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(IM-)MATERIAL FLOW ANALYSIS FOR SYSTEM INNOVATION

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ABSTRACT

System innovation for sustainability requires system and multidisciplinary approach. Current assessment tools are mainly disciplinary and support the assessment of material flows in terms of environmental impacts or economical flows for example. These tools provide helpful quantitative information for system (re)-design but do not explicitly question the value creation factors whereas models derived from financial analysis do so (both quantitative and qualitative assessment).

A material and immaterial resource flows model coupled with extended scorecard to support both the analysis and structuration of territorial projects will be useful to better understand, qualify and quantify the different kinds of resources revealed, mobilized or denied during a project. The aim of this communication is to present the conceptual background for the model development and then to present its partial applications in industrial cases. Benefits, limits and further development will be also dis-cussed.

This model is built on the five dimensions sustainable transition methodology (5D-STM) and the multidisciplinary method for sustainability assessment. It enables both the representation of the tangibles and intangible assets mobilized during the emergence and structuration of territorial projects (e.g. business model transition to functional economy) and sustainability assessment of existing projects (e.g. industrial and territorial ecology projects).

This model is still under development but appears to strengthen strategic analysis and potentially support the integration of sustainability within territorial projects but is not sufficient by itself. It can be used as a tool to support decision-making if integrated within a larger transition-oriented methodology.

1 INTRODUCTION

To cut with current socio-ecological issues due to the capitalist market economy (Schneider et al., 2010; Buclet 2011), researchers from different fields advocate system innovation for sustainability e.g. (Brezet, Van Hemel, 1997; DeHaan, 2010; Gaziulusoy, Brezet 2015) that is the result of a multi-scale transition from one socio-technical system to another over time (Loorbach, Wijsman, 2013). System innovation for sustainability, sustainability transition or transition to sustainability are used as synonyms in this article and are used as *"large-scale disruptive changes in societal systems that emerge over a long period of decades […] facing persistent sustainability challenges, and they present opportunities for more radical, systemic, and accelerated change"* (Loorbach et Al., 2017). These transitions operate in different spatial and temporal scales: 30-50 years for national sectoral level (i.e. energy sector), 5-10 years for transition cities or local projects (EEA report, 2018). Socio-technical transition studies focus on historical cases in real-life contexts to understand causal links and non-linear processes over time in complex situations (EEA report, 2018). Regarding the complexity of this kind of transformative projects, it is necessary to adopt an interdisciplinary approach (e.g. design, politics, engineering, ecology, sociology, economy, etc.) (Max-Neef, 2005) driven by a shared objective (i.e. sustainability).

Organizations have now assimilated this necessity of such fundamental changes and numerous initiatives emerged at the global scale (e.g. COP21), at regional (e.g. industrial ecology strategies), along companies' value chain (i.e. Environmental Management System) or at product level (e.g. eco-design). Those initiatives are not limited to environmental issues and questions both production and consumption (e.g. circular economy) with a systemic approach. Numerous tools and methods address system analysis to support decision during the transformation (e.g. accountability and reporting standards, MFA/territorial metabolism, LCA…). Despite the considerable number of initiatives and associated tools and methods, one must consider that the global socio-ecological system decline faster and faster: how these targets and objectives contribute to sustainability or just slows the forecastable collapse.

This paper describes the premises of a method to support the design of territorial projects that contribute to system transition for sustainability. This multidisciplinary framework focuses on the project level with a multi-scalar approach (i.e. individual, organization and network analysis embedded in the socio-technical regime). It considers both spatial (i.e. territory, influence perimeter) and temporal resolution (i.e. structuration, deployment, operation - or decline - of the project) to define the *'perimeter for action'*. It contributes to system innovation for sustainability thanks to the integration of sustainability principles within decision-support tools.

This communication focuses on the design of an analytical framework for territorial projects. It proposes to analyze the life cycle of a project with a particular focus on its territorial anchorage, considering also tangible and intangible resources mobilized for the project. This tool complements the analytical and assessment tools arsenal, making a bridge between value chain approaches (MFA or LCA) and more spatial-based frames (i.e. territorial metabolism or territorial ecology). The first part displays a state of the art of this different decision-support tools for industrial or spatial planning. It gives insights and inputs for building an original framework, supposed to help the analysis of a project while simultane-

ously considering micro-and meso levels, time and spatial dimensions, as well involved actors. Finally, conclusions and perspectives are proposed.

2 STATE OF THE ART

The following state of the art differentiates tools and frameworks used to assessed impacts of a project or a product from a value-chain point of view or from a territorial angle. First, LCA/LCCA and SLCA consider the product life cycle and some of its externalities. Second, MFA and accounting/reporting tools consider extended value chains, while territorial metabolism and industrial ecology focus on socio-technical systems. Finally, MLP and 5D-STM consider the whole system with a transition perspective.

2.1 Value chain analysis

Product creates both positive and negative externalities on multiple territory on each stage of its life cycle (fig.1).

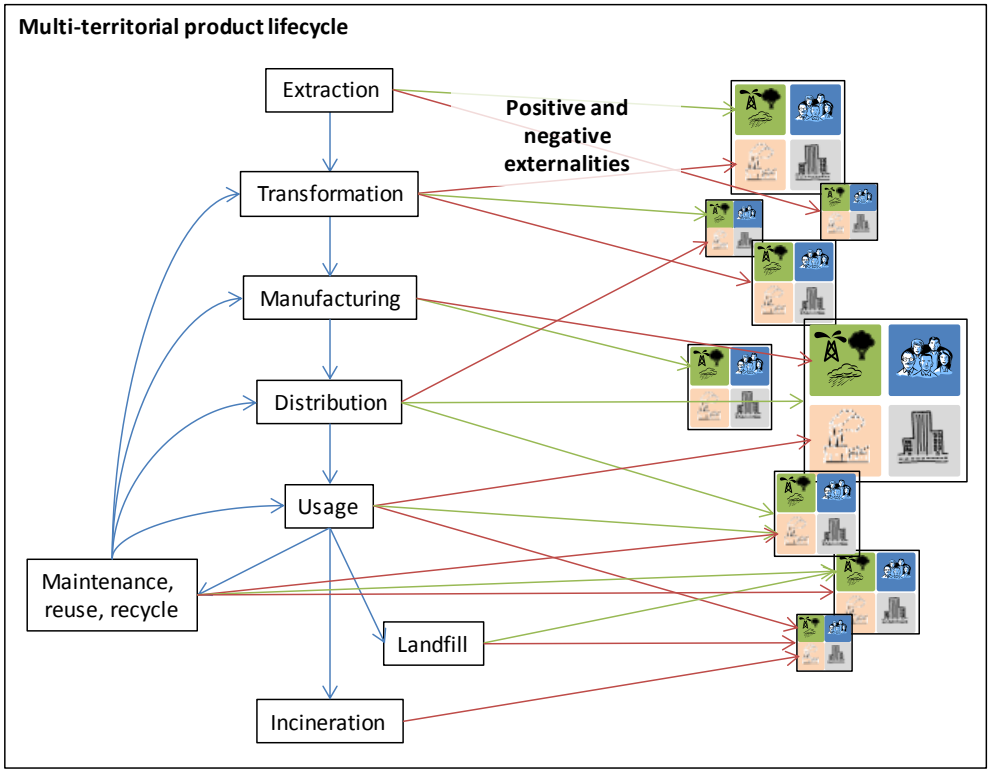

Figure 1 - Multi-territorial life cycle of a product and its positive and negative externalities

Life Cycle Assessment evaluates environmental externalities: “LCA addresses the environmental aspects and potential environmental impacts (e.g. use of resources and the environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave).” (ISO14040, 2006). In addition to environmental impacts, LCC/eLCC or SLCA consider social and economic aspects (see Guidelines for social life cycle assessment of products (UNEP, 2009).

These assessment methods are useful to support decision regarding alternative design choices but lacks the multi-scalar and spatio-temporal dimensions even if work on dynamic LCA emerged over last years, see (Laratte et Al., 2014) as example.

Material Flow Analysis is “a systematic assessment of the flows and stocks of materials (goods and substances) within a system defined in space and time. It connects the sources, the pathways and the intermediate and final sinks of a material” (TU Wien, 2012) (Fig.2). MFA operates at different scales with different time span (e.g., Cardiff’s local authority waste collection system between April 2012 and March 2013 (Turner et Al., 2016) or steel stock and flows across in Europa from 1945 to 2013 (Panasiyk et Al., 2016)). Substances, materials or goods may be associated with their costs and/or environmental impacts to support multi-criteria decision on existing systems or scenarios (e.g. electric vehicle deployment at national scale).

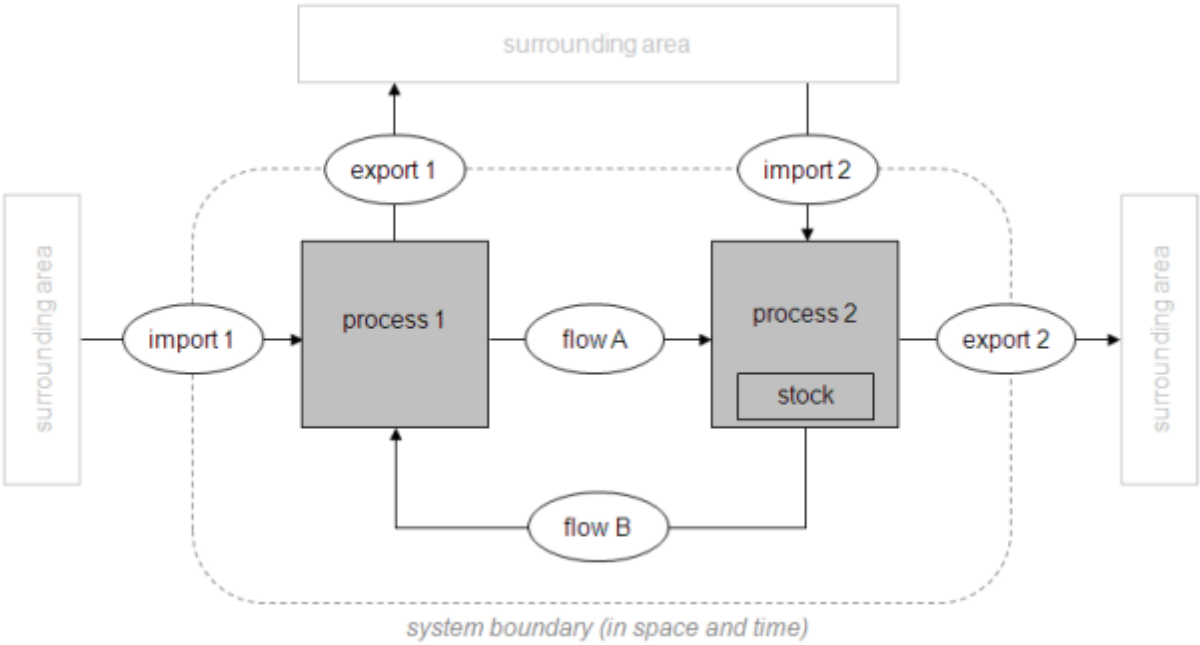

Figure 2 - Typical MFA model (TU Wien, 2012)

Even if LC-based assessment tools quantify the potential impact and MFA evaluate stocks and flows between each physical elements within the system (i.e. total impact is a sum of elementary impacts), it does not provide information on the quality of the assets that enables the value creation.

Financial and extra-financial assessment tools consider companies as systems that enable value creation thanks to tangible and intangible assets (i.e. resources owned by the company). These assets are described as Human, relational and organisational capital for the European project MERITUM (OCDE, 2006), financial, manufactured, intellectual, social/relational and natural capitals for the <IR> initiative (IIRC, 2013) or a taxonomy of 10 intangible and 2 tangibles assets that constitute the necessary and often sufficient portfolio of assets to create value (Fustec et al., 2011). These assets are not described here in detail but a listing of these assets is provided in (table 1) with its associated capital.

Table 1 - Intangible assets and associated capital from (Fustec et Al., 2011)

Assets	Associated capital	Assets	Associated capital

Teams	Human capital	Information system	IS capital
Brands	Brand capital	Customers	Customer capital
Natural resources	Natural heritage	Knowledges and know-how	Knowledge capital
Organization	Organizational capital	Civil environment	Societal capital
Suppliers and partners	Partner capital	Current assets	Financial capital
shareholders	Shareholder capital	Investments	Tangible capital

This framework supports qualitative analysis and assessment of each value creation factor thanks to a large set of indicators (e.g. collaborators and managers are evaluated regarding their competencies, leadership, motivation, stability, serenity… all these indicators are agglomerated in the Human capital to evaluate the quality of teams and their contribution to value creation). This tool is both use for accountability (i.e. qualitative and quantitative asset evaluation once a year: “I have”) and management purpose (i.e. decision-support tool for planning: “I do”).

All these approaches provide information on value chain (i.e. product lifecycle, material metabolism or company’s value creation system) but poorly consider the social environment wherein it operates. In fact, value chains considered in these tools are non-situated systems.

2.2 Territorial transition analysis

Some analytical frameworks[1] and methodologies integrate socio-spatial dimension as they study how stakeholders may interact (or not), how they may enter into conflict or negotiation, create cooperation and shape networks. Stakeholders are acting entities (individuals, organisations, or unorganised groups) with a declared or conceivable interest or stake in a policy concern (which intervenes on the social or political scene without being organised in a formal structure)[2]. Therefore, immaterial flows like culture, organisational proximities, knowledge (and its possible transfer) or know-how emerge from stakeholder network study. Moreover, these frameworks take into consideration the spatial dimension as they analyse how human activities and representations are applied to specific area: the territory. Conversely, they question how the features of this territory influence the actions

[1] A framework is a “metatheoretical language for diagnostic or prescriptive study of phenomena” (Ostrom 2007b; Schlager 2007) that cannot in and of itself predict or explain outcomes. However, some frameworks were distorted from their original goals, to rather become tools of operationalisation, and less conceptualised ways of describing and analysing a situation.

[2] The most integrative socio-technical frameworks do not limit their analytical scope on human entities with a strong and defined interest, but also assimilate the civil society (and then the non-directly concerned and involved persons) as it may be impacted in different manners by economic and industrial choices (negative externalities, societal changes expected from technical/organisational innovations…). Sometimes, as for the ANT (Actor-Network Theory) (Callon, 1986), non-humans (artefacts, natural components) play a major role in the definition of a system and its capacity to withstand chocks and to undertake a transition.

of human and non-human entities. The next paragraphs outline two approaches: industrial ecology and territorial ecology, which are both based on territorial metabolism.

Whereas MFA focuses on goods, material and substances, territorial metabolism (TM) inventories of multiple flows on a particular perimeter (e.g. nation, region, agglomeration, cities…). Territorial metabolism considers a territory that make sense by its human occupation and its environmental conditions, and not on a specific site, a value chain or a product. This tool quantifies and qualifies all flows that nourishes or affects this territory and its activities (consumption, transformation, destruction…) with a particular attention on double counting. This accounting framework is loosely based on an analogy with the metabolism of natural organisms and often requires the collaboration of planners, engineers, political scientists or ecologists.

Territorial metabolism considers cross-boundary material trade and the retention of materials as stock in the built environment (Kennedy & Hoornweg, 2012; Baynes and Wiedmann, 2012). Cities are then in this framework considered as "complex systems that rely on their external environments for inputs of resources and for assimilation of wastes and create ordered structures at the expense of increasing disorder, i.e., environmental disruption outside of their boundaries" (Clift et al., 2015). As example, (Barles, 2014) performed a territorial metabolism on two French regions (i.e. Midi-Pyrénnées and Ile de France). These inventories include local extraction, import and export (e.g. biomass, minerals, fossil fuels…) and outputs to nature (i.e. emissions to air, water, soils). This information at regional scale is useful to policy makers (e.g. waste management policy, dematerialization policy…) and questions the contribution of each sectors (e.g. food and agriculture, building…).

According to Barles (2014) each territory has its own metabolism, which depends on social and natural features. It results from this work not just a territorial photography; it allows to identify dependences and risks for the territorial resilience and sustainability (as example the competition for land and resources into the urban space, the increasing consumption of some materials…). Political answers concerning the governance of flows and materials may be then built to draw the path for transition. Urban metabolism may be put in practice as a framework for undertaking the design of sustainable or low carbon districts/neighbourhoods within cities.

Territorial metabolism is employed for both territorial ecology and industrial ecology. However, MFA et TM approaches are based on mass conservation law and poorly considers intangible resources flows (Buclet et Al., 2015), when they are lonely employed. To overcome this limitation, more integrative frameworks have been emerged for decades like industrial ecology.

One of the central principles of industrial ecology is that industrial systems can develop the types of mass efficiency and cycling of materials exhibited by natural ecosystems (Allen in Ayres 2002, Frosch, Gallapougos 1989). This biomimicry principle is completed by an objective of decarbonisation and dematerialisation of economic activities (Erkman, 1998). According to Merlin-Brogniart (2017) industrial ecology has been an evolving concept, as the original definitions were more focused on the limitation of polluting emissions while reusing them in the production process. Industrial Ecology (IE) can be operationalized by the research and implementation of synergies between stakeholders to reduce the environmental impacts of human activities on ecosystems (Buclet, 2011). Industrial ecology often necessitates the quantitative and qualitative study of materials and energy flows

generated by industrial and consumer activities, so that involved stakeholders could be able to know what they can mutualize or exchange.

Materials, by-products, energy are valorised, exchanged or mutualized among distinct business entities often thanks to geographic proximity (Chertow 2007) but this is not a sufficient condition. Symbiosis take place in a particular territory and cannot expand without taking into account social practices (Boons, Howard-Grenville 2009, Granovetter 1985), cultural norms, the regulatory and legislative regime, and the actions of stakeholders (Brullot et al. 2015, Gobert et al. 2015). Challenges raised by mutualisation and flow exchanges are not just technical but also human and organizational (Boons et al. 1997; Jacobsen, 2006). In fact, the main obstacle to the implementation of synergies is poor coordination between actors (i.e. lack of dialog, common interests or trust between companies, local authorities or academics) (Buclet 2011).

Industrial ecology is based on a system of actors sharing common issues and striving to build collaborative solutions. As a matter of fact, the involved firms are obliged to enlarge their area of action through cooperation with new stakeholders on a specific area[3] to solve new questions concerning their resource supply and their waste discharge and management. In order to implement efficient synergies, the different partners of industrial ecology project (business, public authorities…) can reveal, use or generate different kinds of im- and material resources: infrastructures, organisational and cultural capital; knowledge (Gobert et Brullot, 2017). However, industrial ecology has been diverted from its ecological apprehension (dematerialisation and decoupling of economic and social well-being from resource use), while the concept is often restricted to synergies' development and put in practise in very limited areas (industrial districts). The input and output of industrial ecology initiatives and therefore the impacts into the eco- and bio-spheres (external pollution, biodiversity and ecosystems integrity loss) are not sufficiently considered.

Other frameworks have emerged, trying to grasp these interactions. The social-ecological systems or social-ecological-infrastructural systems frameworks designed to provide common research tools for interdisciplinary investigations integrates more deeply the biophysical components. They associate urban metabolism with life cycle assessment to articulate infrastructure supply chain water, energy, and greenhouse gas (GHG) emission footprints of cities and have a cross-scale point of view (Ramaswani et al., 2012).

We can quote territorial ecology considered as a new field of interdisciplinary research[4] (Barles, 2011; Malderieux, 2017), that targets a better understanding of Nature/Society interactions. These interactions are notably concretised by energy and material flows. Territorial ecology is aligned with industrial ecology, but tries to better take into account space and impacts on Nature (particularly outside the perimeter where synergies have been completed). Cerceau (2017) explains "borrowing ecological principles and concepts, it proposes to analyze the territorial dynamics and trajectories by focusing on the circulation

[3] If they succeed in meeting the challenge of closing loops in their own system, this process do not match the principles of industrial ecology, but of industrial optimization.

[4] It can mobilise researchers in urban and rural planning, in History, in sociology, in biology…

of tangible and intangible flows between human societies and the biosphere." In fact, territorial ecology considers both material and immaterial resources and the ability of stakeholders to build cooperation, limit their emissions and exchange/mutualise their in/outflows.

This approach is supported by two tools: on the one hand, an understanding of the territorial system (how it works while exploring relationships between stakeholders and the territorial political, social and technical conditions), on the other hand a fine analysis of territorial metabolism, supposed to reveal the exchange between environment and humans[5]. The better knowledge of the territorial interactions is supposed to improve the collective capacity of local stakeholders to define new strategies together, to test synergies. Territorial ecology therefore aims at describing, analysing and even transforming the metabolism of territories, while understanding natural and social processes which create energy and material flows and influence them reciprocally (Barles, 2011).

Territorial metabolism, industrial or territorial ecology consider large and complex territorial systems, studying meso-levels actions and their consequences on the territory. With our framework, we intend to analyse the interactions between micro- and meso-levels and how local and territorial assets are mobilised at different steps of the initiative during a project.

2.3 **Sustainability transition analysis**

Sustainability transition research focuses on « large-scale disruptive changes in societal systems that emerge over a long period of decades » (Loorbach et al., 2017). Transition research emerged within different scientific communities (Loorbach et al., 2017) with different research approaches to understand transformation in socio-ecological, socio-economic, socio-technical and socio-political systems (EEA, 2017) (Loorbach et al., 2017).

Socio-technical studies focuses on the way societal functions are performed (i.e. transport, housing, feeding and energy supply). Transition studies have different temporal and geographical focuses regarding the system (i.e. 5-10 years for cities or local projects, 10-15 years for sustainability transition research up to 30-50 years for national sectoral level historical studies) (Geels et Al., 2017). The multi-level perspective (MLP) is an analytical tool for socio-technical transition based on three analytical levels: "niche" is the level where the innovation occurs (e.g. grassroots initiative), "regime" is the dominant and stable set of practices and rules in a societal system (e.g. culture, technology, policy…) and "landscape" stands for the exogenous context that influences the regime. The multiphase model of transition (i.e. predevelopment, take-off, acceleration and stabilization/lock-in/backlash/system breakdown) (Rotmans et al, 2001 cited in Loorbach et al., 2017) add a temporal approach to the MLP for the comprehension of system changes (fig. 3). In addi-

[5] « L'écologie territoriale permet notamment d'étudier la dimension sociétale du métabolisme à travers l'étude des acteurs, mais aussi de la gouvernance qui est administre des processus à l'origine d'un métabolisme » (Barles, 2011)

tion to these structural and temporal dimensions, (Raven, 2012) propose to explicitly consider the spatial scale of socio-technical systems in the MLP and (Debizet et al., 2016) introduce socio-spatial aspects to reveals local and non-local relationships between regime and niches in urban energy systems.

As advocated by (Kemp, Loorbach, 2003), (Loorbach, 2007), (EEA, 2017), transition management promotes a strategic management perspective on system innovation with a major role of government to manage the process of transformation. Transition management consists in structuring the problem, developing coalitionsand agendas, mobilizing actors for project operation with a reflexive approach thanks to monitoring and evaluation (Loorbach, 2013). In fact, sustainability transition requires long–term vision and planning.

The five Dimensions Sustainability Transition Method (5D-STM) (Allais et Al., 2017) is a development of the Framework for Strategic Sustainable Development (FSSD) (Broman, Robèrt, 2017), a principled backcasting method to design organisation transition path toward sustainability. It aims at supporting the transition of industrial companies toward sustainability (fig.4). This The FSSD is based on the seminal definition of sustainable development while the 5D-STM is based on the heterodox definition of sustainability proposed by (Figuière, Rocca, 2008). We assume a hierarchy between Human, environmental and economic dimensions and consider explicitly political and territorial dimensions. In order to support decisions during the transition process, general governance principles from (Buclet, 2011), strategic and operational business governance principle from (Allais, 2017) and political principle from (Renault, 2011) complete sustainability principles (i.e. Human and environment) from the FSSD (Broman, Robèrt, 2017), (Missimier, 2015). Even if these principles are subject to constant improvement and discussions, they are implemented in decision support tools for business transition toward sustainability (i.e. governance maturity grids, extended scorecards and roadmaps – see also (Zhang et Al, 2013) for an overview of the Convergence methodology).

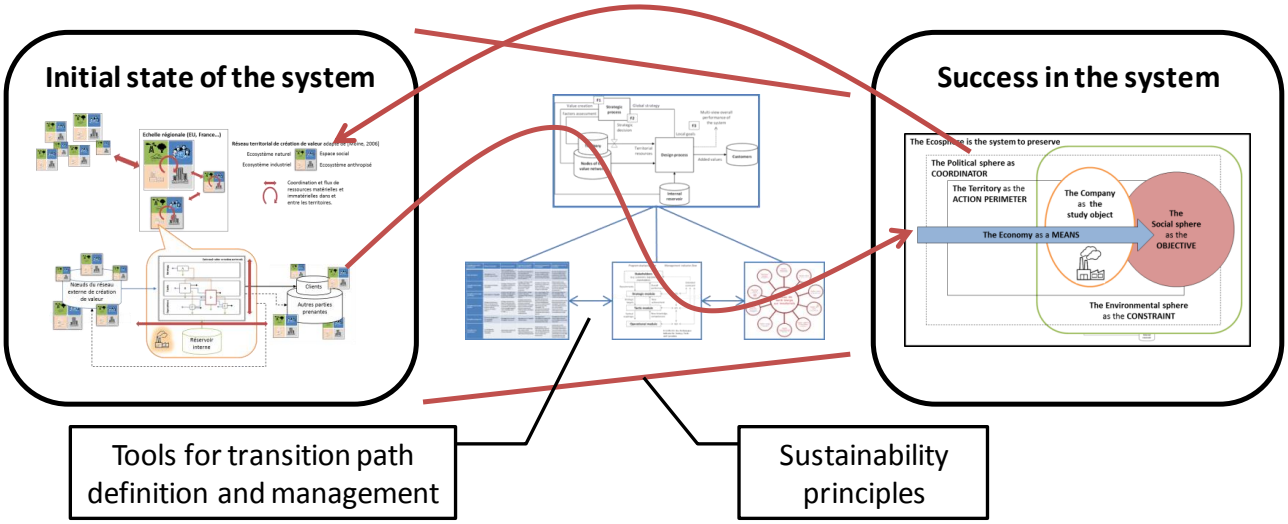

Figure 3 - 5D-STM (Allais et Al., 2017)

In short, we consider that sustainability (i.e. success in the system) must focus its objectives on human development according to the Human principles (i.e. no structural obstacles to health, influence, competence, impartiality and meaning-making). The governance principles supports Human development thanks to governance innovation both in the

business value chain and in its interactions with its territory. Governance innovation is supported by the capability/empowerment principle that aims to maintain and develop capacity of individual/organization to meet their own objectives and the proximity principle that bring together the decision-making level and the one impacted by the decision. This includes a large number of “traditional” stakeholders as consumers, producers, recyclers or local authorities, and other that are often neglected as civil society/citizens. Decisions must integrate also the concept of ecological boundaries, (i.e. no systematic degradation or emissions of substances from society or earth crust). In addition, the geographical proximity and the re-location of the economy principles may favors the integration of locally available tangible and intangible resources; the political decision has to take precedence over economic actors (i.e. decision taken by citizens or their representatives). The participative democracy governance principle balances individual preferences and the common interest in meeting the challenges of sustainability while the proximity principles promote the participation of people impacted by the decision. Territorial specificities have to be considered for the adaptation and deployment of the political decisions. Moreover, both positive and negative externalities must be re-located to cut with globalization issues. Consequently, local value creation (i.e. use of local resource, local employment, local wealth creation) (Tyl et Al., 2015a) may arise as a new regime.

This state of the art proposes a quite large but non-exhaustive overview of analytical tools and methods operating on different systems and perimeters. Some consider product design and industrial sites along their value chain and some consider complex socio-technical systems as territory. Consequently, analysis and transformative tools for system innovation must consider sociotechnical systems in their complexity (i.e. technical, organisational, political and stakeholder network) and thus, requires interdisciplinary. More, spatio-temporal and multi-scalar dimensions have to be explicitly considered.

This communication presents a framework to analyse the emergence of territorial project based on the spatio-temporal analysis of stakeholder network and the pooling of their individual assets with territorial assets.

3 PROPOSITION: SPATIO-TEMPORAL STAKEHOLDER NETWORK FOR PROJECTS ANALYSIS

This part unveils the different dimensions, employed to construct our interdisciplinary framework. The time dimension enables at different steps to border the perimeter of action where the stakeholders of a project evolve and can use their competencies and abilities. This perimeter can change, according to the needs. The spatial dimension cannot be neglected; to launch an initiative a good knowledge of the territory where the project is supposed to take place is a prerequisite. Stakeholders put into action assets and can progressively constitute networks to make true their projects.

3.1 The different dimensions enabling the deployment of a project

3.1.1 Dynamic perimeter for action: the time dimension

As the presented methodology deals with the mobilization by the actors – outside and into the territory – of territorial resources over time, the project shapes the perimeter for action:

- the stakeholders' competences (they can act on specific areas),
- their common willingness and capacity of influence to concretise the project
- And its scalar projection (Gobert, Allais, 2016).

The involved actors, the project ambition and it changes over the project progress define the perimeter for action. It is not necessarily geographically continuous (see also the concept of plurilocal company (Buclet, 2011)).

- Time 0: upstream the project. The perimeter of action is defined by specific local resources, stakeholders, networks that can be mobilized but are still 'latent', non-activated for the project.
- Time 1: project launch. A need emerges or a strategy is built by one or more stakeholders (cf. time0). They will seek to activate resources, create other relationships to find new partners carrying assets necessary for the launch of the project like founders (e.g. government, banks), external expertise (e.g. university, consulting firms). The perimeter for action will evolve according to the objective of the project and the addition of these new partners.
- Time 2: the project. The activation of territorial resources and the association of the missing external skills (subcontractors...) for the realization of the project will thus concretize the perimeter for action.
- Time 3: downstream the project. This is an evolution of time 0: the built-up network becomes a latent network that may be activated for a new project or, on the contrary, in case of conflict or failure, partnerships are broken.

We thus see that the perimeter for the action is dynamic and inscribed in a history: both inherited (prior constructed networks, geographical perimeter, sector ...) (time 0) and constructed during the structuring and realization phases (time 1 and 2).

3.1.2 Territorial assets: the spatial dimension

Here the spatial dimension is introduced, while considering the space is not a *terra nullius*, but an appropriated territory by human occupation and representations, political projections, infrastructure building, a specific culture and identity (Di Méo, 1996; Lévy, 1999). The concept of territorial capitals (Camagni et al., 2013) gives an opportunity to inventory resources that may become an asset for a project, then a capital for an organization or for the territory. These assets do not exist without the action of stakeholders and often their interaction. As an evidence, the presence of oil in the subsoil results from natural geological processes. Yet it has become a main resource of our society, since this fossil element got a technical employment and its transformation was controlled. It was then exploited (and for that specific infrastructure was built, new business roads emerged, and he became a source of wealth for countries which own it (but also a dependence). Without simultaneous and sometimes conflictual technical innovation and its adoption by the social and economic system, oil would not have become "l'or noir".

"These factors [territorial assets] may include the area's geographical location, size, factor of production endowment, climate, traditions, natural resources, quality of life or the agglomeration economies provided by its cities, but may also include […] business networks that reduce transaction costs." (European commission, 2005, p. 15)

We sequence it into different sub-capitals (Gobert, 2015). Some of them are material (infrastructure), others immaterial (culture, relationships[6]) (Fig.6). The territorial assets in their globality is not owned by a specific stakeholder, even if some parts (a facility) can be possessed or exploited by a firm, a local government, an institution (university and scientific expertise) or a NGO.

3.1.3 Scales of action and interaction: the stakeholders' dimension

We consider that a project is implemented and have incidences at different analytical levels designated here as micro, meso-(territorial, civilian, industrial) and macro levels (fig.4). These levels are the results of an interbreeding between engineering sciences, economic sciences and political sciences.

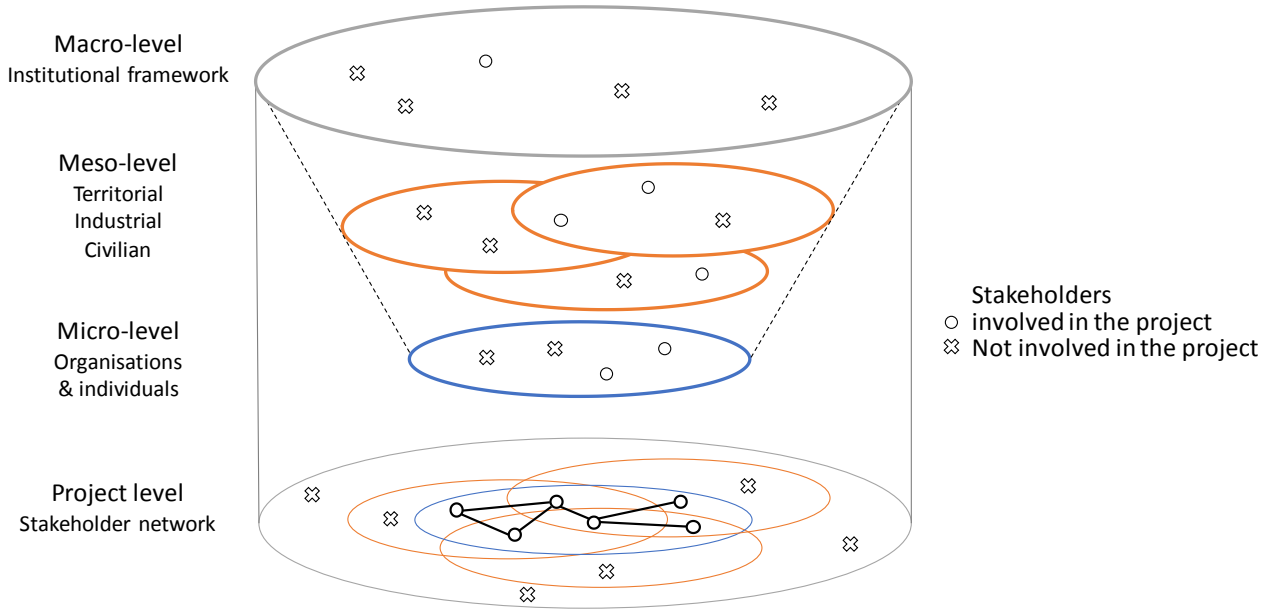

Figure 4 – Perimeter for action as a projection of scales of actions and interactions

The micro level matches the "internal sphere" of stakeholders (moral person or individual) and the internal organization of a firm. Nevertheless, that does not prevent belonging or acting at other levels (as lobbyist at the macro-level, as partner of a project at the meso-level). The decision to take part in a project with other partners can have influence on this organization, as well as the implementation of a new strategy to decrease emissions and environmental impacts can require a meso-territorial intervention. Carefully analyzing this level enables to exhume the internal resources a stakeholder can use (tangible and intangible assets) (Allais, 2015). Then it becomes possible to know if the stakeholder is able to quickly or slowly mobilize them, identify shortcomings between its objectives and its capacities and then identify new necessary assets for the project… A stakeholder can

[6] The territory could have been previously the basis of cooperation opportunities, requiring the mobilization of actors and the constitution of networks.

also use by himself territorial resources (the concept is explained later) if they belong to him, or they benefit from a non-rivalrous or non-excludable accessibility (public or common good), either this stakeholder has received an exploitation license or a contract (from the public or private owner), either he illegally exploits them.

The meso-level is an inter-individual sphere that can be deployed on a specific spatial area or in the frame of a partnership. According to the decision process and the project governance, we define different forms of meso-level interventions.

- The meso-territorial level: the action has a spatial basis, primarily thanks to the coordination of (a) local government(s) that may induce the involvement or constrain the action of different socio-economic stakeholders. The project can deal with different sectors in accordance with the competences of the public stakeholders involved, within a specific perimeter (Gaudin, 2004).
- The meso-industrial level: the main actor is in this case an economic entity. The perimeter of action is firstly defined by the project scope and the stakeholders' willingness.
- The civil-meso level gathers grass-roots initiatives coming from citizens, inhabitants, associations and which involve more than one stakeholder. At this level, the involved actors can simultaneously activate their own resources, the territorial resources, in line with the project. They may also draw consequences of a resources' gap for performing their collective goal and then import/create/reveal new resource.

At the macro-level, public stakeholders can define, regulate, check and promote legal orientations, guidelines and regulations and oblige other stakeholders to implement them. At this level the national or international governments are the main decision makers, and sometimes regional authorities (this is dependent on the national institutional frameworks and the competences distribution). They build public policies through different tools (laws, economic incentives, guidelines) but seldom make regulations directly operational, except while implementing in their own structure. The macro-level contributes to define the socio-political regime; environmental, economic, social public policies or regulations are formulated at this stage. Yet, the legislative or regulatory drawing is a complex process based on the political re-definition of social issues and ground-based initiatives (Knoepfel et al., 2006). It resulted from arrangements between different interests and rationale. Some international cooperation between non-governmental organizations or between firms can also be negotiated at the macro-level, create a global and constraining frame that influence behaviors of other actors.

Levels are not hermetic. Stakeholders at the meso-level may activate a political resource (a personal acquaintance with elected people or an elective function of one of an actor involved into a project) in order to obtain regulation change and then facilitate the progressive integration of a localised project in the mainstream design.

3.2 Framework for (im-)material flow analysis

3.2.1 Resources: a specific relationship between human activity and territory

From geographical and economic points of view, according to (Brunet et al., 1993): "*a resource is the means available to an individual or group to carry out an action, to create wealth. Thus, a resource exists only if it is known, disclosed and exploitable, that if men*

[humans] attribute to it a value of use". Bathelt and Glückler (2005) consider "*resources are used and/or produced in a relational manner, that is, in context-specific social processes."* Glon and Pecqueur (2006) define the concept of territorial resource as a built feature of a territory, intentionally construct by actors from specific socio-cultural and historic contexts (i.e. territorial specificities). Before this process of activation, territorial resources are qualified of latent resources.

According to the system theory[7], resources can be distinguished according to their provenance and destination (i.e. source and sink from (De Rosnay, 1975). We consider resources from natural ecosystems (e.g. wood or water), anthropized ecosystems (e.g. agriculture, industries, communication nodes or cities) or the social space (e.g. values, ideology, relations, culture or knowledge) (adapted from (Moine, 2006) also qualified as "territorial reservoirs" (Allais et al., 2017). Reservoirs may contain both active and passive resources that may be tangible or intangible (e.g., a machine tool is an active tangible resource; local culture is a passive intangible resource).

Reservoirs are differentiated as follow: internal reservoir is the stakeholder network of the project (e.g. machine tool from company A, expertise from company B), territorial reservoir stands for natural resource provider, anthropized ecosystems and social space and external reservoir consider every source outside the territory or the stakeholder network (e.g. exogenous resources). Allais et al. (2015) regard stakeholders as a reservoir as they are directly concerned by the value creation/destruction due to the project (e.g. the customer of a new offer benefits of the product/service and esteem value while residents of a production site can be hindered by noise and they both share air pollution).

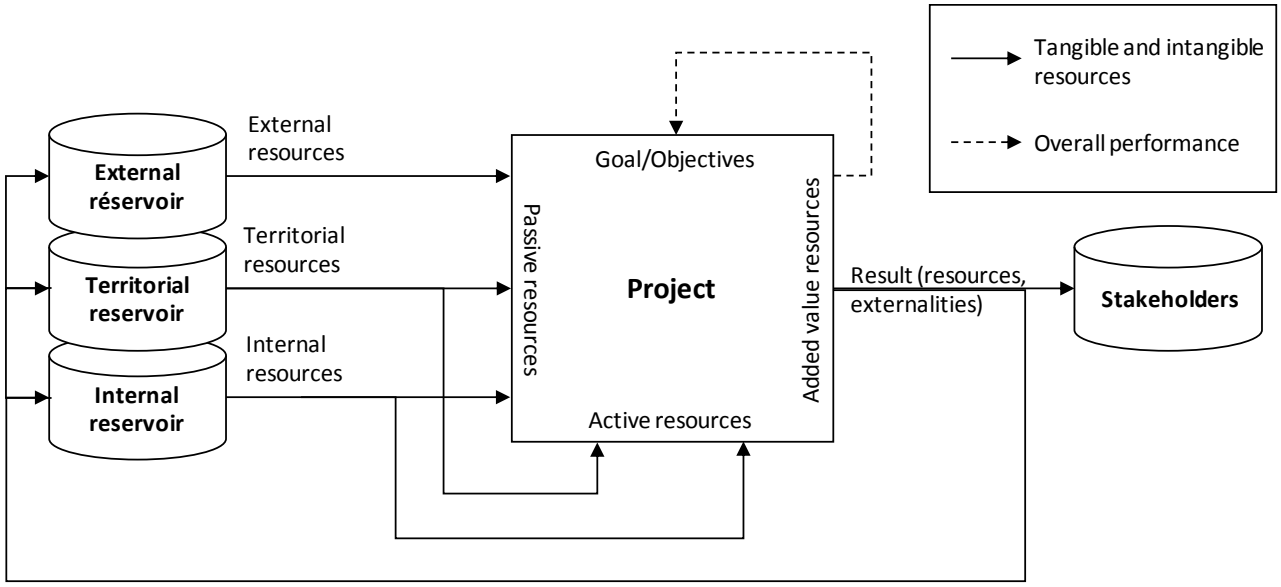

Figure 5 – Territorial project model (adapted from (Allais et Al., 2015))

[7] Systems theory and systemic research aim at understanding the behaviour of elements by studying their relationship patterns within and between the systems they are part of.

A project is a succession of activities as defined in (Boyle, Duffy, Whitfield, 2009): *"an activity is a physical or cognitive action that creates an output from a set of passive resources which are used by active resources to produce the outputs that should satisfy the [project] goals. [...] Thus, a finance manager (active resource) might analyse (activity) market data (passive resource) to identify potential markets for exploitation (output) to increase the financial performance of a company (goal)."*

In order to make possible an interdisciplinary research between these two ways of thinking territory and stakeholders and build a relevant framework, we have striven to combine the geographical, analytical and systemic ways of considering resources and interactions between entities, while integrating time, scale and stakeholders. This work does not delete the differences of understanding the reality but tries to combine it so that they could enrich together. When mobilized within a project, these resources are qualified of assets that may or may not be owned by the actors that use and transform them (i.e. machine tools and patents are owned by a company while its workforce is not; culture or some natural resources are common). We consider here "capital" as the quantitative and qualitative evaluation of these individual or collective resources appropriation.

3.2.2 Analysis framework proposition

The analysis framework displayed here illustrates how immaterial and material assets at the individual (micro) and territorial (meso) scales are combined and activated. The analytical framework (Fig. 6) is designed on (Grin et al, 2010) who states that a project emerges from the will of one or many actors in a particular area whom endogenous assets will have an influence on the form and the success of the project (Gobert, 2015) (Allais and Gobert, 2016).

This analysis framework as the result of a multiscale and interdisciplinary approach, combining engineering sciences, planning, sociology and political sciences was structured allowing to analyse and act during the process of a project and aims answering the following questions:

- What resources are revealed, created, mobilised and/or shared for project (at the different steps identified in 3.1.3.)?
- Who brings this/these resources and how is/are it/they managed during the process? What form of relationships does prevail between resources and stakeholders, between stakeholders to activate them?
- At which level are these resources activated and by who?

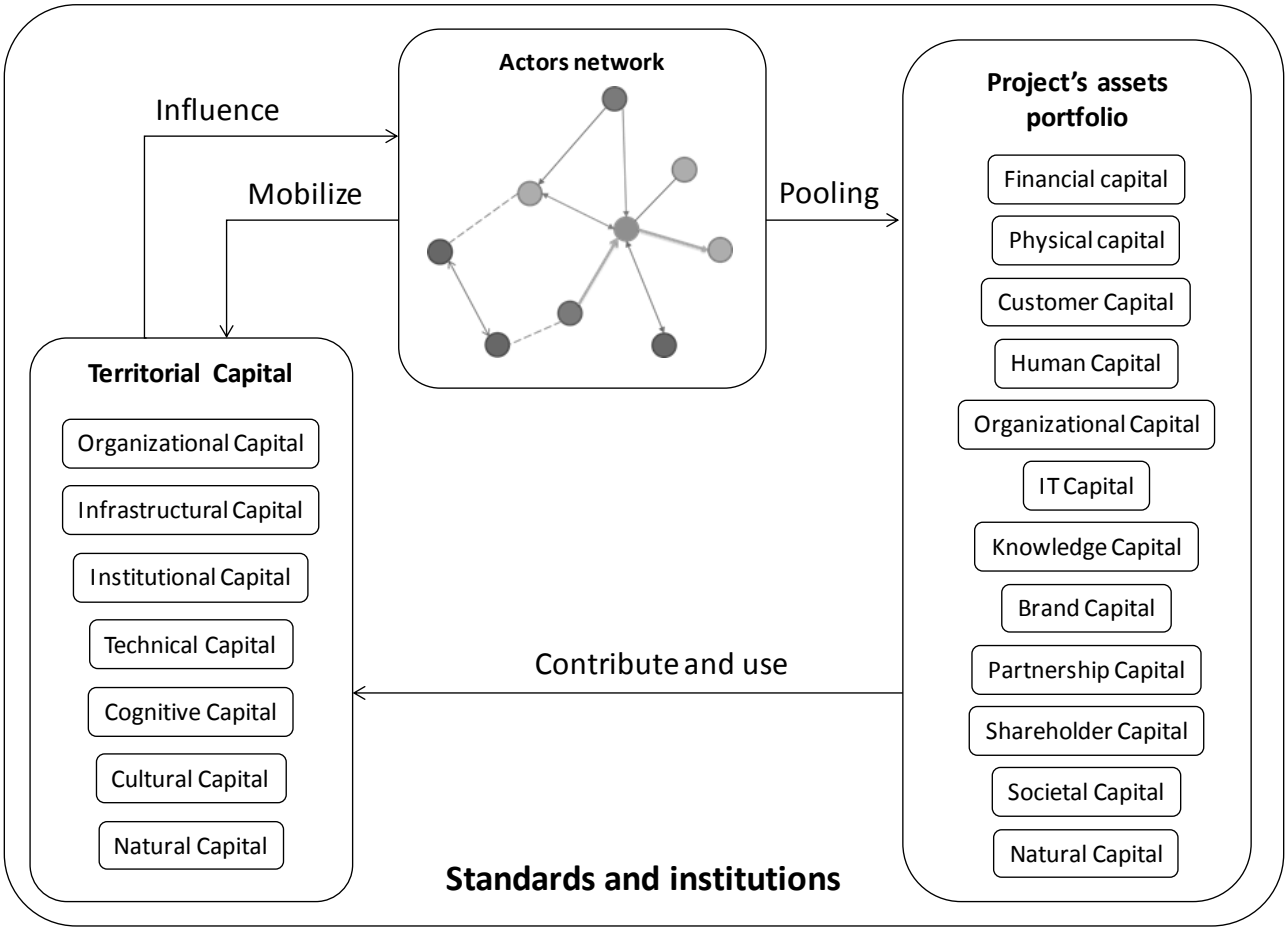

Figure 6 - Assets mobilisation during a project adapted from (Gobert, 2015), (Allais, Gobert, 2016)

The combination of these intangible capital frameworks enables a multi-view analysis and the integration of latent territorial resources in a project. Intangible capital provides information at a micro-level on the project network (i.e. elements and interactions), the meso-level analysis (i.e. resources, culture etc. of the territory) and the macro-level with the institutional framework (e.g. regional, national or EU legislation). This information is a decisive flow to facilitate the project building and the stakeholders' cooperation. However, information is also a source of power and consequently this framework does not undervalue the attractive and opposite strengths that may exist between stakeholders, the management of uncertainties, which may make difficult the project implementation.

Our analysis framework enables to analyse interactions between macro and micro levels for projects of social and environmental innovation, insofar as they are likely to be based on technical, metabolic and human dimensions. These initiatives are often "experiments" (a test before deploying the project at a larger scale) or experiences with a relatively limited diffusion. We strive to study and assist these innovations niches so that they could become viable and potentially upscale. To reach this objective it is necessary to know the material flows (through methodologies like MFA or territorial metabolism), but also intangible assets because the projects do not exist without human and non-human action, the previous interactions between nature and culture. The spatial dimension, and

particularly the role of territories, is particularly relevant, because each region has its particular features and histories.

4 CONCLUSION

This communication aims at clarifying the analytical framework for territorial project. This framework considers socio-spatial and temporal dimensions for niche analysis. In fact, it questions the pooling of tangible and intangible resources during the structuration of actors network and the mobilization of territorial resources for territorial projects (fig.7).

Dynamic network analysis enables the emergence of the concept of perimeter for action, designed by the network of actors, their competences and resources, their common willingness and capacity to influence and concretize the project. The perimeter for action is an evolving, non-continuous and multilocal innovation arena as a result of scalar projection of macro, meso territorial-industrial-civilian and micro levels on the project level (fig.4).

This framework has been initiated for the socio-economic and environmental analysis of a business model transition experimentation from product selling to Product Service System during the Eurêcook project funded by ADEME Bourgogne (Allais, Gobert et al., 2015), (Allais, Gobert, 2016), (Gobert, Allais, 2016), (Gobert, Allais, 2017). It is also deployed in the Recyluse project (2018-2020) (funded by ADEME) for the analysis of territorial repair networks and the development of context-adaptive living labs as intermediary objects to support system transition (Allais, Gobert, Tyl, 2018). This project is performed on two territories in France and imply repair workshops from meso-civilian level, citizens from micro-levels, local authorities from meso-territorial level and fund provider from both meso territorial and macro level. Territorial repair networks have to be considered as emergent local alternative regimes resulting from the coordination between numerous initiatives (niches) at different socio-technical levels. At regional scale (e.g. France), territorial repair networks will be considered as niches in opposition to the over-production, over-consumption regime.

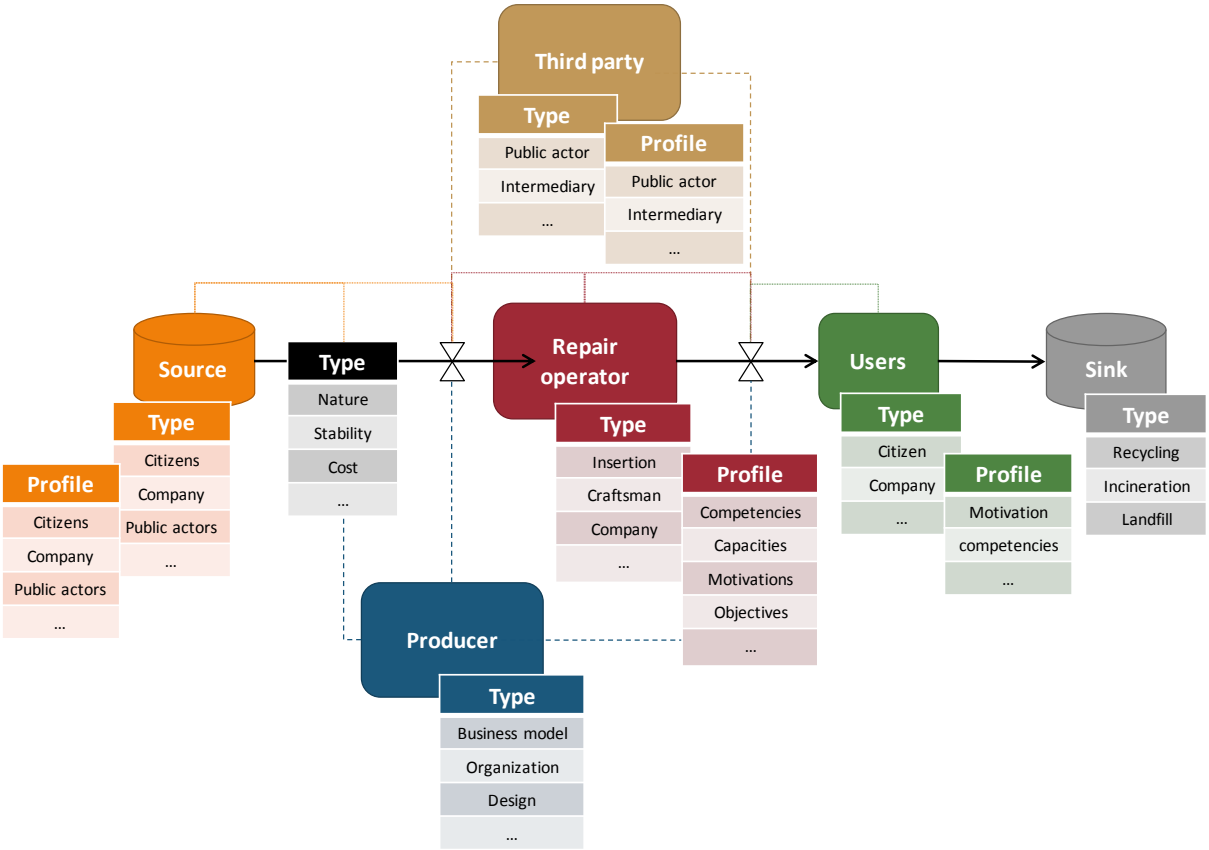

Figure 7 - Territorial repair network infrastructure of RECYLUSE (based on previous work of (Tyl et Al., 2015) for the REVALUE project)

Future work will consist in the integration of the sustainability principles from the 5D-STM thanks to preconisation during the structuration of the perimeter for action and the operation of project (e.g. participative governance, use of local/territorial resources…). This may assist the emergence of sustainability principles compliant niches then, their diffusion or upscaling in regime.

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