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Participatory simulation to foster social learning on coastal flooding prevention

Nicolas Becu [a, *], Marion Amalric [b], Brice Anselme [c], Elise Beck [d], Xavier Bertin [a], Etienne Delay [e], Nathalie Long [a], Nicolas Marilleau [f], Cécilia Pignon-Mussaud [a], Frédéric Rousseaux [a]

[a] UMR 7266 LIENSs, CNRS – Université de La Rochelle, France
[b] UMR 7324 CITERES, University of Tours, France
[c] UMR 8586 PRODIG, University Paris 1, France
[d] UMR 5194 PACTE, University of Grenoble, France
[e] UMR 6042 GEOLAB, University of Limoges, France
[f] UMI 209 UMMISCO, IRD, France

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ABSTRACT

Due to the increase in coastal flooding risk associated with sea-level rise and increasing population along the coasts, there is a strong need to develop efficient and long-term management strategies. In partnership with the local administration of Oléron Island in France, a participatory simulation model was developed to foster social learning about coastal risk prevention measures with local authorities and managers. This simulation integrates a coastal flooding model and a spatially explicit agent-based model that simulates the development of the area and the management of prevention measures. The participatory set-up includes an immersive environment for participants to remember the coastal flooding simulation displayed and a role game mechanism that simulates the coordination issues between the different decision bodies involved in coastal risk management. A first application proved that participants learn about the water expansion dynamics during flood events and the effects of building, raising and restoring dikes.

Software availability

Program title: LittoSIM
Developers: Nicolas Becu (CNRS), Etienne Delay (University of Limoges), Nicolas Marilleau (IRD)
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Contact: Nicolas Becu, UMR LIENSs, 2 rue Olympe de Gouges, 17000 La Rochelle - France
Phone: +33 5 16 49 67 94. nicolas.becu@univ-lr.fr
First available: February 2015 (released on github)
License: creative commons Attribution-shareALike 4.0 international (CC BY-SA 4.0)
Hardware: PC platforms supporting JAVA
Software: GAMA platform, version 1.6 (download from http://gama-platform.org/download#GAMA161)
Toolbox requirements: LisFlood (download from http://www.bristol.ac.uk/geography/research/hydrology/models/lisflood/), appache activeMQ (download from http://activemq.apache.org/), network Gama extension (download from https://github.com/gama-platform/gama/wiki/Extension)
Disk requirements: 250 MB

* Corresponding author.
E-mail addresses: nicolas.becu@cnrs.fr (N. Becu), marion.amalric@univ-tours.fr (M. Amalric), brice.anselme@univ-paris1.fr (B. Anselme), elise.beck@ujf-grenoble.fr (E. Beck), xavier.bertin@univ-lr.fr (X. Bertin), etienne.delay@unilim.fr (E. Delay), nathalie.long@univ-lr.fr (N. Long), nicolas.marilleau@ird.fr (N. Marilleau), cecilia.pignon-mussaud@univ-lr.fr (C. Pignon-Mussaud), frederic.rousseaux@univ-lr.fr (F. Rousseaux).

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1. Introduction

1.1. Coastal flooding, prevention measures and risk culture in France

Coastal flooding is among the most dreading natural disasters at present, and for instance corresponds to the costliest natural disasters in Europe (IPCC, 2007; ONERC, 2010). It is likely that the intensity of such hazard will increase in the future, as a result of climate change, causing sea levels rise and possible local increased intensity of extreme weather events (IPCC, 2014). Estuaries, coastal lagoons and salt marshes are particularly affected because of their very low altitude. Since centuries, humans have constructed defenses, using burdensome techniques against the sea in order to gain land and protect themselves. The importance of the issues – social (urbanization and economy of coastal areas), ecological (high coastal biodiversity), heritage and landscape – requires the implementation of a comprehensive and integrated risk management approach of coastal flooding. Integrated coastal management promotes a strategic (long-term viewing), integrated and adaptive approach to coastal zone planning and management in order to contribute to the sustainable development of coastal areas. Within this framework, this paper proposes an integrated tool for collective reflection on defining and implementing coastal flooding prevention measures.

Coastal flooding occurs when dry and low-lying land is flooded episodically by the sea, during extreme meteorological and/or tidal conditions (Garry et al., 1997). In February 2010, coastal flooding caused by the storm Xynthia (Bertin et al., 2014) highlighted the limits of marine inundation risk management policy in France. This catastrophe has revealed deficiencies in the information provided to populations, in warning and alert systems, in managing dikes network and a relative unsuitability of coastal risk prevention plans. A whole series of decisions made before and during the crisis have considerably worsened the situation, revealing a lack of risk culture (Cartier, 2004; Jousseaume and Mercier, 2008). This lack of risk culture has led to choices, both collective and individual, in which environmental issues and those related to risk have been relegated to the background, while exacerbating consequences of the disaster (Anziani, 2010). On the population side, the last report of the French High Committee for Civil Defense (HCFDC, 2012) pointed out a lack of information and awareness. Thus, Xynthia has clearly highlighted a lack of local culture of coastal risks in France, both for the population and for policymakers.

In France, the development and implementation of a natural risk prevention plan (hereafter PPRN) is under the responsibility of local authorities, mainly municipalities. In February 2011, after Xynthia event, the government urged a number of municipalities to revise their PPRN by 2014 in order to implement measures for the prevention, prediction, protection and safety of populations in areas prone to sudden phenomena of coastal flooding. Yet, less than a third of the 974 coastal municipalities in France metropole has an approved PPRN, and only 18% have a specific plan for coastal risks; furthermore reviewing of existing PPRN defined by the circular of July 2011 (IFEN, 2011) has hardly been started. Moreover, a large number of PPRN developed since this date focused their prevention strategy on coastal defenses such as human-made dikes or natural sand dunes. Yet, scientific bodies and many environmental services of the national and regional administration, are currently calling for a change of policy towards more alternative prevention measures such as strategic withdrawal, natural operation restoration, managed realignment or depoldering, which are less expensive and more environmentally friendly (Anselme et al., 2011; Cariolet and Suanez, 2008; Goeldner-Gianella, 2010).

Such soft defense strategies emerged in Western Europe in the 1980s, mostly in Great Britain, where land use managers estimated that the cost of depoldering was lower than that of maintaining the dike in good condition (Myatt et al., 2003), with maintenance costs also lower at long term. This strategy requires preparedness measures such as organizing regular drills to improve crisis management when exceptional event occur (HCFDC, 2012). Another European example is Flanders (Belgium) where the state finalized a Masterplan Coastal Safety in 2011. The aim is to protect the coast against a storm with a return period of 1000 years and to have no breaching for a +8mTAW storm. Soft prevention measures are used (sand nourishment on beaches and in dunes). Only if necessary, 'hard' structures, such as dikes, are built or further improved. A state agency is in charge of the development and implementation of prevention measures but it requires a prior agreement of the local municipalities. Such risk management policy is very different from the one of France, where municipalities design and implement their PPRN and choose independently the type of defense strategy they evaluate best for their conditions.

In this first part, we identified the poor reflection of local decision bodies in France on a truly integrated approach to coastal risks management, especially the failure of taking into account alternative prevention measures and adaptive strategies. We now present participatory simulation approach as a suitable tool to foster social learning about coastal risk prevention measures with local authorities and managers.

1.2. Participatory simulation for collective learning

Participatory modeling as defined by Voinov and Bousquet (2010) regroups various approaches that use modeling in support of a decision-making process that involves stakeholders. Stakeholders may be involved at different stages of the process of defining, developing and using a simulation model (e.g. problem definition, conceptualization, calibration, scenario definition …) (Barreteau et al., 2011). Among those techniques, participatory simulation (PS) is a branch that involves stakeholders during the latest stage: the simulation of scenario (Voinov and Bousquet, 2010). In PS, several participants are invited to interact with a simulated hybrid environment that incorporates social and computerized components – economic exchanges may be simulated through hand-to-hand exchanges while flooding or bird migration may be computerized process. Participants take decisions according to their own goals and their experience of what occurred at the previous steps of simulation. Throughout the simulation that lasts for a given number of steps, participants progressively build a collective scenario. In this branch of participation; *"the modeling itself is not participatory as the settings and the rules of the games cannot be modified by the stakeholders"* (Voinov and Bousquet, 2010). A famous and emblematic application of such an approach is the Fish Banks game (Meadows, 1986) which mixes a computer simulation of renewable fish stocks and a role-playing game where participants own fishing companies and make decisions about fishing, buying and selling ships. Such simulation game may be used to demonstrate or to convey messages (such as using natural resources effectively and prudently) in an efficient manner as participants are actively involved in the learning process (Klabber, 2009). PS is also used for interventions, changing agents, such as culture reshape, improving internal organization of a social system, or even for planning and scenario design (Marshev and Popov, 1983). Risk and disaster management becomes nowadays a recurrent application domain of gaming and simulation as evidenced by Velasquez (2015) last keynote at the International Conference of Simulation & Gaming. The simulation of risk situations is used to encourage a change of behavior and practices in order to reduce vulnerability. Several applications were