Towards locally adapted livestock production in the Galápagos islands

Characterizing & defining potential redesign strategies for the local poultry and pig production systems of Santa Cruz – Galápagos Islands, Ecuador

Daniel Puente-Rodríguez & A.P. (Bram) Bos

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Samenvatting NL: Dit project is uitgevoerd vanwege de urgentie om het herorganiseren van de veehouderijssystemen van het eiland Santa Cruz (Galápagoseilanden, Ecuador) volgens de kenmerken van de wereldwijd gewaardeerde (sociaal en) ecologische systemen. Momenteel bestaan er twijfels over de duurzaamheid van de richtingen waarin deze sectoren zich ontwikkelen. De doelstelling van dit onderzoek is om de gefundeerde basis voor een herontwerp proces te creëren om de lokale pluimvee en varkenshouderij productiesystemen met een hoge mate van duurzaamheid (vanuit de ecologische en maatschappelijke standpunten) te kunnen ontwikkelen.

Summary UK: This project has been articulated around the need to reorganize the local livestock production systems of the island of Santa Cruz (Galápagos islands, Ecuador) according to the characteristics of the globally respected (socio)ecological systems. This because there are some doubts about the sustainability of the current directions in which these production sectors are evolving. This research takes up the challenge to articulate the basis for a redesign process for the interactive visioning of local livestock (i.e., here pig and poultry) production systems that achieve a high degree of socio-ecological sustainability.

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The ISO 9001 certification by DNV underscores our quality level. All our research commissions are in line with the Terms and Conditions of the Animal Sciences Group. These are filed with the District Court of Zwolle.

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1. Problem field and research objectives

The relative isolation of the Galápagos islands helped the naturalist Charles R. Darwin to define the evolution theory. Nevertheless, current global trends, such as the enduring financial crisis of 2008, climate change, and the extension of tourism and leisure related activities (Benitez-Capistros, Hugé, & Koedam, 2014) are currently also affecting the Galápagos. Although global trends are not intrinsically negative, some of these trends might have a negative impact on the sustainability of the socio-ecological local systems of the archipelago. Some of these trends have, in principle, unexpected results. For instance, it has been reported that tourism industry is responsible (among other sources) for the introduction of invasive species into the islands ecosystems (Viteri Mejía & Brandt, 2015).

There have been some initiatives to eradicate invasive animal species, because of the natural value of, especially, local biodiversity and the areas associated with the Galápagos' natural park. For instance, there have been initiatives to eradicate from the archipelago, rock pigeon (*Columba livia*) (Phillips, Cooke, Carrion, & Snell, 2012) and feral pig (*Sus scrofa*) (Cruz, Josh Donlan, Campbell, & Carrion, 2005). Moreover, Meyer (2014) argued that, in the Pacific Islands, invasive animals have received more attention than invasive plants, although the latter might have a larger impact on local ecosystems. In 2010, the FAO's representative for Ecuador reported on the important issue of invasive species (Cherrett, 2010). He, moreover, argued that this trend is strengthened by changes in and the abandonment of agrarian practices. Other factors that stimulate these developments are, for instance, the extension of urban areas and of the number of people who earn their wages within the tourism industry. Invasive plants have then gained terrain in the Galápagos (see, e.g., Benitez-Capistros et al., 2014).

The issue concerning invasive species is, therefore, closely related to the major changes affecting local agrarian systems. Restrepo et al. (2012) reported that the intensification of animal husbandry in the 30s could have caused the extinction of some plants that did not return after the population of grazers was reduced in the 80s.

This research is situated in a context in which the trend (following the global tendency) towards the industrialization and intensification of agriculture is also gaining traction in the Galápagos archipelago (Chiriboga, Maignan, & Fonseca, 2006; Cherrett, 2010). Among the possible negative effects of this trend we find, for instance, the possible introduction in the archipelago of invasive species by means of feed ingredients, or pathogens which can affect native birds by the import of one-day old chickens for the poultry production systems (Gottdenker et al., 2005; Deem, Cruz, Higashiguchi, & Parker, 2010). Moreover, a poor and, probably, dangerous management of animal husbandry waste (e.g., of pig production systems) has been observed (Chiriboga et al., 2006; Cherrett, 2010). Furthermore there seem to be doubts about the sustainability and profitability of livestock production units within this trend towards an industrialized system. A system that, in the islands, is based on the regular import of animals (poultry), and a relatively high dependence on pharmaceuticals (e.g. antibiotics). Other problems affecting both industrial and traditional livestock systems are, for example, poor management of animal waste, disabling the proper closure of nutrient cycles; and a weaker resilience of animal farms to disturbances and fluctuations in prices together with a weak organizational capacity of animal husbandry farmers (ibid.).

In order to avoid the negative effects of both traditional and industrial livestock production, alternatives are needed. These alternatives should fit and integrate the needs of different stakeholders, and be compatible with local ecosystems. With this project, by applying the first steps according to the Reflexive Interactive Design (RIO¹) approach, which has proven to be successful in (re)designing livestock production systems in the Netherlands (Groot Koerkamp & Bos, 2008; Bos & Groot Koerkamp, 2009; Elzen & Bos, 2016), we contribute to the development of such alternatives.

¹ From the Dutch, '*Reflexief Interactief Ontwerpen*.'

1.1 Research objective

The objective of this research is to *articulate the basis for a redesign process for the interactive visioning of local livestock (i.e., pig and poultry) production systems within the Galápagos province that achieve a high degree of socio-ecological sustainability.*

The research is commissioned by the ministry of Agriculture and Livestock (MAG)², of Ecuador, it is funded by Galapagos Conservancy and it is conducted by Wageningen UR Livestock Research (WLR) (the Netherlands). Initially, the process focuses on the Santa Cruz island. Relevant and related aspects for redesigning these systems are, for instance, food sovereignty, control of invasive species, low input systems, agroecology, responsible systems (concerning diseases and waste), and autonomy.

The formulation of policies and best practices is, on its own, not enough for producing responsible and sustainable agrarian systems. For instance, a set of biosecurity measures and good practices have been formulated for the pig and poultry production systems on the Galápagos islands. Apparently, a narrow percentage of farmers, however, seems to follow them (see, e.g., CGREG, 2014). It is by *working at the level of daily agrarian practices of and with the different stakeholders and their knowledge systems* that are involved in animal husbandry that we can trigger change. This demands a deeper understanding of the local knowledge systems, values, and long-term goals; as well as the many and complex socio-ecological interactions.

It is at the level of multi-stakeholder interaction, social learning and (re)designing of animal husbandry systems and practices that our RIO approach has been effectively applied. In this project we have performed the initial phases of this approach. In this phase structural causes for unsustainability of the current systems are investigated, and needs, expectations, and long-term goals of stakeholders at the local level identified. Next, opportunities for structural change are identified that have to be considered in a subsequent redesign process (not included in this project) in order to synthesize the different and sometimes (seemingly) contradictory goals and needs, and to overcome the unsustainable characteristics of the current systems. The results are validated with the stakeholders involved. The project results, therefore, in basic data, stakeholder engagement and feasible starting points for a subsequent design process that has to be commissioned separately.

Data has been collected through a literature review, interviews and focus groups, participatory observation and collective system analysis. Moreover, within the approx. one year period of the project we have conducted two visits to the island. The first visit (June-July 2016) focussed on (1) the basic system characteristics; (2) the problem definitions (causes and possible solutions) by local stakeholders. After analysis, we validated our findings during a second visit (July 2017) and presented preliminary results (e.g., redesign strategies) to the stakeholders involved. In this way, we think to have engaged some of them for a subsequent and also interactive design process towards locally specific livestock production systems in the Galapagos islands. Our analysis and approach has delivered a grounded perspective on the possibilities and strategies for this.

² Former ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP).

2. Methodological approach

In this chapter we elaborate key methodological issues of this research project. For example, we briefly elaborate the RIO methodologies for afterwards introduce the agroecology concept that inspires the local policies and this research. Then, we explain how we have conducted the first phase of this participatory methodology (i.e., RIO).

In a nutshell, firstly, on the basis of a literature study we have elaborated a working document to understand the local production systems and prepare our first visit to Santa Cruz. Then, in that visit (June-July 2016; Section 2.3.1), two researchers conducted the fieldwork and, as aforementioned, focussed on (1) basic system characteristics; (2) problem definitions by local stakeholders: causes and (3) possible solutions, i.e., the possible strategies of the redesign process were collectively explored. After analysis, and a round of interviews with WUR's experts we elaborated a draft rapport in which we (a) characterized the pig and poultry production systems of Santa Cruz, elaborated (b) the most important problems as defined by the different local stakeholders, (c) the shared and divergent long-term goals and (d) delineated the possible redesign strategies. These results and strategies were presented and validated (and nuanced) during our second visit (July 2017; Section 2.3.2). This report is the final product of this specific research project and aims to work as proposal for guiding the follow up phases of our RIO to redesign the local livestock production systems.

2.1. The RIO approach

There are many efforts to formulate policies and best practices to improve livestock production in Santa Cruz, however this is not enough for producing responsible and sustainable agrarian systems. To trigger change we ought to work at the level of practice by stimulating and articulating a reflection on the contradictions found within a (livestock production) system between the current practices and the socioecological capacities, potentials and limits. As well as by finding the common grounds in the definition of long-term objectives among the different stakeholders. In this way, a better understanding of the socio-ecological interactions is required to meet this end.

It is at the level of multi-stakeholder interaction, social learning and redesign of animal husbandry systems that our reflective interactive design (RIO) approach has been effectively applied (Bos & Groot Koerkamp, 2009; Elzen & Bos, 2016). Within the RIO approach scientific knowledge is integrated with other types of informal knowledge (e.g., this one of livestock producers or policy makers) and it is engaged in practice to, in this way, articulate multi-stakeholder networks, to form knowledge-practice interfaces (Puente-Rodríguez, Giebels, & De Jonge, 2015). That is, inclusive, interactive and reflective knowledge arrangements and/or decision making processes in which different types of knowledge (both formal and informal) and types of actors (including and beyond scientists and policy makers) assume an active role and responsibility regarding environmental management (ibid.).

The RIO approach enables us to make a synthesis of the different and sometimes (seemingly) contradictory needs and expectations of stakeholders at the local level. On the basis of this synthesis we propose, together with local stakeholders, feasible and location-specific redesign strategies for the livestock production systems. Key elements of this approach are:

- An interdisciplinary character. It builds, for instance, on social science, economy, biology, and ecology.
- Making good use of the state of the art in science of the different aspects at stake.
- Collective reflective process. Through a systematic and structured approach (see below) this participatory methodology facilitates the collective definition of problems and objectives, as well as of visions to redefine animal husbandry systems – both on the basis of quantitative and qualitative data.

- The process is facilitated in a network-like structure. Trust and community building are key to facilitate the sharing and integration of knowledge as well as the implementation of the project.
- It is a reflective process working at the level of practice. Therefore, it triggers action that is likely to contribute to the transformation of existing (social and technological) structures.
- A social learning process that results in tangible and, therefore, feasible system redesigns.
- It is inspired by and builds on the methodology of engineering design (Cross, 2008).
- It deploys visualization-strategies to facilitate social learning.
- It is aimed at going beyond the life span of single projects. Therefore, in the process design we anticipate an anchoring phase.
- The understanding that the collective reflection and action on relevant problems does not contradict, and might even require empathy and fun.

The RIO methodology has three fundamental phases that structure the participatory process: The first concerns a *system analysis* and an analysis of the key actors and their practices. In this phase a study of the structural characteristics of local production systems is conducted. The problems and needs of these systems are also studied from the point of view of the different local stakeholders. We do this to open spaces for discussion and reflection on these problems and to gain a further understanding on the different and sometimes contradictory solutions proposed by the various social actors. Moreover, usually, this reflection-spaces help stakeholders to understand the practices and socio-ecological context in which they are involved. Sometimes, furthermore, participants are triggered to start and action. For instance, an attempt to organize the broiler sector emerged after a focus groups (Juni 2016) in which 12 producers participated in an open and constructive dialogue. In this group we identified the disorganization of the sector as the underlying reason for some of the problems that producers face and 'organization' as a requirement for the articulation of a redesign process – see Sections 5, 6, and 7.

In the second phase, i.e., the *structured design*, the systems are redesigned by reorganizing their different elements and functions or by introducing new ones (e.g. technologies, practices, knowledge or processes). Here we build on the methodologies elaborated and practiced in the industrial design (Siers, 2004; Cross, 2008), but we adapt them to the livestock production systems and we do conduct them in a more interactive way. In this phase it is essential to integrate formalized types of knowledge such as scientific knowledge with this based on experience which is usually defined as not formalized, for example, this one of farmers. This should lead to attractive designs for the different participants while at the same time involving clearly defined objectives for sustainability. The RIO (as a participatory) methodology is iterative. This means that sometimes it is necessary to restart or repeat certain exercises in order to progress in the process (that is why sometimes we speak about 4 phases, see figure 1).

The third (fourth) phase, the anchoring phase, attempts to secure innovation and change within the practice of production systems. Moreover, it is aimed at institutionalizing and integrating the process of change in the broad social field (political institutions, consumer and market systems) as well as in the local ecosystems.

Figure 1 shows a visualization of the 3 (or 4) phases through which we usually structured our participatory processes for redesigning animal husbandry systems.

Figure 1 The iterative RIO process, a visualization (Elzen & Bos, 2016).

Participatory methodologies are not within the spectrum of the so-called exact mathematical sciences and require a high degree of flexibility and adaptation to a changing human and relational environment (Puente-Rodríguez, 2014). Moreover and to trigger change, iteration and validation are also required to link, for instance, the appropriate scientific knowledge to a specific problem. In this way, although RIO's phases and steps are clearly defined, in practice, we move back and forward as soon as we feel that this is required. This rapport (partly) concerns the first phase of the RIO approach, accordingly, we have conducted an explorative research concerning a system analysis. This is required for understanding the local production systems within their social and ecological context. Moreover, this allows us to understand the contradictions within the systems. Furthermore, on the basis of the common grounds found in the long-term goals that are elaborated by the different stakeholders we sketch the possible redesign strategies that can be implemented for designing, healthy, resilient and sustainable livestock production systems – i.e. poultry and pig husbandry systems of Santa Cruz. It is our intention to elaborate, in the near future, a full project proposal based on the RIO approach. The closing chapter of this rapport shows the contours of this proposal and redesign process.

2.2. RIO & Agroecology

Currently, the concept of agroecology has been widely accepted and diffusely applied to different types of agrarian production systems, including ecologic, intensive, extensive, etc. The concept aims to understand and transform agrarian practices from the perspective of the ecologic systems embedding and processes.

We find it fascinating to see how paradigms that have emerged and were defined as alternative and even radical become, at one point in history, mainstream. This has been the case, for instance, with the democracy concept in political theory and practice, or with the concept of agroecology in the field of agriculture. Agroecology is a concept that has been defined in opposition to the antagonist global trend towards the industrialization and intensification of agriculture (Alteri, 2002; Alteri & Nicholls, 2012). In its original ('orthodox') form it claims small-scale and empowerment practices as well as low-input and appropriate technologies (ibid.). It is interesting, the argument goes, to see how some

of these principles are currently being embraced by internationally respected knowledge institutes or promoted in a top-down manner by the government of Ecuador, for example, through its 'plan of bioagriculture.'³ No matter how, there are many similarities between the principles hold by the agroecology and the practices conducted within the RIO approach.

RIO is in principle a methodology that has been developed within an applied research institute and as such it lacks a theoretical and conceptual background. Nevertheless, it has been linked to certain theories, such as the (diffusion of) innovation (e.g., Rogers, 1962; Schot & Geels, 2008) and transition theories (Rotmans & Loorbach, 2007). It is, moreover, also inspired by the concept of reflexive modernity (Beck, Giddens, & Scott, 1994). Against this background, the application of these methodologies has been systematically aimed at the systemic redesign of livestock production systems to integrate them in a sustainable way within their social and ecological contexts which shape and which are shaped by these same production systems.

In this context, and inspired by the agroecology approach, the redesign strategies and process that are/is here elaborated are/is aimed at allowing the development of the pig and poultry systems in such a way that the ecological values and services of Santa Cruz are strengthened and become robust from the socio-economic perspectives. Inspired by the agroecology principles, in this project, the following concepts and ideas stimulate our work: livestock production systems which are resilient and do not require high consumption of inputs such as antibiotics, these are, moreover, responsible systems concerning diseases and waste (e.g. appropriate management of manure); food sovereignty, meaning that local actors ought to keep or gain power within the food-chain. An appropriate integration of animal production systems on local social and ecological systems.

2.3. Fieldwork

2.3.1. Collectively defining problems/solutions and long-term goals – The first visit

The specific objectives of the first visit to the field were:

- To gain knowledge on the agrarian, socio-economic and ecological characteristics of current systems.
- To identify (representatives for) relevant stakeholders and the role that they could play in a subsequent design process.
- Moreover, exploring how these stakeholders define problems and their perceived causes.
- To outline both shared and divergent preferred long-term goals and solutions for the food and livestock production systems (i.e., pig and poultry) on the Santa Cruz island.

On the basis of the preceding points and after the analysis of the collected information, we are able to elaborate a grounded perspective on the possibilities and strategies for a (re)design of the pig and poultry production systems on Santa Cruz.

It goes without saying that the visit was also the vehicle to build a durable partnership between Wageningen Livestock Research's team and the representatives of MAG. This first encounter enabled us to make appointments regarding organizational and practical aspects of the research. During this first visit we delivered a presentation to the staff of MAG introducing our research institution, approach and project. In this first visit and field work we used mainly two research methods, semi-structured interviews and focus groups. Moreover, we visited many relevant places (i.e., participant observation), such as production units, the slaughter house, etc.

³ Form the Spanish 'Plan de Bioagricultura para Galápagos: Una oportunidad para el buen vivir insular.' This is an policy document in which the government of the Ecuadorian Republic together with MAG and the ministry of Environment delineates the lines along which the agriculture in the Galápagos Island should be developed, i.e., along the principles of the agroecology.

Semi-structured interviews

A set of (25) semi-structured interviews was conducted with the most important stakeholders who are directly or indirectly involved in the local pig and poultry husbandry systems. E.g., representatives of public institutions, NGOs and projects, farmer's unions, and of the slaughterhouse; also meat and animal feed dealers, and pig and poultry farmers, or entrepreneurs of the tourism sector or the representatives of the National Park Galápagos Directorate were interviewed.

A semi-structured interview is a one-to-one meeting between a researcher and an expert or relevant stakeholder within a system. Through this research method we gather contextual knowledge and the main arguments used by actors (what we call discourse). Moreover, we also are enabled to see the values or reasons that underlie those arguments. The semi-structured character emerges from a set of questions of themes (the interview protocol or script) that, to a certain extent, structure the interview. In this particular case we focused on the aforementioned objectives: identifying problem-perception, (long term and short term) goals, and preferred solutions of actors.

Moreover, this method offers space for new and unexpected issues that might not have emerged from the desk study or in previous interviews.

The steps that we have followed for this method are:

- Protocol design: This is a set of questions reflecting the objectives of the explorative research. There can be some variations according to the different types of informant (e.g. one for policy makers, one for NGO practitioners, etc.). This task was conducted by the research team of Wageningen Livestock Research.
- Selection of informants. On the basis of the desk study we defined the different types and number of actors that will be approached for an interview. Representatives of MAG and Wageningen Livestock Research decided who was contacted.
- Interviews invitations and arrangements. MAG's staff, from Santa Cruz, in close collaboration with the researchers, arranged the meetings in a location that was convenient for the informant and in a way that the researchers could conduct a highest number of interviews per day.
- Conducting the interviews (approximately one to up to two hours per interview).
- Writing interviews summaries.
- Analysis of interviews.

Focus Groups

A set of homogeneous focus groups (10) were also conducted. A focus group is a group interview in which the researcher meets a group of informants (4 to up to 12) for gaining knowledge concerning the deep values and concepts used by the group to define certain specific aspects of the system(s). Focus groups enable us to understand the similitudes and differences in the arguments, values and knowledge employed by the participants to define problems and objectives.

In this explorative research we used homogeneous focus groups. This means that the participants are part of a specific group within the system. In Santa Cruz, for instance, we organized a focus group with small-scale farmers who has creole chickens; and another with intensive broiler producers. A similar differentiation and organization of focus groups was organized within the pig husbandry system. Also focus groups were conducted with veterinarians of MAG and another with the technology innovation team, or another with veterinarians of the Biosecurity Agency of Galápagos, or with representatives of the National Park Galápagos Directorate or the Charles Darwin Foundation.

Just as for the semi-structured interviews, a 'script(s)' was designed to structure and guide the group. The groups were conducted in a friendly space for the participants.

Picture 1 Focus group at the agrarian centre in Bellavista, Santa Cruz.

The steps for this method were:

- Script design: a set of interactive exercises and questions reflecting the objectives of the explorative research were developed.
- Selection of groups and informants.
- Interviews invitations and arrangements.
- Conducting the focus groups.
- Analysis of focus groups.

The information and knowledge emerging from the interviews, focus group and the literature study has been integrated to understand the different ways in which groups and individuals define the most relevant problems affecting local production systems. In this way we triangulate and validate the information (Denzin, 1984; Stake, 1995). Moreover, the three methods are complementary. Literature research enables us to understand the context and the systems. Focus groups are for instance suited for collecting information from all type of actors. However, interviews are usually more efficient to collect information from experts and actors with a formal authority (De Cock Buning, Regeer, & Bunders-Aelen, 2008).

Besides, in our professional experience we have seen that the participants of this type of (individual and group) interviews usually *enjoy and learn from the space that has been created for reflecting on things that affect and matter to them.*

Furthermore, in our participative and reflective approach we usually use these one-to-one and group meetings, not only for gathering data and knowledge, but also, as a means to start a personal relationship with the different individuals and groups. From the scientific literature and our own experience we know that face to face encounters are essential for triggering social learning. This might, moreover, lay the basis for building initial trust and partnerships for starting the RIO process.

Once in Wageningen we have analysed the collected data (see here below next chapters) and discussed the research with some experts. Moreover, we produced a short document for updating and communicating the preliminary results and a video that was requested by MAG to shortly introduce our project in their annual governmental review process.

2.3.2. Communicating and validating – The second visit.

On the basis of the collected data and analytic work we wrote a draft version of this report in which we elaborated the most important characteristics of the local livestock production systems, including the most important trends and the most important problems as defined by the stakeholders. We have worked with 3 main categories: (a) Institutions (governmental organizations); (b) non-governmental organizations, sectorial organizations, businesses and individuals; and (c) livestock producers. We have done this for analytical reasons although these three categories cannot be defined as homogeneous. Moreover, we have defined the shared and divergences among stakeholders in defining the long term goals, and we delineated the redesign strategies that we believe are required to achieve higher levels of sustainability within livestock production on the island. Then, we shared the document with some expert-colleagues here at the Wageningen University and Research and send it to MAG.

The objectives of this second visit were:

- To present our preliminary results to the stakeholders involved for validating and expanding our findings.
- Discuss and nuance the most promising redesign strategies.
- In this way, we aim to engage some of these stakeholders for a subsequent and also interactive design process towards local-specific livestock production systems in the Galapagos Islands.
- It goes without saying that the visit was the vehicle to strengthen the partnership between researchers of Wageningen Livestock Research and representatives of MAG and of Galápagos Conservancy. Moreover, we aimed to explore the possibilities for obtaining additional funding for organizing the redesign process.

The second visit occurred in July 2017. We made a (fancy) invitation in which we summarized the proposals and invited the different stakeholders to a workshop. In one week we shared and validated our results in workshops of approximately 3 hours. This workshops had a homogenous character. For instance, for one workshop we invited poultry producers, i.e., creole chicken, broilers and laying hen producers. Unlike in our first visit in which we, for instance, conducted a focus group with creole producers and another one with intensive broiler producers, and some interviews with egg producers. In total we organized 4 workshops in which we invited (a) poultry producers, (b) pig producers (c) staff of key institutions (e.g. Biosecurity Agency Galápagos, MAG and slaughter house⁴), and (d) with owners of restaurants and hotels. In each of this workshops we focussed on key issues that were relevant for each group. Moreover, we met also some directors of the institutions (who do have decision making power) in personal meetings because we found it more convenient and efficient to present and validate results. Another interview was conducted by MAG's employees with staff of the tourist boat National Geographic Endeavour II⁵ to explore possible forms of collaboration.

Picture 2 Communication and validation workshop in Puerto Ayora.

The response to our proposals was very positive. From the small-scale producer of creole chickens to the representatives of the local institutions, stakeholders showed interest for our analysis of the production systems. Moreover, they accepted and wanted to know more about the redesign strategies. On the basis of this second visit we believe that a turn towards sustainable livestock production systems is possible.

Finally, the report that you have in your hands is the closing product of this research project which, actually, is meant to be the grounded basis for starting the redesign process.

⁴ We have invited also some staff of the National Park Galápagos, but they couldn't attend because they were celebrating the 58th anniversary of the park. Therefore, we decided to conduct an interview with the coordinator of research issues.

⁵ http://www.nationalgeographicexpeditions.com/expeditions/galapagos-cruise/deckplans#National_Geographic_Endeavour_II.

3. Characterizing the livestock production systems of Santa Cruz

3.1. General system characteristics: The context influencing and being influenced by livestock production

The Galapagos are volcanic islands that were formed around 3 to up to 5 million years ago. Today it is still a very active volcanic area. The archipelago is formed by 13 large islands, 6 small islands and some hundred islets. They have a total area of 7.880 Km² (CEPROEC, IAEN, & SNPyD, 2014). They are situated 973Km from the west coast of South America, Ecuador.

Figure 2 (Left) Inhabited urban and rural (orange) and National Park Galapagos (grey) areas (CEPROEC & SNPyD, 2014). (Right) Climatic regions.

The islands cover an area of approx. 799.771 hectares of which 26.245 consist of the so-called rural and urban areas, thus for direct human usage (CGREG, 2014) = 25.059 hectares rural area + 1.186 urban area. 76% (19.010 ha) of the rural area is used for agrarian practices in the form of agrarian production units (APU) (ibid.). Moreover, the other 24% of the rural area (i.e. 6.049 ha) was not used for agrarian activities at the time in which that study was conducted (CGREG, 2014). Agrarian production units (from the Spanish 'unidad de producción agropecuaria') (ibid.) are defined as (1) farms of 500 m² or larger that are owned by one person, and in which agrarian productive activities occur, whether the agrarian products are commercialized or not; or (2) units with less than 500 m² in which products have been commercialized. Santa Cruz had for instance 268 APUs in 2000 and 357 in 2014 (CGREG, 2014). The total rural area of Santa Cruz is approx. 11.441 ha. (Cherrett, 2010). It is estimated that in Santa Cruz (in 2014) a total of 9.592 ha were covered by APUs (ibid.).

A ministerial agreement (No. 0297) of (July) 1979 decided that 96,7 % of the land surface is protected within the National Park Galapagos (NPG), being the other 3,3% of the area used for human purposes (CEPROEC & SNPyD, 2014) – i.e. rural and urban utilization. Only the islands Isabela, Santa Cruz, San Cristobal, and Floreana have stable human settlements.

Table 1 Percentage of inhabited and NPG area (CEPROEC & SNPyD, 2014).

	Floreana	Isabela	San Cristóbal	Santa Cruz	Other islands	Total
Inhabited	1,89%	1,38%	16,07%	14,12%	0,00%	3,76%
PNG	98,11%	98,62%	83,93%	85,88%	100,00%	96,24%

Moreover, the APUs covered, in 2000, a total of 23.400 ha while in 2014 there were 19.000 ha used for agrarian purposes. Meaning that the agrarian usage (in the form of APUs) of the Galapagos rural area has decreased from 94% in 2000 to a 76 % in 2014 (ibid.). Note that not all the surface of the

agrarian production units is used for agrarian purposes, some are covered by forest and/or invasive species (ibid).

Figure 3 Total (columns; ha) and percentage of the rural area covered by APUs in 2000 (light blue) and 2014 (dark blue) (CGREG, 2014).

Santa Cruz covers an area of 986 km² and has a population of approximately 12,000 inhabitants. It is the second largest island of the archipelago. Volcanic activity has long since ceased on Santa Cruz.

Galapagos Conservancy reports the following concerning Santa Cruz.⁶ 'Santa Cruz has a long history of human settlement and agriculture, which has left the landscape permanently altered by invasive species.' People from the United States and Europe' arrived between the two world wars. Two settlements in the humid highlands were established (i.e., Bellavista and Santa Rosa). Here farmers raised cattle and planted crops. Actually, Santa Cruz is the administrative centre and tourist hub for all of the Galapagos island being the fast growing Puerto Ayora the largest city in the archipelago. 'Santa Cruz Island, and more specifically the town of Puerto Ayora, has withstood the brunt of this growth. In addition to the problem of introduced species and the ever-greater probability of introductions, this growth has put increasing pressures on local resources and municipalities in terms of health, education, waste management, and many other aspects of daily life.'⁷ However, although the tsunami of tourists started in the 70s, it has not been until 2006 that a recycling plant has been established.

Fig. 1 Location of Galapagos showing the four inhabited islands (labelled) and climatic regions. The enlargement of the highlands of Santa Cruz Island shows the current agricultural zone (outlined in black), 100 m contours (brown) and village locations (black dots). Labels indicate localities mentioned in the text (including supplementary text)

Figure 4 (Trueman, Hobbs, & Van Niel, 2013; p. 522).

In this section we summarize some information that is relevant to understand the context/system of this study. Moreover, at the end of this section you can find a summary of general trends, among which we find, for instance, the relative low profitability of agrarian and livestock production systems; the tourism industry as economic engine of the islands; the introduction of invasive species; a dependence on imported goods; and water scarcity and pollution.

Concerning Livestock production we see, for instance, the following:

- The literature reports that by means of the import of chickens or feed ingredients for the poultry production systems, pathogens which can affect native birds might be introduced in the Galapagos. (Gottdenker et al. 2005; Soos et al., 2008; Deem et al. 2010).
- (Although there are no evidences of diffusion) Research suggests 'that backyard chickens may pose a greater threat to Galápagos avifauna because they are more likely to be infectious, have a high

⁶ www.galapagos.org/about_galapagos/about-galapagos/the-islands/santa-cruz/ (accessed May 2016).

⁷ www.galapagos.org/about_galapagos/about-galapagos/the-islands/santa-cruz/ (accessed May 2016).

seroprevalence for numerous pathogens, and interact directly with wild birds or wild bird habitat, with no biosecurity measures employed' (Soos et al., 2008).

- Moreover, a poor and, probably, dangerous management of animal waste (e.g., of manure and slaughter offal of pig and poultry production systems) has been observed (see e.g., Chiriboga et al. 2006; Cherret 2010).
- Furthermore, there seem to be doubts about the sustainability and profitability of production units within this trend towards an industrialized system. A system that, in the islands, seems to be based on the regular import of animals (e.g., poultry), feed ingredients and a relatively high dependence on pharmaceuticals (e.g. antibiotics) (ibid.) and which has to compete with imported livestock products.

Figure 5 Recent evolution of several direct and indirect drivers of change in the Galapagos socioecological system. GNP, Galápagos National Park; INGALA, Galápagos National Institute (González, Montes, Rodríguez, & Tapia, 2008).

Some problems affecting both industrial and traditional livestock systems are, for example, poor management of animal waste, disabling the proper closure of nutrient cycles; and a weaker resilience of animal farms to disturbances and fluctuations in prices together with a weak organizational capacity of animal husbandry farmers (ibid.).

Apparently, around 85% of the area destined to agrarian use is not used according to its ecological capacity (from the Spanish 'aptitud biofísica') (CEPROEC et al., 2014).

Moreover, there are well defined protocols regarding biosecurity procedures, however, the level of application is very low-marginal.

Figure 6 An estimation of the biosafety measures for pigs ('porcicultura'), poultry ('avicultura') and both ('ambas') sectors, and their implementation percentage in practice. Last row 'ninguna acción' = no action, meaning no biosecurity measures applied (CGREG, 2014).

Import dependency

To meet the local demand of food the Galápagos islands depend on the import of products (83%) – being coffee the exception. However, apparently, in 2014, was the meat mainly locally produced: 932 tons of meat are locally produced annually while 195 are imported (CEPROEC & SNPyD, 2014).⁸ I.e., according to this census, 17% of the total consumption of residents and tourists (1127 tons) come from the mainland. Fruit production covers the larger area, however, yields are low (ibid.). On the basis of the interviews we conducted in the island, we think that import of chicken meat and eggs are, nevertheless, competing with local products.

Permanent-crop production

In the cantons of Santa Cruz and San Cristobal coffee is the most important permanent (long-cycle) cultivar. 102 APUs cultivated coffee in Santa Cruz in 2014 and 64 in San Cristóbal, while just 8 do this in Isabela (CEPROEC & SNPyD, 2014).

It is estimated that, in the Galápagos islands, 48% of the cultivated area is used for the production of permanent cultivars and 52% is formed by mixed-cropping. These permanent crops are rain fed. Regarding permanent crops, in Santa Cruz there are 381 ha monoculture and 277 ha of mixed cropping – i.e., 658 ha (CGREG, 2014). Sugarcane is mainly produced in mono culture systems, as it is the case with orange, plantain and banana. Moreover, a part of this harvest and related waste could be used to feed animals.

For example, it is estimated that 394 tons of harvested permanent crops that are not used for the household consumption (45%), or other uses (among which we find, for instance, presents to family members, or to pay de loans of the labour force) are used to feed animals 37%. Especially cooking bananas, sweet bananas and sugar cane (CGREG, 2014).

In this context, the local production, regarding permanent crops, might profit from the application of livestock manure (or other type of fertilizers) as it seems that a large majority of farmers do not apply any type of fertilization in their farming systems– see figure here below:

⁸ For biosecurity reasons it is not allowed to import fresh meat. However, frozen chicken and pork as well as smoked and other processed meat can be imported provided the required quality standards are met (Couenberg, personal communication, October 2017).

Figure 7 Use of fertilizers (ha) (yes, orange/no, purple) within monoculture (left column) and mixed cropping (right column) in the Galápagos (CGREG, 2014).

The same source reports that among farmers who fertilize their crops, 89% of the fertilizers used is manure originated in the livestock production systems.

Arable farming

Arable farming concerns crops which development occurs within one (or less than a) year from seeding to harvest; and which require seeding/planting activities every year. In Santa Cruz there is a total area of 69,2 ha dedicated to arable farming (CGREG, 2014). In 2014, it was estimated that, in Santa Cruz, the production of tomatoes, maize and yuca was the largest most cultivated arable crops. Waste and other elements that are not eaten by humans could be also introduced as a feed matter in the livestock production sector. Moreover, it is estimated that (in 2014) 33% (i.e., approx. 65 tons) of the crops that are not sold are used to feed animals (CGREG, 2014). Furthermore, the same source informs that 1,80 tons of unsold products are just thrown away.

Also arable farming might profit from a more efficient management of livestock manure for fertilization purposes as the large majority of farmers seems to don't use any type of fertilizers.

Figure 8 Use of fertilizers (ha), no (purple) and yes (orange); monoculture (left column) and mixed cropping (right column) (CGREG, 2014).

3.2. Invasive species

In a report concerning invasive species, a group of institutions (the Ministry of Environment, Global Environment Facility, INGALA, and the UNDP) argued that the current profitability-decrease and subsequent abandon of agrarian activities is intrinsically related with the expansion of invasive species in the islands (Chiriboga et al., 2006). They argued, moreover, that a population which is based on agrarian activities and which lack economic resources cannot be asked to take care for the environment and to control invasive species. The issue of the so-called invasive species is, therefore, an interesting challenge for our redesign purposes, which is related with to revaluing rural land and agriculture, here, livestock production. Next we briefly elaborate on the most important (so-called) *invasive species*.

Endemic species (CEPROEC & SNPvD, 2014):

- 100 % reptiles.
- 79% mammals.
- 56% insects.
- 49% birds.
- 42% plants.

Cherrett (Cherrett, 2010) reports that among others, in the Galápagos islands we find the following introduced species:

- 110 plant species for agrarian production (45 fruits; 37 vegetables; 7 medicinal herbs, etc.).
- 8 types of grasses (e.g. some of them in Spanish: '*elefante, janeiro, pangola, estrella, yaragua, king grass, saboya y kikuyu*').
- 10 species of animals for husbandry and related (cattle, goats, sheep, horses, poultry birds, pigs, dogs, cats, and rats).
- Insects (nematodes, gastropod and mites, and pests affecting plants and animals (such as aphids, fruit flies, whiteflies, black weevil, fire ant, grass worm, slug, ticks and others').
- Fungi, such as:
 - *alternaria* sp. which affects potatoes, cabbage and beans.
 - *Caprodium* sp affecting citrus, mangos.
 - *Cercospora capsici*, which damages peppers.
 - *Cercospora vicosae*, that affects cassava.
 - *Helminthosporium* sp. which attacks corn and grasses.
 - *Isoriopsis griseola* (beans).
 - *Mycosphaerella musicola* which damage banana.
 - *Phytophthora infestans* (tomato and potato among others).
- Virus, such as:
 - Classical swine fever or hog cholera (and poultry) (from the Spanish: cólera porcino y aviar).
 - Parvovirus.
 - Canine adenovirus.
 - NCD.
- Bacteria, such as:
 - Salmonella.
 - Mycoplasma.

Table 2: 'Worst' invasive plants in Galápagos (according to the Galápagos National Park authorities). Marked in bold, invasive plants that can be found in Santa Cruz.⁹

Blackberry	(<i>Rubus</i>, 5 varieties)
Guava	(<i>Psidium guajava</i>)
Cascarilla o Quinina	(<i>Cinchona pubescens</i>)
Cedrela	(<i>Cedrela odorata</i>)
Supirosa	(<i>Lantana camara</i>)
Sauco	(<i>Cestrum auriculatum</i>)
Maracuyá	(<i>Passiflo</i>)
Pomarosa	(<i>Syzygium jambos</i>)
Hoja del aire	(<i>Bryophyllum pinnatum</i>)
Pasto elefante	(<i>Pennisetum purpureum</i>)
Laurel	(<i>Cordia alliodora</i>)
Cabuya	(<i>Furcraea hexapetala</i>)
Sauco macho	(<i>Citharexylum gentryi</i>-<i>Verbenaceae</i>)
Tulipán africano	(<i>Sphatodea campanulata</i>)
Zaragoza	(<i>Aristolochia odoratisima</i>)
Higuerilla	(<i>Ricinus communis</i>)
Poleo	(<i>Hyptis pectinata</i>)
Saboya	(<i>Panicum maximum</i>)
Floripondio	(<i>Datura y Brugmansia spp</i>)

⁹ http://www.carlospi.com/galapagospark/programas/parque_nacional_introducidas_plantas_santa_cruz.html (accessed June 2016).

A matter of definition

Local institutions and representatives of the conservationists sectors usually use the word 'invasive species'. A focus on invasion, however, is more related with a biogeographical approach rather than with a taxonomic event (Colautti & MacIsaac, 2004).

Another way of naming introduced species is exotic species. 'Exotic species, also known as alien or introduced species, are animals, plants, fungi or micro-organisms imported through human activity into an area where they do not originally occur, but where they proceed to thrive.'¹⁰ They can be introduced deliberately but also by accident.

The word 'invasive' implies negative semantic connotations. For instance in the Oxford dictionary we find that invasive means 'tending to spread in a harmful or unpleasant way: invasive cancer cells/fungi; invasive smells/noises'. One wonders whether all the introduced species could be defined as invasive. Moreover, it is difficult to understand at what point on history we have to look at to define something as foreigner (or invasive). In her dissertation entitled 'The Politics of Invasion: Defining and Defending the Natural, Native and Legal in the Galápagos Islands of Ecuador' Laura Brewington (2011) argues that, in the Galápagos islands "human activity is also viewed as an 'invasion' into nature," and that different stakeholders understand and perceive differently the concept of invasion.

No matter how, it is beyond the scope of this research to influence the way exotic/invasive species are perceived. Moreover, we do also recognize the intrinsic value of the unique endemic biodiversity of the Galápagos.

In this context, it has been estimated that within the NPG the so-called invasive species cover an area of 9.102 ha, that is a 1,14 % of the territory (CEPROEC & SNPyD, 2014).

In the area inhabited by humans the invasive species take 35,7% of the area, meaning 10.735,05 ha (CEPROEC & SNPyD, 2014).

'Invasive mammals are the major driver of biodiversity loss and ecosystem degradation on islands' (Carrion, Donlan, Campbell, Lavoie, & Cruz, 2011). There have been some initiatives to eradicate invasive animal species. For instance, there have been initiatives to eradicate from the archipelago, rock pigeon (*Columba livia*) (Phillips et al. 2012) and feral pig (*Sus scrofa*) (Cruz et al. 2005).

However, Meyer (2014) argued that, in the Pacific Islands, invasive animals have received more attention than invasive plants, although the latter might have a larger impact on local ecosystems. In 2010, the FAO's representative for Ecuador reported on the impact of invasive species (Cherrett 2010). He argued that this trend is strengthened by changes in and the abandonment of agrarian practices. Other factors that influence this trend are, for instance, the extension of urban areas and of the number of people who earn their wages within the tourism industry. Invasive plants have, therefore, gained terrain in the Galápagos (see, e.g., Benitez-Capistros et al. 2014).

The issue concerning invasive species is, therefore, closely related to the major changes affecting local agrarian systems. Restrepo et al. (2012) reported that the intensification of animal husbandry in the 30s could have caused the extinction of some native plants that did not return after the population of grazers was reduced in the 80s.

It has been argued that, moreover, the introduction in the archipelago of invasive species also occurs by means of feed ingredients, or pathogens which can affect native birds by the import of chickens for the poultry production systems (Gottdenker et al. 2005; Wikelski, Foufopoulos, Vargas, & Snell 2004; Deem et al. 2010). Two thoughts in this regard are that, first, if we are afraid of the introduction of seeds that might grow into invasive plants through the import of animal feedstuffs, then, we could just allow into the island grinded feedstuff. Imported chicken can be contaminated with pathogens if quarantine is insufficient. All in all, tourist themselves might, very likely, be also a source of pathogens introduction.

In this context, Deen et al. (2005) in their study concerning the reintroduction of endemic species of birds in the Galápagos determined the prevalence of parasitic and pathogenic agents in chickens and wild birds on the Floreana Island (prior to the reintroduction of the critically endangered mockingbird, *Mimus trifasciatus*). They investigated avian diseases in 175 chickens and 274 wild birds. Chickens

¹⁰ <https://www.wur.nl/en/Dossiers/file/Exotic-species-in-the-Netherlands.htm> (accessed November 2016).

'tested positive for antibodies to paramyxovirus-1 (30%), adenovirus (11,3%) and seven other pathogens of concern for both domestic and wild birds. Wild birds on Floreana had antibodies to paramyxovirus-1 (3%) and adenovirus (2,4%). This is the first report of possible spillover of disease from domestic to wild birds in the archipelago.' On the basis of this data they recommended 'improved poultry biosecurity measures on Floreana, and that mockingbirds only be reintroduced in areas on the island far from poultry and human presence and following further prerelease analyses' (Deem et al., 2010). This might be indeed relevant for the reintroduction of bird species and for the general health of the bird population. However, one wonders why there have not been already some largescale pathogen cross-over in the last century and subsequent problems within the wild fauna and also, whether migratory birds might not pose a (larger) challenge for the introduction of pathogens.

Guzman et al. (2015) argued that according to the rural cadastre (SIGTIERRAS - Spanish acronym) in 2010 and on the land used for agricultural purposes, 9.143 ha (37% of the agricultural zone) are affected by invasive plant species. Within the agricultural area, guava (*Psidium guajava*) is the most widespread species, occupying 63% of the agricultural zone affected by invasive species. They also argue that in El Cascajo, 'a farming area on Santa Cruz with small land owners dedicated to the production of vegetables, invasive species are not a problem (ibid.).' In 2001-02, in San Cristobal, 34 families recovered 350 ha of grassland that had been invaded by blackberry (*Rubus niveus*) and guava' (Guzmán & Poma, 2015). In Santa Cruz, apparently, 2.311 ha are covered with the so called invasive species (ibid.). Therefore, research seems to indicate a reactivation of agrarian activities in the rural areas might help controlling the expansion of the so-called invasive species. Accordingly, this is one of the redesign strategies that we propose – see Section 7.

4. Livestock production systems

Because of the ecological (historical) characteristics of the archipelago, and the tourism growth we see that animal husbandry has relatively remained in the background of the public and scientific attention. This situation is starting to change however. Concerning (agrarian and) livestock production systems, among the objectives formulated by governmental institutions CEPROEC and the National Secretariat of Planning and Development we find for instance (CEPROEC & SNPyD, 2014):

- To facilitate access to the different aspects of agrarian and livestock production and to promote specific crops in a participatory way.
- To promote consumption of healthy and locally produced agrarian products.
- To define and articulate the role of institutions in the agrarian sector.
- To implement a process of innovation to achieve added value in agrarian and livestock products.
- To stimulate the use of agrarian land that has been abandoned due to the low profitability.
- To monitor and control the prices of agrarian, livestock and fishery products.

The policy document 'Bio-agriculture Plan for the Galápagos' defines similar directions. The three core objectives of this policy document are:

1. 'To transform agriculture into the main human activity in Galapagos which will be co-responsible for the conservation of the natural heritage of Galapagos, especially with regards to controlling invasive species, through the design and implementation of highly efficient agro-ecological production systems.
2. To contribute to the sustainability of the Galapagos economy by promoting the local markets on the basis of the principles of solidarity.
3. Consolidate a research system based on a dialogue and knowledge sharing between different types of knowledge, and increasing the local capacity to create and innovate' (Guzmán & Poma, 2015).

In this policy context, the following sections describe the local pig and poultry production systems.

4.1. Pig production

The census published in 2014 estimates that a total of 204 APUs had pigs in the Galápagos, meaning 3.651 pigs (CGREG, 2014). 54% of these pigs live in Santa Cruz (within 97 APUs).

Figure 9 Number of APUs (red line) and number of pigs in the Galápagos (blue, pig boar/ pink, sows/ green, suckling pig) and in the different islands (CGREG, 2014).

Compared with the census published in 2000 ('Censo Nacional Agropecuario, 2000') the census of 2014 shows an increase in pig population of 46% (CGREG, 2014).

Table 3 Number of pigs (elaborated on the basis of, CGREG, 2014).

	2000	2014
San Cristobal	1.461	1.217
Isabela	236	452
Santa Cruz	767	1.982
Galápagos	2.464	3.651

Pig breeds

In 2014 there were identified 5 lines of the so called improved varieties: Yorkshire, Landrace, Pic, Topig, and Duroc (CGREG, 2014). Moreover it was estimated that 3 out of 4 pigs had a 'mestizo' (crossbreed) and 'criollo' (creole, 'native' breeds) origin. This is relevant for issues such as the feed conversion ratio or the manure production – see here below.

Table 4 Pig breeds per island (CGREG, 2014).

Línea	San Cristóbal	Isabela	Santa Cruz	Total
Mestizo	80	68	1.410	1.558
Criollo	385	211	498	1.094
Yorkshire	472	173	6	651
Landrace	112	0	19	131
Pic	91	0	0	91
Topigs	62	0	5	67
Duroc	3	0	0	3
Otros	12	0	44	56
Total	1.217	452	1.982	3.651

Pig feeding

In Santa Cruz, it is estimated that 43% of the pig's diet is based on household and restaurants waste, 29% eats imported concentrates, 12% banana, and 15% other type of feed which mainly consists of sugar cane combined with other products of the APU, and just 1% of 'rice dust' (CGREG, 2014). However, during our fieldwork we got the impression that there are just a couple of producers that systematically feed their pigs with the relatively expensive and imported concentrates. Being, therefore, the most important feedstuff within the pig production the so-called 'lavaza.' The 'lavaza' is produced on the basis of the household and restaurants organic waste; i.e. swill. Below, and although this is an extended practice, we will see that the lavaza has a negative imago, although if correctly processed, this is an interesting practice for recycling food in an efficient manner.

Picture 3 'Lavaza' processing.

Revenues

It is estimated that, in 2014, the revenue for the APUs by selling slaughtered and live pigs was of US\$ 603.813 per year. Moreover, in the Galápagos islands, the larger amount of the (2.907) commercialized pigs is slaughtered (2.375) and the rest (532) is sold alive. Usually, pigs are slaughtered within the APU and are commercialized totally or partially, meaning that some producers use part of the slaughtered animal for the household consumption or for a restaurant owned by the farmer or a relative. Some farmers have their own meat selling point (CGREG, 2014). Apparently, 92% of the pigs are 2 months or older at the moment of slaughtering. In Santa Cruz 10% of pigs were slaughtered at a younger age (CGREG, 2014). In Santa Cruz it is estimated that a total of 1.523 pigs were slaughtered in 2014 (ibid.). Moreover, in the literature, it is argued that pigs are usually sold at an age of 4 to 5 months and at a weight of 50-55 Kg to up to 81 kg (ibid.). However, in practice you find many variations. Pigs might be slaughtered at 8-9 months with a weight of approximately 90 kg

(instead of 6 months in the EU at 90-100 kg). However, those farmers with the economic resources that are required to buy concentrates do reach a better performance, approx. 80-90 kg at 6-7 months (personal communication, July 2016).

Sows are usually discarded after 4 to 5 births (lasting approximately 145 days between each birth) at a weight of around 150-200 kg. The number of piglets per birth is of approximately 10 (Chiriboga et al., 2006).

Regarding feed costs, it is estimated that each sow daily eats 1,3 kg of concentrates; one sack of 40 kg cost around 35 dollars (July 2016), and for pigs 4 quintals are required to achieve a weight of approx. 60 kg at 5 months. However, in Santa Cruz, as aforementioned a larger amount of feed is based on organic waste. It is very difficult to make an estimation of the cost made for the production of 'lavaza' as this is an informal practice. In our fieldwork we have spoken to one producer who used to pay, in July 2016, US\$ 35 dollar each day just for the transport of 6-10 crates of restaurant waste, and he had to pay also the hours of his employee to collect the waste (he got the permission required for owning a car in 2017).

Regarding water, farmers say that for 6 sows one needs to buy 2 tankers weekly in the dry season. The (brackish) water is usually collected at the municipal water collecting point at Puerto Ayora. The municipality owns a tanker, MAG owns also one and there are companies that owns tankers. They all get brackish water for free at this point and sell it to individuals, livestock producers, hotels, etc. The water is therefore for free and people have to pay for the transport costs. There are tankers of approx. 2.650 l (700 US gallons) and others of approx. 6.050 l. The later might cost you around 15 to up to US\$ 20 if you are somewhere in Puerto Ayora, and about US\$ 40 if you need one in El Cascajo (a village in the rural areas) – personal communication, July 2016. A small one can cost US\$ 25. Producers who own land usually have an artificial aquifer in which water is collected in the rainy season.

Finally, there are, of course, other cost that are directly or indirectly related with the production of pig. Among the direct we find, for instance, labour. An employee is paid approx. US\$ 600 per month – personal communication, July 2016.

4.2. Poultry production systems

Broadly speaking there are two differentiated systems of poultry production, the intensive production of broilers for the meat market or of laying hens for egg production and the traditional and informal production of creole/backyard chickens.

The intensive broiler production depends on the import of one day-old chicks. The chicks are imported from breeding companies located in the continental Ecuador. They are brought in boxes of 100 chicks, transported by plane, which explains the fairly high cost per chicks; US\$ 0,9 per chick in July 2016 and up to US\$ 1,20 in July 2017. Moreover, in 2003, 81.380 day-old broiler chicks were imported onto the island of Santa Cruz to support the local broiler industry. This increased to 126.200 chicks in 2004 and 143.000 in 2005 (Soos et al., 2008).

Broilers are fed with concentrates (and eventually some corn). It is estimated that about 120 sacks (i.e., 40 Kg per sack) of concentrates and 30 of corn is required to produce 1.000 chickens (Chiriboga et al., 2006). Therefore, 4.800 kg concentrate + 1.200 kg corn = 6.000 kg feed. Moreover, 6.000 kg/1.000 chickens considering that a broiler reach approximately a weigh of 2 kg = a feed conversion ratio of 3. This is a relative high feed conversion ratio compared to the about 1,6 for a 2 kg bird obtained in the USA and Western Europe (Leenstra, personal communication, September 2017).

Picture 4 Impression of a broiler poultry house.

Moreover, in each production unit we find usually three of four pens (next to each other) in which approximately 1.000 chickens of the same age within one pen (although in practice we have seen that these pens usually house less than 1.000 chickens) are grown. In the other pens older or younger age chicks are grown for guarantying a relatively constant income. According to European standards and regarding animal health, a system in which in each farm just animals of the same age are produced could be more appropriate – the ‘all in all out’ system. This system is usually applied, within each farm, for the different pens. However, the relative low animal density in the local production units might suggest that the current practice is not problematic for health issues (Graham et al., 2008).

Furthermore, the chickens are sold when they are 5 to 7 weeks and reach a weight of around 1,8-2,7 Kg. Among farmers, it seems to be generally recognized that after 42 days the chickens ought to be slaughtered to don't lose money.

Estimated selling prices are (personal communication, July 2016):

- US\$ 2,20 per 0,45 kg (for the tourists ships).
- US\$ 3 /0,45 kg chicken breasts.
- US\$ 2 /0,45 kg (whole frozen chicken) on the Saturday free market.
- Wings, legs, ‘menudencias’ = US\$ 1 /0,45 kg.
- Liver, the heart, (small things...) and gizzards = US\$ 0,50 /0,45 kg.

Other production costs are, for instance, the use of vitamins and medicines (antibiotics) is widespread. Moreover most of the producers have to buy brackish water in the dry season (approx. 6 months). Doña Lourdes, who has 3 pens in her production unit uses, for instance, approx. 3 tankers of 2.600 liters water a week (US\$20 per tanker). In general chickens consume twice as much water as feed. One expects a lower productivity because of the water (shortage and) quality.

In the production units usually works (and lives) a young worker (with or without his family) who is also (usually) ‘imported’ from the Ecuadorian mainland and who takes care of the chickens (and performs many other activities at the farm). Slaughter-time is a labour intensive moment in which extra labour (can)has to be arranged (approx. US\$ 20 a day per person).

Furthermore, it is estimated that, in 2006, an investment of about US\$ 12.000 is required to build a single poultry-pen (cement sheds, drinkers and feeders, water tanks, tools, equipment) (Chiriboga et al., 2006). One thousand chickens might come every three weeks, and the sale is carried out every 5 to 7 weeks, therefore, the producer needs two, and usually has three pens (considering also that according to the biosecurity regulation they also have to wash and disinfect each pen after each round). With this type of system, a producer generates around 15.000 chickens annually (1.000 every three weeks) (Chiriboga et al., 2006).

‘Broiler barns and layer houses typically have metal roofs, concrete floors, and walls constructed from concrete, wood, wire mesh, chain link fencing, or tarps . By contrast, most backyard chickens are allowed to range freely, do not have a set lifespan, and may travel hundreds of meters from the farm site to forage, returning regularly for supplemental feed provided by the farmer’ (Soos et al., 2008; p. 446). However some might go into the wild and remain out there – the so called ‘ariscas’ which are feral chickens. Although in the literature and census one might find some figures giving the number of creole chickens, because of the informal character of this type of production, it is very difficult to count the exact number of backyard chickens that currently are on the island.

In the Galápagos, in 2014, there were 21.180 creole hens, roosters, and chickens counted within 463 APUs (CGREG, 2014). Moreover, 70.750 are housed in poultry houses within 30 APUs. I.e., approximately 100.000 animals. More specifically, in Santa Cruz, a total of approx. 58.000 chickens were counted of which approx. 48.000 in the intensive production system and around 10.000 were counted as creole chickens (ibid.).

Table 5 *Estimated number of chickens in Santa Cruz (CGREG, 2014).*

Santa Cruz	2014
Chickens in poultry houses	48.200
Creole chickens; backyard conditions	10.340
Total	58.540

No matter how, while the number of chickens living in the so called creole conditions, apparently, has remained stable in the last 15 years, we see that the total number of birds living in poultry houses was in 2014 3 times larger than the total number in 2000. Most probably this volume has increased since 2014.

Table 6 *Evolution of the number of chickens in the Galápagos.*

Galápagos	2000 (INEC & MAGAP 2000)	2014 (CGREG, 2014)
Chickens in poultry houses	5.318	70.750
Creole chickens; backyard conditions	21.517	21.180

Research suggests 'that backyard chickens may pose a greater threat to Galápagos avifauna because they are more likely to be infectious, have a high seroprevalence for numerous pathogens, and interact directly with wild birds or wild bird habitat, with no biosecurity measures employed' (Soos et al., 2008).

Poultry commercialization

In the local poultry production, it is estimated that 3 kg of imported food is required for the production of 1 kg of eggs or meat (Chiriboga et al., 2006). Chiriboga et al. (2006) estimated that a hen in her lifetime produces 298 eggs (of 25g each) and is discarded when weighing 2,5 kg, which gives a total of 9,95 kg production while she has consumed approx. 28,9 kg concentrates. Moreover, the one day old chicks are also imported weighing about 0.04 kg, making a total of 29,1 kg of imported products. Therefore, the argument goes, for a local production of 10 there is an import of 30.¹¹

Among the total number of birds produced in poultry houses we find that 68% was, in 2014, destined to the production of meat, and that 12.500 were laying hens (they are all located in Santa Cruz) (CGREG, 2014). In the same census we also read that in Santa Cruz, in 2014, there were 300 'broiler' (meat) breeders. This means that they could (according to the European standards) produce 40.000 broilers/year. However, we assume that these hens produce fertilizer eggs for the creole market as the intensive broiler production relays on the import of day-old chicks. But, one could think of a system in which also a couple of companies in Santa Cruz could hatch fertilized eggs in the island and supply the local sector with chicks – see Section 7.

Creole chickens are usually sold (or given; to family members) restaurants in the rural areas or particulars who want to eat the typical dishes 'aguada' or 'seco', when they reach an age of approx. 6 to up to 9 months. They are usually sold at a price that currently can reach the US\$ 35 each (personal communication, July 2016). It seems that the local population (including some of the farmers who produce broilers) highly appreciate the meat and eggs of creole production and is willing to pay a significant higher price for these products. Usually, these products do not reach the tourism sector.

In 2014, MAG conducted a cost analysis of broiler meat production. Considering 1.000 day-old chick broiler and a growing period of 7 weeks (49 days), a mortality rate of 5%, and a weight of 5 pounds (approx. 2 kg) by the slaughtering. They concluded that, in 2014, production costs, in Santa Cruz, reached US\$ 1,83 per 0,45 kg of meat (personal communication, July 2016):

¹¹ Moreover, within this calculations it is not considered the cost of importing farm infrastructure such as cement, iron, drinkers and eaters, for instance. Furthermore, mortality (approx. 5%, see here below) should be taken into account.

Table 7 *Chicken meat production costs in Santa Cruz in 2014.*

Direct costs	Unit	Quantity	Unity value, US\$	Total value, US\$
Day-old chick	box	1000	0,80	900
Transport chicks to farm		1	30	30
(A) Chickens (total)			30,80	930
Concentrates	sack	140	35	4.900
(B) Feeding (total)			35	4.900
Vitamins and antibiotics	kit	1	100	100
(C) Management costs (total)			100	100
Gas	Cylinder	6	5	30
Water	Tanker	4	35	140
Electric power	Payment	2	20	40
Bags filled with wood chips	Bag	40	2	80
Labour force		2	659	1.318
Disinfectant and lime	Gallon	1	30	30
Chlorine detergent	Gallon	1	30	30
(D) Basis services (total)				1.668
Total (direct costs)				7.272,12
Indirect costs	Unit	Quantity	Unity value	Total value
Slaughtering labour force	Chicken	950	0,55	522,50
Ice	Pound	400	0,35	140
Sheath	Pack	3	5	15
Transport	Cargo	4	20	80
(E) Slaughtering (total)				757,5
Biosecurity permits, patent, intendancy, fire & health	Annual permit	1	115,50	115,50
Chicken entry permit	Permit per lot	1	10	10
Amortization installations	Annual	1	250	250
(F) Formal procedures (total)				375,50
Total (indirect costs)				1.390,50
TOTAL COSTS (direct + indirect)				8.731
Total chickens for slaughtering /5% mortality				950
Weight				2.2 kg (5 pounds)
Total weight				2.155 kg (4.750 pounds)
Production costs of a meat pound, labour and investments excluded				1,83

In 2014, it was estimated that 315 APUs slaughtered a monthly total amount of 24.414 birds (hens, roosters or chickens) in the Galápagos province. According to the same estimation, the canton of Santa Cruz slaughters monthly 14.064 birds, San Cristobal 9.458, and Isabela 894 (CGREG, 2014).

It is estimated, moreover, that quarterly, the commercialization of 102.193 birds (either from creole or poultry houses production systems) delivers US\$ 983.674. The poultry houses commercialized 93% and retrieved US\$ 910.717 and the 2.755 creole birds produced a revenue of US\$ 70.181 (CGREG, 2014).

Egg production

Eggs are mainly produced in the laying hens barns. However, in 2014, there were 338 APUs that produced also eggs from creole chickens that are grown in backyard conditions. Most probably, the eggs produced by backyard chickens are consumed in the household or commercialized in the informal market.

Santa Cruz produces the larger amount of eggs within the backyard conditions in the Galápagos islands; i.e., 17.024 of an estimated total monthly production of approx. 30.000 eggs (CGREG, 2014). That is between 50 and 60 % of the total amount of eggs produced by the 185 APUs of this canton. The total amount of eggs produced in industrial poultry houses is coming from 4 APUs in Santa Cruz (CGREG, 2014) and it was estimated to be of approx. 285.000 eggs per month.

Table 8: Evolution in the monthly production of eggs in the Galápagos islands.

	2000 (INEC & MAGAP 2000)	2014 (CGREG, 2014)
Eggs produced in poultry houses	106.520	285.128
Eggs in backyard conditions	39.051	30.090

In the Galápagos, almost all produced eggs in poultry houses are commercialized (a minimum amount is consumed by the producer's family). On the contrary, half of the total amount of eggs that are monthly produced in backyard conditions are used within the producers' households and their family (14.994), the rest is commercialized (8.549) or incubated for reproductive purposes (6.675) (CGREG, 2014).

The monetary value that is generated by the commercialization of creole eggs was estimated to be of around US\$ 3.000, while this one of those produced in poultry houses amounted approx. US\$ 40.000 in 2014 (ibid.). Meaning that a single creole egg costs an average of US\$ 0,35 and that the average value of single poultry house egg amounts US\$ 0,14 (CGREG, 2014).

Creole eggs are sold in 54 APUs (18 in San Cristobal, 7 in Isabela, and 33 in Santa Cruz). 3 out of a total of 4 poultry houses are located in Santa Cruz.

4.3. General trends livestock production systems

Based on the literature we see the following important trends that are currently affecting or that are related to the agrarian and livestock sectors:

- Low profitability of agrarian and livestock production activities; when compared, for instance, with the profitability of other sectors such as the tourism and fishery sectors (CEPROEC et al., 2014; CEPROEC & SNPyD, 2014).
- Since the 80s we find a growth of urban areas and of the number of people who earn their wages within the tourism industry – i.e., there is a related process of abandoning agrarian practices. In 1980 16% and in 2010 just 6% of the working population was employed within the agrarian sector (CEPROEC et al., 2014; González et al., 2008).
- The tourism industry has grown very rapidly. The hotel-bed capacity has dramatically increased (together with the vessel berths capacity) from 1.928 in 1991 to up to 3.473 in 2006 (increasing the dependence on the import of products) (Epler & Proaño, 2007; González et al., 2008). The Galápagos National Park Directorate reports that a 'total of 224.755 tourists visited Galapagos in 2015 — a 4% increase compared to 2014. Of these, 154.304 were foreign visitors and 70.451 were nationals.¹² It is estimated that, annually, the tourism in the Galápagos generates US\$ 418 million of which US\$63 million enter the local economy = 51% of the Galápagos economy.¹³
- Between 2000 and 2010 the land used for agrarian purposed decreased 23% and the reduction of grassland was of 32% (CEPROEC et al., 2014; CEPROEC & SNPyD, 2014).
- Also since the 80s due to these developments we find that the local and tourist population is increasingly dependent on the import of food (González et al., 2008; CEPROEC et al., 2014;

¹² www.galapagos.org/newsroom/galapagos-tourism-growth-2015/ (accessed January 2017)

¹³ <http://www.galapagos.org/conservation/conservation/conservationchallenges/tourism-growth/> (accessed January 2017)

CEPROEC & SNPyD, 2014). Note for instance that 83% of the food that is consumed in the Galápagos is imported (ibid.).

- It is estimated that only 15.31% of the land that is officially destined to agrarian practices is used according to its ecological aptitude (from the Spanish 'aptitud biofísica') and therefore, there is a subsequent degradation process of land and ecosystems taking place (CEPROEC et al., 2014; CEPROEC & SNPyD, 2014).
- Water basin overexploitation and low water quality (González et al., 2008; Benitez-Capistros et al., 2014; CEPROEC et al., 2014). In the dry season (approx. 6 months) the majority of livestock producers are forced to buy brackish water that will be used for all type of activities (in the household and, e.g., to clean up the pens) and as drinking water for the animals. Some of them, however, do have water reservoirs, and MAG, for instance, is promoting and facilitating the construction of such reservoirs.
- The introduction in the archipelago of invasive species is well monitored and especially within the conservationist circles it is experienced as a problem (Chiriboga et al., 2006; González et al., 2008; Brewington, 2011; Benitez-Capistros et al., 2014).
- Agrarian products (including livestock products) are locally consumed (being coffee the only product that is exported) (CEPROEC et al., 2014; CEPROEC & SNPyD, 2014).
- The (many) controversies between the 'conservationist sectors' and the 'productive sectors' (associated with agricultural, and tourism sectors) form the basis of most of the conflicts in the Galápagos islands (González et al., 2008).

Concerning, more specifically, livestock production we see that:

- By means of the import of chickens or feed ingredients for the poultry production systems, pathogens which can affect native birds might be introduced in the Galapagos (Gottdenker et al. 2005; Soos et al., 2008; Deem et al. 2010). However, one could argue that migratory birds might pose a relative 'bigger' threat to the local wild fauna, and that native diseases might pose a threat to imported chicks...
- Research suggests 'that backyard chickens may pose a greater threat to Galápagos avifauna because they are more likely to be infectious, have a high seroprevalence for numerous pathogens, and interact directly with wild birds or wild bird habitat, with no biosecurity measures employed' (Soos et al., 2008).
- Moreover, a poor and, probably, dangerous management of animal waste (manure and slaughter offal of pig and poultry production systems) has been observed (see, e.g., Chiriboga et al. 2006; Cherret 2010).
- Furthermore there seem to be doubts about the sustainability and profitability of production units within this trend towards an industrialized system. A system that, in the islands, seems to be based on the regular import of animals and feed, and a relatively high dependence on pharmaceuticals (e.g. antibiotics) (ibid.)

Other problems affecting both industrial and traditional livestock systems are, for example, poor management in general and of animal waste in particular, leading to nutrient losses to the environment; and a weaker resilience of animal farms to disturbances and fluctuations in prices together with a weak organizational capacity of animal husbandry farmers.

Moreover, there are well defined protocols and good biosecurity guidelines. Interestingly, these guidelines resemble those of the so called western societies that are defined and primarily implemented for protecting the animals that are under production conditions from the environmental conditions, whether in Santa Cruz, it seems as if these same measures are formulated mainly for protecting the environment and wild fauna from the livestock production. No matter how, the level of compliance with the defined biosecurity guidelines is minimal.

5. Problem definitions and future visions of local stakeholders

This section summarizes the results from the (25) interviews and (10) focus groups (that were conducted in June-July 2016 in Santa Cruz) which focussed on: (1) how problems are defined by local stakeholders and (2) the (shared and divergent) goals for the food and livestock production systems.

Here, we divide the stakeholders in three main categories: (a) Institutions (governmental organizations); (b) non-governmental organizations, sectorial organizations, businesses and individuals; and (c) livestock producers. We have done this for analytical reasons although these three categories cannot be strictly defined as homogeneous.

Picture 5: Focus group in Bellavista.

5.1. Institutions

Experienced problems:

- Dependence on the continental mainland for accessing many (also agrarian) inputs. This increases the prices (among other reasons, because of the transportation and intermediary incurred costs) that the local population has to pay, for instance, for food products. Moreover, this also affects the prices of livestock related inputs (e.g., concentrates). A related issue, from the institutions' perspective, is the many problems that can emerge if the maritime or air transport is broken or delayed.¹⁴
- (Some conflicts and controversies that emerge from) the contradictory visions and positions (concerning, for instance, nature, ecosystems services, and development perspectives) that are held by the conservationist and productive sectors.
- Poor coordination between institutions (also because of the contradictory visions and policies of the different institutions). Moreover, sometimes there is an overlap of competences among these same institutions (e.g., veterinarian competences ABG & MAG).
- Economic problems within the livestock production systems due to, for example, the high prices of inputs (import), a structural overproduction, and the competition with cheap imported meat (which is imported by and for the tourism sector).
- Inadequate management within livestock production systems (of animals and waste). This is experienced as a problem for public health (infectious diseases) and for water and ecosystem health (i.e., pollution).
- The usage of restaurant and household organic waste for feeding pigs (the so called 'lavaza') is seen by these stakeholders as (1) a public health problem and (2) as a problem for the quality of pork meat (which is said to become too fat).
- Water (seasonal) scarcity and contamination. The quality of the available water for human and animal consumption does not meet the required standards (contamination) because of a general inappropriate waste management, also of livestock related waste.
- Exotic species might enter together with the products that are imported, as well as with the tourists that enter the archipelago.
- Rats are seen as a public health problem, as a reason for economic losses. Livestock production units may be a food resource to these (hated) rodents.

¹⁴ E.g., a representative of the town hall of Puerto Ayora told us that when, back in 2014, they got problems because two transport ships sank in a short period of time. Because of which goods supply was temporarily stopped, they realized, at that point, that 'concentrates are much more important than beer supply' since chicken and pig meat became scarce (personal communication, June 2016).

- Large differences in land property. Some owners are not able to manage (cultivate) all the rural areas that they have. Not only because of the size but also because these owners are usually involved in tourism related activities and just do not have the time/desire to, or the resources for conducting agrarian activities.
- 'The world is watching.' A general feeling of high responsibility regarding local ecosystems. This feeling emerge, among other things, due to the international attention given to these same ecosystems through international research institutes, non-governmental organizations, and tour-operators. These ecosystems are also the main reason why tourists are coming to the archipelago.
- Political, economic and knowledge dependency from external actors to meet the many challenges of the archipelago.
- Culturally embedded practices (that are defined as negative by some representatives of the institutions) which are/will be very difficult to change. E.g., lavaza, slaughtering at the farm when this is required, informal marketing of animals and their products, or manure management.
- Dysfunctional livestock producers organizations (actually, there is a good number of non-working organizations).
- Paternalism among producers, they seem to be used to believe that institutions have managed and can manage change.
- Some mention a 'generalized' corruption and a good number of informal practices.
- Illegal import and use of animal vaccines (this seems to be more common for dogs).
- Unwillingness of (young) local people to work on agrarian practices + High cost of local labour force and subsequent 'import' of workers from the mainland.
- A wealthy amount of knowledge around the local conditions (in the form of studies, rapports, experiments, ecological restoration practices, etc.), and of policies and regulations that reflect this knowledge (e.g., biosecurity protocols) and what is expressed as a generalized lack of implementation in practice.
- The current slaughter house is an unhealthy place and some actors doubt about the viability of the new (project for building a new) slaughter house.
- A general lack of trustworthy administration practices. This has been identified for instance, within the tourism sector (e.g., individuals who run a hotel usually work with an informal administration system) but also regarding the management (e.g., feeding, vitamins and medicines dosage) and traceability of livestock.
- Local livestock production systems are unable to deliver a constant supply of food (except for meat).

Proposed solutions for food and livestock production systems

- Food sovereignty. Meaning, that the local production systems ought to be self-sufficient and, therefore, independent from the continent.
- Science and technology based livestock production systems.
- Integrated systems according to the principles of the agroecology together with strong biosecurity strategies.
- Fair trade; linking the local production with the local and tourism related consumption.
- Appropriate management of manure and of animal leftovers.
- Well defined and implemented: policies, livestock management/production protocols and risk assessment.
- A transition, from within the conservationist sector, from a (radical/plain) criticism against livestock production in the Galápagos towards a more constructive position from which advice is provided to address the many challenges of livestock (and food) production systems.
- A demand of an elaboration of policies and management practices protocols based on (real) participation, i.e. participatory policy making.
- To improve water management.
- Sustainable and long-term plan for abandoned rural areas (e.g., by renting land to producers and in this way facilitating the control of invasive species).
- Serious risk analysis of the possible allowance of and regularization of animal vaccines.
- Implementation of a traceability system to improve the quality standards of food and to integrate production chains.
- Institutions and strategic places such as labs and slaughterhouses that are managed by experts and not by politically chosen persons.

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- Organized livestock producers that are able to organise themselves and dialogue with the local population and the tourism sector. Moreover, these organizations adopt and promote responsible practices regarding animals and the environment at the same time that avoid disloyal competition.
 - Effective coordination between the institutions and clear definition of responsibilities.

5.2. Non-governmental organizations, sectoral organizations, businesses and individuals

Experienced problems

- Perceived inadequate management of pig production systems regarding general hygienic conditions and waste (e.g., manure) management.
- Livestock production and especially backyard poultry production is seen as a source of infectious diseases bearing risk for local ecosystems.
- Overproduction of livestock products (and the subsequent low profitability of these production systems).
- Abandonment of rural areas (e.g., it is argued that some landowners own more land than they can manage). Because those areas are not in use, it is said that the so-called invasive species are gaining terrain.
- Some stakeholders believe that rats might be a transmitter of diseases (from livestock to local fauna and vice versa) + the generalized (and uncontrolled) use of poison to control rats is also experienced as problematic because of the introduction of poison in the ecosystems and food chain.
- General dependency on transport (e.g., the cargo from the continent and the taxi system on the island). This transport is seen as monopolized by a few (powerful) families, meaning, higher prices.
- Water scarcity and (low) quality.
- Disorganized livestock production sectors.
- The local institutions are highly politicized ('at the head of the directions of these institutions we find politicians and non-technicians') and some claim that there is corruption. Note, for instance, that the National Park Galápagos controls 97% of the territory, grants tourism and fishing permits, and also provide jobs to a lot of locals. Thus, there is ample incentive to influence this and other institutions.
- Some institutions (especially ABG and NPG) are perceived to prefer a controlling and restrictive role regarding the livestock production systems and are seen as unable to provide 'constructive' advice.
- The general formal-education level of the local population is experienced by some representatives of the conservationist sector as poor.

Proposed solutions for food and livestock production systems

- Appropriate (science-knowledge based, technified but not industrialized) management of livestock production systems that are adapted to the local conditions and which appropriately manage waste (burned or autoclaved¹⁵).
- Long-term and sustainable plan for the management of abandoned areas. 'Control of invasive species' should be a key function of this plan.
- A tourism value chain which is formed by and integrated in the local economy and which, moreover, is in direct contact with local producers to supply (i.e., promote) high quality local products.
- Institutions that understand the complexity of the local socio-ecological systems and that regulate the number of producers and of (pigs, chickens) products. Moreover, these institutions provide the management knowledge that livestock producers require.

¹⁵ Manure is also being defined by some stakeholders as a good fertilizer, when used in a responsible way, in production units where no fertilizers are used, or to replace chemical fertilizers.

5.3. Livestock producers

5.3.1. Pig producers

Experienced problems

- The high prices of concentrates. Producers usually argue that the reasons of these experienced expensive prices are the transport related costs and, therefore, the dependency relationship with the mainland. Apparently, it is generally accepted that concentrates are 'good', i.e. better than lavaza or organic waste from the farms to feed pigs, and it is usually argued that if producers might have the economic resources required to pay for the concentrates they will buy and use them.
- The dependence on transport (taxis and rented cars) and the lack of owned cars/4x4 vans. This increases the prices of inputs (including picking up restaurant and household organic waste for lavaza production) and constrains the overall production process.
- Except for a couple of large scale producers, this is an informal system where little knowledge exist regarding cost/benefits ratios; or where people (are forced to) accept modest margins. Moreover, the market price of meat is experienced as very low.
- The 'distance' to the tourism sector is experienced as huge by most of the producers. They believe that it is nearly impossible to get the sanitation permit which is required to access this market. This is important as price differences of meat between the local and tourism market are significant.
- The bureaucratic character of the local institutions which are unable to provide extension type of work and support to the local producers (and there is also an experienced tendency to provide advice 'only' to the large scale producers) regarding production management.
- A poor genetic pool, because of which situations of consanguinity are emerging and, therefore, also a related low productivity.
- The water scarcity and its low quality, especially in the dry months in which they are forced to buy brackish water.
- Small-scale producers especially miss the capacity to extend their production units or cultivate food for their pigs because they do not have the land for doing so.

Proposed solutions for food and livestock production systems

- Production units that are technified and rationalized according to the knowledge and principles defined by veterinarians and technicians (for instance, from MAG) – regarding, e.g. feeding, waste management, medicines usage. Increasing the knowledge base regarding not only livestock production but also regarding the soil capacity, climatological conditions, market functioning.
- A pig sector that is organized within one single organization (which enables, for instance, the agreements regarding selling-prices).
- Well organized (meaning, less bureaucratic and with more technicians) and coordinated institutions that communicate with the producers.
- Trustworthy government that regulates transport properly.

5.3.2. Poultry producers

Experienced problems

- High prices of farm inputs (e.g., concentrates, maize, medicines, but also, feeding and drinking systems). Everybody thinks that this is directly related to the extra costs that are made due to the dependence on the mainland and transport.
- Water scarcity and the low quality of the brackish water that they are forced to give to the animals during the dry season.
- (Specific for the broiler production) The import of day-old chickens, being the problem here the general increase of the production costs, together with the high mortality rates of the imported chicks.
- Rats' aggressiveness. They eat the chickenfeed and eat the little chickens (to up to 3 months old chickens).
- The informal character of the creole production and the disorganized situation of the broiler sector.
- (because of which they believe that) There is an overproduction of chicken meat.

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- A tourism sectors that imports meat and doesn't buy local chicken meat (except from a couple of large scale producers). Moreover, a tourism sector that doesn't promote local products.
 - (Specific for the creole production) animal health problems (and the subsequent need to experiment with formal and informal/traditional medicines).
 - (Specific for the creole production) Institutions that only support the more intensive broiler sector.
 - Institutions that constrain production with rules and laws and that do not provide constructive advice/solutions for the producers to be able to meet these rules/laws. Institutions are seen, moreover, as not being communicative.
 - (Specific for broiler production) Institutions that don't regulate the number of producers and of produced chickens (and don't dear to prohibit meat import for the tourism sector).
 - A powerful conservation sector and *institutions that*, as a producer framed it: *take more care of 'birdies and the little turtles than of people.'*

Proposed solutions for food and livestock production systems

- An organized sector that is able to negotiate with the institutions a quota of producers and a calendar (and quota) of production (meaning also a regulation or prohibition of the import of chicken-meat).
- Supportive institutions that conduct research and, importantly, report to the poultry sector.
- (Only) Two large scale (an owner of >10.000 broilers and one laying hens entrepreneur) producers wanted to improve the management of manure (drying, gridding).
- A tourism sector that promotes and sells locally produced food.

6. Shared and divergent goals

While conducting the interviews and focus groups in our first visit we focussed on two main aspects, i.e., (1) how problems are defined by local stakeholders and (2) the shared and divergent goals for the food and livestock production systems. This section elaborates further the second aspect. In Section 5 we have outlined the 'proposed solutions for food and livestock production systems.' These proposed solutions are based on the explicit or implicit goals. In this context, there might be a differentiation between short-term and long-term goals. In order to increase the chances of aligning multiple goals, for the design process we build on the long-term goals rather than on the proposed solutions. Therefore, here we are going to look into the deeper reasons behind these proposed solutions. I.e., the 'why-question' that enables us to understand the more fundamental needs behind the wishes or proposed solutions. The methodological reason here (see also, Groot Koerkamp & Bos, 2008; Bos & Groot Koerkamp, 2009) is that, by doing so, we are able to identify and define common-ground domains and, moreover, dialogical spaces are created where reflection and negotiation among the different stakeholders can take place. This will enable the redesign practices towards integrated and locally adapted livestock production systems (Section 7). Moreover, this methodological approach takes advantage of and is inclusive for the plurality of values and goals that are held by different individuals within the defined stakeholder groups (producers, institutions, etc.) and so it might facilitate redesign and collective change practices.

Goals, in this sense, are constructed by aggregating the problem definitions and proposed solutions of a particular stakeholder. In the literature this has been defined as 'frames of meaning' (Schön, 1983; Bos & Groot Koerkamp, 2009). Spybey (1984) defines frames of meaning 'as conceptual frameworks for the collections of values, beliefs, norms, techniques and so on' (ibid., p. 311). This concept builds on Giddens' concept 'duality of structure' in which actors are affected and affect social structures. In our analysis we also include knowledge and technological structures. By elaborating these frames of meaning we try to generate space for reflection to meet the long-term objectives, that is, beyond the current interests, contradictions, controversies (or even conflicts) and short-term defined goals.

However, the most deeply anchored and normative frames that trigger a particular actor to formulate a specific goal, are usually, very difficult to work on, to transform. To achieve our redesign objectives we have to understand these frames of meaning and listen to the proposed, usually, short-term solutions, while at the same time, we focus on the long-term goals which might align different actors and which triggers reflection and negotiation. Afterwards, we can articulate redesign strategies, mainly at the level of biological, ecological, technological or livestock production management related aspects.

In this section we first elaborate the divergent goals (Section 6.1) and then (Section 6.2) the long-term goals of stakeholders are also addressed.

6.1. Divergences and contradictions among stakeholders in the definition of goals

It is contradictory/difficult to try to control open systems, while, for instance, naturally ventilated/open systems are cheaper and more robust to operate. Some stakeholders argue that the implementation of certain biosecurity measures in the livestock production units can control the introduction of exotic species and the extension of pathogens that can affect local ecosystems. While others find these control driven strategies a bit odd. Producers, for instance, speak of a strategy aimed at 'controlling/constraining' production with rules and laws but, the argument goes, without providing the required constructive practical solutions/advice that could palliate the possible risks for the (eco)system. This, moreover, in a context in which more than one hundred thousand tourists from all around the world annually visit the island (González et al., 2008), and in which about 29 migratory

bird species also regularly 'visit' the archipelago. One could argue that those visitors are an open door for the introduction of pathogens or invasive species. At the same time, there are some pathogens that have been already found in the local chicken population, meaning that they cannot be 'introduced' because they are already there. E.g., *Mycoplasma gallisepticum*, infectious laryngotracheitis virus, infectious bronchitis virus, avian reovirus, and Marek's disease virus. Seroprevalence for other pathogens such as avian paramyxovirus- 1, infectious bursal disease, avian encephalomyelitis virus, and avian adeno virus (Soos et al., 2008).

A counter argument is that it is ineffective to increase/impose biosecurity measures on intensive production units while, at the same time, firstly, a large population of creole chickens is tolerated and not controlled at all by the same rules/institutions and stakeholders although this population has an apparent higher level of mortality and is in a more direct contact with local fauna. Secondly, also when pen houses, as they are currently built, can be defined as open systems as, for instance, rodents and small birds such as the finch are able to enter these same pen houses to, e.g., enjoy some concentrate-meals.

Picture 6 Impression of a broiler coop.

Contradictions in prioritizing strategies concerning 'the local'. Some relevant policy papers and institutions argue that local food systems have to be based on locally produced food such as meat. In this context, food sovereignty is a concept that is sometimes used to elaborate this argument. However, for several reasons locally produced food is usually more expensive than continental-imported meat, for instance, because of the transportation costs (to bring in, and move around some products such as concentrates, maize, etc.). This makes it very difficult for local products to compete with imported food – at least at the price-level. Moreover, the tourism sector and the conservationist institutions and stakeholders are powerful agents in the island. It remains an open question whether the claim of supporting 'locally produced food' can be accomplished if one of these two sectors contradicts or does not fully support this goal. Arguments that are now used for not supporting this policy-direction are, for instance, the high purchasing prices of local products, taste/colour/hardness ("we have 'tourists-light', they don't ask for 'aguada'¹⁶ or pork, they just want beef or fish" – personal communication, June 2016), the perceived involved risks that might have the consumption of this local products for human health (meaning a lack of trust on the safety of the local production systems), or the difficulties for producing locally the required volume of food to supply the tourism sector – this is also the case because some of the food, such as vegetables are season-dependent and cannot, therefore, be constantly delivered by local producers.

A contradiction between the aim to 'technify' production and the current human capital capacity. It is generally claimed by the local stakeholders that livestock production ought to be based on science and technology knowledge. To achieve this one needs human capital with the required knowledge and capacities. However, at the local level, as far as we know, there are in Santa Cruz, for instance, around 10 veterinarians working on livestock related institutions. They are the 'technicians' from MAG or ABG that visit and support, or control (i.e., depending on the particular point of view), the production units. Moreover, also at the global level and concerning Galápagos-knowledge we also see that while there are many scientific articles regarding the wild fauna, there are relatively less peer reviewed papers that addresses livestock production in the Galápagos. Furthermore, we have not found specific strategies, both at the level of the daily practices of farms and at the level of scientific research, that might enable this claimed aim regarding the scientification and technification of production.

Contradictions between the claims regarding food sovereignty and clean ecosystems and the missing manure management strategies. Organic matter might be required to increase/improve the local production of vegetables, grains or grasses to enable the goal of food sovereignty, or to strengthen

¹⁶ 'Aguada' is traditional dish which is a kind of soup prepared with creole chicken and which is highly appreciated by the local rural population.

local agrarian production. However, an inappropriate (together with the non-formulation of goals concerning) manure management impedes the proper utilization of this excellent source of organic fertilizers and it might be leading, moreover, to uncontrolled leaches into the environment.

Contradictions between the claims and current practices regarding water management: Although claims are made, and concrete efforts are conducted to improve the water management system (building, e.g., reservoirs to collect rainwater), many livestock producers still depend on tankers of (relatively) 'cheap' brackish water. This affects, according to the local veterinarians, animal health problems during the dry season and, most probably, productivity problems as well. Moreover, the aforementioned poor manure management might negatively contribute to the quality of the available water.

Contradictions between the 'organization'-claims and a generalized disorganization and lack of trust between stakeholders. It is common to hear stakeholders formulating goals concerning the organization of the livestock production sectors and between these sectors and other stakeholders. In this context, we see, moreover, that Santa Cruz has a relatively small population in which everybody knows everybody. However, we also see that, for instance, livestock production sectors are hardly organized. Moreover, among institutions one can also find forms of disorganization and overlapping of competencies, or institutions that are not fully trusted or mistrusted by other stakeholders, in the same way that the majority of producers are not trusted by institutions...

6.2. Future visions and (long-term) goals of stakeholders

In this section we focus on the shared long-term goals that emerge from the proposed solutions that were elaborated on section 5. We do this in order to increase the chances of aligning multiple goals as defined by the different stakeholders and to work on and try to solve the divergences and contradictions defined by the different stakeholders (Section 6.1).

Table 9 Long-term goals of stakeholders.

Stakeholders	Long-term goals
<i>Institutions</i>	<ul style="list-style-type: none"> - Autonomy and self-sufficiency - Healthy ecosystems (requirement: healthy livestock production systems) - Knowledge /science & technology based practices (including policy making, livestock production, market dynamics) - Social dialogue among reliable stakeholders - Sustainable market practices (tourism, livestock production/products)
<i>Non-governmental organizations, sectorial organizations, businesses and individuals</i>	<ul style="list-style-type: none"> - Healthy ecosystems (requirement: healthy livestock production systems) - Reliable society trustworthy stakeholders (that can articulate a required social dialogue) - Knowledge /science & technology based practices (livestock production, policy making)
<i>Livestock producers</i>	<ul style="list-style-type: none"> - Knowledge / science & technology based livestock production systems - Sustainable farm income (including regulatory-cartel type of practices and access to the tourism market) - Social dialogue (among reliable and organized stakeholders) - Dignity (and social recognition/valuing of livestock production practices)

In this table we, on the basis of the conducted interviews, have summarized and conceptualized the most relevant solutions that are proposed by the different stakeholders. Now, we elaborate the shared long-term goals that can be distilled from the integrated perspectives of these stakeholders.

- **Healthy livestock production systems.** Stakeholders aim to have access to locally produced food from systems that pose a tolerable risk for the local (internationally highly valued) environment. Local people do already trust local livestock products and are ready to pay substantially more for these products. Creole chickens, for instance, are usually sold at a price that currently can reach US\$ 35 for a whole chicken (personal communication, July 2016), they are eaten on Sundays or on special occasions to celebrate something. Moreover, local eggs are also highly valued. However, on the other hand, there are some practices on the production chain that are seen as challenging. The local slaughter house, for instance, is defined as insalubrious by everybody. Furthermore, apparently, it is especially from within the tourism sector where claims are made concerning the possible risks of consuming local products. Although, price related issues might play a more important role in the decision of importing the cheap chicken meat from the Ecuadorian mainland instead of consuming local meat.

However, manure and leftovers management in relation with environmental management are issues that stakeholders currently see as a challenge for these local systems.

Although we have heard that among the conservationist sectors there could be some who might be against any form of livestock production (including a healthy or low-risk one) in the island of Santa Cruz, among the wide scope of stakeholders to whom we have spoken there seem to be an (non-spoken) agreement that livestock production is part of the cultural and productive landscape of Santa Cruz, and that therefore, it ought to be further developed as a responsible practice.

- **Healthy ecosystems.** Humans, locally and globally, benefit from the local ecosystems services of the Galápagos islands. For instance, either directly or indirectly local stakeholders profit from the popularity of native nature among international tourists. However, some producers claim that wild animals get much more attention and resources than farm-animals. Moreover, a total of 154.304 international tourists visited the Galápagos in 2015 (together with other 70.351 Ecuadorian mainland tourists). In this sense stakeholders agree on that sustainable practices, including livestock production are required to maintain healthy ecosystems. This matches also the claim made by stakeholders that a condition to achieve the goal of healthy ecosystems is that the local economy ought to be also sustainable.

No matter how, the specific geographic characteristics of the archipelago make of the local ecosystems a valuable reservoir of biodiversity and environmental knowledge (among other possible services) that ought to be sustainably managed.

- **Knowledge/science & technology based practices** (including livestock production, policy making and market dynamics), meaning 'a technified production,' from the Spanish 'una producción tecnificada,' that is, a livestock production that is organized according to the principles, knowledge and methods defined by veterinarians, agronomist, biologist, etc. regarding, for instance, feeding, waste management, medicines usage, or the interaction of livestock production with the ecosystems. This claim concerning the potential of science and technology to improve production is also extended to other domains such as this one of markets organization/regulation and to the formulation and implementation of policies – what in the literature has been called *science-policy interfaces*¹⁷ or, more recently, *knowledge-practice interfaces* (Puentes-Rodríguez et al., 2015). That is, inclusive, interactive and reflective knowledge arrangements and/or decision making processes in which different types of knowledge (both formal and informal) and types of actors (including and beyond scientists and policy makers) assume an active role and responsibility regarding environmental management (ibid.).
- **Social dialogue (among reliable and organized actors).** Scientific knowledge and technological applications on their own are insufficient to achieve sustainability. Participatory knowledge and practices are increasingly required to facilitate the integration and synthesis of different types of knowledge (e.g. formal and informal) or of contradictory visions and goals. The inclusion of different stakeholders to enhance an integrated and socially sustainable livestock and environmental management.

¹⁷ Science-policy interfaces are defined as : 'social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making' (Van den Hove, 2007, p.807).

7. Systems' redesign options

This section elaborates the most promising redesign strategies for the local livestock production systems. In so doing, we focus on the characteristics and functions of these systems, as well as on the expressed and/or implicit long-term goals and the contradictions that we have identified (see previous sections). Moreover, they are also inspired by the principles of the agroecology. A key issue within the agroecology spectrum is to improve the resilience of systems by working on the complexity and diversity, as well as on the interactions between the different elements of these same systems. Moreover, these options try to close (nutrient) cycles and to enhance the internal functioning of the different subsystems, including as well the social component (e.g. food sovereignty). From this perspective some of the most important agro-ecological identified issues are: (a) the dependency from the continent for accessing inputs (e.g., concentrates, one-day old chicks - and subsequent risk of introducing new exotic species) and (b) nutrient losses and subsequent possible environmental degradation.

These strategies are here not fully defined and elaborated, they ought to work, however, as conceptual trajectories that have to be discussed and further elaborated and articulated within a dialogical and participatory process among local stakeholders. Our RIO approach provides the methodological tools for articulating such a process.

7.1. Rural-land restoration; revalorization of abandoned rural land and control of invasive species.

This redesign strategy concerns the restoration and revalorization of abandoned rural land. The idea here is to recuperate these areas for agrarian production, including livestock production (although our focus is on poultry and pigs one might also think of using cattle). This trajectory might fulfil the following functions: (1) The control of invasive species through the reutilization of abandoned land in which these species can, right now, freely grow and, therefore, enter the protected areas. (2) The production of food for the local markets or of feed for local livestock production systems (and thus the reduction of imports). (3) Controlled introduction of animals as landscape managers.

The polipotency of animals. It is usually claimed that a process by which rural areas are abandoned (among other reasons because of the low profitability of agrarian practices) is taking place. This process triggers the expansion of invasive species. In the rural areas of the Galápagos islands the invasive species cover 35,7% of the area, meaning 10.735,05 ha (CEPROEC & SNPyD, 2014). In Santa Cruz they cover 2.311 ha (Guzmán & Poma, 2015). One of the possible overall redesign strategies is the reactivation of agrarian related activities in these areas. By producing crops or allowing livestock to (re)use these areas we can manage the expansion of these so-called invasive species and avoid that they enter the national park.

Therefore, we could focus on (1) the recuperation of all the rural areas for agrarian production, while at the same time (2) placing particular attention on the borders between the rural and the protected areas by stabilising ecological corridors in which livestock will play a role in avoiding the growth of invasive plants into the National Park Galápagos.

In this context, and regarding crop production, due to climate, soil conditions and tradition we believe that multicropping with (partly) perennial crops, are more appropriated than monocultures. Among other reasons, because mechanization options are limited. Moreover, fruit trees or coffee plantations are successful strategies that can be also strengthened in or expanded to these areas. Mixing crops production in combination with trees is a serious agroecological option that should be considered.

An interesting aspect of this redesign trajectory is that livestock has a functional-place within the broader agro-ecosystems, i.e. an agroecological approach (see, e.g., Alexandre, Fanchone, Ozier-Lafontaine, & Diman, 2014). Livestock is an essential part of integrated farming systems for

transforming, for instance, low quality organic matter (recycling waste and sub-products) into high quality human edible proteins. Moreover, livestock is also able to provide rich organic matter. Furthermore, we can also think of other interesting functions, such as the function of controlling the expansion of invasive plants. Pigs, for instance, can be used to clean up areas from unwanted (root)crops. A chicken tractor¹⁸ might also help cleaning up an area of unwanted weeds.

Important related aspects here are: First, the availability of labour to work in the 'new' lands. Labour is available from the mainland, but would ideally be also sourced from the island itself. Second, the availability (seasonality) of water in these lands for crop or/and livestock production.

A third important aspect that might facilitate (or constrict) the process is the articulation of legal and renting mechanisms for renting abandoned land. Abandoned land could then be made productive by agrarian entrepreneurs who do not have to own the land. Moreover, it is possible to design a system that makes it more attractive for land owners themselves to invest in their land and employ workers.

This redesign strategy might also work to alleviate the existing controversies between the conservationist and productive sectors by bringing the interests of these two groups more close together. This might also enable a social dialogue on environmental management and livestock production which we have identified as one of the long-term goals that emerge from the proposed solutions that are formulated by stakeholders.

Follow-up research questions:

- What type of legal (or at least tolerated) mechanisms can be articulated for renting or leasing rural land to reactivate agrarian production and, at the same time, control invasive species?
- What role can play pigs and chickens as landscape managers?
- What other functions can be added (diversification) to make agrarian (including livestock) production profitable and to reactivate these lands?¹⁹
- How expensive will the required labour force be to implement these practices?
- What are the thinkable and tolerated risks that might emerge by extending the area used by pigs and chickens?

7.2. Redesign strategies concerning the poultry sector

Next we present the most promising redesign trajectories which are specific for the poultry sector, starting from the beginning: the egg (or the chicken/hen dilemma).

- a. Incubating fertilized eggs on the island itself. The current practice requires the import of one-day old and non-vaccinated chicks which are transported by airplane. A whole system has been created around this import. Producers had to pay between US\$ 0,6 and US\$ 0,9 per chick at the end of 2016 and in the summer of 2017 the price per chick reached US\$ 1,20. In 2003, 81.380 day-old broiler chicks were imported into the island of Santa Cruz to support the local broiler industry. This increased to 126.200 chicks in 2004 and 143.000 in 2005 (Soos et al., 2008). Chicks are not vaccinated to avoid the entrance of pathogens.

A redesign process in which fertilized eggs are incubated in the island has, therefore, some positive impacts. For instance, it strengthened the autonomy of the local production systems. Moreover, there is a lower risk for importing pathogens, it reduces imports of live material; it *may* also contribute to generate a better equilibrium between supply and demand, and it *may* reduce costs.²⁰

¹⁸ A chicken tractor is a mobile poultry pen without floor which might perform some of the functions of a tractor such as weeding or fertilizing.

¹⁹ For instance, in the Netherlands some farmers have started camping sites or produce energy to support farm income.

²⁰ Note that one of the claims made is that the mortality rate of imported chicks is very high when they arrive to the island. In this regard, the owner of a laying hen's production unit told us that they also import chickens, but that they do this by themselves, and that they have a very low mortality rate, which he estimated as 3 of 1.000 (personal communication, July 2016).

Two options are considered:

- Complete incubation cycle on the island (based on transport of fertilized eggs – need to be cooled below $\pm 20^{\circ}\text{C}$), either centralized or decentralized.
- Three final days of incubation in the barn before hatching (easier for farmers, more biosafety during import than with one day-old chicks, but less than with not-incubated eggs, but requires very strict transport conditions (T, RH) and timing, just as day old chicks.

Worldwide there are many suppliers of the required incubation and hatching technologies. Among the largest suppliers of incubators and hatchers are, for instance:

- Jamesway www.jamesway.com
- Pas Reform www.pasreform.com
- Emka www.emka-incubators.com
- Hatchtech www.hatchtech.nl
- Petersime www.petersime.com

Alternatively, and probably more relevant/adequate technology for the relative small-scale local production of Santa Cruz is the so called *medium-size incubators* (Vroegindewey, personal communication, February 2017). According to the local estimations, in Santa Cruz there is a weekly demand of 8.000 chickens' (personal communication, 2016) and an estimated monthly demand of approx. 30.000 to up to 35.000 chickens (personal communication, 2016).

Considering this local demand and knowing that there are economic and efficient medium-size incubators (that can automatically incubate from about 500 to up to 8.000, or more eggs) a system of, at least, two independent hatchery companies could be organized, that will be able to supply the local producers with chicks (or fertilized eggs). The idea of organizing at least two independent hatchery companies is related to competition, price, and quality issues as well as to avoid supply problems if something wrong occurs.

A hatchery company is a specialized type of business that currently does not exist in the island. This strengthens the complexity and autonomy of the local production chain and enriches the biodiversity of local businesses but, moreover, it also requires entrepreneurs who want to learn the business and can make the required investments (Leenstra, personal communication, January 2017).

Concerning broiler production, this will be the end of the dependency of imported one-day old chicks, which is experienced by all the stakeholders as problematic for different reasons. Poultry farmers argue that this is because of economic reasons, and as far as for the institutions is concerned, mainly because of biosecurity issues. But one could also argue that this is also relevant for the autonomy and 'self-sufficiency long-term goal'.

A related strategy might be to organize broiler-breeder production units. A breeder can produce around 140 chicks per year. Therefore, to meet the current demand of approximately 400.000 chickens per year you roughly need 2.857 breeders in Santa Cruz. However, this is a difficult business which requires specialized activities and labour. Moreover, fertilized eggs fly all over the world making it easier to *choose for 'importing' fertilizer eggs rather than establishing complete farming units for broiler-breeders*.

- b. Reconsidering the current ban on vaccination: Healthy animals are the basis for healthy livestock production systems which might also contribute to healthy ecosystems. Vaccines are worldwide seen as efficient and cheap alternatives to medication. However, due to the careful policies regarding wild species they are currently banned in the Galápagos for livestock production systems.

Nevertheless, specific types of vaccination (animal specific, inactivated vaccine) might actually reduce the risks of pathogen transmission to wild populations. The current ban is also a cause of illegal, uncontrolled import and practices (particularly for dogs). Moreover, it makes also the broiler poultry sector dependent on the import of (non-vaccinated) one-day old chicks. Also it makes it, in a way, dependent on the use of antibiotics on the farm.

The issue of vaccines in the island is, for the poultry sector, an important research question which we have not been able to properly address within the scope of this research.

No matter how, it seems that inactivated or killed vaccines are safe to the ecosystems. Yet, because the immune system reacts in a weaker way to inactivated than to activated viruses more treatments are required than in the case of live vaccines or attenuated vaccines. Therefore, inactivated vaccines might be too slow for (the fast growth of) broilers and, to a certain extent, inappropriate and impractical to the egg production sector as producers might have to treat laying hens several times within their productive life (Leenstra, personal communication, February 2017).

The systematic vaccination of backyard chickens could also have an impact on the health situation of these animals and reduce economic loss at the same time. These could offset the costs for the vaccines themselves and the related labour. The question whether and what type of vaccines are the most effective and appropriate for the local (open) livestock production systems is a relevant one that ought to be addressed by the institutions that are responsible for livestock health issues – and, importantly, also by the institutions that are responsible for public health.

c. (Re-)organization of chicken production for guaranteeing the economic sustainability of the sector.

Because of economic reasons, farmers currently have a continuous production system consisting of 2 or 3 pens with different ages per pen to allow for a constant supply of meat to the local market. This also means a regular cash flow. However, due to the collective overproduction the products are sold at low prices.

To avoid this, the collective supply has to be better tuned to the local demand. This requires either cooperative work by all or most of the poultry farmers on Santa Cruz, or governmental intervention by the introduction of production quota. In the first case, the currently disorganized sector has to organize itself. Organized sectors are among the long-term goals defined by stakeholders.²¹ In the second case, the sector has to be structured by the government. In both cases governmental institutions have to be involved to enable cooperation while at the same time preventing unfair pricing due to cartel formation. This requires specific and dynamic policy making and implementation (i.e., science-policy and knowledge-practice interfaces).

d. Some redesign strategies ought to be targeted at the optimization of current pens. We've seen well-managed pens (for instance, with a density of about 10 chickens/m²) that nevertheless have open spaces between the roof and the wire netting that allow finches to come in and feed on the poultry feed. New/improved functions of the barns should be aimed at (truly) keeping away rodents and other wild animals, a good warming system for the first days of the chicks at the farm, and improve the quality of the water that is given to the chickens, especially during the dry season.

e. Optimize manure management. A single chicken can produce 4 kg manure during its productive life. Some large scale producers apply a simple drying method (under the sun or, in case of one large scale laying hen producer, into a greenhouse built with sticks and plastics) before using it in arable or fruit production. Some (mainly small-scale) producers lack these drying facilities, as well as the know-how. We expect, however, that manure can be extracted out of the pens in a relatively dry state during the dry season due to the high temperatures, and that it can then be directly used for fertilizing purposes. In the wet season, however, *hot composting bins* could be used for storing and composting this manure. A related question is the pathogenicity of litter/manure. Adequate composting processes may reach temperatures between 55 and 70 °C (Ritz & Worley, 2015) which will destroy the majority of germs.

Other possible use of chicken manure is, for instance, as feed in aquaculture. Chicken manure can be put into fish ponds, where some of it is eaten directly by the fish, and the rest taken up by water plants, which in turn are eaten by the fish. Additionally, Van Eekeren et al. (2006) report that dried chicken manure is fed to cattle or goats in many countries, e.g. in a mixture with grains and molasses. For this, the argument goes, the manure must be relatively fresh, and 'must be dried quickly so that it keeps as many of its nutrients as possible' (ibid.). Although, this is not a common practice, gas can be made from this manure, using a biogas digester. The slurry which is

²¹ Interestingly, and as aforementioned, an attempt to organize this sector emerged after the focus group that we facilitated (June 2016) and in which 12 producers participated in an open and constructive dialogue.

then left over is still a very good fertiliser for use on the land and in fish ponds' (Van Eekeren, Maas, Saatkamp, & Vershuur, 2006). The main problem of anaerobic digestion of poultry manure is that chickens don't have an independent urinary system because of which the solids percentage is too high for a fluid-based digester.

The quality of this manure suggests a usage in agriculture rather than in aquaculture. This because the rich ocean and coastal ecosystems surrounding Santa Cruz and the large amount of families that earn their wages through traditional fishing practices might advise against this (aquaculture) practice. However a possible overexploitation of the marine resources (see, e.g., Castrejon & Charles 2013; Usseglio et al. 2016) might be an argument to shift to aquaculture on the island instead of fishing, in order to alleviate the pressure on ocean and coastal ecosystems.

- f. Upgrading the creole production. Backyard production of creole chicken is a cheap way for families to generate additional income without much effort – scratching in the yard costs nothing. However, the semi-creole production systems is thinkable, in which better control for the sake of biosecurity and more efficient food conversion is attained, while at the same time, the cultural and culinary aspects of the current creole production are maintained. This will involve at least a genetic screening and breeding program to find out which lines of the current so-called creole breeds are the most appropriate for the local demand including – importantly – the tourism sector. Genetic requirements and breeding goals might include a high level of adaptation to local climatologic conditions, the capacity to consume locally produced food and food waste, next to feed conversion, robustness and taste. In this way an already highly valued product (at least by the local population) could be produced which might be also antibiotic-free and attractive for the tourism sector as well.

This type of creole production can be done on existing farms, but could also be an element of the more general redesign strategy regarding rural land restoration by the revalorization of abandoned land (see, 7.1).

Finally, the slaughtering process and handling of slaughter waste needs to be considered. This applies to pork as well. Slaughtering is currently done on the farm and remains are dumped in relatively badly managed pits, or just thrown away. Moreover, they might be brought also to the central landfill at KM27, or dumped halfway, under bridges over waterways. This produces risks for the public health and biodiversity.

This does not necessarily imply a centralized slaughtering system. Slaughter waste and dead birds could be easily handled properly on the farm (see, e.g., Ritz & Worley, 2015). Even stronger, if the current on farm slaughtering practice is further optimized, this might produce less risks for the local ecosystems and public health than moving around living animals to the slaughter house.

7.3. Redesign strategies for the pig production systems

- a. The genetic diversity of pigs on the island is limited. There seems to be an informal interchange of boars between farms on the island, but without genetic influx from outside, there is a real risk of inbreeding and consequently negative side effects on animal health and/or production results. A possible strategy in this regard could be the organization of a structured breeding system that not only relies on a more systematic exchange of boars between farms but is supplemented by controlled genetic influx via artificial insemination (AI) of sperm from abroad. AI is required since the import of boars is forbidden and contradicts the expectations of the conservationist sectors. A related issue is the breeding of lines which might be adapted to the local (e.g., weather) and changing conditions. This strategy require a certain degree of coordination and organization among farmers and institutions as well as the required technical/scientific knowledge and practices concerning, for instance, insemination.
- b. Redesign of the water management system at the production unit. The water usage for cleaning current pens is quite high. Water is also needed for preparing the (wet) lavaza. Water is scarce (especially fresh water) and transport is expensive. Mostly brackish water is used for cleaning purposes. MAG transports water for free but they just have one truck, so the distribution capacity is limited. Two possible and related redesign options are to reduce the use of water in the pens

and to improve the storage of water in the production units.

- c. Integral redesign of housing systems for pigs. For several reasons current housing systems for pigs used on the island can be improved considerably. This has to be done in close connection to some of the other redesign options mentioned here, especially the redesign of lavaza feeding, manure management, and water management. This should be a redesign that is also economically feasible at the small-scale of most of current pig farmers. Animal welfare and health could be improved further (for instance, in terms of functional areas for play, and thermal differentiation - esp. cooling), although current practices already comply with standards that are seen and marketed as animal welfare friendly in Europe, like the lack of tail docking, low stocking densities, and overall good air quality due to barns that are completely open sideways.
- d. Self-slaughtering of pigs and subsequent boning and partitioning is done on farm in facilities that do not meet the strict European hygienic standards, but they are being controlled regularly by the ABG. This practice is, or at least can be, an important way for farmers to differentiate on quality and cash a higher part of the margins on meat. The planned central slaughterhouse, probably, together with centralized processing facilities will undermine this unique feature, that makes current pig and poultry farms economically more robust. Improvements in self-slaughtering are thinkable, both in terms of hygiene and labour safety/conditions. For so doing a close collaboration between producers and the institutions is required.
- e. Collective organization of transport (applies also to poultry production). Transport between the production units in the highlands and other villages and, especially, Puerto Ayora is a major bottle neck for production. Farmers depend on it for their inputs and for the delivery of products. Generally, it is expensive, because there is a *de facto* oligopoly on private transport like taxi's due to the server restrictions on car imports. It is inefficient, since every farmer arranges for his or her own transport. As aforementioned, one pig producer, for example, used to pay (July 2016) US\$ 35 each day just for transporting 6-10 crates of restaurant waste to his farm – in addition to the labour cost of his employee who goes with the taxi to collect the waste. Moreover, the costs for concentrates (between US\$ 35 and 40 for a sack of 40 kg) and other inputs increase due to transport expenses. Furthermore, although brackish water is, in principle, free (one can collect it at Puerto Ayora) farmers, as aforementioned have to pay the transportation costs. An alternative could be a cooperative transportation system, in order to reduce costs and increase the efficiency of logistics. Of course, this would go against the interest of the current group of companies controlling transportation. Therefore, local institutions have to play a role in the establishment of such an alternative and the accompanying legal issues, and help to deal with the expected opposition.
- f. Redesign of the system for processing organic waste for feed: Lavaza (i.e., the organic waste that is produced by the tourism sector and the local households and which is used to feed pigs) is an important feed resource that limits the need for import of feed, and contributes to food sovereignty and waste reduction. There are a number of drawbacks and risks in the current implementation of this practice however. This redesign option seeks to retain the benefits and to reduce the risks by centralizing and standardizing the processing of food waste before feeding them to pigs (or poultry).
In principle, this is an interesting process that helps closing nutrient cycles and creates high quality human edible proteins (e.g., pork meat) on the basis of waste. However, 'lavaza' has a negative image, even among pig producers. All the farmers with whom we have spoken argued that if they would have the economic resources they will use concentrates. 'Lavaza' is usually framed as something dirty. The outbreak of classical swine fever in Santa Cruz in 1999 might have helped forming this bad image. Moreover, it is said by many stakeholders that pig producers usually do not separate the organic from the inorganic (e.g., plastic) stuff. Furthermore, although some pig farmers might properly process the collected organic waste, others don't seem to, or straightforwardly say that they don't cook this waste before giving it to the pigs. Furthermore, the generalized use of waste within the pig production is seen as a food source for rats. Finally, the use of Lavaza in current housing systems requires a lot of water and labour for processing, and for cleaning the feed area.

The centralized processing unit suggested could also dehydrate the product before distribution, in order to increase its shelf life and reduce transportation costs, but this would on the other hand also cost a considerable amount of energy for drying, and a subsequent increase in on-farm water demand. On the other hand, if the product is not dried, transportation logistics are much more critical, since it can be stored only a very limited time before feeding.

A sensitive issue that nonetheless could be considered is the usage of slaughter waste as feed ingredient for pigs and poultry. Leftovers are currently just thrown away or in badly managed holes into the ground. Recycling animal waste as protein in feed for pigs and broilers is controversial and currently forbidden in (at least) Europe after the BSE-crisis in the 90s. The number of voices advocating a revision of this policy because of ecological and economic reasons is increasing, however. Zu Ermgassen and colleagues (2016) report that centralized systems in some East Asian states where regulated and have been introduced 'for safely recycling food waste into animal feed.' Subsequently, they made the claim that a revision of the EU policy and by applying 'existing technologies could reduce the land use of EU pork (which is 20% of the world production) by one fifth, potentially saving 1,8 million hectares of agricultural land' (ibid.).

In the Galapagos context, the risks are probably lower as long as no highly contagious diseases like Classical Swine Fever or Foot and Mouth Disease are introduced to the island. As an extra provision chickens leftovers should be given to pigs only and vice versa. Given the current practice, this is probably much easier to apply in pig farming.

In Santa Cruz, one could think of a central processing unit, where waste can be hygienised before being reused. This could be combined with the processing facility for organic waste outlined in the preceding point G. Of course, this trajectory requires strict sanitary controls to avoid contaminations that damage public health (e.g. salmonella).

Important related issues are: (0) an analysis of the total organic waste production in the island to estimate the system capacity to feed livestock (1) due to water scarcity it is important to consider whether the final processed product should be a dry matter substance, vs. wet matter. (2) The organization of the logistics (see redesign strategy F) to gather the waste that is produced by restaurants and household and for supplying the final product to the farms. The challenges of high temperatures in a subtropical region and the current scarcity of transport have to be considered.

Follow-up research questions:

- How to organize a swill processing unit that safeguards public and animal health?
- What lessons can we learned from the Dutch context regarding 'brijvoeding' (wet feeding)?
- Dry vs. wet matter within the climatological conditions of Santa Cruz.
- Which type of transport system can facilitate the whole process?
- In which way and what structural appointments can be made with households and restaurants to guarantee continuous supply of organic waste? How large is this supply?
- Which rodent control strategies are available?

- g. Redesign of manure management. Most current pens are largely closed concrete floors, with one hole to the manure removal system. This requires a lot of water (and a lot of labour) to flush the pens daily (see water management here above, B – most probably a water management system ought to be co-designed with a manure management system). Manure/urine are mixed and transported to a septic tank with an overflow.

In a septic tank the solid part sinks, the liquid part flows over in a second tank and is absorbed by the soil. Minerals will probably largely end in an aquifer and be transported to the water sources of the island, or to the sea. Solid parts

in the septic tank will decompose in an anaerobic process, releasing minerals to the liquid above. Emissions of methane, ammonia and hydrogen sulfide are common. The remaining solid fraction is probably not pathogen free.

In the context of a redesign of the housing system itself (see C.) a better manure removal systems can be designed, to reduce water use and labour input and improve the possibilities for responsible processing and application of remaining minerals and organic matter.

Responsible manure processing can be done in several ways:

- Digesters. Some of the positive effects of this strategy is that through an anaerobic digestion, organic waste is partly converted into biogas that can be used for cooking or other activities. The remaining part can be used as organic fertilizer on the land. There are different types of digesters but the so-called low-cost low-tech digesters (see, e.g. Herrero 2011)²² seem appropriate as they do not require constant power supply and are not labour intensive. Note that approx. 20 L of fresh manure each day (a couple of cows or, 6-7 pigs) is required. Yet some issues have to be considered before applying this technology. For instance, a constant water supply is required to feed the digester. Moreover, small scale digesters currently applied (e.g., in India) have considerable methane loss ($\pm 20\%$), although the currently used septic tanks might have even higher methane emissions.
- Composting is a low tech alternative, yet requires knowledge and maintenance as well to get a good aeration ($\rightarrow$ higher temperatures, less risk of emissions of N_2O and CH_4). The cost of composting are low however. One of the options is the *windrow composting technique*, in which compost is produced by mixing organic matter or biodegradable waste in long rows (windrows). This method is traditionally used for a large-scale production of compost, and thus centralization and mechanization practices might be required. An small-scale alternative is the *hot composting bins* (see, poultry redesign option E).
- Slurry tanker. A tanker (MAG, or collective) could be introduced for collecting the liquid manure and go to arable land for applying it. This can only take place shortly before and in the rainy season (when crops can utilize the manure nutrients).

Urine or the liquid manure could be used for fruit trees, coffee, etc. as water diluted fraction (maybe also in the dry season) (De Buissonje, personal communication, January 2017). More research and dialogue with producers might be required, however, to make decisions regarding which method is the most appropriate for each production unit or sectors.

To improve manure management you have to find ways to connect (intensive) livestock production with crop cultivation. In the Netherlands or in the USA, for instance, it is mandatory to have a manure management plan. You could organize such a plan to enforce and facilitate that livestock producers distribute their manure to arable land and fruit plantations on the island. So if you want to start a production unit (i.e., a condition for starting a production unit) you first have to arrange a (manure)link/agreement with one of several arable/fruit farmers or demonstrate that you can use your manure on your own land.

Before you are able to organize such a plan you have to find out how much manure can the available surface of agricultural land managed (of is required by).

For example, in the Netherlands, you can apply a maximum of 100 Kg phosphate (P_2O_5) per hectare. This means that you are allowed to raise 25 'pig places' per year (approx. 50 pigs with a phosphate excretion of 4 kg per pig place per year of fattening pigs per ha per year).

Moreover, one fattening pig (place) produces around 1 m³ of slurry (the liquid mixture of faeces + urine) per year. Therefore, 2.000 pig places produce 2.000 m³ manure which can be used for 80 hectares.

This means 25 fattening pig places per 1 ha. These figures are for fast growing pigs in The Netherlands; for the slower growing local race pigs on Santa Cruz, an estimated slurry production of 0,5 m³ per pig place per year might be more realistic. This would mean that the slurry of 50 pig places can be applied on one hectare of land in Santa Cruz.

It is estimated that Santa Cruz has 11.441 ha which are available for agrarian production; therefore, if we deny the existence of other animals such as cattle and chickens, we might, hypothetically, conclude that the rural areas of Santa Cruz have a capacity to maintain 570.000 fattening pig places per year – Think thereby that, for instance, 3.000 cows are able to provide

²² <http://redbiolac.org/biodigestores/> (accessed, July 2017).

1.500 has with the required manure (and that it was estimated that, in 2014, the cattle population was around 6.740)

Let's have a look at one of the production units of Santa Cruz, where in 2016 we found 15 fattening pigs, 4 sows (one of which had 10 piglets, see cover photo), and two 2 boars. If we consider the Dutch excretion standards, this means that these pigs produce:

1 sow + piglets = 2 m³ per 7 months

3 sows + 2 boars = 3,6 + 2,6 = 6,2 m³ per 7 months

15 fattening pigs = 10,56 m³ per 7 months

18,85 m³ per 7 months.

This means that each 7 months he needs 0,75 hectares, i.e. according to the Dutch standards.

We could then divide this by two because of the slow growth/feed intake in Santa Cruz (De Buissonje, personal communication, January 2017). Meaning an excretion of 9,42 m³ manure per 7 months and that this farmer needs 0,37 ha arable land (or grassland, fruit trees, etc.) to manage his production of pig-manure.

Note, however, that the total number of animals in Santa Cruz is relatively low and that the redesign of the pens, waste processing and manure management ought to be enough for triggering sustainable production systems.

The articulation of a healthy relationship between the local livestock production systems and ecosystems is a challenging task. We have defined some strategies that help this process forward. Improving the way in which manure is managed, for instance, can be seen as one of the conditions to define a local specific form of biosecurity and to implement healthy livestock production and ecosystems.

8. Following the RIO-current. Drafting the contours of the follow-up phases of the redesign process

This closing section briefly elaborates the contours of the follow-up phases of the redesign process of the pig and poultry production systems of Santa Cruz. We do this by following the methodological approach of the Reflexive Interactive Design. Note, however, that these follow-up steps are not yet funded and that, therefore, at the time of writing it is unclear whether we will be able to facilitate this process. Nevertheless, and due to the positive reception of our proposals by the different local stakeholders (see Section 2.3.2) we believe that a number of the ideas are already gaining terrain on the island, with or without a follow-up project.

Note, moreover, that in this section we play with the acronym of our participatory approach RIO which in Spanish literally means river.

8.1. The RIO current

Currently, we are canoeing into RIO's second phase, i.e., the structured design. The main challenge posed by the RIO approach is to transform structures by designing innovations that can be integrated within existing livestock socio-techno-ecological systems. In this report, we have defined the needs and most relevant problems that are experienced by stakeholders as well as the short- and long-term goals. Moreover, on the basis of this and together with the system analysis we have proposed a set of redesign strategies. The follow-up steps to collectively develop and implement these strategies are:

- Selection of the most promising (combinations of) redesign strategies for further (interactive) development. The list of redesign strategies is not meant as an all-or-nothing package, but gives a range of options that –if further developed– could meaningfully contribute to the attainment of collective and private goals on the island. Given scarcity of resources and funding, a selection should be made of those redesign strategies that combine the highest possible impact with a certain degree of anchoring (i.e. connection of the idea to networks, technology or institutions).
- Depending on the character of the redesign strategy, elements of the structured design cycle of RIO are emphasized. Sometimes, even a further system analysis has to be performed before structured design can take place meaningfully. RIO is an interactive design process. Most of the elements in the structured design cycle take place together with stakeholders, in order to stimulate learning and increase anchoring. Research, experimentation and interaction alternate in an iterative fashion (see section 2.1).
- Development a brief of requirements (BoR) from the perspectives of the different stakeholders involved. The needs and goals of stakeholders are translated into quantified requirements. These requirements are defined independently from the possible solutions. This results in a wider range of solutions available in the redesign process (Bos, Groot Koerkamp, et al., 2009).
- Definition and selection of functions that are key to the (sub) system. RIO is a structured and structuring approach and it is inspired by the industrial design; therefore, the rearrangement and transformation of functions within a system is key. A function is defined as a verb plus a noun, for example, 'produce meat,' 'manage manure,' etc. By analysing the different functions that have to be performed within a system we are able to identify the current bottlenecks and design new functions or rearrange the currently performed functions for enabling an appropriate functioning of the system. For instance, in the rural-land restoration redesign strategy (see Section 7.1) we believe that by allowing animals to perform other functions (beyond 'produce food') such as 'control invasive species' the acceptance and performance of livestock production systems can be improved.

- In a morphological function diagram different solutions or strategies are visualized for conducting the selected functions. There are many thinkable and feasible ways to, e.g., remove manure. Morphological diagrams help to evaluate the different options and make choices regarding the best combination of solutions for a combination of functions. The choices once again, will be made in a participatory fashion.
- The different options and choices are combined and a number of design concepts or drafts of new systems are proposed. This can be done by combining new functions or introducing single innovative functions/solutions within an existing system.
- A detailed proposal(s) is elaborated in which technical and societal aspects are integrated and collectively evaluated against the brief of requirements.
- Finally, or at any moment of the process, the concepts usually become mature enough and stakeholders are ready for implementation, meaning that pilots and actions will be conducted in practice.

The third (fourth) phase is the anchoring phase. It is aimed at integrating innovation and enable change within the practice of production systems. Moreover, it is aimed at institutionalizing and integrating the process of change in the broad social field (political institutions, consumer and market systems) as well as in the local ecosystems. We believe that the proposed redesign strategies and alliances started are currently forming a calm water environment in which to anchor sustainable livestock production practices.

8.2. Definition of business models and expected (science and technology) impacts

The science-policy/knowledge-practice interface initiated by the WUR and MAG with the financial support and sustainability criteria of Galapagos Conservancy has the potency to get an impact on the structures and practices of the livestock production systems. Moreover it enriches the understanding of (and improves) the complex interactions of production and conservation in the fascinating context of the Galápagos islands.

The proposed redesign strategies (Section 7) will facilitate the development of a sustainable relationship between the local ecosystems and the livestock production systems. However, and to reach socioeconomic sustainability, the redesigned production systems ought to achieve also an added value in the services they provide and within the local markets.

For example, and regarding the services delivered by livestock we aim to generate (social) added value by incorporating other functions to pigs and chickens (the polipotency of animals), such as landscape managers and controllers of invasive species (see, Section 7.1). Moreover, the manure management plan might also improve the productivity of the agrarian systems.

Several redesign proposals concern all types of livestock production systems (e.g., manure management) and hopefully will be developed and implemented across the board. As aforementioned it is not our intention to homogenize the local production systems. Diversity might help in creating added value, moreover, is also required to compete with the standard production systems. Most probably, the local production systems will be redesigned in such a way that the local products and services delivered by the two sectors involved (i.e., pigs and poultry) will be attractive for the tourism industry. The semi-creole chicken that will emerge from the genetic breeding program (see, Section 7.3), for instance, are characterized because of their native origin and, therefore, because they are adapted to the local climatologic conditions, because of their capacity to consume locally (waste and weeds...) produced food, or their taste. In this way a highly valued (in principle, by the local population) product like the creole chicken could be produced which might be also antibiotic-free and attractive for the tourists that visit the island. As aforementioned we have already developed some contacts with local restaurants and hotels and validated the idea of commercializing this local specific products (it might apply also to local pork). Moreover, conversations have been initiated to link this RIO redesign challenge with the tourist boat National Geographic Endeavour II which is one of the most renowned boats in the archipelago.

To conclude, the development and implementation of the proposed redesign strategies together with the development of appropriate business models might facilitate the anchoring of the locally adapted livestock production systems to the socio-ecologic systems of the Galápagos Islands.

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References

- Alexandre, G., Fanchone, A., Ozier-Lafontaine, H., & Diman, J.-L. (2014). Livestock Farming Systems and Agroecology in the Tropics. In H. Ozier-Lafontaine & L.-J. M. (Eds.), *Agroecology and Global Change* (Vol. 14, pp. 83-116): Springer.
- Alteri, M. A. (2002). Convergence or Divide in the Movement for Sustainable and Just Agriculture. In E. Lichtfouse (Ed.), *Organic Fertilisation, Soil Quality and Human Health*: Springer Science+Business Media B.V.
- Alteri, M. A., & Nicholls, C. I. (2012). Agroecology Scaling Up for Food Sovereignty and Resiliency. In E. Lichtfouse (Ed.), *Sustainable Agriculture Reviews*: Springer Science+Business Media Dordrecht.
- Beck, U., Giddens, A., & Scott, L. (1994). Stanford, California: Stanford University Press.
- Benitez-Capistros, F., Hugé, J., & Koedam, N. (2014). Environmental impacts on the Galapagos Islands: Identification of interactions, perceptions and steps ahead. *Ecological Indicators*, 38, 113-123. doi: <http://dx.doi.org/10.1016/j.ecolind.2013.10.019>.
- Bos, A. P., & Groot Koerkamp, P. W. G. (2009). Synthesizing needs in system innovation through methodical design. A methodical outline on the role of needs in Reflexive Interactive Design (RIO). In K. J. Poppe, C. Termeer, & M. Slingerland (Eds.), *Transitions towards sustainable agriculture, food chains and peri-urban areas* (pp. 219-237). Wageningen: Wageningen Academic Publishers.
- Bos, A. P., Groot Koerkamp, P. W. G., Gosselink, J. M. J., & Bokma, S. (2009). Reflexive interactive design and its application in a project on sustainable dairy husbandry systems. *Outlook on Agriculture*, 38(2), 137-145.
- Brewington, L. (2011). *The Politics of Invasion: Defining and Defending the Natural, Native and Legal in the Galápagos Islands of Ecuador*. (PhD), University of North Carolina, Chapel Hill.
- Carrion, V., Donlan, C. J., Campbell, K. J., Lavoie, C., & Cruz, F. (2011). Archipelago-Wide Island Restoration in the Galápagos Islands: Reducing Costs of Invasive Mammal Eradication Programs and Reinvasion Risk. *PLoS ONE*, 6(5), e18835. doi: 10.1371/journal.pone.0018835.
- Castrejón, M., & Charles, A. (2013). Improving fisheries co-management through ecosystem-based spatial management: The Galapagos Marine Reserve. *Marine Policy*, 38, 235-245. Doi: 10.1016/j.marpol.2012.05.040.
- CEPROEC, IAEN, & SNPYD. (2014). Diagnóstico y análisis biofísico para evaluación y formulación de escenarios de desarrollo en el Archipiélago de Galápagos: Informe Ejecutivo. Quito: Centro de Prospectiva Estratégica /Instituto de Altos Estudios Nacionales/ Secretaria Nacional de Planificación y Desarrollo.
- CEPROEC, & SNPYD. (2014). Diagnóstico y análisis biofísico de Galápagos. Quito: Centro de Prospectiva Estratégica / Secretaria Nacional de Planificación y Desarrollo.
- CGREG. (2014). Censo de Unidades de Producción Agropecuaria de Galápagos 2014: Consejo de Gobierno del Régimen Especial de Galápagos (CGREG).
- Cherrett, I. (2010). Informe de la visita del representante de FAO en Ecuador a la provincia de Galápagos: 19 as 24 de abril del 2010: Food and Agriculture Organization of the United Nations.
- Chiriboga, R., Maignan, S., & Fonseca, B. (2006). Caracterización de los sistemas de producción en Galápagos en relación con el fenómeno de las Especies Invasoras *Proyecto ECU/00/G31 "Especies invasoras de las Galápagos"; "Desarrollo de políticas y estrategias de manejo del sector Agropecuario y su relación con las especies introducidas en la Provincia de Galápagos"* (Vol. 2, pp. 101): Programa de las Naciones Unidas para el Desarrollo (UNDP), Servicio Parque Nacional Galápagos (SPNG), Instituto Nacional Galápagos (INGALA), Servicio Ecuatoriano de Sanidad Agropecuaria-Galápagos (SESA-Galápagos), y Fundación Charles Darwin (FCD).
- Colautti, R. I., & MacIsaac, H. J. (2004). A neutral terminology to define 'invasive' species. *Diversity and Distributions*, 10, 135-141. doi: 10.1111/j.1366-9516.2004.00061.x.
- Cross, N. (2008). *Engineering Design Methods: Strategies for Product Design* (fourth edition). Chichester: John Wiley and Sons Ltd.
- Cruz, F., Josh Donlan, C., Campbell, K., & Carrion, V. (2005). Conservation action in the Galápagos: feral pig (*Sus scrofa*) eradication from Santiago Island. *Biological Conservation*, 121, 473-478. doi: 10.1016/j.biocon.2004.05.018
- De Cock Buning, J. T., Regeer, B. J., & Bunders-Aelen, J. G. F. (2008). *Biotechnology and food – Towards a societal agenda in 10 steps*. The Hague, Netherlands: RNN.

- Deem, S. L., Cruz, M. B., Higashiguchi, J. M., & Parker, P. G. (2010). Diseases of poultry and endemic birds in Galapagos: implications for the reintroduction of native species. *Animal Conservation*, 15, 73-82. doi: 10.1111/j.1469-1795.2011.00489.x.
- Denzin, N. (1984). *The research act*. Englewood Cliffs, NJ: Prentice Hall.
- Elzen, B., & Bos, B. (2016). The RIO approach: Design and anchoring of sustainable animal husbandry systems. *Technological Forecasting and Social Change*. doi: <http://dx.doi.org/10.1016/j.techfore.2016.05.023>.
- Epler, B., & Proaño, M. E. (2007). *How many tourists can Galapagos accomodate?* in, Galapagos Report 2006–2007 (pp. 36-41): CDF, GNP, and INGALA.
- Ermgassen zu, E.K.H.J., Phalan, B., Green, R. E., & Balmford, A. (2016). Reducing the land use of EU pork production: where there's swill, there's a way. *Food Policy*, 58, 35-48. doi: <http://doi.org/10.1016/j.foodpol.2015.11.001>.
- González, J. A., Montes, C., Rodríguez, J., & Tapia, W. (2008). Rethinking the Galapagos Islands as a Complex Social-Ecological System: Implications for Conservation and Management. *Ecology & Society*, 13(2), 13.
- Gottdenker, N. L., Walsh, T., Vargas, H., Merkel, J., Jiménez, G. U., Miller, R. E., Dailey, M., & Parker, P. G. (2005). Assessing the risks of introduced chickens and their pathogens to native birds in the Galápagos Archipelago. *Biological Conservation*, 126, 429–439. doi: 10.1016/j.biocon.2005.06.025.
- Graham, J. P., Leibler, J. H., Price, L. B., Otte, J. M., Pfeiffer, D. U., Tiensin, T., & Silbergeld, E. K. (2008). The Animal-Human Interface and Infectious Disease in Industrial Food Animal Production: Rethinking Biosecurity and Biocontainment. *Public Health Reports*, 123(3), 282–299. doi: 10.1177/003335490812300309.
- Groot Koerkamp, P. W. G., & Bos, A. P. (2008). Designing complex and sustainable agricultural production systems; an integrated and reflexive approach for the case of table egg production in the Netherlands. *NJAS - Wageningen journal of life sciences*, 55, 113-138.
- Guzmán, J. C., & Poma, J. E. (2015). Bioagriculture: An opportunity for island good living. In G. GNPD, CDF, and GC (Ed.), *Galapagos Report 2013-2014* (pp. 25-29). Puerto Ayora, Galapagos, Ecuador.
- Meyer, J. Y. (2014). Critical issues and new challenges for research and management of invasive plants in the Pacific Islands. *Pacific Conservation Biology*, 20(2), 146-164. doi: 10.1071/PC140146.
- Phillips, R. B., Cooke, B. D., Carrion, V., & Snell, H. L. (2012). Eradication of rock pigeons, *Columba livia*, from the Galápagos Islands. *Biological Conservation*, 147, 264-269. doi: 10.1016/j.biocon.2012.01.013.
- Puente-Rodríguez, D. (2014). The Methodologies of Empowerment? A Systematic Review of the Deployment of Participation in the Coastal Zone Management Literature. *Coastal Management*, 42(5), 426-446. doi: 10.1080/08920753.2014.942029.
- Puente-Rodríguez, D., Giebels, D., & De Jonge, V. N. (2015). Strengthening coastal zone management in the Wadden Sea by applying 'knowledge-practice interfaces'. *Ocean & Coastal management*, 108, 27-38. doi: <http://dx.doi.org/10.1016/j.ocecoaman.2014.05.017>.
- Restrepo, A., Colinviaux, P., Bush, M., Correa-Metrio, A., Conroy, J., Gardener, M. R., Jaramillo, P., Steinitz-Kannan, M., Overpeck, J. (2012). Impacts of climate variability and human colonization on the vegetation of the Galápagos Islands. *Ecology*, 93(8), 1853-1866.
- Ritz, C. W., & Worley, J. W. (2015). *Poultry Mortality Composting Management Guide*: University of Georgia Cooperative Extension.
- Rogers, E. M. (1962). *Diffusion of innovations*. New York: Free Press of Glencoe.
- Rotmans, J., & Loorbach, D. (2007). Transition Management: Reflexive steering of societal complexity through searching, learning and experimenting. In J. v. d. Bergh & F. R. Bruinsma (Eds.), *The transition to renewable energy: Theory and practice*. Cheltenham, UK: Edward Elgar.
- Schön, D. A. (1983). *The reflective practitioner; how professionals think in action*. New York, USA: Basic Books.
- Schot, J., & Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, 20(5), 537–554. doi: 10.1080/09537320802292651.
- Siers, F. J. (2004). *Methodisch ontwerpen: Volgens H.H. van den Kroonenberg* (Third edition ed.). Groningen/Houten, The Netherlands: Noordhoff Uitgevers.
- Soos, C., Padilla, A., Iglesias, A., Gottdenker, N., Cruz Bédon, M., Rios, A., & Parker, P. G. (2008). Comparison of Pathogens in Broiler and Backyard Chickens on the Galápagos Islands: Implications for Transmission to Wildlife. *The Auk*, 125(2), 445-455. doi: <http://dx.doi.org/10.1525/auk.2008.06235>.
- Spybey, T. (1984). Frames of Meaning: the Rationality in Organisational Cultures. *Acta Sociologica*, 27(4), 311-322.
- Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, California: SAGE Publications, Inc.

-
- Trueman, M., Hobbs, R. J., & Van Niel, K. (2013). Interdisciplinary historical vegetation mapping for ecological restoration in Galapagos. *Landscape Ecology*, 28, 519-532. doi: 10.1007/s10980-013-9854-4.
- Usseglio P, Friedlander A.M., Koike H., Zimmerhackel J., Schuhbauer A., Eddy T., & Salinas-de-León P. (2016) So Long and Thanks for All the Fish: Overexploitation of the Regionally Endemic Galapagos Grouper *Mycteroperca olfax* (Jenyns, 1840). PLoS ONE 11(10): e0165167. doi:10.1371/journal.pone.0165167
- Van den Hove, S. (2007). A rationale for science-policy interfaces. *Futures*, 39(7), 807-826. doi: <http://dx.doi.org/10.1016/j.futures.2006.12.004>.
- Van Eekeren, N., Maas, A., Saatkamp, H. W., & Vershuur, M. (Fourth revised edition, 2006). Small-scale chicken production *Agrodok 4*. Wageningen, the Netherlands: Agromisa Foundation and CTA.
- Viteri Mejía, C., & Brandt, S. (2015). Managing tourism in the Galapagos Islands through price incentives: A choice experiment approach. *Ecological Economics*, 117, 1-11. doi: <http://dx.doi.org/10.1016/j.ecolecon.2015.05.014>.
- Wikelski, M., Foufopoulos, J., Vargas, H., & Snell H. (2004). Galápagos birds and diseases: Invasive pathogens as threats for island species. *Ecology and Society*, 9(1), [online] URL: <http://www.ecologyandsociety.org/vol9/iss1/art5/>.

Resumen

El Proyecto

Los sistemas de producción agropecuarios están en continua transformación debido, por ejemplo, al crecimiento de la población mundial, el cambio climático y la evolución de los hábitos culturales y alimenticios (como por ejemplo el incremento del consumo de carne) o los procesos de industrialización. Estas tendencias también están ganando terreno en las Galápagos. Esto genera unos sistemas de producción ganaderos basados en la importación de animales e insumos alimenticios, además de una dependencia en productos farmacéuticos. Algunas de las consecuencias negativas de esta tendencia son por ejemplo la posible introducción de especies invasoras o de agentes patógenos que podrían afectar a las especies autóctonas de aves; un manejo inadecuado de los residuos procedentes de los sistemas de producción, lo que anula el correcto cierre de los ciclos de nutrientes; o una débil adaptabilidad/resiliencia a las irregularidades y las fluctuaciones de precios. Esto provoca dudas

sobre la sostenibilidad y la rentabilidad a largo plazo de las unidades de producción.

En este contexto, el departamento Wageningen Livestock Research de la Universidad de Wageningen & Research en Holanda está organizando las bases necesarias para poder desarrollar un proceso de rediseño de estos sistemas de producción. Esto debe facilitar una visión interactiva de los sistemas locales de producción porcino y de aves de corral con un alto nivel de sostenibilidad desde los puntos de vista ecológico y social. Otros aspectos importantes de este proceso de rediseño son por ejemplo la soberanía alimentaria, el control de especies invasoras, bajos niveles de insumos, sistemas responsables (en lo concerniente a enfermedades y residuos), la autonomía y la agroecología. El proceso se realiza con la colaboración del Ministerio de Agricultura y Ganadería (MAGAP) y la financiación de Galápagos Conservancy.

El Proceso de rediseño – la metodología RIO.

Este proceso lo estamos desarrollando en base a las metodologías participativas RIO (Diseño Reflexivo e Interactivo) que han obtenido resultados positivos en el contexto holandés. Estas metodologías facilitan la identificación de posibles contradicciones y la definición de objetivos comunes en contextos agropecuarios.

Fig. 3. Rounded design from the "Houden van Hennen" project (left; 2004), and a commercial Rondeel-farm in Barneveld (right; since 2010).

Visual 10: Rondeel, unidad de producción de ponedoras diseñado con la metodología RIO.

En este estudio hemos (1) definido las características básicas de los sistemas de producción porcino y avícola (2) alineado los problemas experimentados por los distintos agentes sociales (3) definido los objetivos a largo plazo opuestos y compartidos de estas personas y (4) trazado las posibles estrategias para el rediseño de los sistemas de producción de chanchos, pollos y gallinas en Santa Cruz. Para ello hemos realizado un estudio de la literatura científica y llevado a cabo observaciones participativas así como una serie de entrevistas y grupos de discusión.

Tendencias

Algunas de las tendencias que hemos identificado son:

- Crecimiento de la población
- Incremento del número de turistas
- Turismo *versus* agricultura (\$\$\$\$)
- Crecimiento del sector avícola y dependencia e incremento de la importación de pollitos de un día
 - 2003: 81,380 pollitos

- 2004: 126,200
- 2005: 143,000 (Soos, 2008)

- Abandono de tierras e incremento de especies invasivas 10.735 ha en Galápagos (CEPROEC, 2014) 2.311ha en Santa Cruz (Chiriboga, 2006; Benitez-Capistros, 2014; González, 2008)
- Dependencia de la importación (tb. de alimentos)
- Los productos del agro son consumidos localmente
- Sobreexplotación de los recursos acuíferos (Benitez-Capistros, 2014; CEPROEC, 2014; González, 2008)
- Manejo inapropiado de la materia orgánica de la ganadería (abono); ciclos de nutrientes; posible contaminación
- "exceso" de producción
- Falta de organización

Divergencias y contradicciones en la definición de objetivos

- Control de sistemas abiertos
- Productos locales-importados
- Producción tecnificada sin técnicos
- Soberanía alimentaria y ecosistemas sostenibles *versus* ausencia de prácticas/políticas para el manejo apropiado del estiércol
- Organizadamente desorganizados

Objetivos comunes a largo plazo

De estas contradicciones podemos aprender y aprovecharnos para construir espacios de dialogo y objetivos comunes con los que poder trabajar

(1) Sistemas de producción sanos desde el punto de vista ecológico y socioeconómico. La producción agropecuaria es aceptada y sus productos son consumidos por la población local. Aspectos como el manejo del abono y el acceso a el sector turístico son aspectos importantes.

(2) Ecosistemas saludables. Esta es la condición básica de cualquier estrategia debido al valor intrínseco de estos sistemas y a su valor como pilar socioeconómico de las Galápagos.

(3) Una producción tecnificada. Esto es organizada en base a los principios y metodologías científicas.

(4) Un dialogo social entre agentes sociales responsables y que se respetan mutuamente.

Propuesta: Estrategias de rediseño

Las estrategias que hemos definido son propuestas, son una invitación al diálogo y la reflexión sobre las posibles maneras que se puede implementar para integrar los sistemas de producción agropecuarios de manera adecuada y sostenible en los ecosistemas y las sociedades de las islas Galápagos. A continuación presentamos un resumen de estas estrategias.

1. Recuperando las zonas rurales abandonadas

La idea de esta línea de rediseño es la restauración y revalorización de las tierras abandonadas para la producción agropecuaria, integrando la producción de chanchos, pollos y gallinas. Este trayecto puede cumplir varios objetivos.

Por ejemplo, (1) la **restauración de las zonas agrícolas abandonadas** produciendo alimentos para humanos o animales con la integración de distintos tipos de cultivos incluyendo los llamados cultivos perennes en lugar de monocultivos. De este modo se puede reducir la dependencia de la importación de insumos.

(2) Esta estrategia puede también apoyar los esfuerzos en el control de las especies invasoras que ahora se extienden libremente en las tierras abandonadas. **Corredores agroecológicos** se podrían crear entre el Parque Nacional Galápagos y las zonas rurales que funcionarían como barreras (culturales) agrarias para proteger los recursos naturales de la isla.

(3) **La introducción de animales para manejar los recursos naturales.**

Chanchos y gallinas no solo son capaces de transformar desechos y otra materia orgánica de baja calidad en carne y huevos sino que son maestros en el manejo y eliminación de hierbas y raíces y en la fertilización de suelos.

2. Incubando el cambio

En lo concerniente a los sistemas de producción de pollos y gallina criolla, algunas de las estrategias de rediseño son: (1) La **organización de un sistema para incubar huevos fertilizados en Santa Cruz**. El transporte de pollos es visto como problemático desde muchos puntos de vista. Generando los conocimientos y modelos de negocio necesarios es posible incrementar la diversidad del sistema de producción local así como frenar la posible introducción de agentes patógenos o los costos y pérdidas con la importación de pollitos.

(2) **Organización del sector(res)**. La realización de acuerdos sobre los volúmenes de producción, el transporte colectivo y los precios de venta solo son posibles desde las bases de un sector organizado.

(3) **Revalorización del sistema de producción de gallina criolla**. Sistemas de producción de gallina semi-criolla pueden ayudar a generar gallinas y pollos locales que sean también interesantes desde el punto de vista comercial y acceder por ejemplo al sector turístico como 'pollos galapeños ecológicos' (libres de antibióticos).

3. Rediseñado la producción de chanchos

(1) **Rediseñando el sistema de procesamiento de la lavaza.** La lavaza si bien es actualmente relativamente mal vista ayuda a transformar los desechos orgánicos en proteínas. La organización de una unidad(es) donde la lavaza se pueda procesar de manera adecuada puede ayudar a mejorar esta imagen así como a abolir posibles riesgos para la salud, racionalizar el consumo de agua, y el contenido de nutrientes, así como a reducir la dependencia de la importación de balanceado del continente.

(2) **Organización colectiva del transporte (incluyendo también a los sectores de pollos/gallinas).** El transporte es uno de los aspectos fundamentales para la producción agropecuaria en Santa Cruz. Es necesario para acceder a insumos (alimento, agua, etc.) y la entrega/venta de productos. Un buen sistema de transporte es una de las bases

fundamentales para la comunicación, el acceso a conocimientos y reuniones o la organización de los sectores. El transporte forma parte de uno u otro modo de la mayoría de las líneas de rediseño aquí definidas.

(3) **Manejo y aprovechamiento del estiércol (incluyendo también a los sectores de pollos/gallinas)**

15 chanchos producen aproximadamente 9 m³ de estiércol al año. Esta materia orgánica puede convertirse en una fuente de riqueza o un problema para el productor y el medio ambiente. Todo depende del manejo. Algunas de las estrategias que se pueden seguir para mejorar el manejo del estiércol son por ejemplo la introducción de biodigestores para producir biogás y fertilizantes o la optimización de los procesos para producir compost. La organización de un plan/sistema para **conectar la producción de estiércol con otras actividades agrarias** como la producción de vegetales o frutas es una condición necesaria para integrar y adaptar la producción de chanchos (gallinas/pollos etc.) en las condiciones específicas de Santa Cruz y las Islas Galápagos.

Organizaciones involucradas

Este proyecto es llevado a cabo por Wageningen Livestock Research (Wageningen University & Research) y se realiza gracias a la colaboración de la dirección provincial del Ministerio de Agricultura y Ganadería (MAG) de Ecuador y la financiación de Galápagos Conservancy.

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the potential
of nature to
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Wageningen Livestock Research creates science based solutions for a sustainable and profitable livestock sector. Together with our clients, we integrate scientific knowledge and practical experience to develop livestock concepts for future generations.

Wageningen Livestock Research is part of Wageningen University & Research. Together we work on the mission: 'To explore the potential of nature to improve the quality of life'. A staff of 6,500 and 10,000 students from over 100 countries are working worldwide in the domain of healthy food and living environment for governments and the business community-at-large. The strength of Wageningen University & Research lies in its ability to join the forces of specialised research institutes and the university. It also lies in the combined efforts of the various fields of natural and social sciences. This union of expertise leads to scientific breakthroughs that can quickly be put into practice and be incorporated into education. This is the Wageningen Approach.