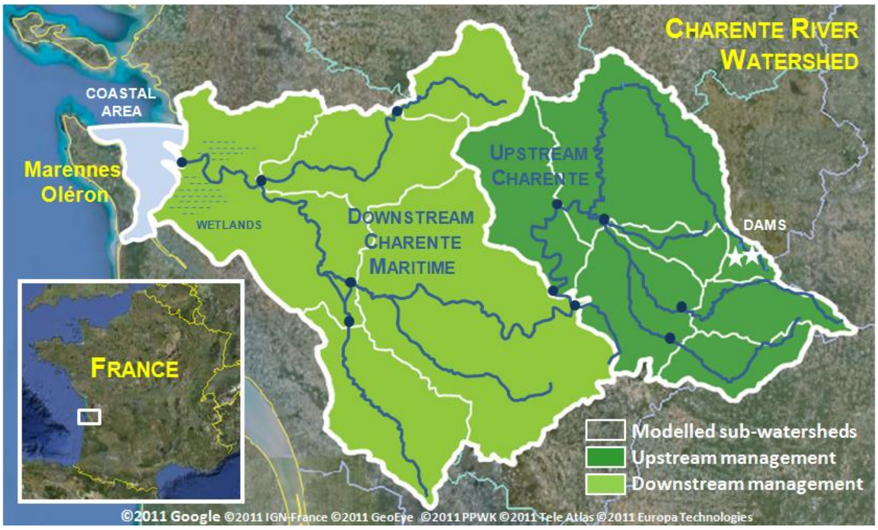

Figure 1. The Charente watershed and the Marennes-Oléron coastal basin.

In this context, a SAF partnership was set up between a stakeholder focus group of local institutions involved in managing the Charente catchment, which included: the Southwest France (Adour-Garonne basin) Regional Water Agency (AEAG), the Territorial Public Agency for the Management of the Charente (EPTB Charente), the Rivers Division of the Council of the Charente-Maritime Department (CG17), the national local space planning administration (DDTM-E), the national local agriculture and forestry administration (DDTM-AF), and the national local maritime affairs administration (DDTM-AM) responsible for shellfish farming policy (Mongruel et al. 2011). The scientific component of the SAF partnership brought together economists, marine ecologists, and modellers from IFREMER and the University of Brest with agriculture specialists from CEMAGREF. The SAF group planned to develop tools and knowledge for exploring management options that would reach the SDAGE goals for freshwater management.

3 PARTICIPATORY MODELLING IN THE PERTUIS CHARENTAIS

3.1 SPICOSA Modelling tools and Experimentation agenda

The SPICOSA project decided on a common modelling platform for all the study sites, namely the ExtendSim® simulation software (www.ExtendSim.com).

ExtendSim was chosen for its system modelling capacities inherited from STELLA type platforms (www.iseesystems.com), with the additional essential feature of hierarchical decomposition of processes (Ballé-Béganton et al. 2010). All modelling was required to be done in ExtendSim, with the goal of building simple system models for ICZM with the participation of the stakeholder group, following four established steps, that is, Design, Formulation, Appraisal, and Outputs. Six meetings of the SPICOSA SAF team were organised in the Pertuis Charentais, during the last two years of the project, two in 2009 and four in 2010. ExtendSim® is proprietary and must be acquired by developers but a free demo version is provided where the models can be run, the set ups and simulation codes can be accessed and even modified but not saved. This allowed the SPICOSA models to be freely distributed and used by the project stakeholders (www.spicosa.org).

3.2 From Conceptual model to Resource/Use/Governance projection

In the Design step, the SAF partnership built a conceptual model of the system for fresh water management, the selected policy issue. The group was asked to describe the different actors, components, processes, interactions, and stakes of the system, and represent it using Cmap software. The group also defined relevant indicators of this policy issue as perceived by the local managers. The resulting representation was a cross between a geographical projection and a relatively exhaustive and thus complex process representation. This exercise was rewarding in terms of group dynamics, as it allowed all participants to give their view of the system without the constraint of structuring the pooled knowledge material.

Figure 2. The SAF platform presenting the numerical model in its Resources-Uses-Governance structure (1), the knowledge area (2), and the simulation panel (3)

Next, the SAF team had to design the simulation platform so as to offer a simple representation, easy to build and to communicate, of a complex system. In the framework of sustainability assessment, we combined the system approach for environmental management, developed in the human ecology domain (Holling 1978), with an analysis of institutions and property rights on natural resources and the environment, developed in political economics (Ostrom 1990). The conceptual map was thus organised in a Resources-Uses-Governance projection (RUG) and implemented in the ExtendSim software using its graphical interface and hierarchical properties (Mongruel et al. 2011):

- Resources or ecosystem services which are available for use without threatening ecosystem sustainability
- Human activities which use resources and ecosystem services through exploitation, pollution, support of culture (tourism, industry, recreational activities, etc.)
- Governance standards, rules, institutional arrangements, and technical measures used to manage the relationships between people and nature and among people with respect to nature, to preserve or restore its status

This representation was welcomed by the stakeholder group as it portrayed possible management actions and offered an integrated view of human/nature interactions with each manager's position clearly represented. At this stage, the RUG projection could have been presented using Powerpoint® slides. However, we chose to present it directly in the ExtendSim software (Figure 2(1)), even though the modellers felt uncomfortable displaying the model with mostly empty component boxes. We observed that this approach subliminally gave a dynamic feeling to the meeting and encouraged the stakeholders to participate in formulation and conception of the model.

3.3 Mathematical formulation and Numerical model

In the Formulation step, the processes identified in the conceptual model were to be expressed in mathematical form before being transcribed in a numerical model using ExtendSim. The scientific team reviewed the existing and available knowledge, data and models. At this stage, the scientists and modellers encountered a number of difficulties inherent in integrated modelling and to transdisciplinary work. In order to explore management options for fresh water, the system model needed to be much more complex than had been planned. The science institutes had a good knowledge of some processes but very little regarding others that seemed to be essential for the conceptual model: for example, the processes of primary production and oyster growth in coastal waters are relatively well documented, while the prevailing factors for larvae and spat collection are still to be quantified. Moreover, some models were already in use: the SWAT model is used by the CEMAGREF to test agricultural scenarios, and IFREMER develops primary production models for coastal waters. But those models were numerically too complex to be transcribed in ExtendSim. The modellers had to devise new strategies for reformulating the processes with the right level of complexity (Ballé-Béganton et al. 2010). In this phase, the experiment showed that the constraint of using common modelling software promoted the complex coordination of the economic, social, physical, biological, land, and marine sciences and facilitated transdisciplinary work. Moreover, the use of the RUG projection as the basis of the system model construction and the SAF team leadership by social scientists helped us to avoid a common pitfall encountered in the development of models at some of the other SPICOSA study sites. In those cases, the different Environmental-Social-Economic components were developed separately and only linked together later on. The resulting models were mostly very complex ecological models with few links to the social and economic components.

3.4 Stakeholder participation for improved integration of local knowledge

The science team did not involve the stakeholder focus group in the Appraisal step. The scientists were not comfortable presenting work in progress that had not been appraised, but this lack of participation led to the absence of local knowledge that was crucial to the functioning of the system. In particular, for the key process of the Charente river hydrology, it was decided to transcribe the Eaucéa–CycleauPE model, originally developed in Excel®, which is calibrated, operational, and used by the EPTB Charente to make decisions on restricting irrigation during droughts and to calculate river flow at regulatory monitoring points in the catchment (Filali et al. 2007). The CycleauPE model is run weekly during the summer, including calibration with hydrology and irrigation data, but regulation of irrigation is not explicitly simulated. For the SAF system model regulation had to be formulated, but we were faced with highly complex and varied administrative decrees and orders from the Prefect covering the eleven sub-watersheds studied (Figure 1). The representative of the EPTB water agency in the SPICOSA stakeholder group was contacted, and helped us to understand the regulation system better.

In our first simulations, the modelled flow and irrigation uptake globally reproduced the interannual variability but showed two noticeable discrepancies when compared to observed flows (Figure 3):
(1) The appraisal of the 2005 “dry” year shows some deviation from the observed. At this point, we learned that the hydrology model provided by the project partners was used for one week predictions with a weekly fit to data and that we were using it inappropriately in interannual runs. The critical period for irrigation governance is the dry season and the modelled flow needs to be highly accurate when the flow draws near the regulatory minimum thresholds or in strong summer rain event. In a future version, the ExtendSim model is being coupled with an off-line hydrological model developed in HMS-HEC (Lample et al. 2012).
(2) The model also showed strong oscillations during the dry spell (Figure 3(a)). In our reading of local regulations and decrees, irrigation was banned whenever the river flow fell below the Crisis Ban Threshold, and allowed again two days after the river flow had recovered. The measured flow did not show those oscillations and was stable through the drought.

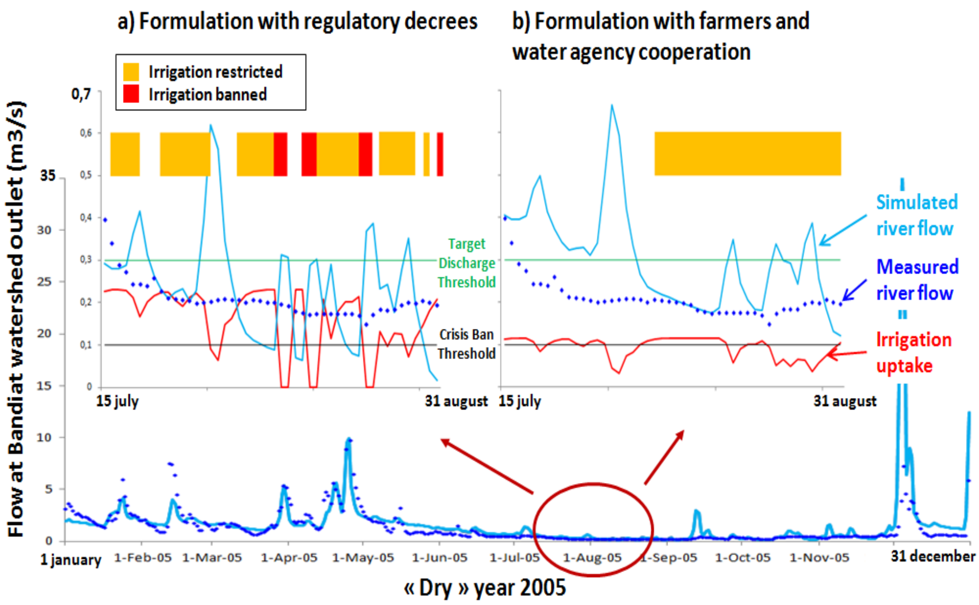

Figure 3. Simulated (blue solid line) and observed (blue diamond) river flow for the Bandiat sub-watershed (m3/s) and irrigation uptake (red solid line) during the dry season in 2005 for: a) irrigation regulation on first reading of regulatory decrees; b) irrigation regulation with collaboration between farmers and the EPTB agency

After thoroughly checking that it was not a numerical problem, we went back to the local water manager, who explained that in the upstream sub-watersheds the EPTB Charente met with the farmers’ representative every Monday during the dry season; depending on the river flow simulated by the CycleauPE model, with the input of the coming week’s weather forecast, they negotiated an irrigation uptake that would not reduce the river flow below the Crisis Ban Threshold. Also, if the river flow did sink below the Crisis Threshold, irrigation would be completely banned until the next heavy rains. With this new formulation, the simulated flow is much smoother and better agreement with observations (Figure 3(b)). In particular, the number of ban days for irrigation went from 10 to 0, which was the observed situation in 2005 (82 days of reduced irrigation to 76 observed). When we asked the water manager why he had not explained in complete detail their operating mode from the start, his answer was that he had not thought this relevant for the model, and that the regulation system was already complex enough to explain. This experience showed how important it was to present the model results to the stakeholder group, even when the results are obviously not accurate: it is only through this participation that we will be able to simulate human-nature interaction more accurately (Lample et al. 2011).

3.5 A platform for communicative knowledge integration and scenario testing

In parallel to the numerical model building, each meeting led the modelling team to use the graphic qualities of ExtendSim to develop a communicative platform to encourage and facilitate group sharing of their knowledge of this complex coastal system. The platform offers a scenario testing panel, with which the model user can test and compare different climatic conditions (dry, wet, or reference years) and test different freshwater management options for the upstream and downstream parts of the Charente catchment (Figure 4). A system view of the model results is presented, with a comparison of a set of indicators over two different scenarios (number of days of irrigation restriction, maize production, river discharge in coastal waters, plankton production, oyster production). A demonstration version of the Pertuis Charentais SAF platform is available at www.spicosa.org.

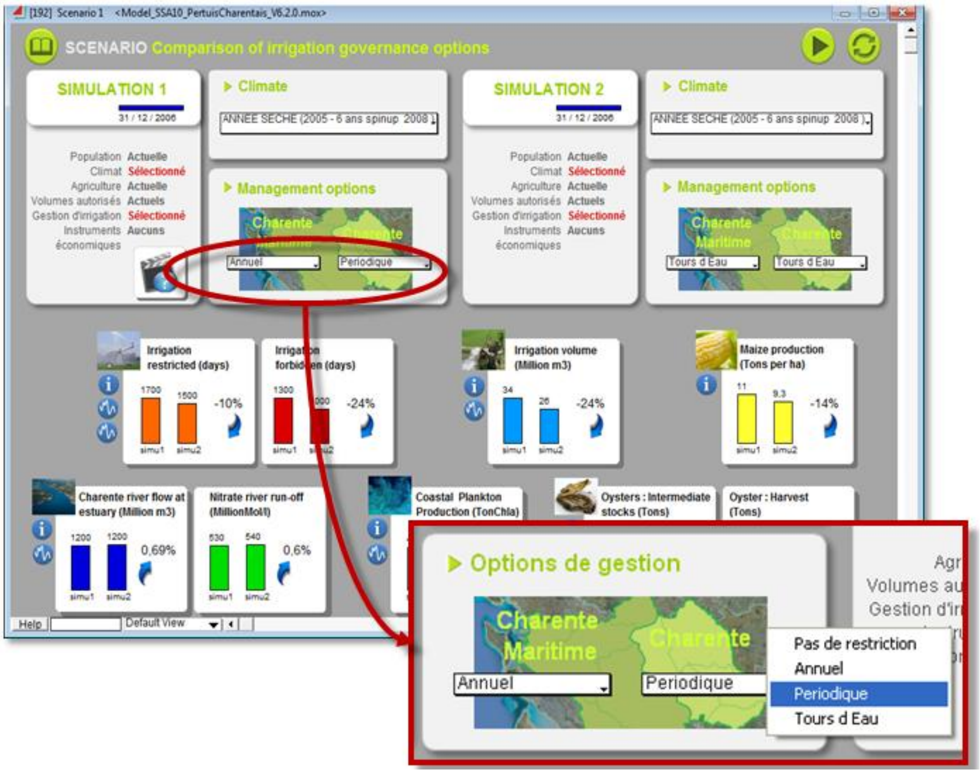

Figure 4. The simulation panel for scenario testing with management options

Apart from the scenario panel, the platform provides a knowledge area, in which information and documentation can be organised and stored with links to PDF files (Figure 2 (2)). In particular, during the SAF meetings the group worked on scenario development independently from the model construction. This part of the participatory process was both much appreciated by the stakeholders and efficient with respect to assessment, as it allowed for a wider discussion of qualitative information without the scientific constraints of data and of the numerical model. It was not finalised in this version of the platform, but the knowledge area could receive the scenario storytelling and thus complement the numerical model.

4 CONCLUSION

Throughout the SPICOSA project, interaction with the stakeholder forum has been a positive incentive to develop a platform that was scientifically sound and dealt with the complex issue of integrated modelling but also functioned as a communicative tool to enhance the knowledge and participation of the stakeholder and scientist groups. The stakeholder group foresees the potential for exploration of different management scenarios and is interested in the communication possibilities of the tool for future local discussions and negotiations; it is now making plans for the future. The experiment demonstrated that participatory modelling is a key element of science and policy integration. The SAF approach offers a methodology and a selection of tools to facilitate the necessary knowledge exchange and transdisciplinarity among stakeholders and scientists for the management of environmental sustainability. The Resources-Uses-Governance projection proved its effectiveness in integrating the social, economic and environmental sciences. The scenario testing simulation platform is an innovative tool for management option testing but also for knowledge organisation and storage. In future, the SPICOSA experiment in the Pertuis Charentais and in the other study sites will provide abundant material for learning new lessons in our ongoing development of the SAF.

ACKNOWLEDGMENTS

This work was funded by the European Commission under the 6th Framework Programme, Priority 1.1.6.3 “Global Change and Ecosystems” (IP SPICOSA, project N° 2007–036992). The authors wish to thank the representatives of local management bodies who participated in the project. The views expressed here are solely those of the authors.

REFERENCES

Ballé-Béganton, J., M. Lample, C. Bacher, A. Fiandrino, V. Guillard, T. Laugier, R. Mongruel, and J.A. Pérez Agúndez, A modelling platform for complex socio-ecosystems: an application to freshwater management in coastal zones, IEMSS Fifth Biennial Meeting, 5–8 July 2010, Ottawa, Canada, 2010.

Bouba-Olga, O., O. Boutry, A. Rivaud, and B. Guimond, Analyse des conflits d’usage sur le littoral picto-charentais, DRE Poitou-Charentes, 90 pp., 2008.

EPTB Charente, Plan de gestion des étiages: bassin de la Charente, Institution interdépartementale pour l’aménagement du fleuve Charente, France, 2004.

Filali, R., B. Coupry, and J. Neveu, La gestion du cycle de l'eau a l'échelle du bassin fluvial de la Charente, Géologues, Volume 154: 9-14, 2007.

Holling C.S., Adaptive Environmental Assessment and Management. London, Wiley, 1978

Hopkins, T.S., D. Bailly, and J.G. Støttrup, A systems approach framework for coastal zones, Ecology and Society, Volume 16(4):25, 2011.

Lample, M., D. Bailly, and J. Ballé-Béganton, A sustainability-driven approach for participatory modelling, 19th International Congress on Modelling and Simulation, Perth, Australia, December 12–16, 2011.

Lample, M., D. Bailly, and J. Ballé-Béganton, Coupling the ExtendSim platform with HEC-HMS hydrological model for irrigation strategies management, IEMSS Sixth Biennial Meeting, Leipzig, Germany (submitted), 2012.

Millennium Ecosystem Assessment: Ecosystems and human well-being – a framework for assessment, Island Press, Washington, D.C., 212 pp., 2003.

Mongruel, R., J. Prou, J. Balle-Beganton, M. Lample, A. Vanhoutte Brunier, H. Rethoret, J.A. Perez Agundez, F. Vernier, P. Bordenave, and C. Bacher, Modelling soft institutional change and the improvement of freshwater governance in the coastal zone, Ecology and Society, Volume 16(4):15, 2011.

Ostrom, E., Governing the commons: the evolution of institutions for collective action, Cambridge University Press, New York, NY, 1990.