Final **report WP 1.2**

Conceptual modeling of organic matter flows to assess agroecological transition

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List of acronyms and abbreviations

AVSF	Agronomes et vétérinaires sans frontières
DyTAEL	Dynamics for a Local Agro-Ecological Transition
DyTAES	Dynamique pour une Transition Agro Écologique au Sénégal
EDSTM	Doctoral School of Science and Technology of Mali
ESP	Ecole Supérieur Polytechnique (UCAD)
GMV	Great Green Wall
IAE	AgroEcology Initiative
ODD	Sustainable Development Goals
PRAPS	Projet Régional d'Appui au Pastoralisme au Sahel
SENS	Savoirs Environnement et Société (UMR)
UCAD	Cheikh Anta Diop University
UMR	Unité Mixte de Recherche
USTTB	University of Sciences, Techniques and Technologies of Bamako

1. Introduction

1.1. Context

Agriculture in the 21st century has the major challenge of finding the necessary balance to mitigate climate change, to which it is an active contributor, without compromising its sovereign role of generating resilient food systems. Concerned about this vital challenge, the international community, through the Paris climate agreements in 2015 reinforced by the IPCC report on food systems in 2019, is militating for an ecological agriculture based on the principles of sustainable development, i.e. multi-dimensional performance (agronomy/environment, economic and social).

At the country level, in Senegal, the economic development reference framework (Plan Sénégal émergent-PSE) initiated in 2014 for the 2035 horizon has been readjusted in 2021 in PSE_Vert to devote 30% of agricultural land to agroecology.

However, despite the important place of agroecology in international and national agendas, it occupies a small proportion of the funding windows of donors, except for some, including the European Union (EU). Indeed, it is very often reduced to its biophysical dimension. Seen from this angle for a long time, agro-ecology today has very little scientific evidence to prove to donors its economic profitability, its scalability and its ability to meet short implementation deadlines in order to be recognized as a key solution for building sustainable food systems.

In order to bridge this information gap, a holistic vision of agroecology is being tested in Senegal along the East-Central-East transect, through initiatives such as Africa Milk and DESIRA FAIR Sahel, funded by the EU, for a sustainable intensification of food systems. These initiatives revealed, among other things, that in the central zone, represented by the department of Fatick, farms are more sensitive to agroecological practices. The market (processor and trader) also has enormous potential to boost and pull local production, despite the problem of destructuring.

Valorizing this potential through the identification of key success factors for creating short and sustainable agroecological value chains could enrich arguments, such as the CGIAR agroecology initiative, on the timely profitability and scalability of agroecology.
Indeed, in Senegal, the CGIAR agroecology initiative will build on proven achievements in agroecological intensification of food systems to support value chains composed of profitable and sustainable enterprises.

The WP1: “Living lab and co-conception of Innovation” is organized around 3 main axes: the accompaniment of the DyTAEL Fatick, the scaling up of agroecological innovations, and the modeling of accompaniment allowing for the definition of viable paths of agroecological transitions.

Firstly, the accompaniment of the DyTAEL will involve defining objectives and scope, roles and responsibilities, governance rules, the type of facilitation, elaborating a vision building collectively a shared vision of the most desirable agroecological transition pathway(s), and adjusting the Action Plan.

Secondly, the accompanying modeling on the territorial dimension of the agroecological transition will be integrated with interactions between agricultural productivity (crops, livestock, forestry), resource management (water, air, biodiversity), and production of ecosystem services (support, supply, socio-cultural). Computer modeling may allow for the boosting of coordination and generating discussion about common issues and interests with a territorial development view. The objective of this WP is to support, through a computer-assisted simulation process, a more productive territorial ecology.

Thirdly, the scaling up of agroecological innovations will focus on the valorisation of innovations tested in the framework of co-design schemes conducted in other projects, mainly the FAIR Sahel project. The FAIR Sahel system combines agronomic diagnoses and tests of agroecological options in central and satellite fields. Reflections will be carried out on the identification of obstacles and levers for these innovations to reach other producers in the region. The forms of adaptation of innovations among potential new users will be explored.

This activity is in support of the second point: accompaniment modeling.

1. Introduction

1.2. Objectives

The proposed intervention is to equip the Fatick DyTAEL with a simulation model to support the exploration of agro-ecological management options and enable the possible impact of these options to be estimated and discussed.

The methodology for setting up this system comprises several phases:

01 A conceptual modeling phase of the territory's functioning on the basis of the questions that the DyTAEL wants to address, which includes

1. **A workshop with DyTAEL** to present the modeling approach, define the relevant questions and sketch a first outline of what is expected;

2. **A series of interviews** or workshops with experts/technical advisors to assemble the elements of the conceptual model (i.e. to take stock of both the knowledge and the data required);

3. **A feedback workshop** to validate the conceptual model obtained;

02 A simulation model design phase, essentially based on expert judgement, involving a sequence of meetings to refine the outlines sketched out in the first phase;

03 A simulation model implementation phase, with a feedback workshop for validation by the experts and by DyTAEL (does the model correctly reflect the way their territory operates as they know it);

04 An implementation phase with a workshop on the different agro-ecological management options.

Phase 1 is being coordinated with FerloSiné, as the kick-off meeting in October 2023 discussed the creation of a conceptual model to better specify how the agricultural model MAELIA can meet the needs of their project (what already exists in MAELIA and what missing modules need to be developed). For the record, the FerloSiné workshop held from October 2. to 5. 2024 in Dakar consisted of :

- Reminder of the FAIRCARBON-SLAM B-FERLOSINE project objectives (JL Chotte);
- The MAELIA platform (Olivier Théron & Manon Dardonville en visio) ;
- Collaborative research approaches (Living Lab) (JD Cesaro, E Delay);
- Carbon and climate scenarios in Senegal (Amadou Thierno Gaye) ;
- Data and study sites: presentation based on current projects DSCATT (D Masse / E Delay), SUSTAINSAHEL, FAIDHERBIA FLUX (F Do), CASSECS (P Salgado, JD Cesaro, H Assouma), FAIRSAHEL/Initiative Agroécologie (JD Cesaro) ;
- Description of activities (based in particular on recruitment profiles): by those responsible for recruitment;
- Chronogram of activities, responsibilities, participation.

It was followed by field work on the Diohine (groundnut basin) and Labgar (reforestation in pastoral areas) sites. It was therefore important to share workshops/interviews (at least in part), or even develop specific modules together.

In addition, Tingouro Sanogo has been awarded a PRAPS PhD grant under the co-direction of Oumar Maïga, Jean-Pierre Müller and Souleymane Traoré at the University of Bamako (Mali). His subject is to instrument this model development methodology, illustrated by the issue of pastoralism (which is linked with agroecology on the one hand, and with carbon flow problems on the other) and the production of indicators that can be used by PRAPS to assess its interventions. He therefore come in support of the modeling process. This report concerns the phase 1 of this modeling activity during two missions (one in June and a last one in Septembre) and the obtained results.

1. Introduction

1.3. Chronogram of the two missions

Date	Activity	People met
June 23.	Arrival in Dakar (J.-P. Müller and T. Sanogo)	
June 24.	Planification of the mission	Etienne Delay, Alassane Bah
June 25.	Discussion about the formalization of modeling workflow	Etienne Delay, Alassane Bah
June 26.	Travel to the Mampuya workshop center	
June 27-28.	Workshop of co-construction of a first conceptual model	FerloSine project team: Dominique Masse, Etienne Delay, Alassane Bah, Anna Ndiaye
July 01	Travel to Fatick to meet DYTAEL stakeholders	The stakeholders of the DyTAEL of Fatick (Annex 1)
July 02	Workshop with the stakeholders of Diohine Travel to Linguère	The stakeholders of Diohine (Annexe 2)
July 03	Meeting with AVSF people Workshop with the stakeholders of Labgar	AVSF people The stakeholders of Labgar (Annexe 3)
July 04	Return from Dakar (J.-P. Müller)	

July 12	Restitution workshop	Etienne Delay, Dominique Masse
July 19	Technical comite workshop of Fatick DYTAEL	Mame Birame Sene
July 22	Return from Dakar (T. Sanogo)	
September 16.	Arrival in Dakar (J.-P. Müller et T. Sanogo)	
September 17 .	Mission planning and work on the conceptual model	Etienne Delay
September 18. – 20.	Work on the conceptual model	Etienne Delay
September 23.	Work on the conceptual model Meeting with F. Vendel (DYNAMIC project in Ferlo)	François Vendel
September 24.	Workshop preparation Travel to Fatick	
September 25.	Workshop in CEDAF at Fatick	DyTAEL technical comittee
September 26.	Interviews with resource persons Field Visit	M. Adama FAYE Cheick Amar
September 27.	Return to Dakar Update of the conceptual model	

1.3. Chronogram of the two missions

September 30.	Return from Dakar (J.-P. Müller)	
October 1. – 4.	Workshop	François Vendel
October 8.	Travel to Linguère	
October 9. – 11.	Workshop with the stakeholders of Velingara	
October 13.	Return from Dakar (T. Sanogo)	

2. The detailed activities

2.1. Day of 25/06/2024

Discussion of the question of formalizing the modeling workflow

On Tuesday June 25, an exchange session took place on modeling approaches, including the phases of interviewing and understanding the system, conceptual model design, model specification and implementation. Discussion also focused on the idea of setting up a partially automated workflow using model-driven engineering (MDE). IDM is based on the design of successive models, from the conceptual model to the target programming language model, and transformations between these models.

Videoconference interview with the Secretary General of the Fatick DyTAEL : ***Mame Birame Sene***

The interview took place on the evening of July 25. The aim was to establish contact and present our project, but also to discuss key issues for the Fatick department. In a first analysis, our modeling experiences could support stakeholders' reflections (DYTAEL or fora at commune level) on soil fertility management (AfD AgrEco project) and the organization of commodity chains (Dagana project on the dairy sector). This would be an opportunity to combine these two approaches to address the role of organic fertilizers (manure, compost) and animal feed. The introduction of water and food issues would considerably complicate the model.

It was suggested to organize an extended videoconference with all members of the technical committee or to hold a workshop with the technical committee during the next mission

2.2. Workshop on the co-construction of a conceptual model

On June 27 and 28, a workshop was held at the Mampuya center to discuss the co-construction of a conceptual model. It focused on the convergence between FerloSine and IAE issues, with a particular focus on carbon neutrality in agro-sylvo-pastoral contexts and local agroecological transition dynamics (DyTAEL).

After a phase of clarifying the objectives of the two projects a discussion phase on the links between the two projects followed, and considered the following points:

- Common Concepts: Identity of conceptual objects with specificities on monitoring-evaluation indicators (more carbon for one, more organic matter for the other).
- Scales and Entities: Need to define the minimum grain (e.g. the elementary unit may be the household and the associated farm area).
- Conceptual Model: Importance of not limiting oneself to defined scales, and of taking into account geographical relationships between objects.

With this in mind, the modeling question selected is:

What agro-sylvo-pastoral practices are needed to achieve carbon neutrality and the sustainability of the trajectories desired by the stakeholders of a territory: the cases of diohine and Labgar?

A number of recommendations were made during the workshop, including:

- Continue discussions with the various local players to better identify and describe their practices.
- Validate conceptual models with thematicians (interdisciplinary model) but also with local actors (transdisciplinary model).
- Reflect on and reorganize modeling activities to clarify expectations and obligation regimes vis-à-vis the model, the project and the participants.

2.3. Meeting with Fatick DyTAEL stakeholders

On Monday 1er July in the evening was held the meeting with the actors of the DyTAEL (see the list of participants in appendix 1). The purpose of this meeting was to establish initial contact with members of the Fatick DyTAEL as part of our project to set up a model.

The meeting provided an opportunity to clarify the objectives of the modeling project and identify the key aspects to be taken into consideration. Participants demonstrated their support and dedication to the project. To deepen the discussions and prepare for the forthcoming mission, participation in the next quarterly meeting of the DYTAEL technical committee is requested.

2.4. Field visit in Diohine

On Tuesday July 2, the workshop was held with local stakeholders from Diohine (see list of participants in Appendix 2). The aim of the meeting was to identify the current agropastoral practices of local stakeholders.

Workshop with local stakeholders in Diohine - Identification of agro-pastoral practices and resources

The workshop provided an opportunity to gather key information on agropastoral practices in Diohine.

2.5. Field visit in Labgar

Interview with AVSF agents

On the morning of Wednesday July 3, a meeting was held with two AVSF agents from Linguère, including Seydou Badji. This meeting enabled us to establish initial contact with them, and to discuss the mission's objective and the area of intervention (Labgar).

This interview enabled us to establish initial contact and discuss our mission objective in detail. We received contact recommendations, a detailed presentation of the Labgar territory, and discussions on the management structure and livestock farming.

Workshop with Labgar stakeholders

On Wednesday 03 July, a workshop was held with local stakeholders from Labgar (see list of participants in appendix 3). The workshop provided crucial information on pastoral practices in Labgar. Discussions highlighted, among other things, the challenges of transhumance.

2.6. Restitution of the obtained results

On July 12, the feedback workshop took place by videoconference with the presence of : Tingouro Sanogo, Etienne Delay and Dominique Masse. It focused on the first conceptual model, developed after the two workshops held with local stakeholders.

The workshop was structured around three points:

- First, a reminder of the chosen question
- Then a presentation of all the graphs making up the conceptual model.
- Finally, discussions on the conceptual model.

A number of comments were made, notably on the fact that soil is considered as a carrier of resources, notably fertility, carbon, nitrogen and biodiversity.

2.7. Meeting of the Fatick DyTAEL technical committee

On July 19, 2024, the Fatick DyTAEL Technical Committee met in the presence of Tingouro Sanogo (the PhD student). The meeting agenda included, firstly, the presentation of general information and the DyTAEL quarterly report, as well as prospects and miscellaneous.

The presentation of our modeling project was also discussed. Tingouro Sanogo briefly explained what a model is, what constitutes it, and presented an example of a model carried out on another field not related to agroecology to give a clear idea of the concept. The project was unanimously accepted by DyTAEL members and incorporated into their action plan for 2024. The next workshop with the technical committee is scheduled for September-October.

2.8. Day of 17/09/2024

The first meeting took place on Tuesday September 17 at the École Supérieure Polytechnique (ESP) de Dakar (UCAD). The aim was to work on the conceptual model and discuss the overall approach, including generating a table of contents for specification documents from the conceptual model.

This session enabled us to refine the overall approach and delve deeper into key aspects of the conceptual model, while discussing resource management and theoretical notions useful for the project.

2.9. Days from 18/09/2024 to 20/09/2024

2.9.1. ***18 septembre 2024*** - École Supérieure Polytechnique

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2.9.2. ***19 septembre 2024*** - Institut de Recherche pour le Développement (IRD)

Reflection on the conceptual model continued. Étienne noted the similarities between the ARDI, PARDI and category theory approaches.

2.9. Days from 18/09/2024 to 20/09/2024

2.9.2. ***19 septembre 2024*** - Institut de Recherche pour le Développement (IRD)

The preparation of the workshop was also discussed. It was proposed to use an interactive approach with post-its and the model, enabling participants' ideas to be visualized and structured in a more engaging way.

Discussions also covered reverse engineering and Maelia's decision rules.

A key point raised was the implementation of a validator for the model. The idea would be to display tooltips in the event of inconsistencies, enabling conceptual errors to be detected and corrected effectively.

2.9.3. ***20 septembre 2024*** - Direction Régionale du CIRAD

The following points were discussed:

- Time-Place-Form approach to vhange.
- Pathways: designing a diagram to represent the composite pathways of resource transport and transformation.

We began by exploring transformation processes, in particular composting. This led to the design of an overall diagram of the value chains, including both transport and processing aspects. This diagram captures the complexity of the value chain and will be essential in representing the different dynamics at play in the model.

We also held discussions with the regional manager of CIRAD: Ibra Touré who is part of the PRAPS initiative.

These three days of activities enabled us to continue improving the conceptual model.

2.10. Day of 23/09/2024

On September 23, 2024, we held an exchange session with François Vendel, a PhD student from the Dundi Ferlo project, who is working on modeling in the Ferlo field. The main objective of this meeting was to make an initial point of contact to identify potential avenues of collaboration between our modeling work.

We began the meeting by presenting our respective conceptual models, which gave everyone a better understanding of each other's work. This presentation laid the foundations for constructive exchanges and enabled F. Vendel to see the similarities and points of divergence between our approaches.

Following the presentations, we exchanged views on the points we share. These discussions focused in particular on methodologies.

This first meeting opened up some interesting prospects for future collaboration.

2.11. Day of 24/09/2024

On September 24, a working session took place at IRD to prepare the visual aids for the validation workshop of our conceptual model. The aim of this session was to make the presentation clear, understandable and engaging for a non-computer-savvy audience, while ensuring the effective transmission of the technical aspects of the model.

2.12. Workshop with the Fatick DyTAEL technical comittee

On Wednesday September 25, the DyTAEL technical committee held a workshop to validate the conceptual model. The aim of this workshop, entitled “Workshop on the modeling of organic matter flows at territorial level”, was to present and validate an initial conceptual model of how territories function around organic matter flows.

The workshop concluded with a discussion on the next steps, with the identification of resource persons who would contribute to the following day's discussions. Stakeholder collaboration and commitment were reaffirmed as essential to the modeling of organic matter flows.

The workshop helped to advance thinking on the modeling of organic matter flows at territorial level, taking into account local specificities. Participants actively contributed to improving the model, and several avenues of work were identified for future phases.

2.13. Interviews with the resource persons and filed visit

On September 26, 2024, we had the opportunity to talk with Mr. Adama Faye (community representative), a key resource person, as well as to carry out a field visit. The meeting with Mr. Faye provided an opportunity to discuss local issues relating to agriculture, livestock and natural resource management in the department. We also met with a root specialist and an Eaux et Forêts agent, who shared their perspectives on soil management and reforestation.

Following the interview with Mr. Faye, we visited the Niakhar field and met with a root specialist. The discussion focused on technical aspects relating to litter, roots and plant growth. These exchanges enabled us to gain a better understanding of the interactions between organic matter and soil health, as well as the importance of these dynamics for the sustainable management of agricultural land.

The visit continued to Niakhar, where we spoke with a Water and Forestry officer. This agent shared his experience of reforestation, highlighting the challenges he faces, including uncontrolled burning and excessive collection of crop residues, which weaken the soil. He also mentioned that several forest regeneration projects had failed due to the population's inability to adopt the good practices necessary for their success.

The interview with Mr. Adama Faye and the field visits provided a comprehensive overview of local agricultural and livestock practices, while identifying the challenges to be met for a more sustainable management of natural resources. Integrating agro-ecology into these practices appears to be a promising way of meeting these challenges, while ensuring greater community resilience in the face of demographic and environmental pressures.

Discussions also highlighted the need for close collaboration between the various local players to promote sustainable agricultural practices, and for greater awareness of the importance of forest regeneration.

2.14. Workshop with F. Vendel and workshop in Velingara

From October 1 to 4, 2024, T. Sanogo and F. Vendel held working sessions on the Dundi Ferlo project model, in particular the breeding strategies. They discussed the strategies and implemented the basics so as to be able to approach local players and list the strategies in detail so as to be able to implement them.

From September 9 to 11, 2024, F. Vendel organized a workshop with the aim of presenting the current version of the simulation model and discussing with local stakeholders to validate the strategies implemented.

The workshop in Vélingara with François began with an introduction of the participants, including the facilitation team and local players, the vast majority of whom were village chiefs. The first day was marked by the presentation of a report on activities to date, with a focus on transhumance-related problems. Discussions focused on the coordination of transhumant settlements to avoid conflicts. Although management rules exist, their application remains limited. A number of solutions were proposed, including reducing herd size, promoting good practices or allocating private land to each household. A key suggestion was to give more power to sector chiefs to control anarchic settlements, or to reorganize the territory into zones dedicated to agriculture and livestock farming. A more drastic solution was to deprive transhumants of access to water from boreholes, although this would be difficult to implement.

Discussions also covered the two types of transhumance: that of local inhabitants during the dry season, and that of agro-pastoralists from the south during the rainy season. The day concluded with a presentation of the simulation model, explaining its various functions and its simulation environment.

The second day began with a recap, followed by a discussion of breeding strategies. This included practices such as grazing, pruning in case of food deficit during the dry season, and the benefits of pruning for certain tree species. However, some destructive practices, such as the direct cutting of trees, were denounced. Solutions, such as educating and raising the awareness of shepherds, as well as forest regeneration actions, were discussed.

The third day focused on the use of crop residues, mainly used to feed the herds before transhumance. The residues are stored in the houses and consumed by the cows, contributing to more efficient management of local food resources.

3. Results obtained

The aim of the activities fo 2024 was to identify the question of interest for the stakeholders, in particular the DyTAEL, to design the adequate conceptual model for answering the question of interest and to advocate the utility of modeling for supporting agroecological transition monitoring and management.

Workshop with Labgar stakeholders

What are the impacts of agro-sylvo-pastoral practices on the sustainability of the trajectories desired by the stakeholders of a territory?

From the collaboration with the FerloSine project, sustainability includes carbon neutrality and from the exchanges with the stakeholders, a better management of organic matter flows within the territory.

Accordingly, a conceptual model was incrementally designed and refined. The aim of the conceptual model is to provide an agreed upon view of the territorial structure and dynamics. It is a first step towards the production of a simulation model. From the exchanges with the stakeholders, the simulation model can be used in different ways:

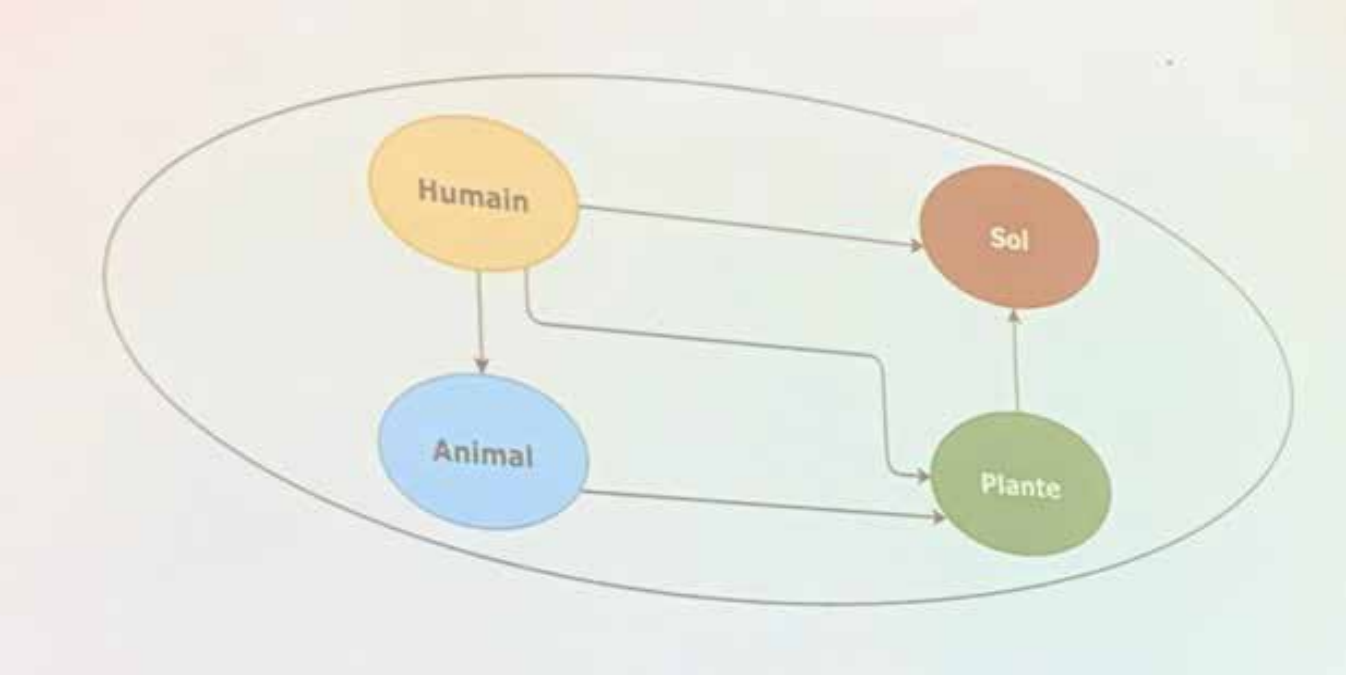
- To explore a number of agroecological practices and policies to assess the expected impacts they may have on the sustainability at the territorial level;
- To provide advocacies of various agroecological practices and policies by demonstrating the impact on the resilience at the territorial level;
- As an innovation diffusion tool by demonstrating the expected effects of various agroecological practices.

The last two uses seem similar but the first is addressed to the policy makers, and the second to the farmers for innovation diffusion. These various uses have been clearly identified and understood by the stakeholders during the workshops and interviews.

In the context of our modeling of organic matter material flows, the local players are

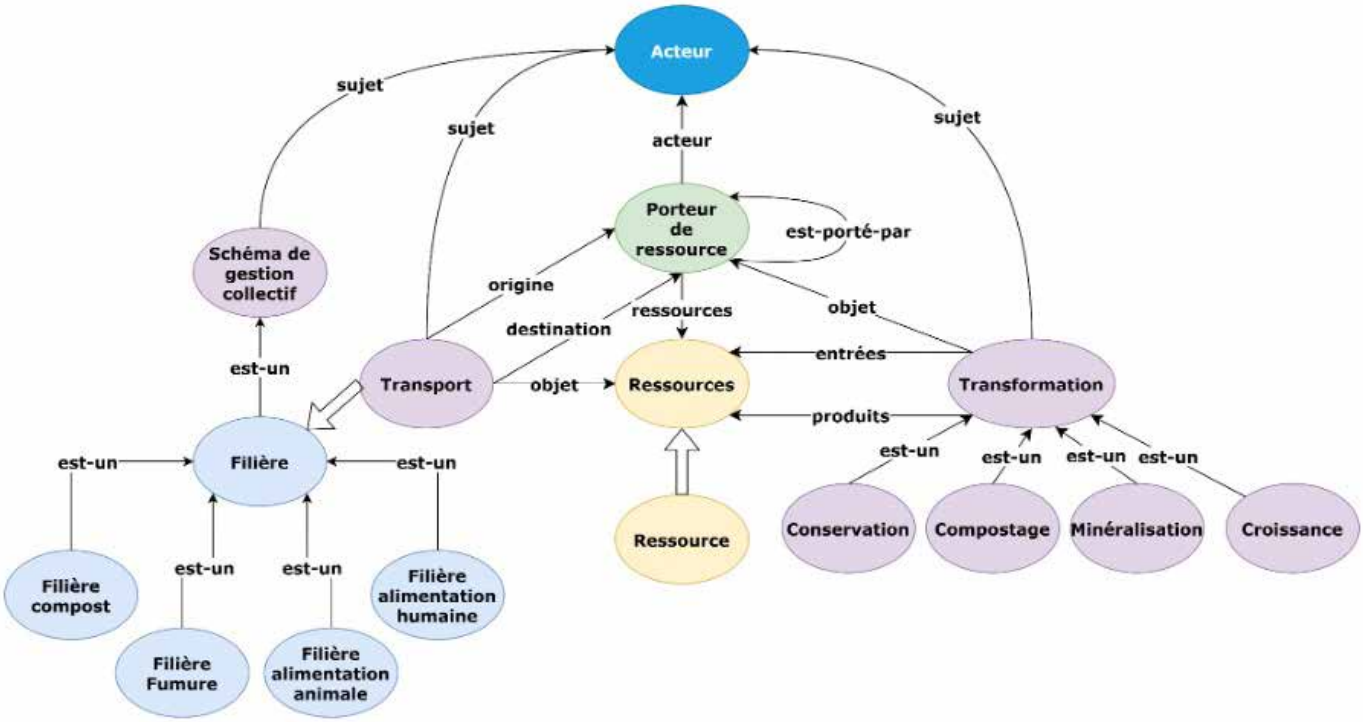
- o humans
- o Soil
- o Animals
- o Plants

Each provides the other with what it needs to live. The atmospheric and hydrographic systems are added to this schema, but have not been developed here to avoid complicating the model.



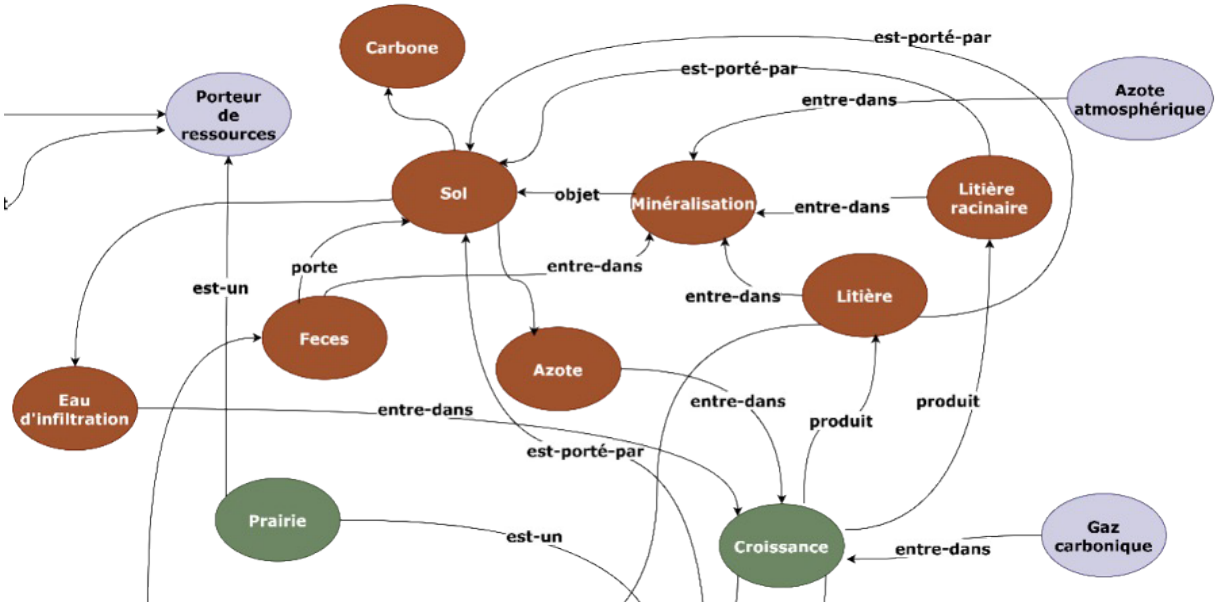
To account for the structure of the system, the concept of resource holder is introduced. All the mentioned actors are resource holders. For example, a plant can be a source of food (for animals and/or humans), of forage and of liter (for the soil). This multifunctional aspect is essential to understand organic matter flows and understand the effect of the agroecological practices.

To account for the dynamics, each actor of the system is performing both transformations and transportations (flows) as it is illustrated in the following figure:

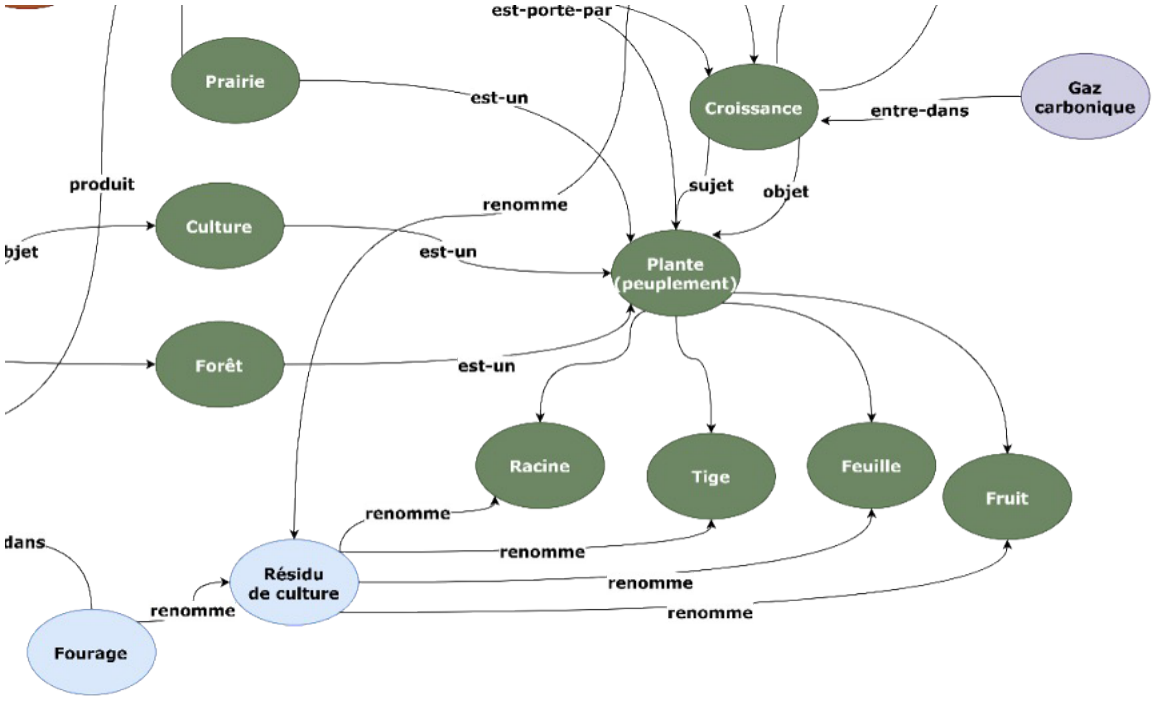


The transformations change resources into other resources. The transportations move resources (or resource holders) from a place to another. Supply chains are just the human counterpart of these flows and participate to organic matter circulation within the territory, as do the animals and water flows.

The following figure illustrates how the soil transform the surface resources (manure, liter) and atmospheric gazes into organic matter and its main compounds: carbon and nitrogen for fertility:



The following figure does the same for the plants, providing liter and various kind of food (for humans and/or animals):



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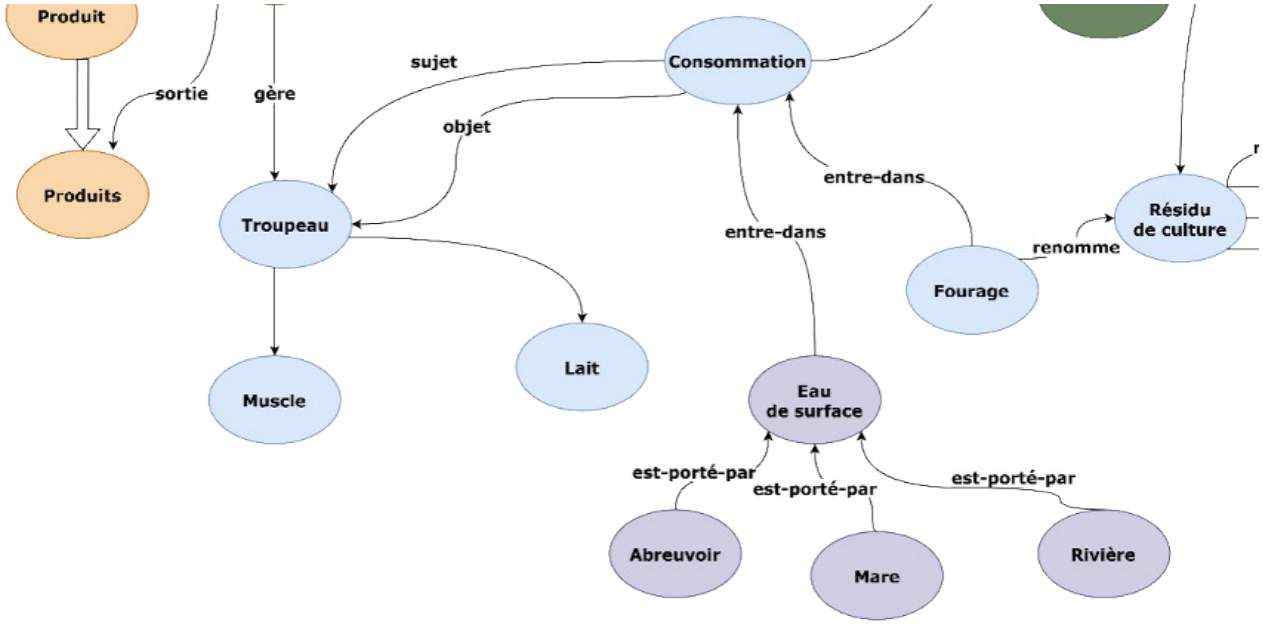
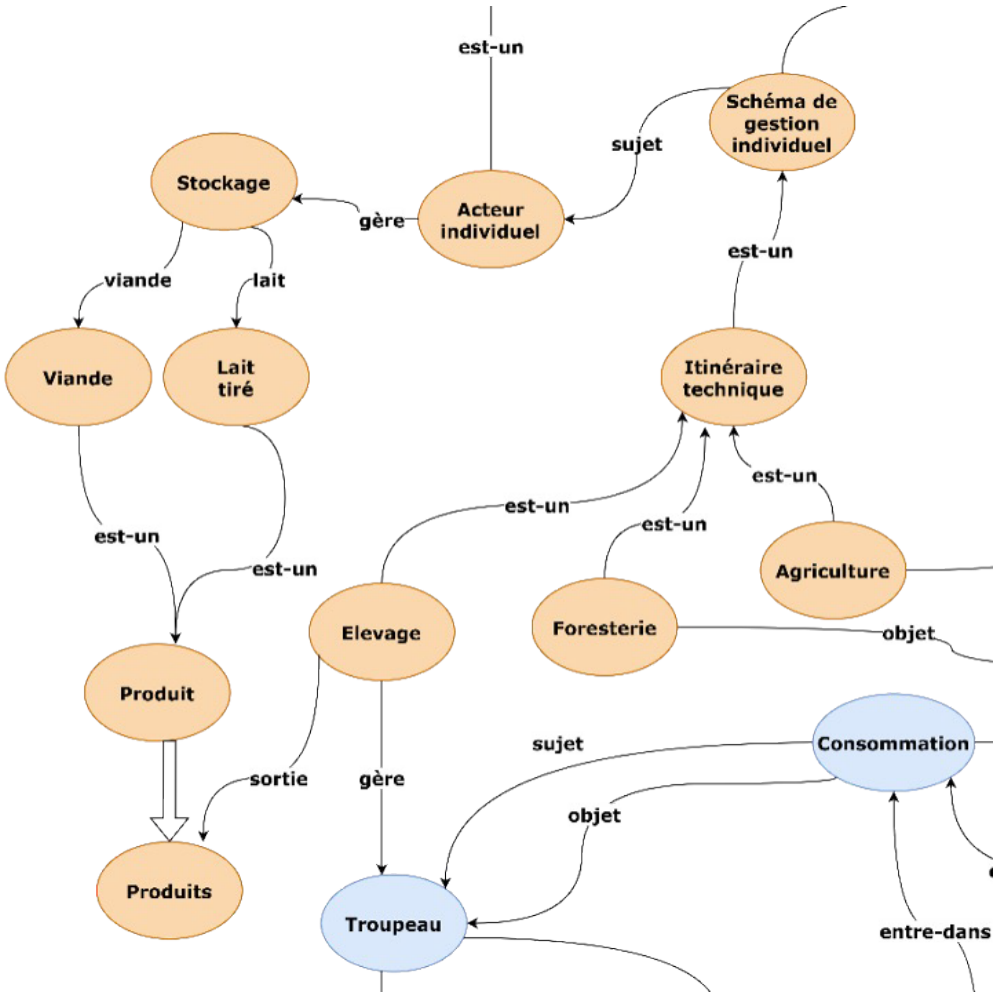


Finally, humans deploy a number of practices transforming and transporting resources through a number of technical itineraries that have been detailed in the conceptual model:



All together, the conceptual model shows the strong intricacy of resource transformation and transport among these four actors that are humans, animals, plants and soil.

The details of the technical itineraries for livestock (animals), forestry (plants) and agriculture (plants) have been elaborated and validated with the stakeholders. Therefore, we have a conceptual model that I sufficiently detailed to design the simulation model in a later activity.

4. Conclusions and recommendations

The missions carried out in June and September 2024 enabled considerable progress to be made on several fronts linked to the modeling of agro-ecological dynamics and pastoral livestock farming. Through various workshops, meetings and exchanges with local stakeholders, several key results have emerged.

In-depth discussions around the conceptual model laid the foundations for a better structuring of territorial dynamics, particularly around organic matter flows. The active involvement of stakeholders, whether through the workshop with DyTAEL or working sessions plus, facilitated the adaptation of the model to local realities and the specific needs of the project.

The various workshops, notably in Diohine, Labgar, Fatick and Vélingara, reinforced the importance of co-design and the involvement of local stakeholders in the modeling process. These workshops helped validate the model's assumptions and integrate concrete feedback to refine the scenarios. Discussions on livestock strategies, transhumance and the regeneration of natural resources also highlighted challenges to be met, but also opportunities to improve current practices.

Recommendations

- Continue to involve local stakeholders in the modeling process to ensure greater ownership of the model and the scenarios envisaged.
- Strengthen synergies between various ongoing projects, such as FerloSine, Dundi Ferlo, to share resources and best practices in agro-ecological dynamics modeling.
- The village scale seems more appropriate for detailed simulation models and it has been suggested to reactivate the village councils. However, the complementarity of villages activities requires to explore networks of villages where the benefits of agroecology could be fully exploited.

In conclusion, this mission has enabled significant progress to be made, particularly on the conceptual model. The next phases are:

- Detailed specification of the model;
- Design of the simulation model.

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Final **report WP 1.2**

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. **www.cgiar.org**

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