TATA-BOX: "Territorial Agroecological Transition in Action": a tool-Box for designing and implementing a transition to a territorial agroecological system in agriculture

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Abstract: The impact of agriculture on the environment and human health, energy crisis and climate change enjoin policy-makers and farmers to rethink the model of agricultural production. One way is to promote a strong ecologisation of agriculture by reducing inputs and using ecosystem services at field, farm and landscape levels. Designing and implementing such an approach requires changing deeply the management of farming systems, of natural resources and of the food–chain while dealing with a wide range of environmental and societal changes. To support this change, agricultural actors and researchers require new tools. Based on the concept of agroecological transitions, the Tata-box project aims at testing and adapting a methodology to help local agricultural stakeholders to develop a vision of the desirable transition of local agricultural systems and to steer it. The methodology is based on 5 steps:

i. design and set-up a multi-actor system that will perform the design process and collectively define the "situation/problem" set, i.e. the management actors and the key "causality chains" in the functioning of local agriculture and management of natural resources;
ii. accompany the actors and researchers in the construction of scenarios of factors of change for local agriculture and natural-resource management that are out of the control of the actors of local agriculture;
iii. construct a shared vision of the organisation of strong ecologisation of agriculture that would address their local issues, both present and future, and that ensure a socio-economic control of local agriculture by local actors, and is resilient to future external changes. Biggs principles are used as foundation principles in this step : three systems properties have to be managed (diversity and redundancy, connectivity, slow dynamic variable) and four management and governance properties have to be addressed (understand the system as a complex adaptive system, encourage learning and experimentation, develop participation and promote polycentric subsystems of governance);
iv. design the transition pathway to a strong ecologisation of agriculture, i.e. the procedures for progressive transformation of actual agricultural system into a real territorial agroecological system in agriculture. For this, we propose implementing a "backcasting" approach. It consists of defining the transition steps, the strategies associated with each step, and the criteria (or indicators) for successfully attaining each step;
v. design an adaptive governance form necessary for the transition developed in the previous step and define and implement the adaptive management necessary for the strong-agroecologisation of agriculture. As Tata-Box is based on the four attributes of the governance system of Biggs, it will consist of defining the governance types, i.e. the multi-actor systems and their modes of coordination that ensure adaptive management types based on social learning. We propose a local governance and management in order to steer this transition.

The field study project is a large agricultural watershed in the southwestern part of France (Aveyron & Tarn et Garonne). The Tarn river basin is about 300 km long from east to west and

50 km north-south, and covers a wide diversity of rural territories. From current and past projects, local agricultural dynamics have been identified and will be enrolled in the project.

Keywords: Adaptive Governance, Adaptative Management, Agriculture, Biodiversity, Collective action, Complex adaptive systems, Innovation , Interdisciplinary, Land management, Scenario analysis, Stakeholder engagement, Sustainable development, Trajectories, Water management

Context

After World War, the productivist model of agriculture, led to a standardisation of production methods and, as a consequence, to a decrease in the specific cognitive resources necessary to implement them. It also contributed to a specialisation of territories as a function of their comparative advantages (Lamine, 2011). In the 1990s, the development of the concepts of sustainability and multifunctionality challenged the monolithic logic of the productivist model. Objectification of the environmental impacts of agriculture, social awareness linked to media coverage of it, and redefinition of the objectives of agriculture due to agricultural policies are the sources of two forms of ecological modernisation of agriculture (Horlings and Mardsen, 2011).

The first one that takes roots in the productivist model, corresponds to “a weak Ecological Modernisation of Agriculture” (weak-EMA). It is based on an increase in resource-use efficiency (e.g., water), the recycling of waste or by-products (Kuisma et al., 2012), and the application of good agricultural practices (Ingram, 2008) and/or of precision-agriculture technologies (Rains et al., 2011). It can also be based on new off-the-shelf technologies, such as organic inputs (Singh et al., 2011) or genetically modified organisms.

The other one is a real break from the productivist model. It corresponds to “a Strong Ecological Modernisation of Agriculture” (strong-EMA). Compared to weak-EMA, strong-EMA needs a paradigm shift in the way to think the link between environment and production. Along with the principles of resource recycling and flow management, it includes the use of biodiversity to produce “input services” that support production (e.g. water availability, fertility, pest control) and regulate flows (e.g. water quality, control of biogeochemical cycles) (Zhang et al., 2007). These services depend on the practices implemented at field and farm scales, as well as at the landscape scale (Kremen et al., 2012). Strong-EMA allows agricultural production and management (conservation, improvement) of natural resources to be reconciled. This form of ecological modernisation of agriculture founded on ecological concepts is also called “ecologically intensive agriculture” (Griffon, 2006). While weak-EMA is essentially based on off-the-shelf technologies and/or agricultural practices that render the environment artificial, the goal of strong-EMA is to apply agricultural practices that can capitalise on functional complementarities between organisms or on services that agroecosystems can render.

Features of strong-EMA

The implementation of strong-EMA to ensure the expression of ecosystem services faces different difficulties:

a) Strong-EMA requires a redesign of the agricultural systems (Meynard et al., 2012);
b) Strong-EMA enhances actors to coordinate with each other, particularly for the arrangement of landscape structures, spatial crop distribution, and exchanges of matter (Brewer and Goodel, 2010);
c) The development of new cropping systems based on crop diversity (e.g. crop mixtures) and a decrease of inputs may cause problems for production and marketing chains (Fares et al., 2011);

d) Incomplete information during implementation of practices (difficulty in observing ecosystem states, or difficulty in predicting the effects of actions) lead to risk-taking by farmers (Williams, 2011);
e) Given the decidedly local character of production methods to be implemented to take advantage of biological regulating services (Douthwaite et al., 2002), the process of innovation must also be localised (Klerkx and Leeuwis, 2008);
f) Steering strong-EMA at a territorial level will not happen without changes in the mode of production of knowledge and socio-technical systems (Vanloqueren and Baret, 2009). An effective integration of societal concerns into scientific practice may require more fundamental changes in the nature of scientific enquiry, and a move towards truly transdisciplinary research strongly involving external stakeholders in the research process (Pahl-Wostl, 2012).

Through a thorough review, Biggs et al. (2012) identify seven general key principles to increase the production of ecosystem services within a social-ecological system, like an agroecosystem, and their resilience to social, economical and environmental changes. They distinguish **three system properties to manage**, all considering the biophysical and social dimensions of the system, and **four attributes for its governance**.

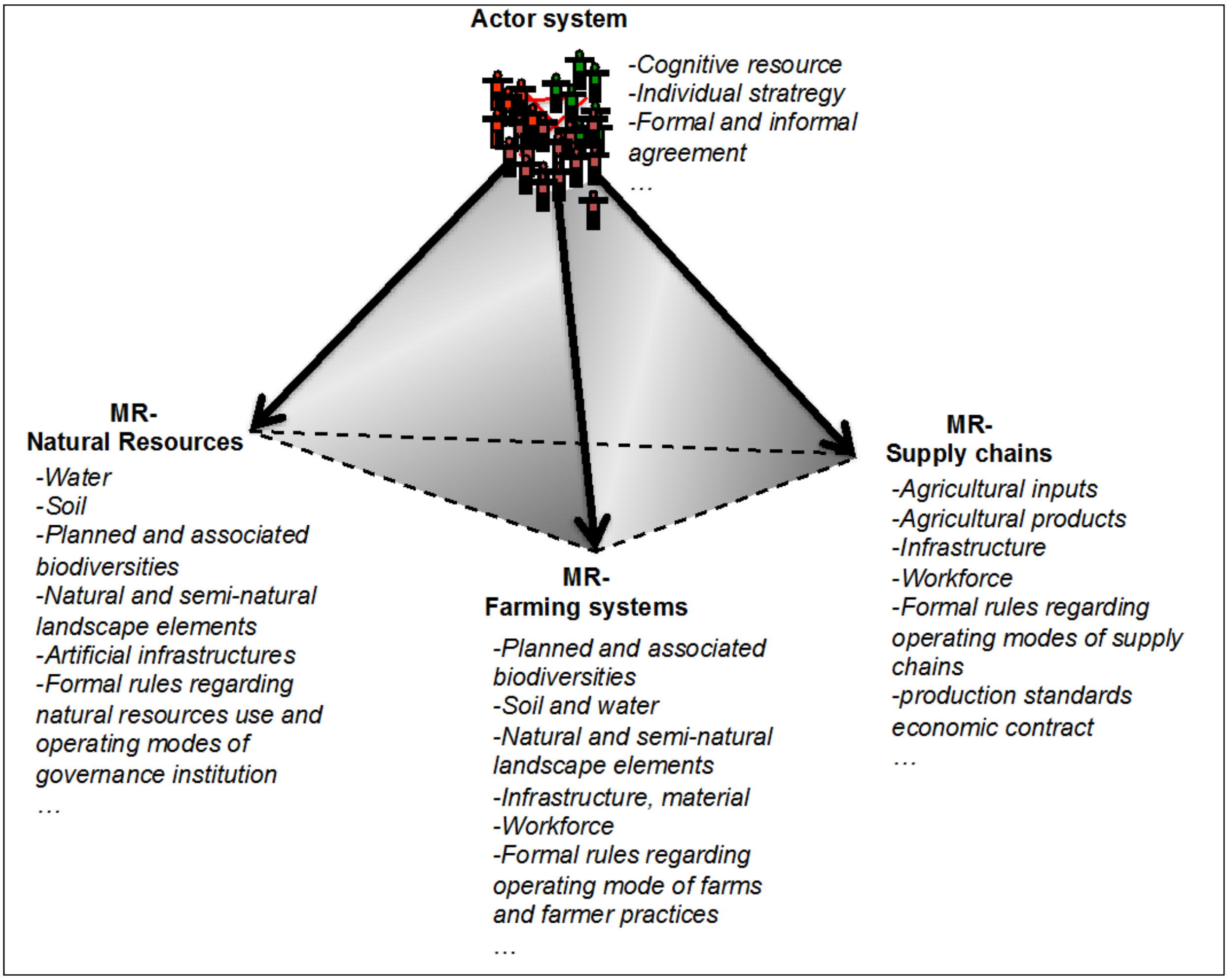
The three system properties are (i) **Diversity and redundancy**: the diversity (taxonomic and functional), biological (genes, species, ecosystems, spatial heterogeneity) and social (individual, social groups, strategies, institutions) equilibria, and their levels of redundancy, define the potential for adaptations and innovations about the system, (ii) **Connectivity** defines the conditions and level of circulation of material and cognitive resources and actors in the system that determine the exchange capacity among system components and thus the system's performance level and (iii) **Slow dynamic variables**: the dynamics of complex systems are determined by the interaction between slow dynamic variables (e.g. farm size, soil organic matter, management agencies and social values) and fast dynamic variables (e.g. water withdrawals, authorisation to access to resources). The way of middle- or long-term management of the former determine the conditions under which the latter occur both determining regimes of ecosystem services.

The management and governance systems to develop must be able to: (i) **understand the system as a complex adaptive one** that is characterised by emergent, non-linear and path-dependency behaviour, self-organisation and adaptation, ontological uncertainties and accordingly requires adaptive governance and management, (ii) **encourage learning and experimentation** to structure and stimulate production and acquisition of knowledge, skills, and values at the individual or organisation levels necessary for managing the agroecosystem in situations of uncertainty. Experimentation, particularly in the framework of adaptive management, is a powerful tool for generating such learning, (iii) **develop participation** in governance and management processes to facilitate collective action, relevance, transparency, legitimacy, and ultimately acceptability of social organisations, decisions, and actions, and (iv) **promote polycentric subsystems of governance** that structure debate and decision-making among different types of actors, at different levels of organisation, and of different forms (e.g., bureaucratic, collective, associative, informal). The basic principle of polycentric governance is to organise governance systems at the spatial scale at which the problems to manage or objectives to attain emerge.

Promoting strong-EMA requires designing, developing and steering a multi-level, multi-domain participatory framework dealing explicitly with trade-off issues.

The DFT-framework

Figure 1: The DFT-Framework



To face with the limitations of some well-known frameworks (Farming Systems, Social-Ecological System, Socio-Technical System) when applied to implement strong-EMA, Duru, Fares and Therond (2014a, 2014b) built an integrated framework (**DFT**-Framework – **Fig. 1**) to describe the nature of the complex system concerned by the strong-EMA also called agroecological transition of agriculture. This framework should help thinking on and support the design of this transition. The DFT-Framework represents local agriculture as a system of various actors whose behaviour is determined by formal and informal norms and agreements that manage, via technology, the material resources specific to farms, supply chains, and natural resource management. The two main types of managed resources: material resources (with a biophysical dimension) and cognitive resources. The last ones are intangible and correspond to knowledge, beliefs, values, and procedures that actors use to define their objectives, devise their own strategies or alliances, and perform actions. This framework distinguishes three main systems of material resources (MR): (i) the MR system of the farm (MR-F), used by the farmer for agricultural activities; (ii) the MR system used by actors of each supply chain for collection, processing, and marketing activities (MR-PC); and (iii) the MR system used by actors for management of the natural resources of local agriculture (MR-NT). Each MR systems include components that interconnect or interact, such as fields, planned biodiversity (crops, domestic animals), associated biodiversity, machinery, buildings, water resources, and labour for the MR-F system; transportation, storage, and processing equipment and roads for the MR-PC system; and water, soil, and biodiversity (including associated) resources and landscape structures (hedgerows, forests, hydrological network) for the MR-NT system. The three systems of material resources are interdependent, if not interlocked. Material resources, more particularly natural resources, are considered as a social construct and not as an intrinsic characteristic of biophysical objects that become resources for actors. Indeed, the dimensions and properties that qualify a biophysical object as a resource depend directly on the management process considered. Each management process is based on, and determined by, technologies that are specific to it and used to act upon the concerned resource system. Within these technologies, information systems determine the way of characterising resources, the knowledge that actors have about the state of material resources over time, and consequently their actions for managing them in time and space, and finally, their ability to meet their performance objectives. Following New Institutional Economics (Williamson, 2002) and the Sociology of Organised Action (Crozier and Friedberg, 1977), the DFT-Framework considers that formal norms do not completely determine the behaviour of actors. Thus, having limited rationality, actors have a certain degree of freedom and autonomy in their choices and actions.

This conceptual framework can be used to analyse and characterise current forms of agriculture called "**Agricultural Systems in a Territory**" (**ASaT**) and to design a future "**Territorial AgroEcological System**" (**TAES**) corresponding to a strong-EMA of current ASaT. A key characteristic of the TAES is to organise, at the local level, interactions between the production systems to take advantage of their complementarities, whether biophysical (best use of differing soil and/or climate characteristics and/or of access to some natural resources of the farms) and/or production-oriented (e.g. organisation of crop-livestock interactions at the local scale) (Moraine, Duru, Therond, 2012, 2013). Duru, Farès, Therond (2014b) present also a generic participatory methodology (DFT-methodology) aiming at steering stakeholders to design **transition to Territorial AgroEcological System** (**tTAES**).

To put DFT in action, we identify currently four main scientific challenges:

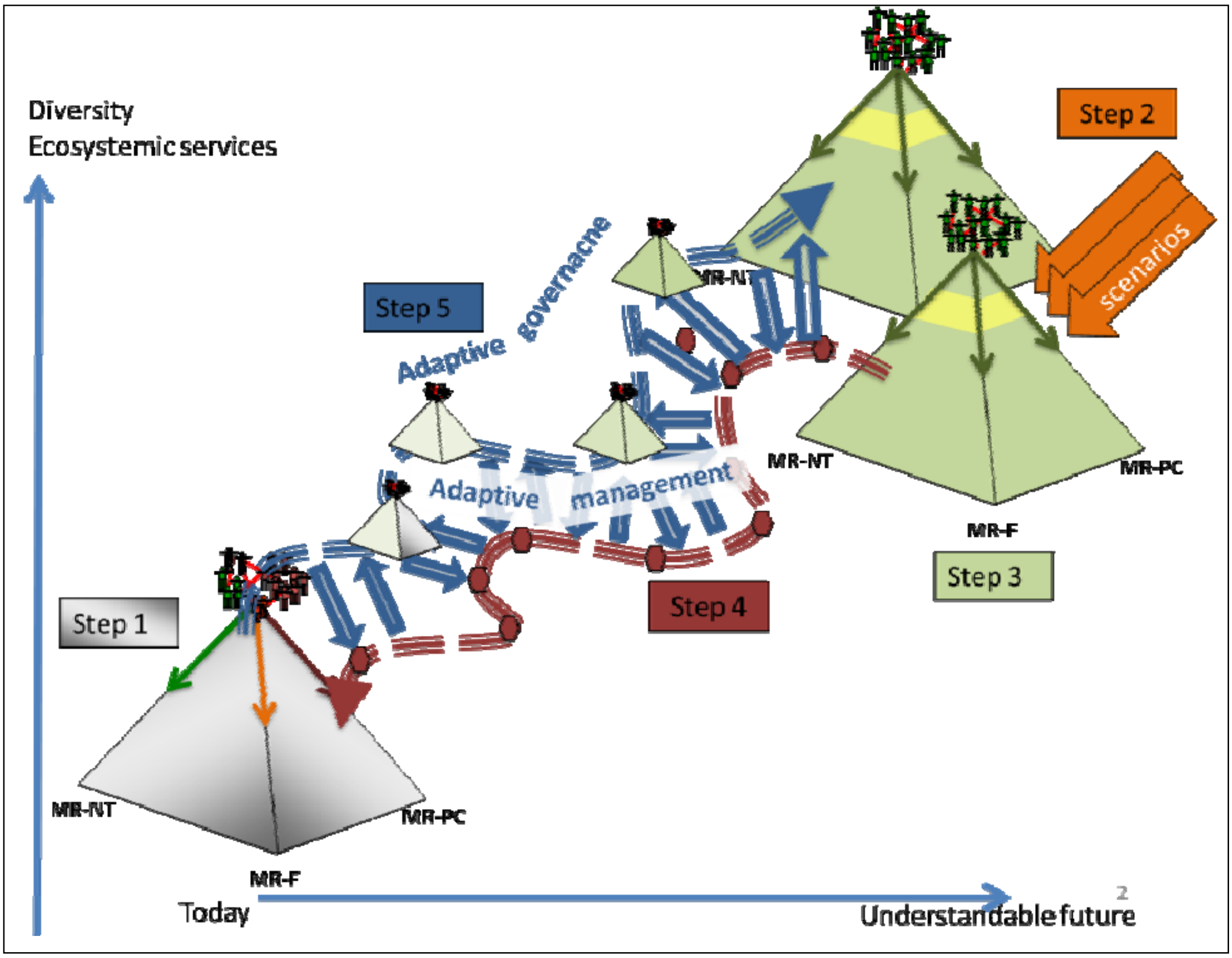
- developing boundary objects (conceptual model, computerized-model, indicators, dashboard…) used in the different participatory workshop by stakeholders and enabling trade-offs analysis and multicriteria representation. Those have to be based on a sound scientific background;
- developing information systems (required for adaptive management) allowing stakeholders to share information and knowledge, to build a collective representation of the current and expected local agriculture and to monitor effect of multi-level and multi-domain management on the development of targeted ecosystem services.
- developing adaptive governance and management enabling stakeholders to locally steer the agroecological transition.

TATA-BOX: a methodological project

The goal of Tata-Box is to put in action this generic transdisciplinary DFT-framework for designing at the local level, an agroecological transition that fosters the strong-EMA and allow stakeholders to develop a Territorial AgroEcological System (TAES). Here, the local level is defined as an area where stakeholders act to directly or indirectly manage resources in order to promote ecosystem services. This geographical level corresponds to an intermediate scale. The territorial agroecological systems will be defined in terms of geographical, economical, environmental and social patterns. This participatory design approach will be applied and tested in the Tarn river watershed (south-western France) where farming systems range from arable to livestock ones, water and biodiversity resources are at stake and some collective dynamics toward agroecology already exist. Putting the methodological framework into action will lead researchers to support local actors of agriculture and natural-resources management in using methods to organise local agroecological transition.

New ways of thinking locally agriculture cannot be imposed by a project leader, but has to be co-constructed in an arena of various stakeholders whom differ in terms of professions, interests, skills, and believes. The DFT-methodology applied in Tata-Box is composed of five main steps (Fig. 2):

Figure 2: the 5-steps approach of the TATABOX project



Step 1 consists of (i) designing and setting up a multi-actor system that will perform the design process and (ii) collectively defining the “situation/problem” set, i.e. the management actors (called “effective management” by Mermet et al., 2005) and the key “causality chains” (Kajikawa, 2008) in the functioning of local agriculture and management of natural resources. It is a matter of identifying all the actors, resources, human actions, and ecological processes having a decisive influence on the functioning of farms, supply chains, and natural-resource management. To build this situation/problem representation, two types of analysis will be carried out in Tata-Box. The first, performed by social scientists, will be a strategic analysis of the system of actors (Crozier and Frieberg, 1977). The second type of analysis, collectively performed by the actors and researchers will aim to co-construct conceptual representations of the functioning of farms, natural-resource management, and supply chains through the use of methods for collective construction of cognitive maps (Rouan et al. 2010, Sibertin et al., 2011).

Step 2 consists of accompanying the actors and researchers in the construction of scenarios of factors of change for local agriculture and natural-resource management that are out of the control of the actors of local agriculture (Bos et al., 2008; Kajikawa, 2008; Therond et al., 2009). They can integrate information produced by forecasting exercises performed at the supra-local scale to be disaggregated locally. In Tata-Box, to construct the images of possible futures the morphological approach of Godet (2006) will be used. It was already used to analyse the future of the field-crop industry in the Midi-Pyrenees region (Bergez et al., 2011). The analysis of the situation/problem and in particular the causality chains, performed in step 1, will be used in this step to guide the stakeholders in the identification of the forces of potential change.

Step 3 aims at allowing actors, assisted by researchers, to construct a shared vision of the TAES that would address their local issues, both present and future, and that ensure a socio-economic understanding of local agriculture by local actors, and be resilient to future external changes identified in step 2. The actors work iteratively from the conceptual DFT-framework, the 7 Biggs' principles, considered as foundation principles of the TAES and the results of the two previous steps. In Tata-Box this work will be performed on the basis of conceptual representation (texts, diagram, cognitive maps, and images of the future) and, in combination with the use of models (Voinov and Bousquet, 2010), allowing assessment of potential impacts of given internal or external changes at the farm level (e.g. Martin et al., 2011) and at the watershed level (e.g. Clavel et al., 2012).

Step 4 allows actors, assisted by researchers, to design the transition toward TAES, i.e. the procedures for progressive transformation of ASaT into TAES. For this, we propose implementing a "backcasting" approach. Given the TAES to construct, it consists of defining the transition steps, the strategies associated with each step, and the criteria (or indicators) for successfully attaining each step. These backcasting methods are now well known, widely disseminated (Kajikawa, 2008; Quist, 2007) and will be used in the Tata-Box project. The main point will be to define realistic management strategies for the transition that will help overcome actors' resistance to changing the "effective" management system, identified by analysing the system in step 1.

Step 5 aims at accompanying the actors in: (i) designing an adaptive governance structure necessary for the transition developed in the previous step; (ii) defining and implementing the adaptive management necessary for leading the strong-EMA designed in the step 4. As Tata-Box is based on the four attributes of the governance system of Biggs, it will consist of defining the governance types, i.e. the multi-actor systems and their modes of coordination that ensure adaptive management types based on social learning. More precisely, the objective is to design formal norms and modes of ad-hoc informal coordinations that would allow for the emergence and/or development of niches nursering the agroecological transition and their coordination at the local level.

In Tata-Box to support the participatory process and the necessary important information exchanges between stakeholders and researchers, specific collaborative tools will be developed. The collaborative tools group together two functions: knowledge management and innovation. According to the definition of a collaborative work, the chosen system will have to build a space of existing knowledge and/or to store a directory of experts to develop new knowledge (Balmisse, 2006; Le Boterf, 2008; Soulignac, 2012). Iconic approaches to knowledge representation and management will provide tools to support collaborative practices between members of communities of actors in critical, dynamical, and sometimes controversial fields of interest (Gödert, 1991; Menard et al., 2010). These approaches known as 'Knowledge-based Icons Systems' lays on the idea that iconic categorization based on a relevant model can improve the quality of collaborative knowledge management via social tagging and participative annotation via graphical communication (Lamy et al., 2009). Furthermore, the evolution of local agriculture towards a TAES depends on the dynamic of knowledge production and its passing on. Thus, collaborative softwares will manage explicit knowledge while others will manage tacit knowledge, i.e. knowledge embedded in individuals (Polanyi, 1966; Nonaka and Takeuchi, 1995).

Finally Tata-Box will organise a reflexive analysis on the implementation of the DFT-methodology in order to assist the various participants of the project in the development of both their activities and objects of activities (methodologies, SAET, governance rules, conceptualization of Socially Acute Question) in a reflexive and constructive manner. This reflexive activity is firstly grounded in the perspective of constructive ergonomics (Falzon, 2013), which aims at developing "enabling environment" of work, i.e. a non-deleterious environment that support both performance and development of people in a sustainable perspective. In this frame, the design process of technical and organisational artefacts appears participative and involves simulation of activities to be transformed by these new artefacts (Barcellini, Van Belleghem & Daniellou, 2013). In the context of TATA-BOX, an issue for constructive ergonomics will be to organize the design of cooperation between stakeholders but also to enhance the development of real epistemic communities of work. The reflexive work in this project is also grounded in the perspective of socio-scientific issues education and the framework of Socially Acute Questions (SAQ, Simmoneaux and Simmoneaux 2011) linked with the educational trend of Socio-Scientific Issues (SSIs) which is gradually spreading internationally. The agroecological transition is an "acute" question in society, in research and professional fields and in classrooms and often related in the media. Many different actors take part in knowledge production including scientists, professionals, and course citizens and even whistleblowers. Consequently we assert that the knowledge involved in SAQs can be conceived as plural (polyparadigmatic) or/and engaged (analyzing the controversies, uncertainties and risks) or/and contextualized (observing empirical data within a given context), or/and distributed (constructed by different knowledge producers).

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