New designs to facilitate a transition towards sustainable egg production

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Abstract
Modern animal-based food production faces a multiplicity of challenges in the light of sustainable development. If the sustainability issues are addressed one at a time there is a risk that new solutions will contradict each other and avert negative consequences on other sustainability aspects; people, planet, profit. To avoid this conflict, there is a need for structural change in production and consumption systems.

The goal of the *Well-Fair Eggs* project is to initiate and stimulate private initiatives towards an in all regards sustainable development of the egg production sector in the Netherlands. An integral system design methodology (called RIO; Bos et al., 2009) was followed, in which stakeholders from the egg production chain and the periphery participated through co-design. RIO originated from engineering design by van den Kroonenberg (Siers, 2004) supported by methodical and theoretical contributions from social (Mierlo et al., 2010) and innovation (Grin et al., 2004) studies. RIO takes the needs of a set of key actors as the starting point in an effort to overcome short-term interests, and scrutinizes the functions of the system (Bos & Groot Koerkamp, 2009).

The project *'Well-Fair Eggs'* resulted in two integral sustainable designs for laying hen husbandry; a single-age and a multi-age rearing and laying system. The two designs concepts show that a high level of animal welfare can be combined with a lower environmental footprint and a high product quality standard. Several innovative integrated solutions to circumvent trade-offs are suggested, as well as structural rearrangements. Examples are: 1) the separation of different functional areas for the behaviour of the laying hen, in particular a separated dust bath unit that prevents dust originating from dust and sun bathing behaviour to enter the living space, 2) a smart foraging facility for the hens, existing of tiers at various levels with long artificial grass wherein corn, grain and wheat are supplied. This allows for the animals to perform natural foraging behaviour, while at the same time preventing dust and ammonia emission at source level.

Stakeholder involvement in the design workshops did not only contribute to the integral nature, the quality and feasibility of the final designs and elements, active participation also increased ownership of and commitment to the results, and the promises therein. Currently public-private parties have started joint venture initiatives to further develop and realise the Eggsphere (single-age) concept. Other sector parties in the Netherlands are willing to realise parts of the design and the key-innovations herein.

Keywords: reflexive interactive design (integral bio-systems design); system innovation; sustainable development, egg production

1. Introduction

In this 21st century the world community is confronted with numerous challenges around agriculture and food production. Since World War II agricultural modernization has been guided by a production-paradigm of efficiency, being increasing production volume (output) and decreasing production costs (input) (Bos, 2008). This mode of modernization has led to increasing controversy of livestock production systems and questions the long term viability and legitimacy. Concerns about animal welfare, human and animal health, farmers profit and local and global environmental issues have led to a call to develop an in all regards sustainable animal-based food production, that accounts for people, planet & profit simultaneously without averting negative consequences to others, and thus moves away from a single focus on production efficiency (Wijffels, 2001). A transition towards sustainable development forms a complex challenge that needs a structured approach and collective action.

For this purpose the Reflexive Interactive Design (RIO, a Dutch acronym) methodology has been developed. RIO aims at promoting and stimulating structural change ('system innovation') by interactively redesigning animal husbandry (Bos et al., 2009) and examining the whole food and production chain. The central idea of RIO is that many sustainability issues are not invincible natural laws. Through systematic reflection on presuppositions, goals, needs, functions and their arrangements, apparent contradictions can be softened or bypassed by design (Groot Koerkamp & Bos, 2008). The core of RIO is to introduce feasible innovations in existing socio-technical systems in order to contribute to a change in practice.

RIO is not a recipe from a cookbook and is an approach still under construction. RIO (in parts) has been applied and tested in previous projects (for instance, Keeping and loving hens, 2004; Cow Power, 2008; Pork Opportunities, 2009). This paper reports on a system innovation project, *Well-Fair Eggs*, with the application of RIO on the Dutch egg (table and industry eggs) production sector. The Dutch Ministry of Economic Affairs, Agriculture and Innovation commissioned the assignment in order to initiate a system innovation in the Dutch egg production sector. The Ministry has the ambition to achieve an 'in all regards sustainable livestock sector in the Netherlands' and promotes this by stimulating system innovation initiatives.

The results of the project are twofold: 1) it reveals the sustainability challenge through a system analysis and visualizes this by two design concepts of laying hen husbandry systems and the integrated innovations therein and; 2) through active involvement of stakeholders from within and around the sector in the process of analysis and design, commitment and ownership of the sustainability challenge is generated.

2. Materials and methods

The presented case is the result of a project on sustainable development of egg production in the Netherlands, called *Well-Fair Eggs*. In this project new design concepts are co-created that unifies the needs, through the application of RIO, of involved and concerned actors, in order to improve on sustainability in more than one respect simultaneously.

RIO is an interactive design approach, based on a thorough system- and actor analysis, a process of joint and interactive learning through a structured design process, and explicit anticipation of transitions in practice. These phases are interconnected in three iterative loops (Figure 1, see Bos et al., (2009) for an explanation of the activities).

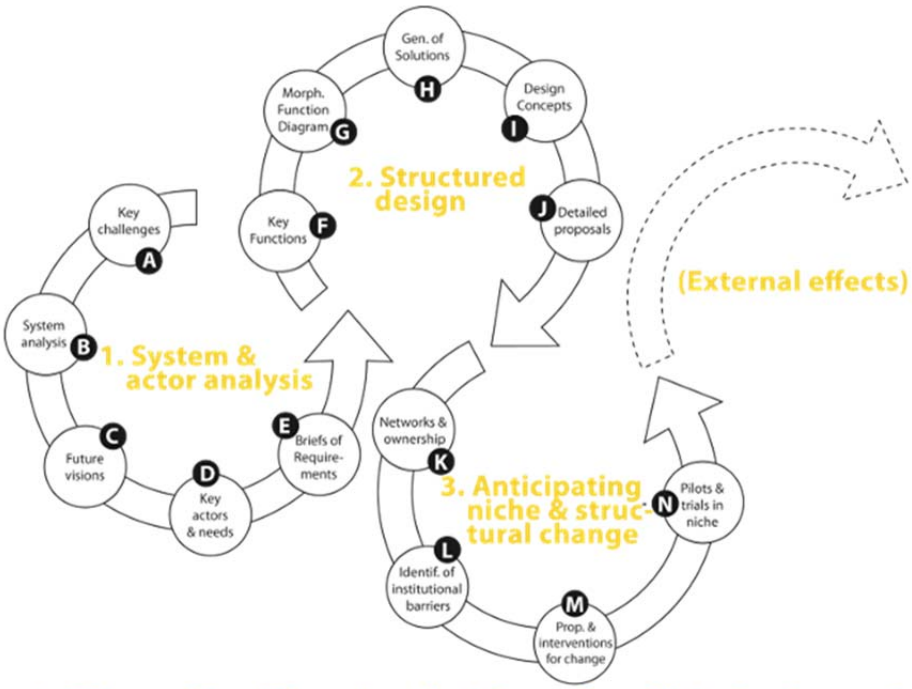

Figure 1. RTO consists of three iteratively looped and linked cycles: system and actor analysis, structured design, and anticipating niche and structural change (Bos et al., 2009)

In the system and actor analysis phase we identified, together with prominent stakeholders of the value chain, the opportunities and barriers for sustainable development of the egg production sector. A collective system analysis (CSA) was done according to Mierlo et al. (2010). The CSA tool is very useful to collect information on the system and secondly can be seen as an intervention in the system by bringing people and knowledge together in an effort to facilitate social learning (Mierlo et al., 2010). In the following structured design phase, this information was used to set up two divergent and successive design workshops with a time-span over a couple of months. Starting with a broad and heterogeneous group of co-designers from the whole production chain and periphery and funnelled in the second round on a selection of designers with the most added value (in terms of design and engineering skills as well as the potential to make actual decisions and changes in practice). The participatory design phase ended in a shared vision of sustainability for the Dutch egg sector with accompanying design concepts and the innovations therein.

3. Results

Well-Fair Eggs resulted into two different integral sustainable design concepts for laying hen husbandry, a single-age (Eggsphere, see Figure 2) and a multi-age (Eggventure) rearing and laying system. Both designs are a coherent means to address the multiple goals of integral sustainable egg production, by unifying the heterogeneous needs of laying hens, farmers, consumer-citizen and the extracted requirements of the environment. Sustainability issues are overcome through the combination of several new integrated solutions.

3.1. Results analysis

The most important barriers for sustainable development identified by the sector were: 1) the many transport moments of hens between the specialized parties in the production chain, 2) the low base of trust between production partners, 3) the production and emission of high levels of dust and ammonia, 4) an unclosed nutrient cycle (accumulation and incineration of manure in the Netherlands and depletion of phosphate and nitrate in feed production areas), 5) low quality of eggs for the industry (egg products, such as egg white, yolk and whole egg, that are used in consumer foods, such as mayonnaise, pasta, bakery products) and 6) animal welfare issues (feather pecking and cannibalism resulting from non-debeaked hens, not satisfying hen needs). We shall continue with a short explanation of the design concept Eggsphere, which can be seen as an example of a new husbandry system to overcome the barriers mentioned above.

3.2. Eggsphere concept

The Eggsphere is a single-age farming system for laying hens partially sunken in the ground that rises from the surrounding landscape in the form of a tiered green oval. There are 50.000 laying hens without trimmed beaks of the same age living together. From hatching of the egg, rearing to 17 weeks, laying phase up until slaughter; all phases of life are integrated within one building. The animals are visible from the outside. The housing system is divided into several functional areas: egg laying, resting and sleeping, foraging, dust-bathing, eating and drinking. Storage, loading and unloading takes place in the inner core of the system. This way, the design connects with its surroundings, whereby the individual animal is the key element.

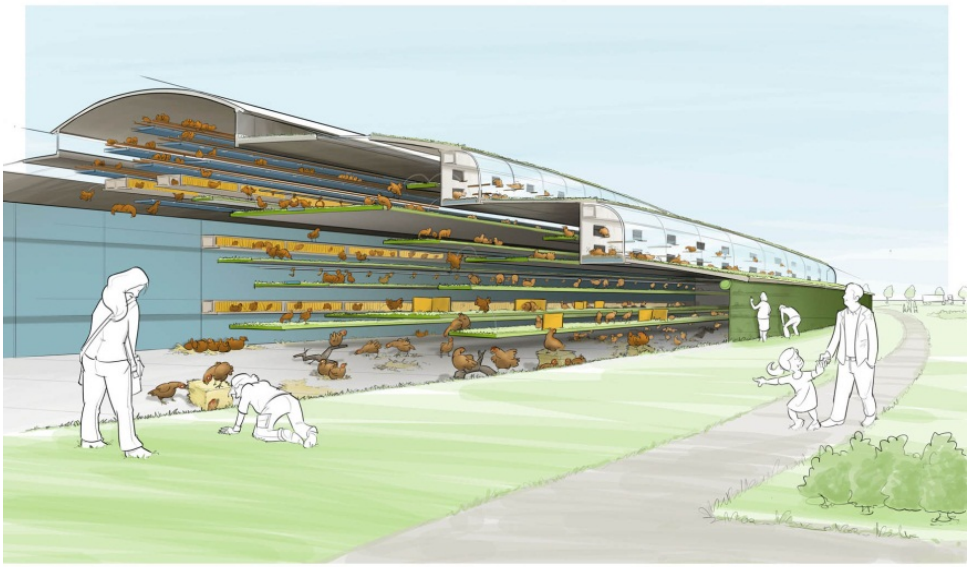

Figure 2. Eggsphere design. A single-age hatching and rearing system for laying hens

Learning is essential

Chicks are born in the well-insulated area at the top of this barn. Learning is essential at this early age. The surroundings and technical systems are the same as the surroundings where the animal will be living during the later laying phase. This way, the animal learns to deal with the technical system. At the same time, learning of social behaviour is important as well. This is why the young animals grow up together with several mother hens. Dark brooders are also available for the chicks. These are warm and dark domes where chicks can crawl under for protection and shelter.

Variation and freedom of choice

For all its different needs the animal can make use of special adapted functional areas. Temperature and climate conditions differ ranging from the naturally ventilated covered outdoor area with plenty of daylight to the climatised indoor living space. Various types of feeds are also offered: concentrated feed in feeding troughs, course litter feed such as corn on the foraging plateaus and roughage feed such as pressed lucerne in the enriched outer ring. The variation in climate, feed and living environment are all possibilities for the hen to choose for herself where she prefers to be.

Manure and animals are transported on conveyor belts

Conveyor belts placed under the perches collect most of the manure, which is pre-dried on the conveyor belts, removed from the barn at regular intervals, dried further to 80% dry matter and stored under low emission conditions. Hens at the end of their laying cycle are transported by the same conveyor belts to the slaughter unit in the core of the system. The

conveyor belts are also used to transport the animals to a central area in the barn where they can be vaccinated by the veterinarian

Pleasant working environment
Due to the clever placing of the many plateaus, the poultry farmer has a good overview for control purposes and everything is accessible. Instead of keeping a keen eye on the production figures and adjusting feed and temperature, the poultry farmer leaves part of the work to the chicken. This way, the poultry farmer keeps enough overview without over-controlling the animals. In addition, daylight illuminates the entire area, and creates together with the low dust and ammonia concentrations, a pleasant working environment for the farmer.

Attractive and visible
The building has an attractive design and fits nicely in the landscape. The hens are visible from the outside in the enrichment area and dust-bathing units. The design offers the possibility for a visit or a meeting with a view on the animals through the glass. In the closed inner core, activities such as selection and packaging of the eggs, drying and storage of manure, storage of feed, as well as loading and unloading take place.

3.3. Innovative integrated solution: Dust-bath
Eggventure and Eggsphere are a break-through in the way we think about sustainable production and consumption of eggs. They harbour several key-innovations that are crucial in the realisation of the integral sustainability aim. Unique is, as an outcome of an integral (holistic) approach, that the separate solutions reinforce and amplify each other instead of averting negative consequences to other sustainability aspects. Here we shall address one of these ‘structural rearrangements’.

Separated dust-bathing
The dust-bathing unit (Figure 3) is a separate area covered by a thick layer of sand or turf at the periphery of the barn. The hens can only enter via the lower entrances and have sufficient space available for regular dust-baths together. Hens like to dust-bathe and this is necessary to maintain their plumage. After dust-bathing the hens can jump or fly to the perches above, whereby the superfluous dust falls out of their feathers. They can leave the unit via the upper one-way gates. Part of the dust will fall to the ground; the rest is removed by a dust filter which applies negative pressure via an air channel. Used sand or turf on the floor can simply be replaced via conveyor belts.

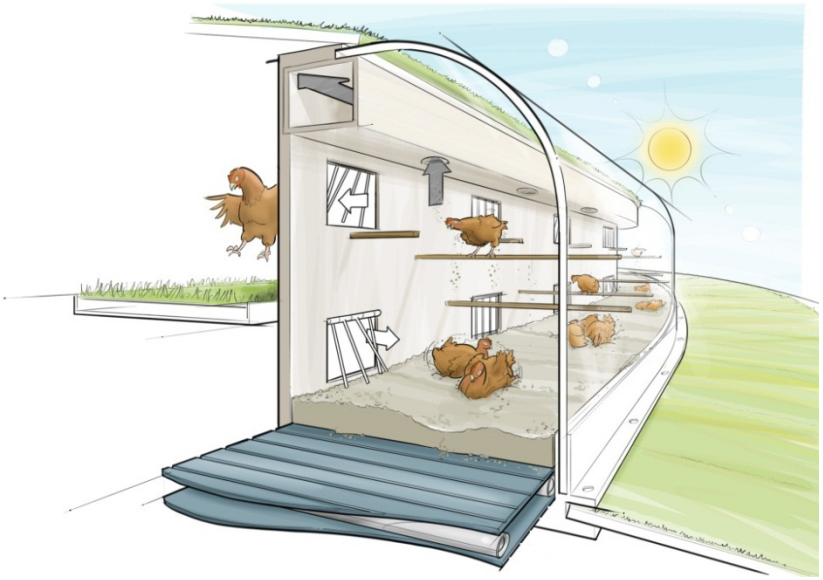

Figure 3. Dust-bath unit on the outer site of the laying hen husbandry system for synchronous dust-bathing in sand or turf

4. Discussion and conclusions

The Eggventure and Eggsphere designs are well thought-out concepts. However, they are not blue prints ready to be built tomorrow. They show two different directions towards sustainable development for different types of entrepreneurs, locations and products. Further development and research is necessary to make the ideas ready for practice. This accounts for the total design concepts as well as (parts of) the separate solutions.

The active involvement of various stakeholders of the sector and periphery played an important role for the integral nature of the designs. Moreover, participation also increased ownership of and commitment to the results, and the promises therein. Currently, after the project's end, a consortium of enthusiastic and devoted egg production sector players continue with the design concept Eggsphere, with the high ambition of making the ideas therein concrete in practice. They are currently enrolled in an innovation programme with a feasibility study opportunity. The design concepts and the ideas can be best seen as thought directions and are not fully developed and operational proven, therefore there are enough research and development questions to be answered in a feasibility study. The 'Lifestyle Egg' consortium are in succession of the successful implementation of 'the Roundel', a design concept of a previous design project 'Keeping and loving hens' also performed by Wageningen UR Livestock Research, and also want to realise the total system design concept in practice with the combined key solutions that lies therein.

We conclude that an integral sustainable laying hen production system is possible whereby a high level of animal welfare can be combined with a lower environmental footprint and a high product quality standard. This multi-objective goal can be attained through participatory design and a holistic approach, that takes the needs of all actors, in our case the animal, the farmer, citizen-consumer and the environmental requirements, into account.

5. Acknowledgements

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