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## **GAMA - an open-source complex system agent-based modelling and simulation platform**

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## PASHAMAMA-MONOIL model – impacts oil development activities in Ecuador

The northern Oriente region (Ecuadorian Amazon) has been colonized since the 1970s due to the combined effect of a significant state incentive for colonization by Andean inhabitants and oil development, which has led to the building of new roads and pollution. The PASHAMAMA-MONOIL model is designed to assess the combined impacts of these dynamics on both the environment and the human population by simulating population growth patterns, mostly immigration-driven, and oil pollution exposure over time. This model, which was built on the GAMA modelling platform (see below), is agent-based and spatialized. It serves as a basis for retrospective/prospective studies:

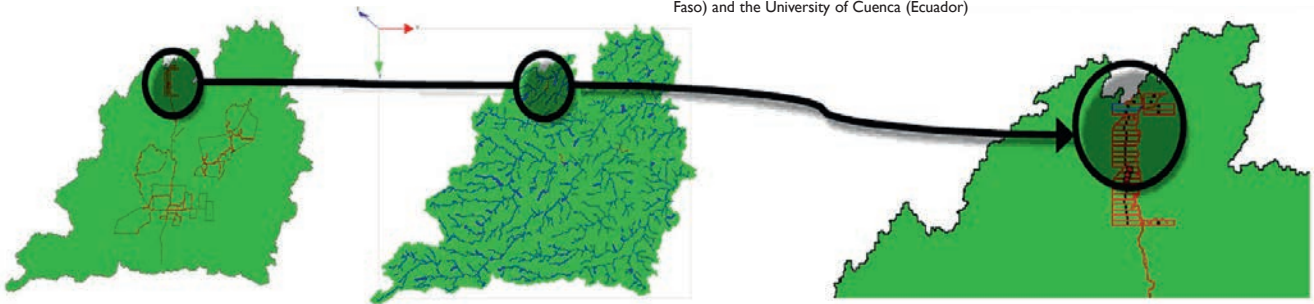
- a retrospective study of past dynamics (demographic, environmental and contamination)
- a prospective study (scenarios) according to future policies, oil or agricultural commodity prices, demographics, etc.

The model was developed by the IRIT and GEODE joint research units (UMRs) and their partners\* in three study areas: Pacayacu, Joya de Los Sachas and Dayuma. It couples two main dynamics:

- Oil companies are building roads, pipelines and other infrastructure. These cause leaks, breakages and other accidents that result in the leaching of local oil pollution into waterways, then affecting surrounding soils, farms and people.
- Colonizers from the Andes, the coastal region and southern Amazon settled on agricultural concessions that they chose to be as close as possible to roads, and they then produced food and cash crops there. Spatial, oil infrastructure and road data were from the Ecuadorian Ministry of Environment as well as local governments, while demographic data was from the National Ecuadorian Census Institute. The categorization of farmers was based on agricultural, anthropological and economic surveys carried out from 2014 to 2016.

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▲ Example of an oil spill causing pollution at the Dayuma site (Ecuador) and impacting colonized areas.

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## GAMA – an open-source complex system agent-based modelling and simulation platform

Agent-based modelling is becoming increasingly attractive for complex systems research. This approach consists of studying a system by modelling its components in the form of autonomous computational entities called agents, with their own specific characteristics and behaviours. The agent concept, which derives from the artificial intelligence field, is versatile—an agent can represent different types and levels of entities, e.g. a human being, house, social group or city. An agent-based model can deliver relevant information on the dynamics of the system it represents through agent-interaction. It can also serve as a virtual laboratory to test and predict the impact of new policies. Finally, it may be used as a discussion medium in participatory modelling and simulation processes. Agent-based model construction requires extensive computer programming because all agents and their behaviours must be described via algorithms. The GAMA open-source platform, which has been under development since 2007 by a consortium of research teams under the leadership of the UMMISCO



international joint research unit (IMU), aims to help modellers carry out this work. GAMA is a generic platform (adapted to any type of application), which allows model content building using GAML, an easy-access modelling language. GAMA has enjoyed significant growth in recent years because of its capacity to build and simulate large-scale models, including hundreds of thousands of agents and detailed geographic data. It also has advanced 3D visualization tools as well as tools devoted to the construction of serious games. This platform is now used in many research projects tackling issues as varied as epidemiology, land-use change, natural or technological risks, natural resource management and urban mobility.

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**For further information:** <http://gama-platform.org>



▲ Screenshot of a road traffic simulation for the French city of Rouen generated using GAMA.



◀ Screenshot of a simulation concerning indoor air quality generated using GAMA.