Integration: Valuing stakeholder input in setting priorities for socially sustainable egg production[1]

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ABSTRACT Setting directions and goals for animal production systems requires the integration of information achieved through internal and external processes. The importance of stakeholder input in setting goals for sustainable animal production systems should not be overlooked by the agricultural animal industries. Stakeholders play an integral role in setting the course for many aspects of animal production, from influencing consumer preferences to setting public policy. The Socially Sustainable Egg Production Project (SSEP) involved the development of white papers on various aspects of egg production, followed by a stakeholder workshop to help frame the issues for the future of sustainable egg production. Representatives from the environmental, food safety, food retail, consumer, animal welfare, and the general farm and egg production sectors participated with members of the SSEP coordination team in a 1.5-d workshop to explore socially sustainable egg production. This paper reviews the published literature on values integration methodologies and the lessons learned from animal welfare assessment models. The integration method used for the SSEP stakeholder workshop and its outcome are then summarized. The method used for the SSEP stakeholder workshop can be used to obtain stakeholder input on sustainable production in other farm animal industries.

Key words: egg production, stakeholder, sustainable

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INTRODUCTION

Stakeholder input is a critical component of setting future directions and goals for research, policy, and producer innovation that will support the development of socially sustainable egg production. An important step in obtaining meaningful stakeholder input is to first identify a strategy to discover the diverse values held by each of the stakeholder groups and then to integrate those values into a framework for developing socially supported and sustainable production practices. As part of the Socially Sustainable Egg Production Project (**SSEP**; Swanson et al., 2011), a 1.5-d workshop was held in Washington, DC, for stakeholders representing groups with identified interests in each of 5 critical study areas: hen health and welfare; values and public acceptability dimensions; economic issues; food safety, quality, security, and human health; and environmental sustainability. The stakeholders represented consumer groups, animal welfare groups, environmental groups, human health organizations, community food banks, groups concerned with sustainability and rural community development, food retailers, and egg producers. Before meeting, the stakeholders reviewed a background paper and the 5 white papers produced by each of the project study groups (Holt et al., 2011; Lay et al., 2011; Mench et al., 2011; Sumner et al., 2011; Thompson et al., 2011; Xin et al., 2011). The goal of the workshop was to obtain information and input into prioritizing research related to each sustainability area and to work through scenarios that would lead to the development of this integrated framework paper.

INTEGRATION METHODS AND SUSTAINABILITY

Sustainability of any agricultural production system involves many different facets and many competing values (Thompson et al., 2011). An integrated assessment tool for sustainability will eventually require some

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method for combining or at least in some way reflecting all of these different values. Because each dimension of sustainability represents one or more types of value determination, taking into account values that reflect distinct scales and classes of value becomes one of the main challenges for decision making.

Although there is a lot of literature discussing alternative theoretical proposals for integrating diverse value scales in a decision-making process, there have been very few attempts to validate or apply these methods to the comparison of alternative livestock and poultry production systems. This section of the paper discusses a portion of the literature describing how diverse values can be reflected and weighed. We discuss 4 broad strategies for integrating information to facilitate decision making: 1) quantitative methods, 2) deliberative approaches, 3) informal decision making, and 4) group or participatory approaches. In practice, these strategies may overlap or be used in various combinations.

Quantitative Methods

In many technical fields analytic methods allow one to calculate the maximum achievable amount of some quantity that can be produced in a given system. These methods allow the determination of standards for efficiency and optima in the relevant system. One can, for example, define "fuel efficiency" through a measure such as miles per gallon, and it would be easy to determine the best or optimal choice if all one wanted was fuel efficiency. However, traditional quantitative methods do not permit the optimization of more than one variable at a time, and decision making often involves considering multiple variables. Most people do not purchase a vehicle for fuel efficiency alone, for example. They consider things such as style and function relative to anticipated use. As long as fuel efficiency, style, and function are measured in distinct units, there is no way to develop a technical measure for figuring out which of several vehicle options is the optimal choice; there is no mathematical way to optimize all 3 values at once. However, if one can reconcile fuel efficiency, style, and function in common terms (such as the dollar value a person associates with each), then one can develop quantifications that identify which vehicle is the best or optimal choice reflecting all of these values. For this reason, quantitative methods have been developed that try to reduce multiple values to a common denominator so that the decision can be approached as a typical optimization problem.

Reductive strategies have been used to place monetary values on goods such as the loss of human life and environmental amenities. In some cases, one can find price data that to some degree reflect the value in question, so that one may estimate the value of a human life by estimating lost income, or the value of a scenic view by comparing real estate prices. Contingent valuation methods that use surveys and experimental methods to estimate willingness to pay for goods that are not, in fact, traded in markets have been widely deployed to assign a value to environmental goods such as endangered species conservation. Economists have applied contingent valuation methods to animal welfare in several studies since the mid 1990s (Blandford and Fulponi, 1999; Bennett and Blaney, 2003). Strategies that provide unambiguous quantitative ways to compare and integrate variables yield highly tractable decision aids; decision-makers with even minimal training in the use of these methods can use information easily because the methodology itself goes a long way toward resolving conceptual or values conflicts that would otherwise be left to human judgment.

There are reasons to be cautious about the introduction of common units, however, because it may involve a significant loss or distortion of information. If fuel efficiency, style, or function becomes represented solely as a dollar value, this quantity may not fully encompass all the aspects and dimensions that a buyer actually associates with each of these conceptually distinct reasons for selecting a vehicle. A human decision-maker will recognize subtle differences in valuation or emphasis based on context. The above example of purchasing a vehicle illustrates how there may be less information available to a decision-maker who is presented a set of options in which all of the various factors that go into fuel efficiency, style, and function have been represented simply in terms of the dollar value associated with each option. For example, one can incorporate fuel efficiency into a lifetime-ownership vehicle-cost measure. Doing so might be very meaningful to someone comparing the standard and hybrid versions of 2 similar models. But this way of integrating values would be unhelpful to someone who hopes to balance fuel efficiency against the need to impress clients or to drive on unpaved surfaces. Factors that a human being or a group might take to be decisive may be overlooked or ignored in any integrative approach that represents all values on a single scale.

Hence, a second set of approaches has been developed that mimics formal methods for optimizing the value of a quantitative variable as closely as possible. Different goods, traits, or characteristics are *not* expressed in common terms, but quantitative methods are introduced that allow one to approximate the general logic of optimization while attempting to maintain the integrity of data sources. Significant differences in value scales or types of information are permitted, but at the same time, some use of quantitative methods (and the rigor associated with them) is retained. Multivariate analysis in statistics can be used for some decision problems and has been applied widely in evaluating subsets of the variables relevant to an integrated assessment of laying hen production systems (for example, Nijdam et al., 2004; Mollenhorst et al., 2005). Conjoint analysis was developed to reflect the way that consumers evaluate several seemingly incompatible product attributes, very much in line with the vehicle-choice model discussed above. This method has been used to approximate consumer response to animal welfare attributes, although not the full range of attributes we are attempting to consider in this project (Hobbs, 1996; Den Ouden et al., 1997). Although both approaches may provide more satisfying results for complex problems than straightforward reductive strategies, they, too, can result in substantial loss of information. For example, conjoint analysis may be very useful for a firm trying to understand how a potential automobile buyer will weigh factors such as efficiency, style, and function, but someone actually buying a vehicle would probably find that simply being handed the result of such an analysis provides less information on each of these factors than they would want to have to make their own decision.

Deliberative Approaches

Deliberative approaches lay out trade-offs among strategies as clearly as possible, leaving the final decision to human judgment. These strategies make no attempt to aid the decision-maker in adjudicating which of several options might be most preferable. Instead, the analysis tries only to provide a clear and readily understandable portrayal of the way that trade-offs in outcomes or values are inevitable, given the complexity of values and the ways in which they may involve conflicts. Structured decision making is an approach that has been used in several environmental management contexts. Decision-makers work through a series of questions, scenarios, or short problem statements in which they are faced explicitly with the way that doing one thing may preclude doing something else. The aim is to help decision-makers apply their own values in a manner that results in a feasible course of action, but the methodology makes no assumptions about the relative value of various goods (e.g., environmental protection, food safety, animal welfare, price, or taste). Structured decision making may be augmented with quantitative tools that support the identification of options and characterization of trade-offs (Ralls and Starfield, 2002). There is, however, a range of ways to develop a deliberative approach. One that actually incorporates a fairly high degree of quantification of contrasting values has been applied to egg production (Cornelissen et al., 2001). Others that use more qualitative matrices that illustrate the pattern of trade-offs for farm decision making have been used in other livestock sectors (Sørensen et al., 2001).

Informal Decision Making

In contrast to approaches for integrating values, there are those who would argue that unaided human intuition is adequate for the task of making individual decisions and that mechanisms such as the market or the existing political process provide better approaches to the integration of multiple values than any application of decision science (Burke and Miller, 1999). Others argue that in managerial contexts intuition successfully performs key integration tasks without also implying that formal techniques are inferior (Dane and Pratt, 2007). We note this option without further amplification or discussion, because it has been the approach that has effectively been taken in the United States up to now. To the extent that there is a perceived need among industry leaders and the public to explore alternative approaches, it is safe to assume that the status quo default approach may have exhausted its appeal for the time being.

Participatory Decision Making

Group or participatory decision-making strategies do not attempt to provide an analytic structure that contributes to a ranking of options or that indicates which is the best, or optimal, choice of several options. However, science and analysis *are* used in helping a group of stakeholders or their representatives discuss and evaluate options. These discussions may be structured as group decision processes, or alternatively a report of the stakeholder discussion can be used by designated decision-makers to clarify how options are viewed by diverse sectors of the public and in what sense achieving diverse goods is actually possible.

Participatory decision making may use all of the tools described above in preparing and presenting information to a group of stakeholders, but the idea behind group-based stakeholder decision making and negotiation is that when individuals who represent a wide variety of perspectives discuss and negotiate in the spirit of consensus decision making, the social process itself provides a mechanism for resolving conflict arising from the diversity in values (Stoffle and Arnold, 2003). This approach has been used experimentally for land-use decision making in connection with livestock production, especially in developing-country settings (D'Aquino et al., 2003; Fraser et al., 2006).

Participatory decision making may be one of the most promising approaches for resolving issues related to agricultural sustainability. Rittel and Webber (1974) make a distinction between "wicked" and "tame" problems. Agricultural research has focused on problem solving where there are specific predetermined endpoints and where the research task is to identify and evaluate possible means of achieving these ends. When ends are clearly identified, this is what Rittel and Webber call a "tame" problem. "Wicked" problems are characterized by ambiguity and vagueness in their underlying definition and by the lack of any clear standard for determining what solves or answers the problem. They tend to admit improvement or amelioration rather than solution and as a result simply are not amenable to optimization strategies. Wicked problems are also often contested problems, and there is often significant and perhaps irresolvable disagreement among stakeholders as to problem formulation or direction of improvement (Rittel and Webber, 1974). Resource economist

Sandra Batie (2008) has recently argued that sustainability in agriculture should be considered a wicked problem, not amenable to the kind of traditional scientific research methods that are used to address tame problems. Achieving sustainability in egg production can be formulated in terms of economic, political, and environmental values. Although traditional problem-solving science can provide important information on some dimensions of sustainability, others are elusive. Research on public attitudes in particular is inherently uncertain (Thompson et al., 2011), and different constituencies view sustainability differently. Batie's view suggests that deliberative and participatory strategies for integration may be more successful in accomplishing the goals of a fully integrated approach to the sustainability of agricultural systems, including systems such as egg production. Similarly, Fisher et al. (1983), working in the contentious world of international relations, have suggested that such problems can be managed (and sometimes resolved) by asking participants to agree on a future 10 or 20 years hence. That accomplished, they can then ask what specific steps might be taken to move in that direction.

This sample of methods for integrating values is not exhaustive. Most studies cited have been conducted outside the United States, and thus the results cannot be easily extended to the US case because of differences in values. What is more, none of these studies include the full range of values or attributes described by Lay et al. (2011), Holt et al. (2011), Sumner et al. (2011), and Xin et al. (2011). However, this representative discussion of methods shows that measurement and comparison of these diverse values is a tractable problem and that methods exist and have been applied to independent dimensions of livestock production systems. Adaptation of these methods to the US situation accompanied by a program of integration would clearly be a significant research challenge, but these methods and studies indicate that precedents exist. As an illustration of the usefulness and pitfalls of these approaches, we now discuss how some of these strategies have been used to evaluate another type of wicked problem, the problem of assessing animal welfare.

LESSONS FROM ANIMAL WELFARE ASSESSMENT

Animal welfare assessment is a truly wicked problem. There is no single accepted operational definition of animal welfare partly because animal welfare can be evaluated from several different ethical perspectives or combinations of these perspectives (Fraser, 2003). Not surprisingly there is also no single animal welfare assessment methodology, but instead there are diverse assessment methodologies drawn from fields such as animal behavior, animal production, physiology, genetics, and veterinary medicine. To compound matters further, practical welfare assessments themselves have become increasingly detailed, multistep procedures, with each step requiring the collection and integration of information that will be used as input in the following step of the procedure (Rushen et al., 2011).

By discussing 2 common steps that many animal welfare assessment methodologies undertake, our intent is to demonstrate how the information integration strategies discussed previously can be applied in practice, as well as identify some of the advantages and disadvantages of each strategy that surface in the practical setting. The 2 common steps addressed in our discussion are how each animal welfare assessment method identifies parameters and expresses data, with respect to the use of ranks versus scores and the level of integration.

Selecting Animal Welfare Parameters

All animal welfare assessment techniques require a means of measuring the level of welfare experienced by the animals. Because there is a wide range of parameters, one of the first steps of all welfare assessments involves the identification and selection of assessment parameters that will serve the methodology the best. This process involves collecting information about various parameters and then deciding based on the information collected which parameters to use.

Ad Hoc Selection

Several animal welfare assessment schemes have been developed that rely on the ad hoc selection of welfare parameters by individual researchers and research teams. For example, Hegelund and colleagues (2003) developed an overall welfare assessment method for laying hens derived from both environment- and animal-based parameters. The authors selected the parameters based on information and applicability to on-farm situations. Measures obtained on farm were then evaluated by experts (the researchers), who formed an opinion on the welfare level of the animals on that particular farm. Although this method is very practical and manageable, because so much of the assessment relies on the opinions of the experts, the assessment it produces is highly subjective and not standardizable nor repeatable by nonexperts or nonresearchers (Spoolder et al., 2003).

Parameter Identification Using Deliberative, Participatory, and Hybrid Approaches

An example of how parameter identification can be performed using a deliberative approach is through the Delphi method. Whay et al. (2003) used this method in an iterative process to mine the knowledge base of experts in animal welfare, as determined by membership in internationally recognized animal welfare organizations or attendance at the International Workshop into the Assessment of Animal Welfare (Copenhagen, 1999).

In the first iteration, each expert was asked to identify a set number of parameters he or she believed affect animal welfare assessment. The parameters identified in the first questionnaire were compiled into categories based on the welfare issues each parameter evaluated and its associated measurement method, such as "observe disease," "examine mortality," and "observe stereotypes." In the second iteration, the compiled information was sent back to the experts as a second questionnaire in which they were asked to assign importance scores to each parameter on a 5-point scale, for which a percent maximum possible score (the score each parameter received divided by the maximum possible score of 5 from all experts) was calculated. The experts were also asked to identify and rank the 5 most important parameters. Results were then used to calculate a cumulative sum of rankings for each parameter based on its percent maximum possible score. Relative weightings (discussed in further detail under Quantitative Integration) could be determined based on these summed rankings.

Another example of a participatory analysis is participatory SWOT (strengths, weaknesses, opportunities, and threats) analysis. The developers of the Welfare Quality project program used this method in an iterative fashion to identify and select animal welfare assessment parameters for cattle, pigs, and poultry (Bouyssou, 1990; Botreau et al., 2007a,b,c, 2009). This method was chosen because the developers of the Welfare Quality project sought to design an assessment tool that could help farmers and slaughterhouse managers identify welfare problems and monitor conditions at their facilities, as well as provide information to consumers about the welfare of the animals used to produce the products they were purchasing (Botreau et al., 2009). Thus, parameters that would be understood by and resonate with consumers needed to be identified.

Unlike the expert analysis methods described above, participatory SWOT analysis involves identifying and inviting a "diverse and heterogeneous" (Mollenhorst and de Boer, 2004) group of stakeholders to participate in a brainstorming session. The intended outcome of the brainstorming session is for the stakeholders to produce a list of characteristics, clustered into issues, related to the problem at hand. Identification of a sufficiently diverse and heterogeneous stakeholder group is critical to the success of this method, because greater diversity and heterogeneity improve the chances that the gathered stakeholders will successfully identify a more complete list of characteristics and issues. Based on the list, the stakeholders reconvene to perform the actual SWOT analysis, through which they evaluate each item on the list for strengths, weaknesses, opportunities, and threats. Finally, the irrelevant issues are eliminated based on information obtained from literature reviews and feedback from experts. What remains is a list of relevant parameters. For instance, in the Welfare Quality project this process yielded 12 welfare parameters: 1) absence of prolonged hunger, 2) absence of prolonged thirst, 3) comfort around resting, 4) thermal comfort, 5) ease of movement, 6) absence of injuries, 7) absence of disease, 8) absence of pain induced by management procedures, 9) expression of social behavior, 10) expression of other behaviors, 11) good human-animal relationship, and 12) absence of general fear (Botreau et al., 2007c).

The advantage of the Delphi method over participatory SWOT analysis or other methods involving face-to-face interaction is that it eliminates the logistical complications of organizing a meeting. In addition, although participatory analysis that involves a diverse range of stakeholders, like SWOT analysis, is effective at identifying a broad range of relevant issues, the results still require confirmation through both scientific literature reviews and expert consultation. Finally, a weakness common to all methods that incorporate opinions, whether expert or otherwise, is that opinions are formed through the subjective experiences of those forming the opinions (Fraser, 1995; Fraser, 2003). The iterative process combined with the goal of reaching expert consensus on parameter identification and weighting is directed at reducing the subjectivity inherent in relying on expert opinion alone (Whay et al., 2003). The degree to which subjectivity influences the final assessment can also be reduced through various methods to be discussed next.

To reduce some of the subjectivity inherent in methods that rely on opinion alone, Rodenburg et al. (2008b) developed an approach that contained elements of both the SWOT and Delphi approaches, which they termed "assimilation of expert opinion." They distributed questionnaires to experts who were asked to score the importance of predetermined parameters and to suggest important parameters that had not been included. The researchers also conducted on-farm visits to evaluate the practicality of measuring each parameter. They then convened a panel of experts whose goal was to assign relative weightings to the parameters. The experts were first asked to score the importance of each parameter without being provided with the information about the practicality of measuring those indicators. This essentially resulted in an assessment of the parameters based on theoretical and not practical importance. The researchers then gave brief presentations on each parameter, including the method of measuring each parameter on farm and the sample data collected, and then allowed a period for questions and discussion. The experts were once again asked to score the importance of each parameter, taking into account any practical considerations. The experts tended to assign higher scores to certain parameters before they were presented with additional information about the practical difficulties of measuring those parameters. Finally, the authors were able to rank the parameters with moderate agreement between the experts.

Due to the recent publication of Rodenburg and colleagues' hybrid method (Rodenburg et al., 2008b), only one published study has used this method to perform an assessment of laying hen welfare (Rodenburg et al., 2008a). Although one of the stated advantages of this hybrid method is that it helps to reduce the inherent subjectivity associated with basing decisions on opinion alone, it still involves the logistical complication of convening a panel of experts. In addition, the authors mentioned that allowing the experts to discuss (and debate) the importance of the parameters may actually have introduced an opportunity for subjectivity to reenter the process and that the accuracy of statements made during the discussion could not be verified. Thus, the authors remain ambivalent as to the usefulness of the discussion session.

Bracke et al. (2002a) developed another method for reducing subjectivity in parameter selection weighting (discussed in further detail under Quantitative Integration). Semantic modeling is a method of assessing overall animal welfare based on an initial set of "attributes" and the subject species' needs, such as food intake, that are entered into a relational database. The number of scientific statements to which an attribute becomes linked determines that attribute's weighting relative to all other attributes, with attributes that are linked to the most scientific statements receiving the greatest weighting. Measures for each retained attribute are included in a model that calculates an overall assessment score (Bracke et al., 2002b).

Semantic modeling has been used by Bracke and colleagues to evaluate the welfare of sows under different housing conditions (Bracke et al., 2002a,b, 2005, 2007, 2008). The intent of the procedure is to reduce subjectivity in attribute selection and weighting. However, due in part to the complicated computer model used for the relational database, opportunities for subjectivity to enter the process during the selection of the initial set of attributes and needs as well as during the exclusion process remain (Bracke et al., 2002a).

Quantitative Integration

In animal welfare assessments, quantitative integration strategies come into play at the step during which decisions are made about how the data will be expressed. Quantitative data from animal welfare assessments can be expressed as either ranks or scores. On the surface, ranks appear more accessible to the general public and can help farmers appreciate their farm's position among the others included in the observation sample. Scores are somewhat less transparent and, depending on their form (absolute score vs. a percentage), can be rather arbitrary. However, the comparative value of ranks is limited by the sample of observations from which the ranking was produced (Botreau et al., 2007a). As a result, it is conceivable that animals on a farm that earned a high rank could in fact not be experiencing good welfare if the sample population consisted of poor-quality farms. In contrast, because scores are absolute values, they are independent of the sample observed and can be used to form an absolute judgment about a particular farm (Botreau et al., 2007a). On the other hand, collecting data as scores creates a host of different complications if the data are to be aggregated.

The difficulties that arise when scores from multiple parameters are aggregated into a single overall assessment score reflect the complicated nature of animal welfare and other wicked problems and demonstrate some of the problems associated with the reductive strategies discussed above. Animal welfare is a multidimensional concept that is typically defined at the individual level, but an overall assessment score reflects data collected at the farm level. Thus issues of compensation among individual animals (whether the poor welfare of one individual can be compensated for by the good welfare of others) and among the parameters themselves (when a poor score for one parameter is compensated for by good scores on others) arise that invite the opportunity for subjectivity to enter into the process. In addition, not all trade-offs are equal even when the absolute amount of a trade-off may be the same. For instance, the welfare of the cows on a farm that has an increase in mastitis incidence from 0 to 5% but a decrease in lameness of 20 to 15% is not the same as the welfare of the cows on a farm that has an increase in mastitis incidence of 10 to 15% but a similar magnitude decrease in lameness, even though mathematically these 2 farms would reflect the same change in their overall welfare score (Botreau et al., 2007a).

Another problem arises because scores are expressed as cardinal numbers and it is easy to assume that the intervals between the levels of scores for each parameter are the same, even when they are not. For instance, parameters frequently have different numbers of levels (e.g., lying down might have 3 levels, whereas response to human approach could have 5). As a result, the same absolute score will have vastly different welfare implications for each parameter (Botreau et al., 2007a). In addition, individual parameters often have different levels of precision (e.g., temperature vs. gait score) that may not be accounted for in an overall score (Botreau et al., 2007b). Furthermore, a single aggregated score for each farm can mask disparities between farms that may be important for animal welfare. For example, a farm that receives an overall average score due to little variation among its individual parameter scores will be indistinguishable from another farm that receives an overall average score due to large variation of very good scores on some parameters and very poor scores on others (Botreau et al., 2007a).

Despite all these limitations, the allure of using aggregated overall scores remains strong. Such scores maintain their appeal because nonscientists can readily comprehend them, and partial scores can be determined to indicate areas of strengths and weaknesses. Therefore, methods to reduce the effect of compensation on aggregated parameter scores have been developed. One of the most common methods of reducing the likelihood that overcompensation will occur is assigning relative weights to the indicators based on their importance to welfare assessment. One way of assigning these weights is by using expert opinion. For example, through their hybrid method, Rodenburg et al. (2008a) identified and assigned relative weightings to animal welfare parameters that consisted of a combination of environment- and animal-based parameters. The relative weighting of parameters was performed by assimilating expert opinion to reduce the likelihood of overcompensation occurring among the parameters.

Another method of reducing the likelihood of overcompensation is to impose minimum thresholds for each parameter below which welfare is deemed unacceptable. The developers of the Welfare Quality project used both minimum thresholds and relative weights to reduce overcompensation. After grouping the parameters they identified into 4 categories (good feeding, good housing, good health, and appropriate behavior; Botreau et al., 2009), they entered the data collected on the measures for each parameter into a computer program that assigned weights and calculated scores for each parameter. The computer then summed the scores to generate 4 category scores. Using the category scores, the researchers assessed the overall welfare score of the facility being evaluated (Welfare Quality project: http://www.welfarequality.net/everyone).

The methods reviewed in this section reflect the construction framework for on-farm strategies to assess a single issue such as animal welfare. They represent a long-term work in progress by individuals and countries engaged in answering public concerns about the welfare of animals for over 20 years and are instructive for considering sustainability. However, it is even more challenging to apply these kinds of integrative methodologies to chart the future social sustainability of a whole production system such as egg production, rather than simply focusing on a single component of that system, such as animal welfare. One method for obtaining and integrating holistic input into a future sustainable system engages a creative scenario framework developed by stakeholders.

SYSTEMS, SCENARIOS, AND STRATEGIES FOR SUSTAINABILITY

Envisioning an ideal future for sustainable egg production is inherently difficult, especially if the goal is to achieve that future in practice. The future has a habit of not turning out as planned because production systems are embedded within environments that consist of networks of influences or variables that are complex, dynamic, and turbulent. Systems are thus unpredictable in terms of the actual influence that they will have on the networks of influence (subsystems) embedded within them. Under these circumstances it makes little sense to approach the future from the perspective of trying to get it right by realizing a vision of the best possible future for the production system. A more sensible and responsible approach is to work at trying to avoid getting it wrong. The essence here is to generate and then explore a range of different but plausible future states of the environment in which the production system might well have to operate because of the unpredictability of external variables. This captures the logic behind the process of scenario planning: “Planning for the future in an uncertain world” (Schwartz, 1991). Scenario planning emphasizes the importance of (a) approaching the issue of sustainability from a systems (or systemic) perspective and (b) generating and exploring the significance of alternative scenarios of the future states of the environment in which the system of interest (in this case the egg production system) might have to operate.

Although there is a great deal of sophistication of theory and practical applications within the so-called systems sciences, 3 key principles are foundational to them. At the heart of any systems perspective lie the assumptions that (i) whole entities (called systems) have unique properties that no study of their component parts (called subsystems) can ever reveal, meaning that the whole is different from the sum of its parts; (ii) these particular properties emerge as a function of the dynamic relationships between the interconnected subsystems; and (iii) just as the components of systems are subsystems, so the systems themselves are subsystems of higher-order systems (called suprasystems) that are said to constitute their environment. To approach any issue from a systems perspective is to approach it in 3 dimensions. The sustainability of any system depends on its capacity to adapt to changes in the nature and dynamics of the interrelationships between its component subsystems and any changes in the environmental suprasystems in which it is embedded.

Systems also have variable capacities to influence their environmental suprasystems. Changes in climate that are caused by systems of human activities are a classic example. For this reason, those responsible for planning for sustainable futures for any production system need to develop a range of strategies that are intended to be *adaptive* (to the influences of changes in the suprasystems) and those that are *generative* (with the capacity to influence their environments). In both cases, critical consideration needs to be given to the possible negative as well as positive effects of any planned strategic actions across the system hierarchy. The history of strategic developments in agriculture is replete with examples of inadequate adaptive responses to changing environmental influences as well as the undesirable effects of generative change. Reports of the unintended consequences of technological innovations are an example, from the chemical pollution of food by biocide residues to the salinization of soil following intensive irrigation. Generative changes in practices within agricultural systems related to biocide use and irrigation technologies have led to changes in the environment, and likewise both have resulted in the need for new adaptive strategies. All too often the strategies have been inadequate for the scale of the challenge, with systemic perspectives overlooked and systems competencies fatally undeveloped.

Although systemic effects as cited above might certainly have been unintended, they were not unforeseeable. The development of foresight is another critical element, along with 3-dimensional systems thinking, of what is regarded as vital to systemic competency. Scenario planning is a process that can be used to explore the vital interrelationships between a production system and potential future states of the dynamic, turbulent, and unpredictable environmental suprasystems in which it might have to operate. The potential adaptive and generative changes of the future state of production systems can be identified through stakeholder participation in a scenario-planning exercise. Scenario planning helps not only to develop a systems perspective through 3-dimensional thinking about the future of egg production but also allows for the active development of foresight by stakeholders.

INSPECT

The central idea of scenario planning is that a range of different future states of the environments of a particular production system can be creatively generated or imagined into being through assuming different changes across the network of influences of the system hierarchy. Specifically, the goal is to focus particularly on different changes in the system's environment that might plausibly occur as the future unfolds. A convenient framework for exploring the environment is to segment it into 6 categories of influence—natural, social, political, economic, cultural, and technological (INSPECT)—all the while recognizing that everything that is observed or imagined into being with respect to the character of the environment is a function of those (in this case stakeholders) doing the observing or imagining. In other words, the nature of the environment is always an interpretation—reflecting personal or collective worldviews—of the way things are or could plausibly be. Figure 1 provides general examples of key influences within each of the domains of the INSPECT model. Interactions between each of these domains lead to complex multidimensional systemic influences. For example, changes in cultural values (e.g., human-animal relationships) change social conditions (e.g., public concern about particular housing systems), which in turn leads to calls for changes in policies (e.g., ballot initiatives), which have economic (e.g., egg prices) consequences, and so on.

Several different scenarios of future production system environments can emerge from practical exercises in scenario planning. These scenarios are used as a contextual framework for exploring the implications

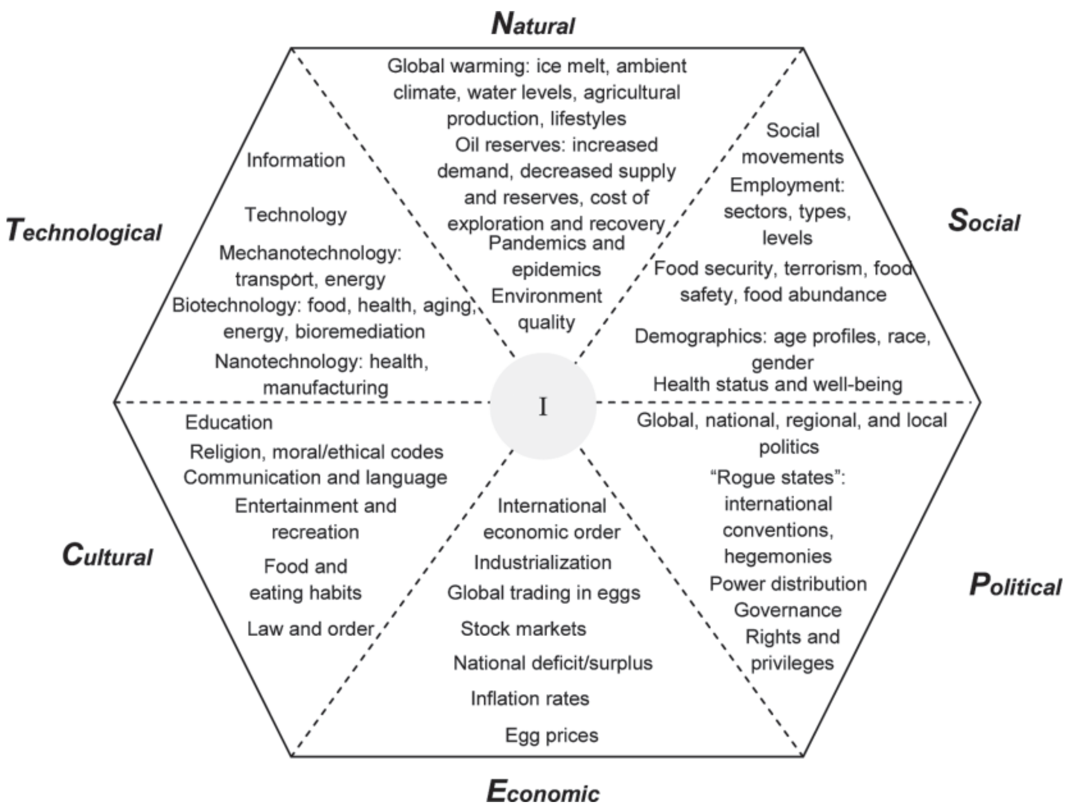

Figure 1. Example of key influences within each domain of the INSPECT model that can influence different aspects of the egg production system. The "I" in the middle of the inner circle emphasizes that any statement about the future states in which egg production will operate in each domain are only interpretations of the individuals engaged in the scenario exercise.

of change relative to the development of appropriate strategies under the different circumstances that each scenario presents. Using a structured process to generate and explore plausibly different scenarios of the future promotes heightened capacities for developing foresight by stakeholders. Ideally the scenario planning process would be carefully evolved over a period of time, with stakeholders reconvening at appropriate intervals to reconsider, further develop, and refine the scenarios and the generative and adaptive changes affecting the future system hierarchy.

The time constraints of the SSEP Stakeholder Workshop allowed little more than brief exposure to the logic, techniques, and use of outcomes from a systemic scenario planning exercise. The process adopted was however entirely consistent with the 3 workshop goals:

- To engage in collaborative discussion regarding social sustainability of egg production,
- To explore how different variables associated with social sustainability of egg production interact, and
- To identify and discuss potential research priorities for advancing social sustainability of egg production.

SSEP Scenario Workshop

Using the INSPECT model, the SSEP stakeholder workshop participants were asked to envision the environment in which the egg production system would need to be operating in the year 2035 using the category realms of natural, social, political, economic, cultural, and technological influences. To help lay the framework before the workshop, stakeholder participants were each provided with the SSEP study group white papers (Holt et al., 2011; Lay et al., 2011; Mench et al., 2011; Sumner et al., 2011; Thompson et al., 2011; Xin et al., 2011). At the workshop, and before engaging in scenario planning using INSPECT, participants were provided with a brief presentation of each white paper by the respective SSEP study group chair and a current overview of egg industry housing systems. After the presentations participants engaged in a facilitated discussion, thus setting the stage for the INSPECT exercise.

The workshop participants were divided into 5 working groups. Each participant was provided with Post-it notes and asked to write down 3 items they believed would be of importance relative to egg production in the year 2035 within each of the respective INSPECT realms of influence. Each participant then posted his or her notes within each of the relevant realms. After all notes were posted, the members of each group discussed the entries recorded on the notes. This discussion led to a range of future predictions emerging from the 5 groups, as was evident when each group reported back to the plenary at the end of the 2.5-h session. Ideally these future predictions would have formed the basis for continuing the scenario development for sustainable egg production at the next workshop. The same stakeholders would have reconvened on several occasions to work through each scenario with the goal of producing a range of plausible outcomes for the production system depending on how the different systems of influence behaved.

For this workshop report, the future predictions posted by stakeholders were pooled to examine the consistency with which similar predictions were repeated among the different groups for the different realms of influence. Because our goal was to gauge whether research priority areas identified by the SSEP study groups connected with the predicted concerns and observations posted by the stakeholders during the scenario exercise, realm comments were then placed within each of the 5 critical areas represented by the SSEP study groups: (i) hen health and welfare; (ii) supply chain dynamics, economics, and labor; (iii) environmental effects, ecological integrity, and sustainability; (iv) food safety, quality, security, and human health; and (v) public attitudes, discourse, and assurance. In the following section we summarize stakeholder responses under each of these 5 critical areas.

SSEP Stakeholder Response

Stakeholders produced predictions that clearly indicate there are consistent observations or concerns (3 or more consistent observations or concerns) under each of the 5 critical areas. When comments were grouped, some stakeholder comments were cross-cutting to other critical areas of the SSEP. The following is a brief summary of stakeholder observations and concerns within an INSPECT realm (if applicable) for each critical study area of the SSEP. So, what does the egg production system in 2035 look like to these stakeholders?

Hen Health and Welfare. Stakeholders predicted that niche markets for animal-welfare-driven products will thrive. Animal care standards for laying hens will have been adopted, and animal care practices will be standardized and harmonized globally. Political, national, and global events have embedded animal welfare into the political framework. United States citizens will be more aware of animal welfare and drive public policy toward continuous improvement of housing systems for laying hens. Technology will be increasingly applied to egg production, including technology associated with breeding poultry for specific characteristics such as less aggression and higher productivity. There will be a greater prevalence of animal disease in general, zoonosis, and the emergence of new diseases.

Supply Chain Dynamics, Economics, and Labor. Changes in food price and financial disparity between rich and poor were major concerns of the stakeholders. Food prices (including the price of eggs) were envisioned as higher in 2035. Increasing income disparity and further widening of the economic gap between the "haves" and "have nots" were consistent concerns. Participants indicated that trade scales will have tipped to the United States being a major importer of eggs in 2035 and, as indicated earlier, that prices will rise for meat, milk, and egg products. China and India will be dominating the processed egg market, and eggs in general will be in short supply in the United States. Along with the loss of jobs in the US food production sector, there will be significant outsourcing of food production. Participants envisioned farmers and laborers as having more economic security and small producers and supermarkets as being the dominating power in the food marketplace.

Environmental Effects, Ecological Integrity, and Sustainability. Stakeholders consistently articulated that water, air quality, land resources, and weather will be major issues in 2035. Fresh water scarcity and quality will be an important factor in egg production. Warmer and more severe and erratic weather patterns, with associated natural disasters, were likely to be reported as commonplace in the 2035. As a result, food production patterns will be changed within the United States. Stakeholders consistently reported that air quality will be poor and carbon footprints larger. With respect to land resources, stakeholders envision that habitats will be altered and natural resources will be in short supply, thus limiting further expansion of ground dedicated to food production. Consistent visions emerged of energy drawn from fossil fuel resources being scarce and alternative energy resources more abundant and cheaper than they were a decade earlier.

Food Safety, Quality, Security, and Human Health. Stakeholders consistently reported 2 primary phenomena in 2035: increases in locally grown food and pathogen risks. Urban agriculture will have lost its novelty and become mainstream, with greater availability of locally grown food for purchase by consumers. However, there will be new pathogen threats and a greater prevalence of disease, in particular zoonotic disease. Economically, stakeholders consistently envisioned the outsourcing of food production, a higher demand for food, eggs in short supply, and importing eggs from Asia. Cage-free eggs will still be expensive. In 2035 the affordability of food will be an issue. Most participants thought that food costs would be higher, although a minority felt the price would remain stable or represent a lower percentage of the household income. Food availability, food security, and the commencement of "wars" over resources and food will be prominent political and social concerns in 2035. A minority of stakeholders reported that there would be a major dietary shift to less consumption of animal-based products. Stakeholder scenarios consistently indicated that developing countries will provide a major portion of our food. Worldwide cooperation for feeding people will be a topic of debate. Most interestingly, only one participant referenced bioterrorism as a major concern in 2035.

The exploration of nonanimal sources of "meat and eggs" or alternative protein sources developed from cell-based technologies will be part of the food innovation framework in 2035. Relative to disease, a better understanding of preventative strategies, the drivers of disease, and new types of medical delivery systems were envisioned as part of our sustainable future.

Public Attitudes, Discourse, and Assurance. Politically, animal welfare policies were consistently envisioned as being unified and global with a focus on continuous improvement. By 2035 global trade policies addressing animal welfare will be in place, and the southern hemisphere will be a major producer of animal food products. Water and air quality will remain a source of public concern, with stringent policies in place to protect these 2 resources. The United Nations will play a larger role in instigation of worldwide cooperative effort and governance to impose global policies to feed the world population that lean toward fairness and equitable distribution of the food supply. Stakeholders indicated that resource competition will continue to instigate conflicts. Food safety and security issues will present significant challenges to food systems. Stakeholders saw US legislators as continuing to be largely disconnected, dysfunctional, and even dictatorial with respect to developing intelligent policies affecting food production.

Stakeholders reported that there would be no abatement of the debate about animal welfare in 2035. Consumers and the general public will be aware and engaged in the issue. Housing facilities for laying hens will change, but other concerns such as biosecurity may overtake this particular issue. Diets that were once considered alternative will be mainstream. More of the population will have shifted to a plant-based diet, and food will be considered an important resource no longer taken for granted. Stakeholders envisioned the populations of the world as oriented toward urban living, with smaller family size and often cohabitating as an extended family. The culture within the United States will have changed due to ease of immigration, and the population demographics will mirror this change. In the global context, education will be more readily available to people living in developing countries, internationalism will overtake nationalism, and in most countries children will be required to speak a second language in 2035.

Finally, stakeholders had mixed visions with respect to agricultural production strategy in 2035. Some predicted that urban agriculture would be commonplace, agricultural education would be incorporated into school curricula, and students would be performing community service on farms. Others reported the public will be largely disconnected from agriculture and food production. Disparity in income, loss of an agricultural workforce, and an urban-rural misalignment in values paint a less attractive picture of life in 2035 than today.

DISCUSSION AND CONCLUSIONS

From the SSEP stakeholder scenario exercise, various themes, observations, predictions, and constructs of the future emerged as stakeholders envisioned the future for egg production in 2035. The point of this scenario exercise was not to develop what egg production in 2035 will *actually* look like, but to expose the deep-seated values that stakeholders hold that motivated their predictions and observations while imagining that they were currently experiencing the year 2035. Thus, embedded in these observations are the respective stakeholder worldviews of egg production.

To reach a true consensus among the stakeholders on plausible future scenarios for a socially sustainable egg production system would require several additional workshops to complete the INSPECT exercise. The stakeholders we engaged in this workshop strongly recommended we continue the stakeholder dialog and INSPECT workshops. The final step in the process would be to fully integrate these values into a working framework for achieving socially supported and sustainable egg production.

A strength of this scenario exercise is that it permitted the SSEP study groups to compare how the research priorities we identified, after careful review of the scientific literature (Swanson et al., 2011), in each of the critical areas aligned with stakeholder values. This alignment is critical. If the SSEP scientists and the stakeholders identify similar areas of interest, then the research priorities should be relevant to addressing public concerns about egg production systems. If priorities are mismatched, then support for those priorities may fail. Further deliberation is required to understand the basis for the value dissimilarities driving research priority selection by scientists and stakeholders. The methods used in this project may also be applied to addressing other production systems of concern such as pig and veal calf production.

The SSEP is a work in progress, and additional stakeholder input will be required to achieve appropriate integration of the diverse social values held toward egg production. The SSEP is one step of many toward achieving a socially sustainable egg production system for the United States.

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