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Abbreviations: StAnD, Sustainable animal diets; E&SEA, East and Southeast Asia; LAC, Latin America/Caribbean; NENA, Near East and North Africa; SSA, Sub-Saharan Africa; GMO, genetically modified organisms

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# Towards sustainable animal diets: A survey based study

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**ABSTRACT.** Animal feed and feeding is pivotal to livestock production. Animal productivity, health and welfare, product quality and safety, producers' income, household security, but also land use and land use change, water pollution and greenhouse gas emission, are affected to a great extent by diet selection and how a diet is fed to livestock. Also animal feed and feeding directly or indirectly affects the entire livestock sector and associated services. Through consultative processes a concept has been developed of *sustainable animal diets* (StAnD), integrating the importance of protecting the environment, efficient use of natural resources, socio-cultural benefits, and ethical integrity and sensitivity, in addition to currently recognized nutrition-based criteria in producing safe and economically viable feed. The concept is based on the *Three-P* dimensions of sustainability (*Planet, People* and *Profit*), complemented by a further vital aspect, namely the ethics of using a particular feed. The analysis reported here derives from 1195 respondents worldwide. The opinions reflected were from both developing (59%) and developed countries (41%). Respondents ranged across Academia, Industry, Farmers' associations, government organizations, non-governmental organizations and Intergovernmental organizations. This survey has identified directions for positive change that should be followed in the production and feeding of StAnD. That positive change is dictated by higher importance assigned to the *Planet, People* and *Ethics* dimensions, and lower to the *Profit* dimension. The survey has also prioritized elements of the sustainability dimensions of StAnD, and identified sectors that should take the initiative, and has also presented modalities for incorporating the StAnD concept into practice. These could be the focus in follow-up studies and actions. Also the study has laid foundation for developing: a) a global framework for multi-criteria evaluation of feed resources, based on the sustainability dimensions, b) a basis for monitoring of the R&D priorities of R&D organizations and donors, and to align them to the needs of the animal

production system, and c) a framework for future R&D needs and priorities, driven by sustainability principles.

**KEYWORDS.** Sustainable animal diets, Stakeholders' opinions, Feed, Sustainable livestock development, Sustainability dimensions

## 1. INTRODUCTION

Change and innovation is required in many livestock production systems if they are to meet in a sustainable manner present and future demand for animal products, because livestock production systems demand high energy inputs, land, chemicals and water — all of which are becoming increasingly scarce (Preston, 2009). Through various consultative processes such as meetings, workshops, expert consultations we have developed a concept of sustainable animal diets (StAnD). This concept is based on the *Three-P* dimensions of sustainability (*Planet, People* and *Profit*), inter alia, have been used to describe the term, implying economic growth, social equity and ecological soundness (IUCN, 2005). Using the three-P definition of sustainability, an approach or a technology is considered to be sustainable if it is profitable; socio culturally acceptable and beneficial to people; and protects the environment and natural resource base. The StAnD concept, in addition to currently recognized nutrition-based criteria for delivering economically viable and safe animal products by producing safe feed, integrates the importance of efficient use of natural resources, protection of the environment, socio-cultural benefits (the *Three P* dimensions) and ethical integrity and sensitivity. The fourth dimension namely the ethics of using a particular feed is a further vital aspect of animal nutrition particularly where there are associated animal welfare issues (FAO, 2013a). Furthermore, at a time when over one billion people are hungry and suitable land for growing crops is becoming increasingly scarce, the use of food-grade grains in the diets of ruminants is certain to face increased questioning on both resource-use efficiency and ethical grounds (FAO, 2012a, 2013a). The rumen is not physiologically designed to cope with high-grain rations. It would therefore appear questionable whether feeding a diet containing large levels of grain to ruminants can be considered ethical, either from a (scarce) resource use perspective or from an animal welfare perspective. Such a diet may result in acidosis, lameness and other associated welfare problems (FAO, 2013a). Feeding grains to animals competes with grain use in human food and nutrition, while improved use of grasslands is more efficient in converting energy into food (Kratli et al. 2013; SAFA, 2013). A sustainable diet may be defined as the diet that has the core traits i.e. balanced in all nutrients, free from deleterious components, meet production objective, generate animal products that are safe for human consumption and integrates the *Three-P* dimensions and also the ethical dimension (Fig. 1). The details of the

concept are available in Makkar (2013).

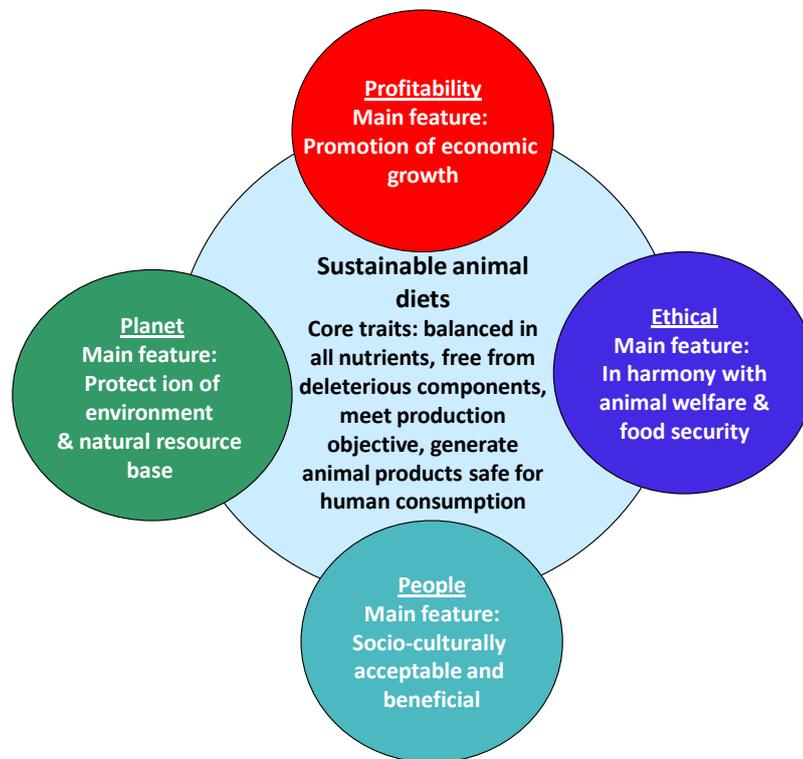


Figure 1. Conceptual framework of sustainable animal diets

A pertinent question is: why should we focus on sustainability of animal diets? Animal feed and feeding is the foundation of livestock systems. It has impacts on animal productivity, health and welfare, product quality and safety, producer incomes, household security, land use and land use change, water pollution and greenhouse gas emission (FAO, 2012a). Also it directly or indirectly affects the entire livestock sector and associated services. Furthermore, feed is financially the single most important element of animal husbandry, irrespective of species and production system, forming up to 70% of the cost of production (Makkar, 2013; Buza et al., 2014). The sustainability of animal diets is crucial in the sustainable development of livestock production across production systems.

The objectives of this survey based study were to prioritize the main constituent elements of the concept, and also to obtain opinion of stakeholders on how to translate this concept into action by integrating its elements and components into sound management practices.

## 2. METHODS

A questionnaire containing 10 questions was developed (<https://www.surveymonkey.com/s/WNTFTZD>) and pilot tested before sending to a large number of potential respondents. The elements for each pillar of StAnD (the *Three-Ps* and the ethical dimension) and corresponding questions were selected using literature information and inputs from experts including in-house experts having extensive experience of assessing sustainability in the agriculture sector. In addition, the questions included a set of miscellaneous questions that addresses more than one dimension of sustainability. Opinion was also sought on which sectors should take a particular initiative, and the modalities of putting the concept into practice.

A survey was conducted during July and August 2013. The questionnaire was sent to approximately 5000 stakeholders in Academia, Industry, science management, and policy-making, together with consultants, Farmers and farmers' associations, extension workers and non-government organizations (NGOs) and intergovernmental organizations. A total of 1195 replies were received worldwide. The opinions reflected were those of both developing and developed countries (respondents: developing countries 59%; developed ones 41%). The largest contribution was from Academia (67%) and least from International organizations (2%). A good number of respondents were from NGOs (9%) and livestock-sector industries (15%). Consultants formed 7%. Among different areas of expertise, the largest number of the respondents (44%) were from animal nutrition. Because of the unbalanced sample, a segregated analysis was also conducted in addition to the global analysis. Also it is important to note that for all the parameters studied, the weighted averages of results from Academia were very close to the global weighted averages, and same was the case for the animal nutrition group.

Respondents were asked to rank the importance of elements of each sustainability dimension, based on a five-level rating scale (5 = extremely important; 4 = important; 3 = reasonably important; 2 = somewhat important; and 1 = not important) and ranking was done on the basis of weighted average score in the global analysis. Higher the score, higher is the ranking.

The weighted mean  $M_\omega$  of a set of  $N$  values  $\chi_1, \chi_2, \dots, \chi_N$  is computed according to the following formula:

$$M_\omega(\chi_1, \chi_2, \dots, \chi_N) = \frac{\sum_{i=1}^{i=N} \omega_i \cdot \chi_i}{\sum_{i=1}^{i=N} \omega_i}; \omega_i \geq 0.$$

where

$\omega_1, \omega_2, \dots, \omega_N$  are non-negative coefficients, called "weights", that are ascribed to the corresponding values  $\chi_1, \chi_2, \dots, \chi_N$ .

For segregated analyses, high or low importance given to an element by a group of respondents was based on weighted average for that element being higher or lower than the overall average of all the groups (i.e. relative to the global weighted average) for that element. The analysis in this paper has been reported both as global, and segregated by region, sector and field of expertise. Consumers are of course an important stakeholder group, but at this initial stage when the concept is evolving it was not considered pertinent to involve customers.

The Regional designations used throughout this report are East and Southeast Asia (E&SEA); Europe; Latin America/Caribbean (LAC); Near East and North Africa (NENA); North America; Oceania; South Asia; and Sub-Saharan Africa (SSA).

### **3. RESULTS**

The results are presented as global and segregated as region-, sector- and expertise-wise.

#### **3.1 A global view**

##### *3.1.1 Distribution of respondents*

The highest number of respondents were from Europe, followed by SSA and then LAC. These three

regions together contributed more than 60% of the replies (Table 1).

Table 1. Number of respondents by region

Region	Number of respondents	Percent distribution
E&SEA	114	9.5
Europe	338	28.3
LAC	184	15.4
NENA	63	5.3
North America	91	7.6
Oceania	59	4.9
South Asia	126	10.5
SSA	220	18.4
Total	1195	-

E&SEA: East and Southeast Asia; LAC: Latin America/Caribbean (LAC); NENA: Near East and North Africa; SSA: Sub-Saharan Africa

### *3.1.2 Importance of the StAnD elements that aim to protect environment and natural resource base*

These are the elements for the ‘*Planet* dimension’ of sustainability and are listed in Fig. 2. The most important elements of StAnD that emerged through the survey are: Minimize water pollution; Not lead to deforestation and land degradation; Minimize air pollution; Preferably use locally available feed resources; Enhance resilience of the livestock production systems; and Enhance or at least not decrease biodiversity. On the other hand, Reduction in water footprint and Reduction in carbon footprint were not considered as important as those mentioned earlier, although Reduction in carbon footprint was considered the more important of the two (Fig. 2). This preference for reduction in carbon footprint could be a reflection of greater interest of donor agencies, international organizations, researchers and politicians alike, due to ongoing climate changes and the importance it is being given by all stakeholders, as well as the media. However, in the context of StAnD, reduction in water footprint is also of great importance, since water use for feed production is highest among other water-dependent activities in the livestock sector. Preferable use of locally available feed resources is also likely to reduce the carbon footprint of StAnD (Alqaisi et al. 2014). Reduction in water pollution will also decrease the water footprint of preparing and feeding StAnD. Higher importance was given to reduction in water pollution rather than reduction of air pollution, and this might be driven by the

possible greater adverse impact of water pollution on human and animal health.

### *3.1.3 Importance of the socio-cultural elements of StAnD that provide benefits for people*

The elements in this category on which ranking was sought from the respondents are presented in Fig. 3. The four most important elements were in the order: Animal products should be affordable to consumers > Promote and preserve local knowledge > Do not compete with human food > Avoid exacerbation of unfavourable legal processes > Consider social aspects of rearing livestock > Not be culturally offensive to producers and consumers of animal products. Respondents gave less importance to elements such as Empower women and Break social barriers and promote social harmony (Fig. 3). From the respondents' perspective, the production of StAnD should not make animal products so expensive that consumers cannot afford them. Production of animal products with ingredients that do not compete with human food was considered important, which could possibly be attributed to the increasing world food insecurity. Thus the direct use of grains for feeding humans would be considered as more acceptable than producing animal products by feeding those grains.

### *3.1.4 Importance of the economic elements of StAnD*

For the *Profit* dimension, the highest importance was given to the Need to internalize socio-environmental costs to the true cost of production, which was followed by Enhancing benefit:cost ratio for all stakeholders from the livestock sector, and Not enhancing volatility in price of feed ingredients (Fig. 4).

Figure 2. Importance of the elements of Sustainable Animal Diets (StAnD) that aim to protect environment and natural resource base (*Planet* dimension of sustainability)

Key: 1 = Not important; 2 = Somewhat Important; 3 = Reasonably important; 4 = Important; 5 = Extremely Important.

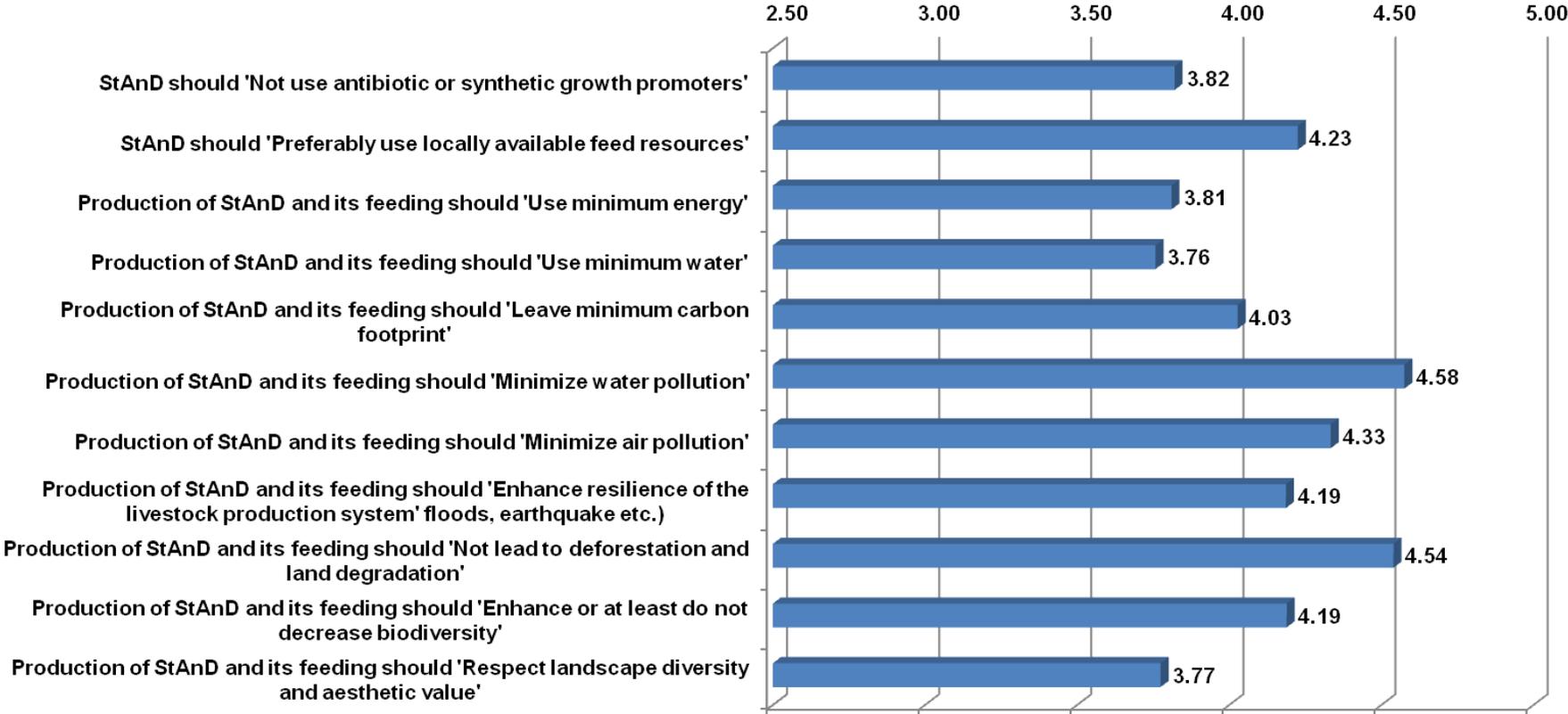


Figure 3. Importance of the socio-cultural elements of Sustainable Animal Diets (StAnD) that provide benefits for people (*People* dimension of sustainability)

Key: 1 = Not important; 2 = Somewhat Important; 3 = Reasonably important; 4 = Important; 5 = Extremely Important.

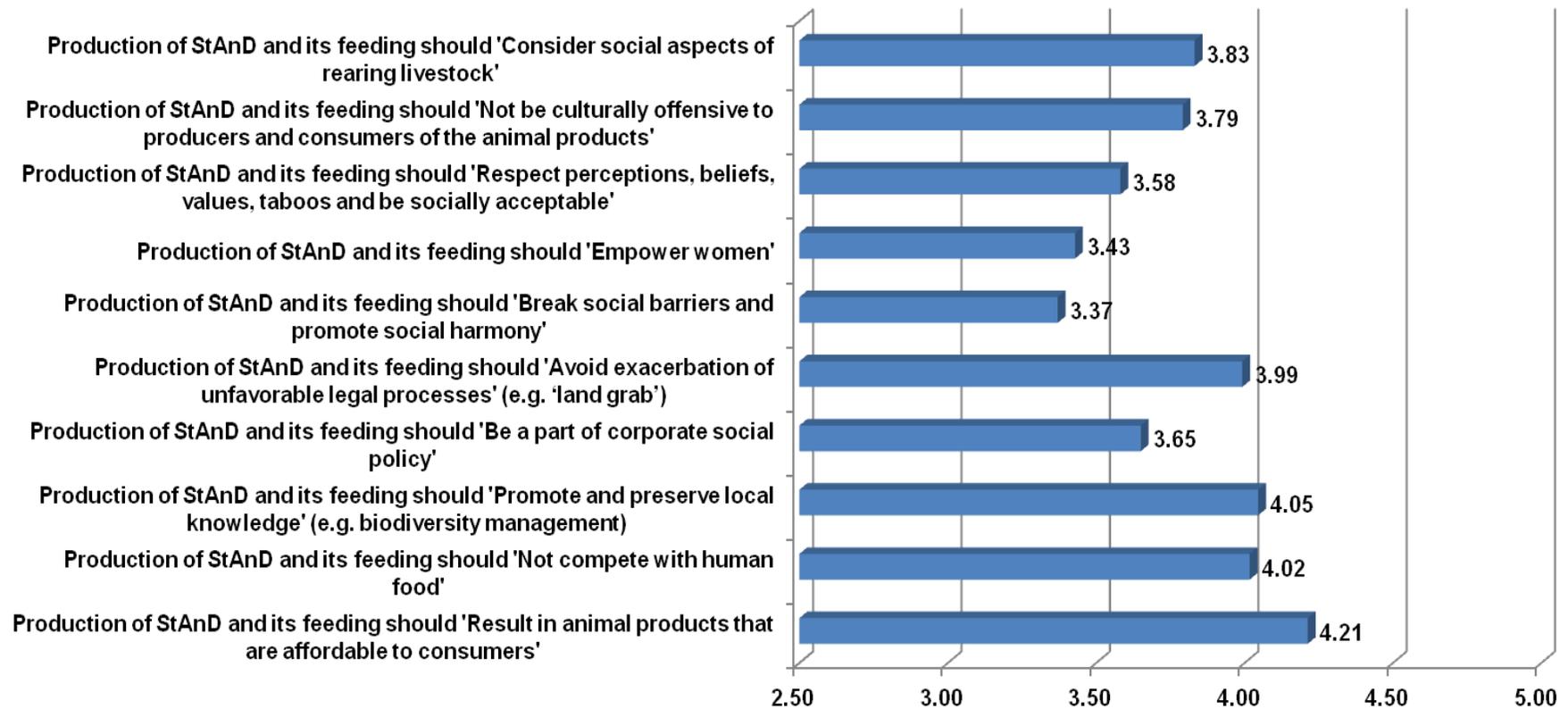


Figure 4. Importance of the economic elements of Sustainable Animal Diets (StAnD) (*Profit dimension of sustainability*)

Key: 1 = Not important; 2 = Somewhat Important; 3 = Reasonably important; 4 = Important; 5 = Extremely Important.

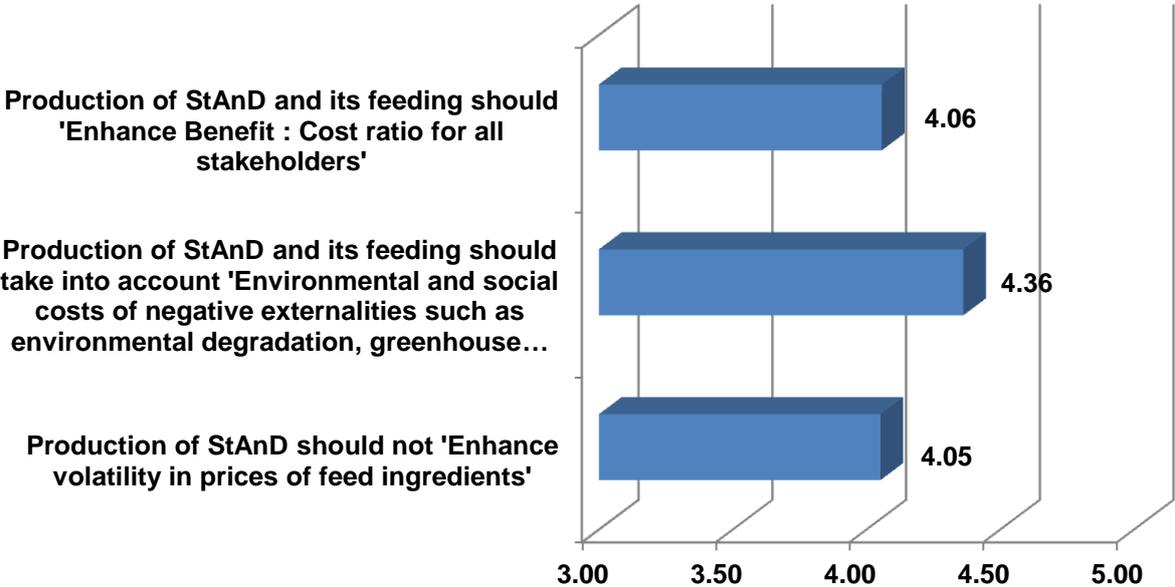
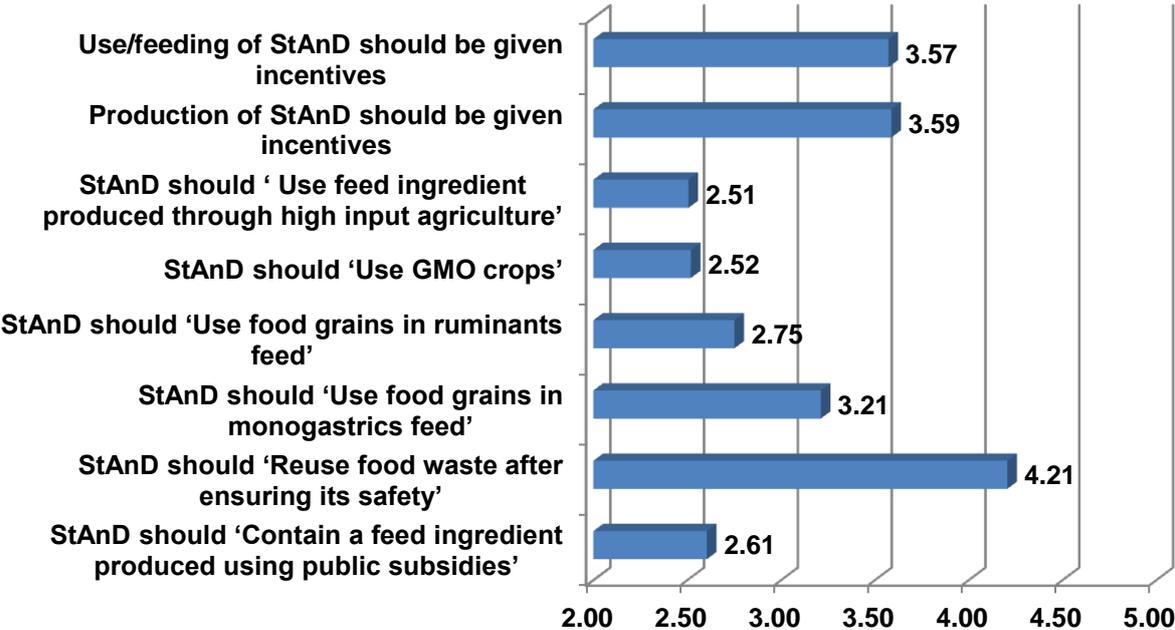


Figure 5. Importance of other elements of Sustainable Animal Diets (StAnD)

Key: 1 = Not important; 2 = Somewhat Important; 3 = Reasonably important; 4 = Important; 5 = Extremely Important.



### *3.1.5 Importance of the miscellaneous elements of StAnD*

The miscellaneous elements are cross cutting and cannot be categorized under the *Three-P* pillars of StAnD. Re-use of food waste after ensuring its safety in animal diets was given the top priority, which was followed by Giving incentives to promote production and use of StAnD. The elements Use of feed ingredients produced through high-input agriculture, and genetically modified organisms (GMO) crops and food grains in ruminant feed, did not receive high prominence, suggesting their avoidance in the production and use of StAnD (Fig. 5). Approximately one-third of food produced is wasted (FAO 2011), and to increase the overall resource use efficiency to decrease water and carbon footprints, it is imperative that waste should be decreased, and its use as animal feed is one of the attractive options. For countries in the tropics, microbial contamination, and especially infestation with mycotoxin-producing fungi, would be an important aspect to consider. Very high ranking (importance) given to this parameter of using food waste in animal diets must inspire researchers and policy-makers to give serious thought to this option and to transforming food waste into a feed resource.

### *3.1.6 Extent of agreement of stakeholders on integration of the ethical dimension into StAnD*

Almost 85% of the respondents acknowledged that the Ethical dimension should be integrated into the concept. Some were of the opinion that it should be a part of the *People* dimensions of StAnD, and animal welfare must be included in StAnD (Fig. 6). Generally, sustainability in the conventional sense takes into consideration the *Three-P* dimensions. A strong opinion given by respondents to integrate ethics into the sustainability of the animal diets illustrates that the ethical dimension must be integrated into the sustainability considerations.

Who should take the initiative to re-structure feed production system for meeting StAnD requirements? According to respondents the initiative should first be taken by Farmers and farmers' associations, followed by scientists, Regulatory bodies, and Industry (in that order) (Fig. 7). There are

different ways in which these bodies can play their part, and some of the options have been identified through this survey (see next section).

Figure 6. Extent of agreement of stakeholders on integration of the ethical dimensions into Sustainable Animal Diets (StAnD)

Key: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither Agree nor Disagree; 4 = Agree; 5 = Strongly Agree

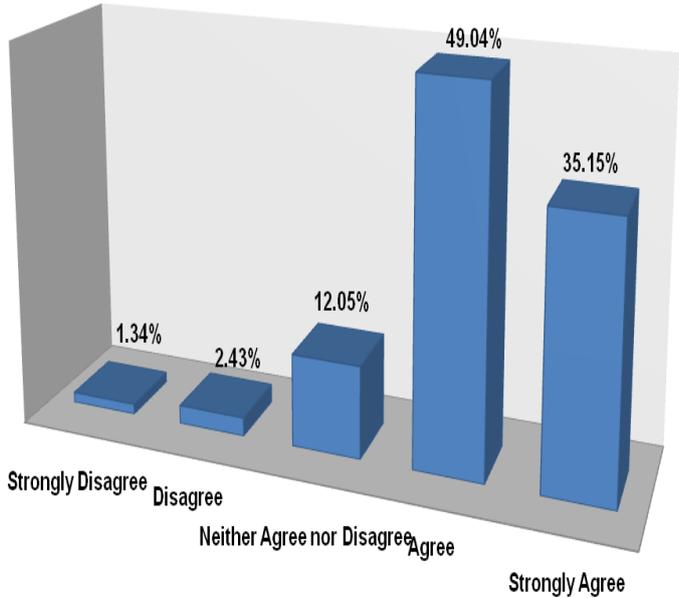
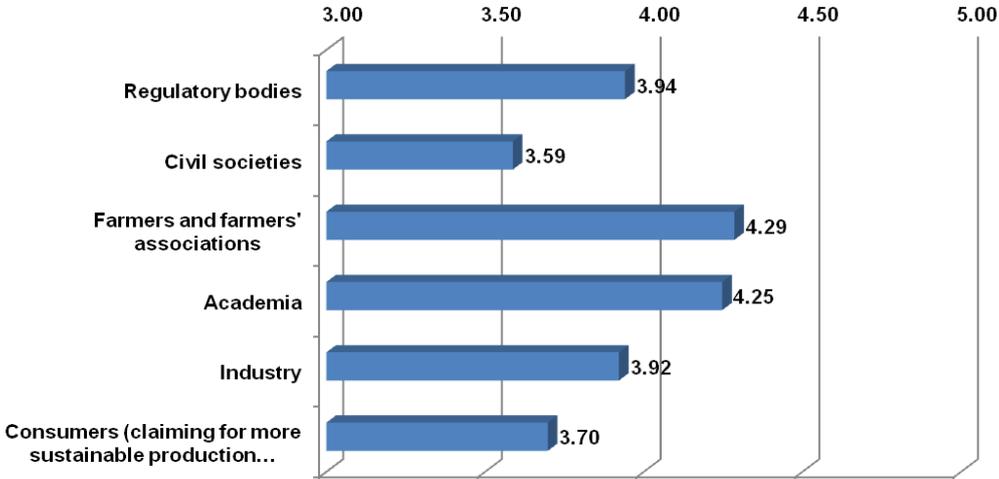


Figure 7. Bodies or organizations that should take initiative first to re-structure the feed production system for meeting the requirements of sustainable animal diets (StAnD)

Key: 1 = Not important; 2 = Somewhat Important; 3 = Reasonably important; 4 = Important; 5 = Extremely Important.

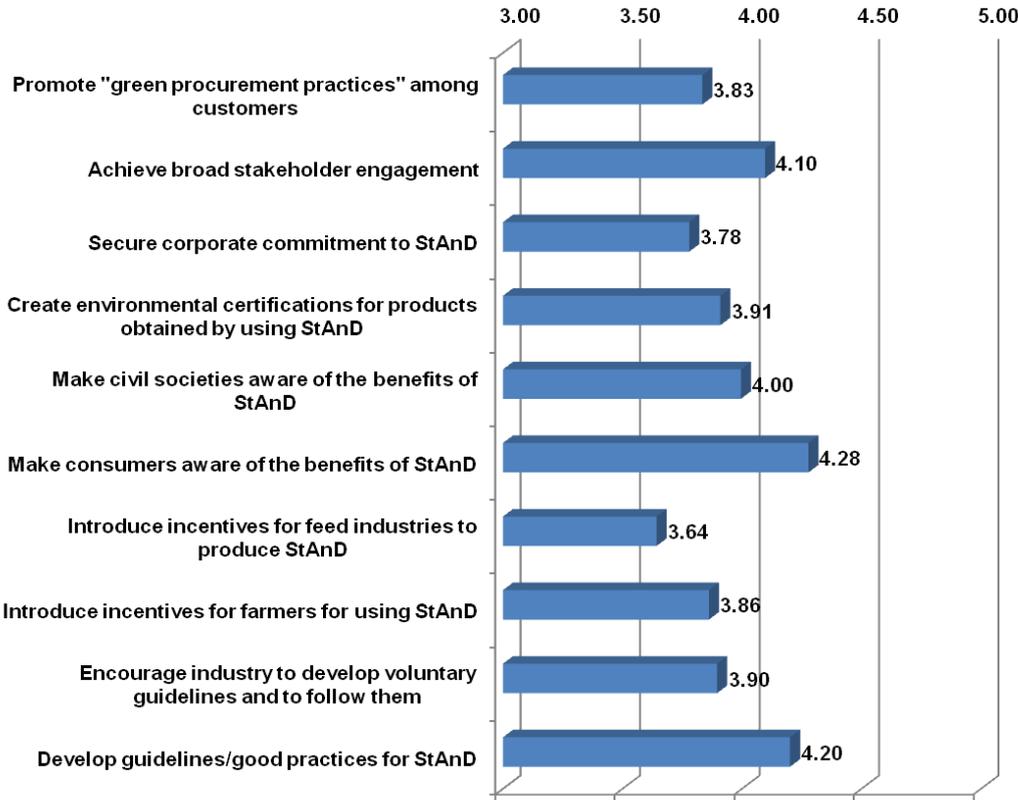


*3.1.7 Modalities through which the StAnD concept can be put into sound management practices*

For putting the StAnD concept into practice, the Need for making consumers aware of its benefit was given the first ranking, followed by Development of guidelines and practices, Achievement of broad stakeholder engagement, and Making civil society aware of the benefits of StAnD (Fig. 8). Good and transparent communication between all stakeholders is vital for the successful implementation of StAnD. There would be a strong need to inform all stakeholders of the benefits of StAnD to achieve their broad engagement. This will also enable the bodies identified in the previous section to take initiative to implement the StAnD concept. All stakeholders should also join forces in developing guidelines and practices for putting the StAnD concept into practice.

Figure 8. Modalities to put the concept of Sustainable Animal Diets (StAnD) into sound management practices

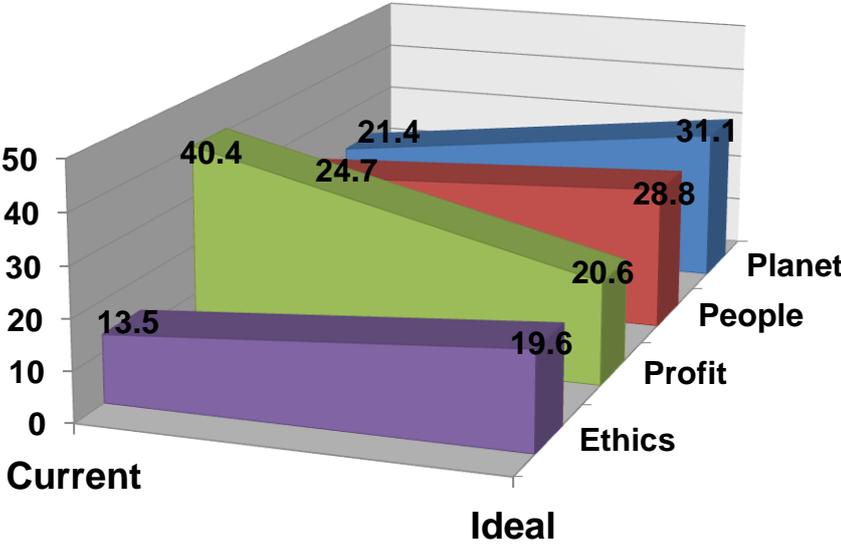
Key: 1 = Not important; 2 = Somewhat Important; 3 = Reasonably important; 4 = Important; 5 = Extremely Important



3.1.8 Importance of Planet, People, Profit and Ethical dimension of StAnD

The respondents were asked to cast a vote (out of 100) to each of these four pillars in the current situation and in a desired ideal situation. The respondents were of the opinion that at present there is increased emphasis on generating profit, while the other three dimensions of sustainability—*Planet*, *People* and *Ethics*—are being neglected, and under ideal conditions the weight given to the *Profit* dimension should be halved from 40 units to almost 20 units and importance to *Planet*, *Ethics* and *People* dimensions should be enhanced (importance in the order mentioned) (Fig. 9).

Figure 9. Importance of *Planet*, *People*, *Profit* and Ethical dimension of StAnD (of 100 votes, casting of votes for each pillar in the current and ideal situations)



As a general agreement, it appeared that currently high emphasis is given to generating profit, while the other three dimensions of sustainability—*Planet*, *People* and *Ethics*—are being neglected, and that under ideal conditions the importance given to the *Profit* element should be halved and that to the *Planet*, *Ethics* and *People* dimensions should be enhanced accordingly.

## 3.2 Segregated analyses

Main finding from the segregated analyses by region, sector and expertise are discussed below (detailed results not shown). It may be noted in these analyses that high or low importance given to an element by a group of respondents was based on weighted average for that element being higher or lower than the overall average of all the groups (see Methodology section).

### 3.2.1 Regional analysis

There was a good distribution of respondents across all regions (Table 1). Respondents from two regions, SSA and LAC, were highly sensitive to the environmental issues, while those from North America and Oceania gave low importance to these issues. In the *People* dimension of StAnD, overall, higher importance was given to socio-cultural elements by stakeholders in SSA, LAC and South Asia. Developing countries were more sensitive to socio-cultural issues than developed ones. Respondents from SSA, South Asia, LAC and NENA gave higher importance to increase in benefit:cost ratio than the global average. Stakeholders in LAC, SSA, South Asia and Europe (in that order) gave higher importance to the need to take into account environmental and social costs of negative externalities in the production and feeding of diets, while those in Oceania and North America were least sensitive towards it. Respondents from SSA, NENA, South Asia and LAC gave a high score to the production of StAnD without enhancing volatility in price of feed ingredients, while North America gave lowest importance to this criterion.

On other miscellaneous elements, respondents from LAC and Europe appear to be less inclined to include grains in animal diets. The degree of acceptability to grains in monogastric diets was higher than in ruminant diets, suggesting the need to decrease grain use in diets of animals, but more so for ruminants. Stakeholders in Oceania and North America gave higher scores to the use of GMO than the global average. Use of GMO crops and feed ingredients produced through high-input systems was given low importance by LAC respondents, despite this region producing substantial

amounts of GMO crops. Stakeholders in developing countries gave higher importance to the Use of incentives in production and use of StAnD than those in developed countries. Stakeholders in almost all regions highlighted the need to integrate ethical dimensions into StAnD.

In developed countries, Farmers and farmers' associations should take the lead in introducing the StAnD concept in practice, while in developing countries the responsibility fell on Academia. In addition, the roles of Regulatory bodies and of Industry were also considered important. Modalities that could be applied in all regions to translate the StAnD concept into practice were: Develop guideline and good practices; Make consumers and civil society aware of the benefits of StAnD; and Achieve broad stakeholder engagement. The realization of StAnD demands shift in all dimensions of sustainability in all regions, with the shift being of almost the same magnitude in all regions. For keeping animal products affordable for consumers (respondents stressed this element) and making a profit, the general opinion appears to be that production and use of StAnD should give higher importance to the *Planet* and *People* dimensions, even if profit were to be sacrificed to some extent.

### 3.2.2 Sectoral analysis

The respondents were from the five sectors of Academia, Industry, Civil society, Consultants and NGOs (Table 2). The segregated analysis by sector showed that to most of the elements related to the environmental issues of StAnD, respondents from International organizations, NGOs and Academia gave high importance, while those from Industry gave them the least importance. Overall, higher importance was given to socio-cultural elements by respondents from NGOs, International organizations and Academia, while those from Industry were less sensitive towards these elements. All sectors gave high agreement to increasing benefit:cost ratio; however, least importance was given to this element by NGOs. Stakeholders in all sectors gave higher importance to taking into account environmental and social costs of negative externalities in the production and feeding of StAnD, while those in Industry gave it lowest score. The element, Production of StAnD should not enhance volatility in price of feed ingredients, received a higher score from respondents from International organizations and Academia and lowest from those from Industry. Respondents from NGOs, Academia, and

Industry gave higher importance to Re-use of food waste as feed. Compared with the other sectors, Industry stakeholders gave higher score to the Use of food grains in the diets of monogastric and ruminants, and use of GMO feeds. Use of incentives in production and use of StAnD was favoured more by Academia than by the other sectors.

Table 2. Number of respondents from different sectors

Sector	Number of respondents
Academia	623
Consultant	66
Livestock-sector Industry	145
International organization	15
NGOs	82
Total	931*

\*Out of the total, 264 respondents did not reveal their sector

Almost all sectors except Industry gave a high score to the integration of the ethical dimension into StAnD, overall showing willingness to integrate ethical dimensions. The analysis showed that the initiative to re-structure the feed production system for meeting StAnD requirements should first be taken by Academia, followed by Farmers and farmers’ associations. Other bodies that could play an important role in meeting the requirements are Industry and Regulatory bodies. The modalities through which the StAnD concept can be put into sound management practices, as identified by the sectors, were: Make consumers aware of the benefits of StAnD, Develop guidelines and good practices, Encourage Industry to develop voluntary guidelines and to follow them, and Introduce incentives for farmers to apply StAnD. All sectors were of the opinion that the realization of StAnD demands a shift in all the dimensions. In the future, higher importance needs to be given to the *Planet*, *People* and Ethical dimensions of StAnD. All regions responded in the same manner, suggesting that all stakeholders in all regions have similar opinions.

### 3.2.3 Expertise-wise analysis

From all regions, most respondents were from the field of animal nutrition. On a regional basis, most animal health experts were from SSA followed by LAC, while Animal welfare experts were highest from Europe and lowest from E&SEA. Farm management and Technology transfer experts were also in considerable numbers from all regions except Oceania (Table 3). Animal health specialists consistently gave higher importance to the elements that aim to better environmental health. Animal welfare experts also gave higher importance to these elements. For the elements of the *People* dimension, no generalized field-related pattern emerged. Respondents from all fields except Farm management and Animal nutrition gave a higher score to the need to incorporate environmental and social costs of negative externalities in total costs. Animal nutrition, Extension and technology transfer, and Animal health specialists gave higher than the global average importance to increase in benefit:cost ratio. Animal health and Animal nutrition experts gave higher score to the production of StAnD without enhancing volatility in price of feed ingredients.

Animal welfare experts appear to be less inclined to include grains, GMO and feed ingredients produced through high-input agriculture in animal diets. Re-use of food waste as animal feed received a high score by experts of all the areas. Overall tolerance to grain use in the diets of ruminants was lower. Experts from almost all fields were in strong agreement to the integration of ethical dimensions into StAnD. Among all the expert areas, Animal welfare experts gave highest importance to this element.

According to Animal welfare experts, action should first be taken by Consumers, Farmers and farmers' associations and Regulatory bodies to re-structure the feed production system for meeting StAnD criteria, while Science managers and policy-makers were of the opinion that Industry should take the lead. Animal nutritionists and Animal health experts felt that Academia should drive the change, and in the view of Socio-economists, Civil society should take the initiative. Irrespective of the field of specialization, the modalities that were expected to be effective in implementing the StAnD concept are: Development of guidelines and good practices, Encouragement to Industry to

develop voluntary guidelines, Making consumers and civil society aware of StAnD benefits, Creation of environmental certifications for products obtained by StAnD, and Securing corporate commitment to StAnD.

Table 3. Field of expertise of respondents (n = 1195) in different regions

	E&SEA	Europe	LAC	NENA	North America	Oceania	South Asia	SSA
Animal nutrition	63.2%	32.2%	48.4%	58.7%	41.8%	44.1%	54.8%	41.4%
Animal health	8.8%	7.1%	12.5%	9.5%	6.6%	1.7%	7.1%	15.9%
Animal welfare	0.9%	16.0%	10.9%	1.6%	14.3%	8.5%	4.8%	2.7%
Animal genetics	7.0%	1.2%	3.3%	7.9%	3.3%	3.4%	4.8%	7.7%
Farm management	5.3%	9.5%	7.1%	11.1%	6.6%	16.9%	5.6%	5.0%
Extension & technology transfer	9.6%	7.4%	8.7%	4.8%	6.6%	0.0%	11.9%	10.9%
Social science	0.0%	5.9%	1.6%	1.6%	5.5%	0.0%	2.4%	2.7%
Economics	0.9%	3.3%	1.1%	0.0%	2.2%	0.0%	0.8%	2.3%
Science management	0.9%	4.1%	3.8%	1.6%	2.2%	8.5%	0.8%	5.5%
Policy	1.8%	10.4%	2.2%	1.6%	7.7%	8.5%	5.6%	5.9%
Not working	1.8%	3.0%	0.5%	1.6%	3.3%	8.5%	1.6%	0.0%

E&SEA: East and Southeast Asia; LAC: Latin America/Caribbean (LAC); NENA: Near East and North Africa; SSA: Sub-Saharan Africa

Overall, the weight given to all the dimensions of the StAnD concept by all the groups was of similar magnitude. All the expert groups were of the opinion that currently *People*, *Planet* and *Ethic* dimensions are being neglected and higher importance should be given to them. At the same time, too much emphasis is currently placed on profit generation. The drive to increase profitability could lead to negligence of other sustainability dimensions of StAnD. The need of change in *Profit*, *People*, *Planet* and *Ethic* dimensions of StAnD, from current and ideal situations, demonstrated by all the groups was similar to those identified in the Global, Regional and Sectoral analyses. A strong agreement emerged from all regions, all sectors and experts from all areas regarding the desired changes implicit in implementing the StAnD concept.

## 4. DISCUSSION

For enhancing sustainability of animal farming systems, this study focused on implementation of the StAnD concept, which is based on the *Three-P* dimensions of sustainability (*Planet, People* and *Profit*) and complemented by a further vital aspect, namely the ethics of using a feed. Against the backdrop that livestock industry faces a number of sustainability challenges, the manner in which feed is produced, procured and fed needs revisiting (Bocquier and González-García, 2010) and the StAnD concept is an important pathway towards enhancing sustainability of livestock production systems. In this study the respondents are from all the continents, and the opinions reflected are from both developing and developed countries (59% of the respondents were from developing countries and 41% from developed ones). Globally, the important elements (in the order mentioned) for each dimension of the StAnD concept that emerge from the study and should form the subject of future follow-up studies and action are:

### *Planet* dimension

- Minimize water pollution
- Not lead to deforestation and land degradation
- Minimize air pollution
- Preferably use locally available feed resources.

### *People* dimension

- Animal products should be affordable to consumers
- Promote and preserve local knowledge
- No competition with human food
- Avoid exacerbation of unfavourable legal processes

### *Profit* dimension

- Need to internalize socio-environmental costs to the true cost of production
- Enhance benefit:cost ratio for all stakeholders from the livestock sector
- Not enhance volatility in price of feed ingredients

### Other cross cutting elements

- Re-use food waste in animal diets
- Give incentives to promote production and use of StAnD
- Not use food grains in monogastric diets
- Not use food grains in ruminant diets

All stakeholders strongly agree on integration of the ethical dimension into the StAnD concept. In order to re-structure feed productions system for meeting StAnD requirements, the initiative should first be taken by Farmers and farmers' associations, followed by Academia, Regulatory bodies and Industry. For implementing the StAnD concept there is a need for making consumers aware of its benefits. Other modalities suggested were: Develop guidelines and practices, Achieve broad stakeholder engagement, and Make civil society aware of the benefits of StAnD.

The segregated analyses give a broad consensus to the above synthesis; however, some subtle differences do exist towards prioritised elements, in the degree of change desired or in the extent of agreement, and who should take the lead to operationalize the StAnD concept. Setting up of a multi-stakeholder process to manage multi-stakeholder dialogues, with the objective to achieve common agreement would be an important step towards operationalization of the StAnD concept.

#### **4.1 What is new in the StAnD concept and what difference can its implementation make**

The concept has:

- (a) a thematic focus of meeting the production objectives by improving feed-nutrient use efficiency;
- (b) multi-dimensional scope, embracing socio-cultural, ethical and environmental dimensions in addition to the economic one;
- (c) an action-oriented holistic approach, targeting change in practices; and
- (d) multi-stakeholder participation, harnessing synergies and complementarities.

In advanced stages of the implementation of the StAnD concept, it is possible that a model could be developed to compare diets against the indicators of sustainable animal diets. A decision tool based on this concept could also be integrated into other models, thus enabling comparison of animal products from different animal species and assisting consumers to select one animal product over another. Similarly, animal products originating from different livestock production systems could be compared.

The concept and its likely outcomes also hold potential for integration into other sustainability mechanisms, such as the ‘Global Agenda for Sustainable Livestock’ (FAO, 2013b). Also the concept could pave the way for a new system of feed evaluation and be an instrument to induce change towards enhanced sustainability (discussed below).

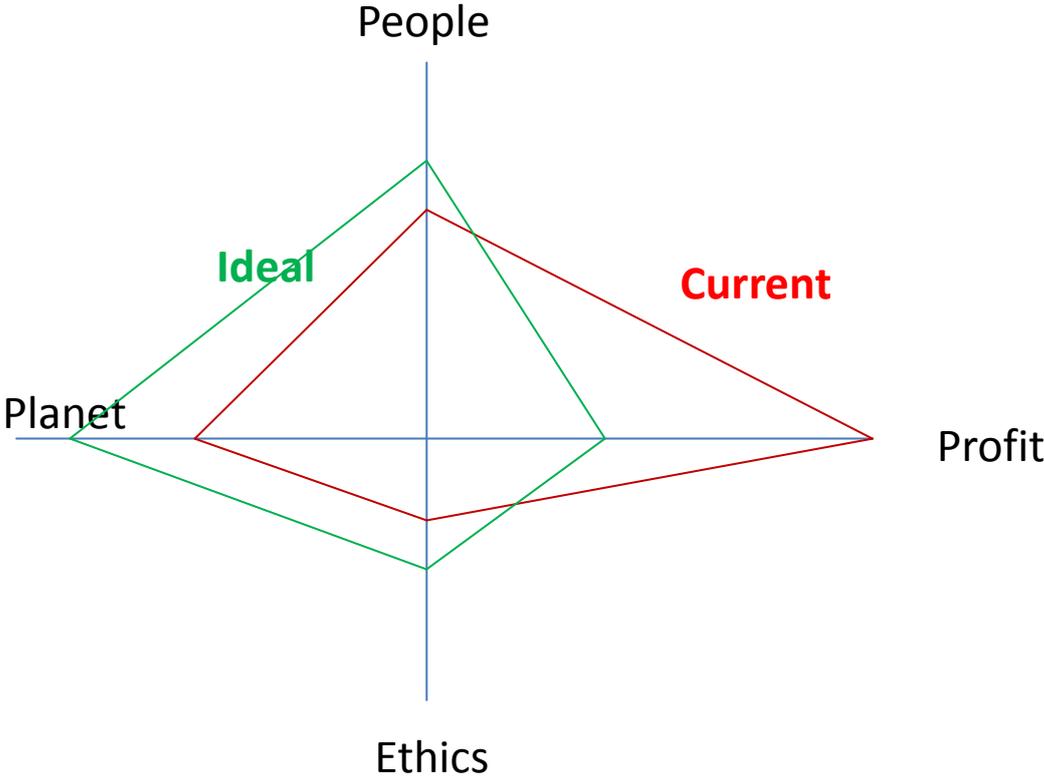
## 4.2 The desired change

The concept places animal diets in a holistic sustainability context. The survey shows a strong agreement among all stakeholders, irrespective of region, sector or field of specialization, concerning the direction of positive change they would wish to follow in the production and feeding of StAnD. The positive change is dictated by higher importance to the *Planet*, *People* and *Ethic* dimensions of StAnD, and less to the *Profit* dimension (Fig 10). An important message that could be derived from the survey is that making profit is important and this drives the production system, but making profit at the cost of the environment, socio-cultural benefits to people and animal welfare and other ethical aspects of raising livestock may not be appropriate. Decrease in importance to *Profit* dimension does not imply that livestock farming will be less profitable. The profitability could be achieved by better consideration of the other dimensions of the StAnD concept, as suggested in context to sustainability of livestock production systems (Peterson, 2013), and ensuring that there is equitable distribution of profit and that not one segment of the stakeholders only benefit.

The implementation of the StAnD concept is not a destination but a journey, following a path of desired change that all stakeholders converge on. It is based on the principle of respecting the manner in which animal diets are prepared and fed. However, it directs the stakeholders to compete with each other or oneself, aiming to improve with time, by embracing a direction of positive change. All stakeholders can play their part in implementation of the concept by joining the journey at any point, following the framework

and principles of the concept and working towards the positive direction of change. The realization of the positive change could be monitored by measuring the indicators (SAFA, 2013) of each element of the StAnD concept.

Figure 10. Sustainability quadrant – depicting current and ideal situations (based on a survey of 1195 respondents)



For each of the StAnD element, indicators must be identified, developed and given weight for ranking diets as to their sustainability. Methodologies for indicator measurement also needs to be identified and developed. If methodologies are not available, proxy parameters need to be identified. Since the concept of sustainable animal diets has the *Three-P—Profit, People and Planet*—dimensions and an additional ethical dimension, the relative importance of the indicators and weight given to them is expected to differ between regions. There will always be tradeoffs between these dimensions (SOFA, 2009; Peterson, 2013). The prioritization of

the indicators in different regions may assist in balancing the objectives of sustainable diets. It is impossible to define a standard or an ideal StAnD, and this is not the objective of this concept. The aim should be to move towards enhanced sustainability of animal diets based on the agreed indicators of the StAnD concept. Since the concept is evolving and in the nascent stages, currently no examples are available that systematically capture all the elements of the four pillars of the StAnD; however, a number of examples can be cited from the literature that support some elements and also the positive direction of change that all stakeholders agreed and converged to. These are: use of a balanced diet approach at smallholders doorsteps (Garg et al., 2013) that decrease environmental pollutants, empower women, enhance feed use efficiency, decrease feed wastage and increase income of smallholder farmers (Ahuja et al., 2014); a number of animal nutrition strategies including decrease in grain feeding that increase animal welfare and concurrently increase farmers' incomes (FAO, 2013a); plant breeding approaches that increase quality and digestibility of the feeds and as a result increase productivity and decrease environment pollutants (Flachowsky et al., 2013a); decrease in the amount of grains and increase of agro-industrial by-products and green forages to address ethical concerns of feeding grains to animals in light of food-feed competition (Sewell et al., 2009; Wang et al., 2014); quest for identification of novel feed resources such as co-products of biofuel industry, algae, insects aiming to replace grains in animal diets (Makkar, 2012c; Makkar et al., 2014); and use of phase feeding and precision feeding options that decrease release of phosphorus and nitrogen into the environment without compromising animal productivity (Nahm, 2002). Infact several other examples can be quoted from literature that support different elements of the StAnD. The need is to integrate these elements in the production systems in a holistic manner and measure progress with time using indicators of these elements.

### 4.3 Policy dimensions and decision tools

Proper policies need to be formulated and applied (Niles, 2013) to stimulate the further development and use of the StAnD concept. Currently, in most situations, most policies support enabling the environment to maximize yields and profits by the livestock producers, rather than delivering sustainability of the production systems in terms of the *Three-P* dimensions (Beauchemin and McGeough, 2013). The ‘Pressure Phenomenon’ seen to affect policy decisions in various sectors affects the livestock sector as well: ‘there is pull of market demand and economic benefits and push of the technologies that promise rapid growth’. Rapid increase in demand and prices of livestock products is resulting in pressure to take steps that would increase production rapidly (Wezel et al., 2009). The first component that is affected in this cascade of events is the ‘Animal Diet’, since it has a major impact on performance of animals and its cost forms a major part of the total cost of production (Makkar, 2013; Buza et al., 2014), with decisions being made at the cost of sustainability. There is therefore a need for policies that address various components of StAnD, which have been elaborated and prioritized through this study. This would require involvement of all stakeholders, including Ministries of Agriculture, Finance, Environment and Culture; private industry, including feed industries; NGOs; and national and International organizations. Also the stakeholders should make use of various respondent-suggested modalities, such as Development of guidelines and good practices, Encouragement to Industry to develop voluntary guidelines, Making consumers aware of StAnD benefits, and Securing corporate commitment to StAnD in order to put the StAnD concept into practice. Also, various bodies and organizations identified and prioritized through this survey for taking the initiative to implement the StAnD concept, should act and work in tandem. Two cross-cutting themes, Gender (ensuring that gender equality becomes a regular feature of the work) and Governance (focusing on mechanisms that improve interactions between multiple actors) (SAFA, 2013)

are integral to achievement of StAnD. Desired impact cannot be realised without making practical changes by the stakeholders in the manner the feed is produced and fed.

Comparison of diets based on sustainability criteria would be easier than arriving at a decision as to whether a diet is sustainable or not, since fulfilling the criteria implicit in the StAnD concept requires critical decisions, such as regarding the levels of agro-chemical, energy and water use, and on how to measure biodiversity and resilience of production systems, amongst many others. Decision tools and methodologies, e.g. for assessing the carbon footprints of production and use of feeds and associated environmental costs, to measure the resilience of production systems and to assess their impacts on biodiversity need to be developed. Efforts being made through a multi-stakeholder partnership (LEAP, 2012) are expected to contribute to implementation of the concept through provision of some of the methodologies and tools. The availability of the tools or improvement in the tools and methodologies should not impede the implementation of the StAnD concept. A move towards positive change can still be made using the available tools and methodologies.

The role of research organizations is equally important, for example the ‘desired change’ requires feeding systems for both monogastric and ruminants animals that use no grains or low amounts of grains. The challenge for the researchers is to identify novel, alternate feedstuffs that do not compete with human food and their incorporation in the diets results in feed use efficiency as high or greater than that obtained using grain-containing animal diets currently in-use. Some encouraging developments have been made lately, showing that decreasing grains and increasing fibre in the diets of animals including monogastrics enhance both animal welfare and animal production (FAO, 2012a; Souza da Silva et al., 2012, 2013). There is a possibility that in future due to increasing cost of inputs and on-going climate change, consideration of the costs of repairing the socio-environmental damage and reflecting that in the total cost of production might not be sufficient for producing

animal products in a sustainable manner. Also implementation of options, identified through this study, in conjunction with each other is expected to have higher impact than the application of an option in isolation. Studies to gain a better insight into these challenges are required.

It would be a challenge to reconcile two opposing forces: consideration of the costs of including the socio-environmental damage into the total cost of production (which is likely enhance cost of production; SOFA, 2009) and increase in benefit:cost ratio, the two elements prioritised by the respondents. Towards this end, an attractive option would be decoupling of fossil fuel use from feed production and feed use (FAO, 2012b) , and this possibly could be done through the use of solar or wind energy, possibly through simultaneous production of feeds and energy. Furthermore, new ways of production and use of animal diets need to be considered. Increase in feed use efficiency to reduce the cost of production would be an attractive option (Beever and Drackley, 2013). For increasing feed use efficiency it will be pivotal to consider a holistic approach embracing not only biological means but also structural and institutional approaches, including reduction in the loss of feed resources in the food and agriculture supply chain (Gill, 2013). Another option would be to use agro-industrial by-products and alternative resources as feed (FAO, 2012b; Wadhwa and Bakshi, 2013) including realisation of full potential of grasslands (Taube et al., 2013; Paciullo et al., 2014), which is likely to reduce cost as well as water and possibly carbon footprints. Overall, the focus needs to shift from profit maximization towards feed and other inputs use optimization. However, there is no one-size-fits-all solution, and innovative practices tailored towards the needs of production systems should be considered. Research organizations have a number of such challenges ahead to address.

#### **4.4 Multi-functional feeding systems and multi-criteria feed evaluation systems**

Currently the feeding systems are based on evaluation of feed ingredients and formation of animal diets based on the nutrient composition and nutrient availability (chemical composition of the feed, digestibility, intake, feed conversion efficiency, etc.) such as NRC, INRA, NorFor, among others (Martinez Marin et al., 2010; Volden, 2011). However, to face new and emerging challenges that the livestock sector faces (elaborated earlier in the Introduction section), it is important to integrate the dimensions of StAnD into feed evaluation and feed formulation systems. This survey has laid the foundation for development of a global framework for multi-criteria evaluation of feed resources, based on the core principles of sustainability integrated with ethics and animal welfare, and with the current feed evaluation system based on feed composition and nutrient availability; and then for putting the framework into practice. Certainly this would require criteria and indicators and methodologies to measure them (as discussed above), based on all the dimensions of sustainability (environmental, social and economics integrated with ethics and animal welfare).

#### **4.5 A framework for research and knowledge**

Extending the stakeholders' sentiments, expressed in this StAnD survey, to sustainability of the entire livestock production system would not be out of place, as is evident from the views of a number of authors (Beede, 2013). The survey results could form the basis for monitoring of the research and development priorities of research and development organizations and donors, and to align them to the needs of the livestock production system, as perceived by the stakeholders. The present analysis could also pave the way for developing a framework for future research and development needs and priorities.

Some of the points discussed above are indeed the starting points for further discussion among the scientific community interested in sustainability of the livestock sector. These deliberations would lead to new areas of work and development of methodologies, strategies and tools for enhancing sustainability of the livestock production systems. The StAnD is an important components; however, it should not be considered in isolation. It is one of the strategies in a basket of other good management practices such as increase in genetic potential of animals; efficient and timely disease monitoring, diagnosis and treatment; and good animal housing, comfort and welfare. These approaches will enhance sustainability of the livestock production systems from the production side – making animal products available in a more sustainable manner. Equally important is to address sustainability of the livestock systems from the side of consumption of animal products. Rationalisation of the consumption i.e. increase in consumption of animal products in developing countries and in particular African countries and decrease in developed countries would help; however for this it is important to arrive at a consensus on the amount of animal proteins required by an adult, a growing child or a pregnant lady per day for leading a healthy life (Flachowsky et al., 2013b).

## **5. CONCLUSION**

For making animal farming systems more sustainable, through implementation of the StAnD concept, the study has:

- established a direction for positive change;
- prioritized various elements;
- proposed sectors that should take the initiative; and
- identified modalities to put the concept into practice

Also the results have laid foundation for developing:

- a global framework for multi-criteria evaluation of feed resources, based on the sustainability dimensions;
- a basis for monitoring of the R&D priorities of R&D organizations and donors, and to align them to the needs of the animal production system; and
- a framework for future R&D needs and priorities, driven by sustainability principles.

Society expects animal agriculture to provide safe and affordable animal products, while maintaining environmental quality and biodiversity. The use of sustainable animal diets is an important step towards achieving this. Sustainable animal diets are expected to be beneficial for the animal, the environment and society, and are likely to generate socio-economic benefits, furthering poverty alleviation and food security efforts. This requires active participation of researchers, extension workers, science managers, policy-makers, industry and farmers.

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