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# QUESTIONING POULTRY INDUSTRY ABOUT SUSTAINABILITY AND BONDS TO TERRITORIES: A CASE STUDY IN FRANCE AND BRAZIL

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**Abstract —** Poultry production chain is an integrated sector seen as “off land”. However this chain is strongly interacting with territories leading to various impacts. Therefore to deal with sustainability requires transdisciplinarity and exchanges with numerous stakeholders. The first step is to define the studied dynamic system, here the “poultry production chain \* county” aggregate. The second is to share between disciplines a common knowledge on this system through a unique representation. The third is to accept the approaches proposed by other disciplines even though time and space scales are consequently evolving. Due to the approach complexity, fruitful but time-consuming transactions between researchers are observed.

**Key words :** poultry production chain, territory, sustainability, transdisciplinarity

**Résumé —** Interrogations sur l’impact des filières avicoles concernant la durabilité des territoires : exemples au Brésil et en France. Les filières avicoles sont un secteur très intégré considéré comme « Hors-sol ». Mais cette production est en fait très liée aux territoires par différents impacts. Par conséquent, parler de durabilité nécessite une approche transdisciplinaire et des échanges nombreux avec les classes d’acteurs présentes au sein de la filière et du territoire. La première étape consiste à définir le système dynamique étudié, ici la combinaison « Filières Avicoles X Territoire ». La seconde est de partager entre les disciplines une représentation commune afin de transmettre un socle de connaissances adaptées et suffisantes pour traiter des problèmes de durabilité. La troisième étape, pas toujours la plus simple, est pour chaque discipline d’accepter les approches des autres, même si les échelles de temps et d’espaces ne sont pas les mêmes et évoluent sans cesse. Due à la complexité de l’approche, des transactions entre disciplines, fructueuses mais très consommatrices de temps.

**Mots clés :** filières avicoles, territoire, durabilité, transdisciplinarité

This manuscript is a companion paper of Bonaudo et al (2010b) presented at the same ISDA conference

## INTRODUCTION: AIM AND BUILDING OF THE TRANSDISPLINARY PROJECT AVITER

The aim of this manuscript is to present a multidisciplinary or transdisciplinary research approach in the field of sustainability of the poultry production sector in interaction with territories in which this industry has taken a major importance. The project called AviTer, for poultry chain and sustainable development of the impacted territories, is a first attempt to build a multidisciplinary research network on a complex issue dealing simultaneously with poultry chains interactions with lands over several countries. To the authors' knowledge, this is the first time that the system including poultry chain and the impacted land is studied. This could be connected with the fact that in the EU and Brazil, poultry production is a very industrialized economical sector. Each part of the production chain is identified and linked to the other sectors mostly through physical fluxes (birds, food, etc...) and through technological packages imposed by one sector (usually the slaughter plants) to the production one (within each farm through technical advices given by union of producers linked with the firms operator). Therefore poultry production could be identified more as a modern supply chain than a traditional agricultural sector. Moreover, poultry is a very ubiquitous production, developed in all continents and climate with a strong international market, both of final products and of vegetal feedstuffs. Additionally governing industries dealing with poultry are working at world scale. Poultry production could consequently be considered as a world sized production with world sized stakeholders. However two points could not be forgotten: poultry is produced over given territories and poultry protein is one of the cheapest animal protein sources for human consumption and therefore one of the key items to deal with human food supply.

In front of this complex system, animal production scientists are interested to deal with poultry production chain sustainability as a whole but also on given lands, since obvious economical differences were stressed between producing countries, jeopardizing French and more broadly EU production on a short time scale. However as soon as the question of sustainability is written, several issues are raised: which dimensions should be studied to reach a complete approach of sustainability, if reachable? Which disciplines should consequently be associated to gather and articulate the different required approaches? How to define consistent criteria to choose these disciplines? Of which "poultry production chain" are we talking about? And last but not least, the poultry chain is initially represented "off land" and without governing or acting actors. Moreover stakeholders from a defined land have to be included together with a defined avian production system.

Therefore a consortium including researchers from different disciplines was created driven by animal production scientists. For the economical aspects, researchers were involved: from the French poultry extension services and from a private consulting company in Brazil. Due to the isolation of the poultry sector in the French agricultural research system, it was not possible to find a state researcher on the poultry production chain economics. It could also be linked to the very sensitive issue due to the low margins and the very high level of instantaneous competitiveness needed to "stay on the market". Therefore open research on economical issues is very difficult to perform in the avian sector. All along the program, informal transactions between economists and stakeholders were observed to keep strict confidentiality on given pieces of information.

For the environmental issues, the choice was to include researchers on life cycle assessment in both countries. It was production chain orientated since the aim was to evaluate the environmental costs of poultry production chains in different areas, stressing the whole production impact (e.g.: CO<sub>2</sub> production) versus the localised impact (e.g.: water quality). This has affected the evaluation of the interaction between land and poultry production and has therefore interfered local interpretations of the environmental issues. Moreover, questions regarding research activities on poultry environmental impacts should be questioned through AviTer: should we devote means to study this aspect at the animal

scale or have we other ways of gaining faster progress on that issue notably through systems of crop production?

For the social side, due to the existing networks or to the available contacts and certainly to the lack of knowledge of the consortium builder (However, we do not have any regret to have included our sociologist colleagues and very consistent results were obtained), several competences were recruited: public decision specialists, family farming experts, rural sociologists and geographers. The project leader discovered during the study that there could have more differences between two sociologists than between two animal production scientists. An output from AviTer is the need from a prerequisite regarding the social issues to be included in the project. If we were aware of the economical or technical issues to be dealt with, we were short of arguments to isolate the questions in "sociology of sustainability". We knew that we should include stakeholders' standpoints and the interactions between actors at different scales. Next project will require a first step to identify the sociological part of the project.

One aim was to study health issues. Therefore many contacts were initiated on the French and Brazilian sides and two French veterinary institutes joined the project. However it has never been possible to include Brazilian colleagues. The main reason, strongly underevaluated by the program leaders, was that sanitary aspects are deeply impacting poultry markets through non-trade barriers. Therefore this item was only treated partially in the program and on an unbalanced way since no work was performed in Brazil. It also impacted the overall relationships with the field actors who are very sensitive to any comment on health issues due to their economical impact. To stress this point, it has to be reminded that this research program was performed during the avian flu crisis. At the end of AviTer, we do not know how to deal with health issues and this is very disturbing since sanitary aspects are key-topics to define poultry chain sustainability within a given county not only for the economical part but also to obtain relevant avian products for the population fed from this county.

An additional question was asked to the research consortium at the beginning of the program: should we include private partners? As an example, there is only one industrial actor in the developing cluster of Rio Verde in Central Brazil. Due to the high competitiveness in the avian sector, it was therefore decided to reject this option: working with one stakeholder would have banned us from discussing with the other ones. Nevertheless, these actors play a key-role in the program as part in the local and distant governance of the poultry production chain within a given land. Therefore many formal or informal exchanges were performed with them through iterative talks. Public bodies were also questioned but not included *per se* as project partners, one difficulty being to understand their relationships with local producing actors which are strongly depending on their impact on the studied county.

At the end of the day, the consortium included 12 partners coming from contrasted scientific background and culture. Moreover a majority has never worked within the poultry production system.

Consequently three theses are proposed in this study. Firstly, a common definition of the studied system (poultry production chain \* county aggregate) has to be reached through an iterative and dynamic process. Secondly, tools should be chosen and afterwards used to collect and share common knowledge on the system to deal with the sustainability paradigm. Thirdly, rules should be found so that each discipline should accept the approaches proposed by the other ones requiring a minimal level of mutual comprehension.

## 1. METHODS: A HEURISTIC APPROACH

Physical and information fluxes within the poultry chain were obtained through official datasets combined with actors' interviews. These fluxes could be considered as easy-to-obtain ones. However, their articulations within the "poultry chain \* county" aggregate and their regulations are not obvious. To go further, the following step was to reach a high

confidence level with governing partners. Individual interviews were performed with a strong emphasis on the data and ideas which had to remain confidential. Differences were strictly kept between confirmation of public data and tactic or strategic standpoints explained explicitly or not by the stakeholders. Researchers came back to each firm to give them some of the results, and to discuss on their specific problems. As an example, one company is performing a life cycle assessment that we enriched strongly in a win-win situation. In Brazil, since that was the first contact with our network, it was very hard to open some firms' door. We partially managed through commons seminars and travels i.e. one production director from the biggest Brazilian poultry company, BrazilFoods, came for a one-week visit and after many discussions, he is now a facilitator for our project at Rio Verde. Public stakeholders were also interviewed, perhaps not enough. Their roles as actors in the link between the territory and the food chain have to be emphasized. One issue that was taken care of was the relative position of the public bodies near the private ones: which relationships? Was there any domination links? The answers differed from one county to another.

A multidisciplinary approach was performed as far as possible. However, mixing animal scientists and sociologists is not an easy task. Nevertheless, due to a large number of exchanges, a common knowledge of the different territories is shared by the researchers, and it helps for the overall integration of the results. Last but not least, crossing Brazilian and French approaches led to innovative points of views on both sides. This should open to new questions and common research programs on sustainability. On a practical standpoint, related to these particular conditions, various approaches, using different disciplines and tools, have been used in view to know how the poultry sector can achieve sustainability in each territory. Food chain analysis, life cycle assessment, sociological approaches, geographical surveys, veterinary inquiries were carried on. Many professional people have been interviewed: poultry men, specialists of poultry production, employees of professional organisations, and managers of industrial plants such as abattoirs, feed mills, and hatcheries. The resulting problem from these approaches is their articulation: are we covering enough gaps of knowledge to deal with the issue of sustainability of the aggregate "Poultry production \* county"? The answer is obviously no but is inherent to the chosen approach, i.e. a systemic one.

All these approaches were managed with the objective to evaluate and combine the 3 major components of sustainable development: social, economical and environmental. Finally, a modelling approach, after the end of AviTer, will help to integrate the different dimensions, and will challenge them with different scenario.

## **2. DEFINING THE STUDIED SYSTEM: AN ITERATIVE AND DYNAMIC PROCESS**

The poultry production chain is usually considered as a highly technically evolved animal production system. It is therefore organized as an industrial sector with different specialized tasks devoted to qualified workers (including the farmers as one actor among others). However this very technical standpoint should be strongly questioned as soon as the locations of these different steps are exposed. As an illustration, Figure 1 (obtained from the organization in the municipie of Rio Verde) is a common representation of the poultry production chain by animal production experts: the overall figure is focused on the animal or food fluxes. This representation can be considered with a very high level of genericity since you can draw the same one in every country. It can be used to discuss technological issues by firm engineers dealing with industrial logistics or to analyze the critical points regarding the production chain organization. To our understanding after interviewing the major stakeholders of the poultry chain, we could consider that this representation is the model used by most actors keeping in mind that they only focus on the fluxes and they do not account for the locations of the different steps.

But it is of very little use dealing with avian production sustainability in a given county. Two main drawbacks can be stressed since the central question is to understand the process driving to a given dynamics of a poultry production system \* county aggregate. The first one is the lack of explicit location of the production chain. Since we intend to evaluate the

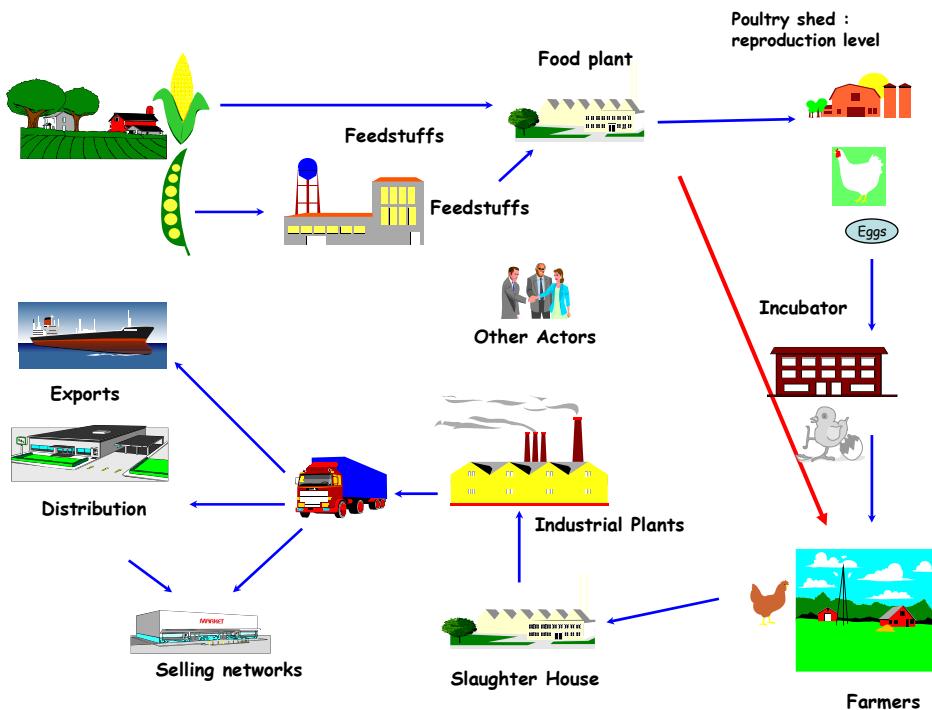
economical, sociological and environmental impact of the poultry chain on a given county, the locations have to be known. This question of location is only raised by the stakeholders in some cases: local environmental impacts in saturated counties as Western Santa Catarina or Bretagne, economical costs of lorry transportations in Rio Verde. Social links through direct or indirect employment is not explicitly discussed by the firms' governing bodies whereas the local public institutions are very sensitive to this issue. A research issue is therefore to measure the strength of the link between the production chain and the territory, which is quite often weak. Moreover the border of the county has to be defined since it could obviously differ from the treated question and the stakeholder standpoint.

The second drawback of a generic representation is the lack of the actors' definition. By actors, we consider both the governing and acting bodies of the poultry chain (in a broad sense) but also all the class of actors living within the county and interacting or being impacted by the poultry chain (e.g.: local institutions). A complex issue is that some actors can have large impacts on the system but are living away from the county (e.g.: international firms, consumers or citizens unions) which might weaken the sustainability of the system due to the loose relation between the decision maker and the field.

From this fuzzy representation, several "sub-systems" are defined according to the studied sustainability axes. For the economical one, up to now, the system is mainly focused on evaluating the poultry production costs (by kg of living bird or kg of carcass) for the different counties to compare the competitiveness on given markets. The spatial aspect is mostly taken through the distances needed to transport the vegetal feeds, to collect the birds and to sell the meat. This economical representation is consistent with the poultry world market: even though we deal with counties in France and Brazil, they are strictly competing on the same ground due to very low sea transport costs. However, discussions with other disciplines as geographers or rural sociologists push to evaluate the economical interactions between the considered county and the local poultry chain. Therefore, economical traits as the produced employment or the public support are included. The economical system could be represented as an industrial cluster with different dynamics (young, mature or decreasing) depending on the county. However, all stakeholders stress the fact that without economical efficiency, short term sustainability is corrupted and the whole local system is at danger.

For the environmental axes, large discussions between disciplines have been held. One question was easy to solve: what were the units of measurements for the life cycle assessment? Since the economical axis was expressed in kg of carcass, the same unit was chosen. A second question was and is still difficult to fix: which spatial bounds of the systems should be fixed? Whatever the considered poultry chain, soya bean from Brazil is used. The cropping region is very important due to the Amazonian deforestation. The bound is still in debate since including or not some Amazonian area inverts some results on Green Gas Effect, which is very sensitive on the sustainability standpoint. Another interest of transdisciplinarity is the supply of large sets of information from some of the involved disciplines to the environmentalists. The latter are developing and using a new methodology, Life Cycle Assessment (LCA) while the former (poultry chain experts) are helping its parameterization and evaluation of the results. A result is the need of being very cautious on the LCA outcomes: they are depending on the reliability of the included data and their analysis on several criteria could be conflicting. Therefore LCA researches are really transdisciplinary up-to-date methods but they need expertise from the treated chains to obtain any consistent result. The poultry production LCA is more or less a global environmental impact. Consequently, animal production researchers, geographers and rural sociologists pinpointed the need to deal with the environmental local impact within each county. Therefore, depending on the level of available pieces of information, environmental indicators were proposed (e.g.: water quality). However the main difficulty remains: which proportion of the measured environmental impact can be considered as linked to the poultry production chain? Asking this question could lead to include the other animal productions in the system which is certainly not worth according to the focused target of the program. Nevertheless, next programs will include these productions since pollution ranking between animal productions will be a top of the pile issue in the stakeholders' debate.

*Figure 1: System representation: which limits and which objects and actors to include?*



For the social side, the studied sub-systems are changing according to the focus of the question. According to the expertise of the researchers regarding the sociological issues, several questions were raised. The approaches could be classified at three levels. The first one is a combination of the farms and the very close community. The aim is to evaluate the dynamics of the farm renewal and the long term impact on the sustainability of the poultry chain in a given county. The key-parts of this sub-system are the farmers and their families, who are a tiny part of the overall system. The second is the local interaction with the society through a close analysis of local events. The hypothesis is that a positive interaction could be measured through the common implication of the poultry chains' actors and of the citizens, which could strengthen the bond between the poultry chain and the land. The third approach is to analyze the links and the balanced influences of the governing bodies, both from the territories and from the poultry chains. In the three cases, the proposed systems are not connected to any physical fluxes even though the results could impact them. As an example, poultry shed developments and litter utilizations are directly connected to the social interactions. The proposed sub-systems are therefore mainly including links between classes of actors. Moreover the spatial dimension is not straightforwardly included in the model. One interesting part of the program was that the sociology scientists have to explain their hypothesis and the need to test them on the different scales. The animal production scientists were not familiar to these approaches combining actors influence on the whole system behaviour or at least, they did not know how to evaluate them.

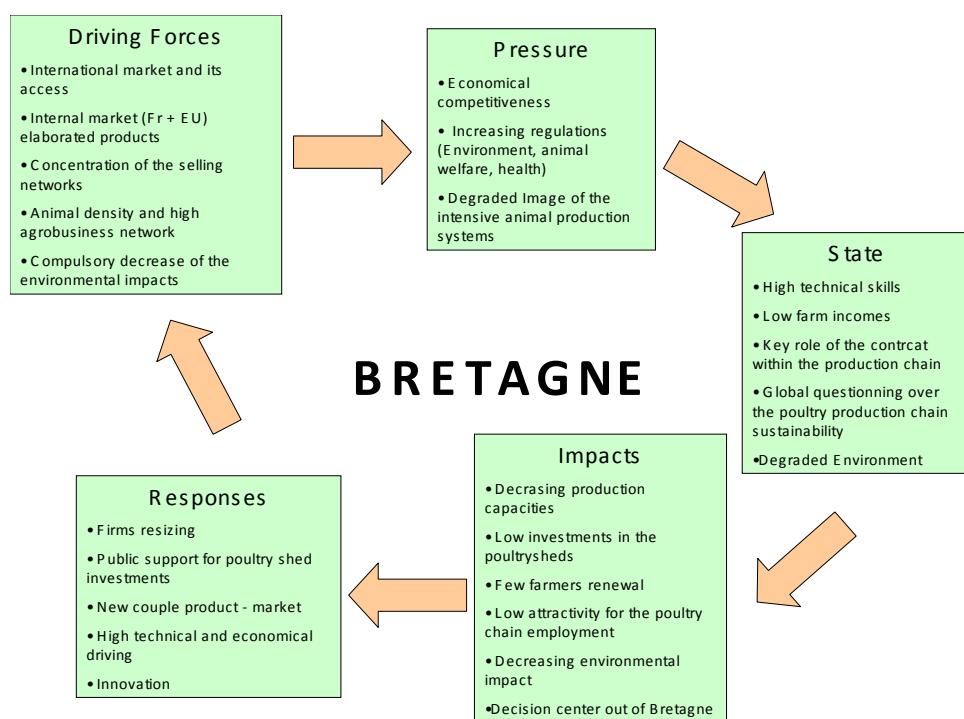
To conclude on the system definitions, transdisciplinarity was a way to question the approach of each discipline. A whole frame was proposed and accepted, each partner explaining his definition to the other colleagues. However the process of the system definition is a dynamic one and is continuously questioned. An evolution could be traced during the three years long program: the first system was only to draw the poultry chain on a given field while the last version could be considered as a set of interactions including actors from the land and the poultry chain, with a concern on the land use and if possible a time dimension. Obviously,

Figure 1 was an initial representation and numerous other conceptual visions could be proposed depending at least partially on the transactions between disciplines. An additional question could be the distance to the systems that these representations should lead to: which issues are we deleting by modelized representations of the “poultry chain \* county” system? Iteration of the process will show which areas were forgotten and required or included and unnecessary.

### 3. SHARING KNOWLEDGE ON THE SYSTEM: REQUIREMENT OF COMMON TOOLS

The main aim of the program was to deal with the “poultry chain \* county” systems’ sustainability. However mixing disciplines made it difficult to reach and agree of a common knowledge of this system. A first step was proposed by several disciplines through existing examples: classical poultry production chain representation (Magdelaine, 2008), life cycle assessment model (Coutinho et al, 2009), local production system representation (Mior, 2005). However a common tool was required so that the partners could exchange on the main characteristics of the systems and on the methodology to rank them. A conceptual frame was proposed adapted from OECD approaches (Bonaudo et al, 2010, Figure 2a for Bretagne and Figure 2b for West of the state of Santa Catarina).

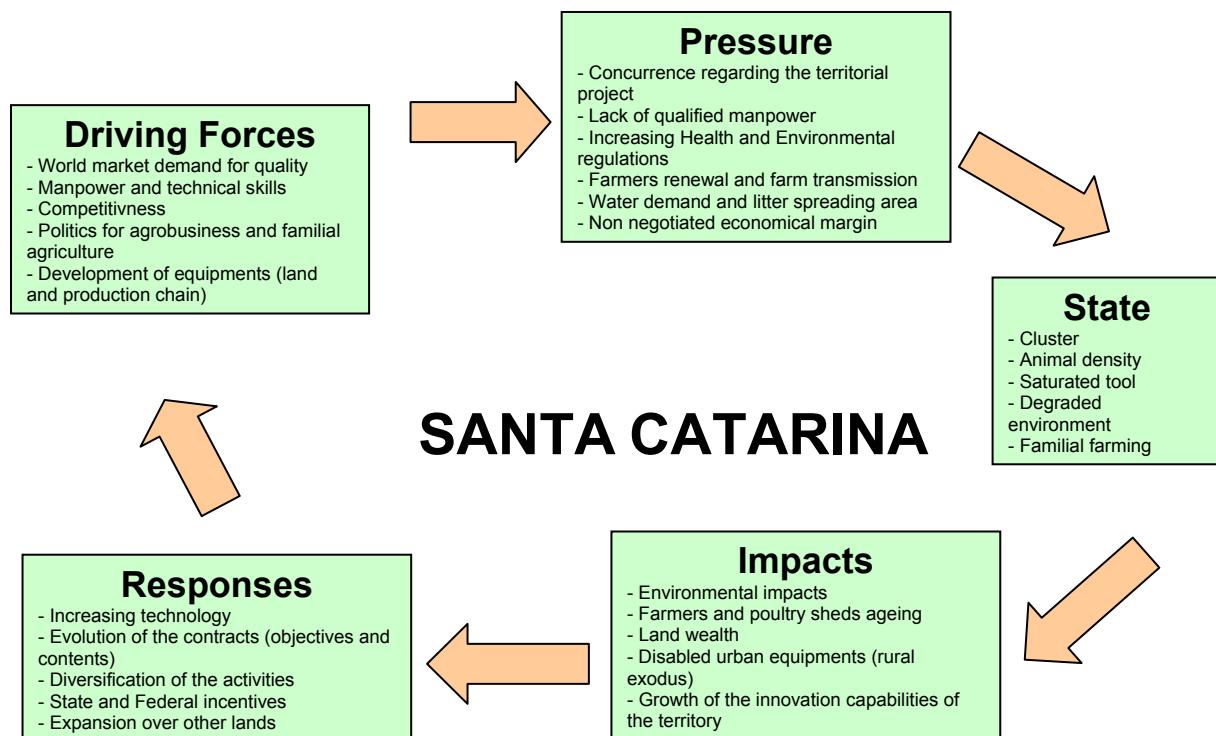
*Figure 2a Common representation: a shared tool for a transaction on the system description and evaluation, example of a French county, Bretagne*



The main idea was to consider the whole system through five sets of parameters. Firstly, driving forces were identified. Discussions were to determine if these drivers are in or out of the system bounds. This was a between discipline issue since these limits were varying depending on the involved axes. As an example, Figure 2a is illustrating for Bretagne this question: international market is out of the system while animal density is in. For Western state of Santa Catarina (Figure 2b) world market is out while manpower is in. The second set of parameters is the pressures on the system. A difficult task was to include pressures representing the different parts of the system, i.e. both the production chain and the county.

Economical competitiveness deals with the production chain of a given county while the regulations are for the different regions even though the same pressure could be a negative or a positive one depending on the territory. The most striking example is the welfare regulations applying a consistent stress on most EU poultry producers' sustainability while it is less effective in Brazil. A difficulty that was not observed in our program was the possibility from some experts to reject the interpretation of some parameters proposed by other disciplines. Discussions have prevented this situation even though external readings could lead to new interpretation and enlarge the definitions of the proposed pressures. As an example, "concurrence regarding the territorial project" in Santa Catarina could be understood by animal production scientists as land uses by the different species whereas it could be urban – rural concurrence for sociologists. These contrasted expanded definitions might impact the choice of the sustainability indicators and their ranking.

*Figure 2b Common representation: a shared tool for a transaction on the system description and evaluation, example of a Brazilian county: West of the state of Santa Catarina*



The third set of characteristics is the state variables of the system: how to describe it today? The proposals are the results of the dynamics induced by the driving forces and the pressures. Since the studied system is very large, the characteristics proposed could be considered as "representative samples" of the bunch of possible parameters. For the state variables in Bretagne, most of them are presenting the poultry chain including human aspects but the territory is nearly ignored, the only one-way relation being the environmental impact. No proposal on the territory influence on the system is included. This result comes from a consensus between the researchers: to keep a readable representation of the system's characteristics, each set could not have more than five items. Therefore transactions were performed and Figure 2a is a cut version of the first ones. Since sociologists were involved in the Santa Catarina work, human characteristics were included through cluster and familial farming. A question should consequently be raised regarding the possible comparison of the two figures. The two last sets of parameters are flooding from the three previous ones: the impacts and the responses.

The danger of this approach is that depending on the leader or on the exchange during the building of these schemes, an unbalancing between the disciplines might be observed. Moreover summarizing could simplify too much the complexity of the “poultry chain \* county” sustainability. Three topics could be underestimated through this representation: the spatial issue (How to integrate the double sided interaction between the land use, the population and the poultry chain?), the time scale (How to mix short term items (e.g. annual income or even batch technical result) and long term ones (e.g. farmers' renewal)?) and the dynamics of the system. Figure 2a and 2b are illustrating the state of the art at a given time but the last arrow between responses and driving forces underlines that the processes are iterating through a never ending exchanges between the researchers and for some points with the stakeholders.

Nevertheless the choice of a unique systemic tool has very interesting advantages. It pushes the different disciplines to straightforwardly exchange on the same frame. Negotiating the items and the way to measure them help to share knowledge between researchers. This approach could be compared with the “Problem based learning” used as a pedagogical tool to deal with complex questions. We find the same steps: problem description, system representation through a conceptual model, information gathering around this system, information articulation and proposal of “solutions”. However as commonly observed in system analysis, iterations are needed and since this is a very time-consuming process, it is very hard to implement due to the workload of the different partners.

#### **4. ACCEPTATION OF THE APPROACHES PROPOSED BY THE OTHER DISCIPLINES AND BY THE FIELD STAKEHOLDERS**

Poultry chain and land utilization are nearly independent research areas to each other due to their own dynamics. Poultry research was mainly focused on the within poultry shed technical improvement and on the economical competitiveness while land utilization is dealing with a much larger scope but is ignoring poultry production. Other disciplines involved in the program were “in between”. As examples, environmentalists are developing life cycle assessment tool but they had no connection with poultry production before this program. Rural sociologists were studying family farming systems but avian production was one among a large number of their activities. Therefore lack of cross-knowledge from one discipline to another leads to a compulsory time of sharing definitions and methodologies. One question coming out from this program is to evaluate if the bonds developed between disciplines could have alleviated the trajectories of some of the performed research transiently or more permanently. The sustainability of the research network developed from AviTer will be the answer of that question.

A difficulty issued from these different scientific cultures is the ability to comprehend the concepts proposed by the other disciplines. This aspect was partially overcome by numerous crossed presentations during the program: rural sociologists showed their analysis of the farmer status, economists presented costs comparisons and environmentalists developed their methodology in front of the other scientists, and environmentalists showed LCA results and discussed the obtained values. However two aspects have to be validated. The first is to ensure that the different involved scientific teams reach a minimal common level of cross-knowledge to articulate the different approaches. The second is quite correlated to the first one: each proposal on the system analysis or definition submitted by one discipline should be at least partially “peer-checked” by the other disciplines. This could be illustrated on Figure 2a: “Degraded image of the animal intensive production systems” was validated as a pressure. This item was the aggregation of several sub ideas: farmers or citizens rejection of the poultry production system and environmental negative impacts. This characteristic is therefore a multidimensional one and was validated through the standpoint of each discipline. This will be clearly seen when indicators to measure this item will be determined and will raise debate between disciplines. A second example on Figure 2a was in the state set: “Global questioning over the poultry production chain sustainability”. This sentence

obviously reached an easy agreement since all disciplines could contribute to its building. However problems could be encountered as soon as criteria will be proposed.

From the program experience, it could be said that methodology is required to build a real transdisciplinary consortium. If a “poultry chain \* county” system is studied, it is performed by a system of connected disciplines including classes of scientists. The driving of the scientific teams should therefore be carefully performed, which was not fully the case in this program due to the lack of experience of the project leader (the first author of this paper). Moreover a consistent leading would have helped to articulate the issues presented by the different disciplines specifically through an analysis to check if the different dimensions were correctly represented. An emphasis should be put on the spatial dimensions since local and global poultry chains issues could be conflicting. It should also deal with the governing bodies of both the county and the poultry chains which are in contrasted dynamics depending on the treated subject: together when public bodies finance the plants, opposed when state of federal bodies impose additional regulations. And the final dimension is the historical one describing the “poultry chain \* county” system as evolving system with an own life cycle. From this standpoint, it could be concluded that some gaps are not covered by the transdisciplinarity consortium, due to the complex concept of sustainability of dynamic systems. Nevertheless, a very fruitful output of the program could be a global representation and an inventory of the studied issues on one side and the untreated ones on the other side.

Another way of confronting the proposals of the different disciplines is to include systematically the actors from the “poultry chain \* county” system in the loop of the sustainability studies. Scientists are supposed to be out of the system, even though this hypothesis could be rejected since several partners are deeply connected with the poultry chains sectors. Moreover the idea of neutral scientists should not be supported: the scientists are one class of actor of the model. Therefore involving strongly the field actors is a powerful method to challenge the hypothesis proposed by the scientists. All along the program, interviews were performed by each category of scientists with actors of the system. First of all, to understand the poultry chain governance, key-industrial actors were questioned. Due to the high competitiveness in the avian sector, it was difficult to get pieces of information that could be openly used. However these discussions help to build some of the items included in the conceptual representation. Secondly, farmers were interviewed as central actors in the system. They fed the hypothesis around the dynamics and renewal of the farming systems. Additionally local governing bodies (local politician or civil servants) were also involved as witnesses of the connections between the poultry chain and the county. This inclusion of field actors should be considered as compulsory as soon as iterative building of a model representing complex system, here the poultry chain, the county and the interactions between these two sub-systems.

## **5. A DYNAMIC COMPLEX “POULTRY PRODUCTION \* COUNTY” AGREGATE: A MOVING SYSTEM NEEDING A MOVING COMBINATION OF DISCIPLINES**

The studied system is complex: a combination dynamically evolving with varying borders, outputs and inputs. Moreover the research consortium is a gathering of disciplines which were not used to exchange at least for some of them. Therefore, several conclusions could be raised to enhance the research on the sustainability of the poultry chain \* county through a transdisciplinary approach. First of all, building a common and consistent representation is a very time consuming process. Researchers should be convinced to include their own expertises, they should therefore exchange on a long time frame. We are looking for methods of team management to shorten this step. The hazard of the exchanges is that the only reached step at the end of the program might be the description one.

Secondly, some disciplines were not included in the consortium dynamics. Either their inclusion could jeopardize the exchanges with the field actors. This was the case of our colleagues from the veterinary state services: cooperation was impossible due to the high

sensitivity of the health issues. The other missing disciplines were those that we did not identified. As an example, scientists on the contractual issues or on the local environmental impacts could have been a positive addition to the consortium. The question is how to open the network since these disciplines are needed to study the overall system sustainability? And is it relevant to "cover" all the sustainability issues?

Transdisciplinarity is mostly though through the scientific actors. However stakeholders have a key role within the "poultry chain \* county" system. Their standpoints within the different areas of the systems help to cross check the hypothesis proposed by the researcher and to impulse new questions. The stakeholders are required as actors in this system analysis approach. Nevertheless, in the poultry chain sector, two guidelines should be strictly followed. Firstly, we have to be careful of not "overgrazing" the stakeholders. They have heavy workload and they would not accept easily to be interviewed too many times for the same project. Secondly, we should never forget to send them a feedback. This will increase the strength and the sustainability of the overall research system.

The last issue is that the historical perspective should not be forgotten. In the treated system, this could help to understand the status of the poultry chain \* county interactions at a given time and to make hypothesis on coming scenario. However, this historical dimension was not easily included in our program due to a focus on the present situation. To put all in a nutshell, this program gave birth to both a first conceptual model of the system "poultry chain \* county" with the inclusion of the stakeholders and a scientific network to study sustainability issues.

## **6. CONTRIBUTING TO ANSWER HOT TOPIC 5: RENEWING RESEARCH MODELS AND PRACTICES**

Several questions were proposed regarding research renewal to innovate in close collaboration with society. Some short sentences could be given from our study on a practical side, no genericity being obtained from our approach.

- *In what ways does innovation for sustainable development require specific research positions and approaches (participatory approaches, involvement of stakeholders, interdisciplinarity)?*

To manage any field innovation in poultry production, stakeholders have to be associated. On a first side, technical issues could jeopardize any attempt and therefore they need to be challenged by field actors. Moreover, large bunch of disciplines are needed due to the complex interactions between actors. The most important could be the contractualization issued from negotiations within the poultry chains. Depending on its content, it could be very conservative. Participatory approaches should therefore be proposed. However, in poultry chain \* county aggregate, due to the high competitiveness, it might be advised to exchange by class of actors or even by individuals.

- *How should research practices and organisations change to enable them to produce innovations for sustainable development and to evaluate them?*

Sustainability might be studied at local level, even though some analysis should be more global as the LCA ones. Therefore, instead of being a top-down process, it would be, to the authors' standpoint, more relevant to ensure an iterative process including several rounds of top-down and bottom-up approaches. Specifically, evaluation should be performed on both sides. The main drawback of this organization will be the limited application of the practical results, however increasing experiences of the network should speed the following rounds.

- *What new forms of acknowledgement (legal, institutional) will encourage research, especially in Southern countries?*

System approach has proposed above is really at the intersection should be considered *per se* as applied research and specific criteria of evaluation should be proposed. On our standpoint, several on field inquiries might be performed at different times to comprehend the practical progress, if any. Regarding more conventional outputs, as peer-reviewed publications, they have to be encouraged through dedicated journals.

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- *What type of partnerships should be developed to encourage new forms of research cooperation between countries?*

AviTer, thanks to the different partners, lead to the birth of a new network that we hope will be sustainable. Regarding new partnerships, our advice would be to create “squared-exchanges”: researchers from both countries cross-exchanging between them and exchanging with stakeholders since we are convinced that crossed visions are fruitful tools to reach consistent innovations.

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