PhD POSITION in Computer Science

ANR CopeWater Project

Agent-based hydro-social modelling for adaptive water governance in Mayotte

Supervision	**Kevin Chapuis** (Espace-Dev, IRD, Researcher) and **Benoit Gaudou** (Université Toulouse Capitole / IRIT, Professor)
Duration	3 years (doctoral contract)
Funding	ANR CopeWater Project
Location	**Université Toulouse Capitole / IRIT (Toulouse)** Missions to Mayotte (fieldwork) and UMR Espace-Dev (Montpellier)
Application	Before the 14th of July, send your CV, master transcript, and cover letter to kevin.chapuis@ird.fr and benoit.gaudou@ut-capitole.fr. An interview will be organised in the week.
Start Date	Autumn 2026 (flexible)

Research Context

Mayotte: a territory under hydrological and social pressure

Mayotte is a French overseas department and region in the Indian Ocean that experienced severe water scarcity during the past years. This island territory of approximately 375 km² depends entirely on locally generated freshwater resources, driven by rainfall and a compact hydrographic network with limited storage capacity.

Exceptionally rapid demographic growth — with a population estimated at over 300,000 and sustained migratory flows — is placing increasing pressure on water resources, straining existing infrastructure, and deepening access inequalities. Compounding these dynamics are rapid land-use changes (urbanisation, agricultural expansion), marked climatic variability structured around alternating wet and dry seasons, and climate change projections that are expected to intensify hydrological extremes in the coming decades.

The water crisis of 2023–2024 — during which prolonged supply cuts affected the entire population for several months — exposed the deep vulnerability of the water management system. It demonstrated the inadequacy of purely technical responses in the face of complex social and institutional challenges, and underscored the urgent need for an integrated approach encompassing biophysical, social, and governance dimensions [Morea, 2024; Terranti, 2024].

The scientific challenge of hydro-social modelling

Adaptive water management in socio-ecological systems such as Mayotte poses a fundamental research challenge: understanding and simulating how human decisions, institutions, and practices co-evolve with hydrological dynamics [McGinnis & Ostrom, 2014; Morehouse et al., 2008; Ostrom, 2009]. This co-evolution may steer the system towards resilience or, conversely, towards crises and tipping behaviour. Conventional modelling approaches — often siloed between physical and social dimensions — struggle to capture this complexity. The proposed PhD will be funded within the ANR CopeWater[1] project that aims to meet this challenge by developing a participatory and integrated hydro-social modelling framework. Its major objectives are: (i) to develop knowledge on interactions, feedback, and potential tipping points between the environment and society regarding water quality and quantity, and (ii) to search for adaptation measures with stakeholders for rendering socio-hydro systems more resilient to ongoing and future changes [Chapuis et al., 2022].

Research Project

General objectives

The central objective of the PhD is to develop an integrated model coupling an Agent-Based Model (ABM) with a parsimonious hydrological-hydro-sedimentary model, embedded in a participatory process grounded in Mayotte's catchments.

This framework aims to:

- Represent bidirectional feedbacks between social decisions and the physical state of the hydrological system;
- Reconstruct past vulnerability trajectories and identify future adaptation levers;
- Detect early-warning configurations associated with crisis regimes and tipping dynamics;
- Deliver a simulation-based deliberation and decision-support tool co-constructed with local stakeholders.

Study sites

The PhD focuses on the Ourovéni and Hajangua-Salim Bé catchments, selected for their representativeness of the dynamics at play in Mayotte: combined urban and rural pressures, agricultural water uses, ecological stakes, and governance complexity. Together, these two catchments offer sufficient diversity to test and generalise the approaches developed throughout the project.

Methodological architecture

a) Participatory Agent-Based Modelling (ABM)

The first component of the PhD involves co-constructing an agent-based model with local stakeholders — public institutions, water operators, municipalities, NGOs, farmers, and

[1] https://anr.fr/Project-ANR-25-CE32-2968

inhabitants — through companion modelling workshops. Agents represent heterogeneous decision-makers whose choices are shaped by water access, perceived risk, institutional rules, economic constraints, social norms, and crisis memory. Governance is represented through both formal arrangements and de facto practices, enabling the simulation of mismatches between policy intent and on-the-ground implementation. The Companion Modeling approach will be used to engage stakeholders to co-design the ABM [Barreteau et al., 2003; Etienne, 2014]. The agent-based model will be implemented using the GAMA platform [Taillandier et al., 2019], already used in many SES modeling (e.g. [Gaudou et al., 2013]).

b) Hydrological-hydro-sedimentary modelling
The second component relies on coupling the ABM with a parsimonious hydrological model, calibrated for the target catchments that represent rainfall-runoff dynamics, hydro-sedimentary pressures, and water availability and quality indicators. The coupling architecture is staged: a loose coupling is first implemented to stabilise variable exchange and calibration, after which dynamic coupling supported by a surrogate ML proxy model is progressively introduced to restore two-way feedback between society and the hydrosystem.

c) Simulation experiments
The coupled framework is used for two types of experiments. Retrospective simulations replay past crisis episodes and policy interventions to analyse underlying mechanisms (climatic variability, infrastructure limits, governance fragmentation, illegal extraction, demand growth). Prospective simulations explore adaptation trajectories under alternative climate and societal scenarios to identify robust, equitable, and effective combinations of adaptation measures.

Candidate Profile

Required qualifications and skills

Applicants must hold a Master's degree (or equivalent) in one of the following fields: computer science, data science; environmental science and engineering, including hydrology, water sciences, or geography; complex systems modelling, sustainability science, or systems ecology.

Competencies in several of the following areas are expected or strongly valued:
- Programming (Python, R, or Java) and geographic data processing (GIS);
- Agent-based modelling (NetLogo, GAMA, Mesa, or equivalent platform);
- Simulation, including exploration, sensitivity analysis …;
- Knowledge of socio-ecological systems analysis frameworks (Ostrom, IWRM, local adaptations).

Knowledge in hydrological modelling or mixed methods (qualitative and quantitative) and participatory or transdisciplinary approaches would be a plus.

Personal qualities

The successful candidate will demonstrate:
- Scientific rigour and the capacity to conduct independent research;

- Interdisciplinary openness and ability to work at the interface of natural and social sciences;
- Enthusiasm for fieldwork and engagement with diverse stakeholders (institutions, local communities, operators);
- Excellent written and oral communication skills in French; functional scientific English is required.

Prior experience in French overseas territories or southern island contexts would be an additional asset.

Application

Applications should be submitted before **the 14th of July 2026** to Kevin Chapuis and Benoit Gaudou at kevin.chapuis@ird.fr and benoit.gaudou@ut-capitole.fr.

The application package must include:
- A detailed curriculum vitae;
- A cover letter (maximum 2 pages) outlining the applicant's motivation and vision for the project;
- Master's degree transcripts (or equivalent);

For selected candidates, an interview will be organised quickly (in the week of the 13th of July, if possible).

References

[Barreteau et al., 2003] Barreteau, O., Antona, M., D'Aquino, P., Aubert, S., Boissau, S., Bousquet, F., ... & Weber, J. (2003). Our companion modelling approach.

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[Etienne, 2014] Étienne, M. (2014). Companion modelling. A participatory Approach to Support Sustainable Development. Éditions Quæ, Versailles, FR.

[Gaudou et al., 2013] Gaudou, B., Sibertin-Blanc, C., Therond, O., Amblard, F., Auda, Y., Arcangeli, J. P., ... & Mazzega, P. (2013, May). The MAELIA multi-agent platform for integrated analysis of interactions between agricultural land-use and low-water management strategies. In International workshop on multi-agent systems and agent-based simulation (pp. 85-100). Berlin, Heidelberg: Springer Berlin Heidelberg.

[McGinnis & Ostrom, 2014] McGinnis, M. D., & Ostrom, E. (2014). Social-ecological system framework: initial changes and continuing challenges. Ecology and society, 19(2).

[Morea, 2024] Morea F., 2024, Les impacts et conséquences de la crise de l'eau 2023 dans les bidonvilles de Mayotte, Etude du bidonville de Doujani 1, Master Thesis, univ. Paris 1 Panthéon-Sorbonne, 153 p.

[Morehouse et al., 2008] Morehouse, B. J., Ferguson, D. B., Owen, G., Browning-Aiken, A., Wong-Gonzalez, P., Pineda, N., & Varady, R. (2008). Science and socio-ecological resilience: examples from the Arizona-Sonora Border. environmental science & policy, 11(3), 272-284.

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[Terranti, 2024] Terranti L., 2024, Caractérisation de trois bassins versants (Hajangua, Salim Bé et Ourovéni): état des lieux de leur fonctionnement hydrologique, des usages de l'eau et leurs conséquences, Master Thesis, Univ. Paris Cité, 84 p.