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GLIMPSE 2.0: a framework to feed the world

RESEARCH ARTICLE

Aidan J. Connolly[Ⓐ], Luiz R. Sodre^ᵇ, and Kate Phillips-Connolly^ᶜ

^ᶜ*Chief Innovation Officer and Vice-President, Corporate Accounts, Alltech,
3031 Catnip Hill Road, Nicholasville, KY 40356, USA*

^ᵇ*Co-founder and CEO, Perfarm, Rua Tefé, 292, São Paulo, SP, 01251-050, Brazil*

^ᶜ*PhD, Institute for International Integration Studies, Trinity College Dublin,
University of Dublin, College Green, Dublin 2, Ireland, United Kingdom*

Abstract

Five years ago a new acronym GLIMPSE was proposed in the *International Food and Agribusiness Management Review* to summarize the seven barriers faced by agriculture in its quest to feed the world, based on interviews of 25 agribusiness experts. Through an iterative, grounded theory methodology the original research that led to the GLIMPSE framework was validated, deepened and expanded. The new research made minor revisions to the original GLIMPSE, but confirmed it as an effective framework to explain to an interested public how agriculture can tackle the planet's nutritional requirements if certain constraints are addressed. Specifically, international policy makers, governments, non-governmental organization, charities, industry organizations, integrated food companies and farmers often struggle to explain the complex challenges agribusiness faces, and in this respect the GLIMPSE framework allows all stakeholders to describe the main challenges agriculture faces on its journey to feed almost 10 billion people by 2050.

Keywords: future of food, agriculture, agribusiness, sustainability, feeding the world

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[Ⓐ]Corresponding author: aconnolly@alltech.com

1. Introduction

The collective businesses involved in agricultural production commonly referred to as the agribusiness sector (Davis and Goldberg, 1957), face a number of serious challenges in feeding a global population that is increasing exponentially in size and income. At the same time, the expectations and attitudes towards agribusiness are changing. There has been little research either to identify areas where agribusiness can make a difference in meeting these challenges or to understand changing attitudes towards agribusiness. One of the most comprehensive efforts was the GLIMPSE framework of 2012 (Connolly *et al.*, 2012), which sought to identify both the obstacles and opportunities in agribusiness. GLIMPSE has sparked considerable discussion over the four years since its publication. Recently both external input and continued research by the authors has generated sufficient new information that it warrants a review of the GLIMPSE framework. In this paper we extend the research, update and expand the data, and offer some modifications that reflect the additional contributions from academic experts, industry leaders, professionals and consumers at large.

The paper begins with a brief background section, noting the ‘wicked problem’ of population growth, the changing expectations facing the sector, and the limited literature available. The next section outlines the methodology used, including a review of 1.3 million websites, followed by a summary of the results. A discussion on the findings for each element of the acronym GLIMPSE is then provided, and the paper concludes with a brief discussion of the revised GLIMPSE model, its uses and implications. The paper provides managers with useful tools for assessing ways in which consumer attitudes are changing so that they can orient their business towards growing to feed the 9 billion people projected to be living in the world by 2050.

Background

The original impetus for GLIMPSE was to try and identify the obstacles to feeding the rapidly growing population, and then to see where there were opportunities for agribusiness to contribute to that effort. Since then world population growth projections have been revised sharply upward again: it is now estimated that the world will have 2.5 billion more people to feed in 35 years, and 11 billion by 2100. As the benefits of the Green Revolution of the last century level out, and the amount of arable land is limited, finding ways to increase food production to feed everybody is a significant challenge.

Equally challenging is the growth of the ‘consuming class’¹: more than 1.2 billion people were added to that group in the past decade, and another 1.8 billion are expected to join in the next decade (Dobbs *et al.*, 2015). Much of this growth will come from rising incomes, notably in developing countries such as Brazil, Russia, India and China. Gross domestic product growth in 20 emerging economies is expected to nearly triple by 2050 (PwC, 2015). As income rises, demand for protein and other types of non-grain foods increases substantially.

And, just as consumers in developing regions are changing their expectations about food, so are consumers in more developed markets. Attitudes about food, and importantly, agribusiness are changing sharply. In part that reflects a growing disconnect: as populations move away from rural areas and become connected to agriculture only through the food that they eat, their focus moves to how they relate to food and food production.

Increasingly, these issues concentrate around safety, nutrition and the environment. Food safety concerns include disease outbreaks (e.g. bovine spongiform encephalopathy/mad cow disease, avian influenza), food contaminations (e.g. *Salmonella*, *Escherichia coli*) and food adulteration. Nutritional concerns include the presence of additives, carcinogens, fats, salts, sugars, etc. Environmental issues relate to the impact on the environment or the animals of modern farming methods. Through various media platforms consumers are

¹ Individuals who have over \$10 per day to buy discretionary items.

increasingly aware of these issues, and they use these same platforms to both monitor what is happening and express their views.

For these consumers, despite occasional spikes in food prices (e.g. the 2007-2008 world food price crisis), the cost of food is no longer a major part of their household budget: in more developed countries the proportion of the household budget spent on food has fallen from about 45% in 1900 to 6-15% in 2009 (Bill & Melinda Gates Foundation, 2012). They can afford to focus on preferences rather than needs.

The challenge for agribusiness is to feed a rapidly growing population whose food preferences and expectations of agribusiness are changing rapidly, yet there is surprisingly little research on the subject. There has been some work on specific agribusiness challenges, such as a study that asked agribusiness professionals around the world to rank the probability of various challenge scenarios happening; it concluded that global warming is seen as the greatest future challenge (Lakner and Baker, 2014). A useful, but regionally limited survey of CEOs in Africa asked for challenges constraining agribusiness expansion in Africa; the conclusion was that scarcity of resources, access to technology and climate change were the major challenges for the near future (PwC, 2015). Other work has addressed climate change (Vervoort *et al.*, 2014); a scenario-guided analysis of food security challenges due to climate change (Wheeler and Von Braun, 2013); environmental sustainability; and the use of natural resources.

There have also been literature reviews seeking a more cohesive analysis of these challenges, such as a review of the challenges in achieving sustainable agricultural production by 2050, including action recommendations. McKenzie and Williams (2015) and Boehlje *et al.* (2011) attempted to categorize and evaluate the challenges faced by agriculture using frameworks, and suggested that the three major issues are growing risk and uncertainty; developing and adopting new technologies; and rapid market responsiveness to changes in industry structure. A meta-analysis of a set of Food and Agriculture Organization foresight studies asserts that the serious challenges are not about producing more food but on managing the social and political issues that drive food insecurity (Bourgeois, 2014). None of this work is comprehensive, and what recommendations are offered are of use only to small segments of the food chain.

Thus, the decision was made to revisit GLIMPSE, substantially increasing the depth and scope of the research to test the validity and relevance of the work. Extensive new research was conducted to ensure that the views of participants throughout the food chain about the challenges facing them were captured.

2. Methodology

The research was conducted in three phases. Phase 1 consisted of in-depth open-ended interviews with experts in agriculture, which were followed in Phase 2 with a survey by industry leaders ranking the challenges they face. Finally, in Phase 3, consumer views and attitudes were explored through an analysis of social media content. In total, the views of some 600 academic experts and senior level executives, as well as more than a million social media posts published in the past three years were collected and analyzed. The first two phases followed the same methodology as the original GLIMPSE work, but with larger sample sizes and specific attention to regional, functional, sector distribution, while the third turned to a newly available, and still underutilized, tool.

Phase 1: interviews

Phase 1 consisted of 59 in-depth interviews with academic experts and industry leaders from 23 different countries, from a range of backgrounds. The participants were chosen to ensure a valid response rate, broad regional coverage (to allow for differentiation of regional differences), and industry backgrounds. Participants from the government sector included a former United States Secretary of Agriculture and a recent European Union Commissioner on Health and Food Safety, while participants from the academic arena included professors from universities including Harvard, Purdue, UC Davis, University of Sunshine Coast (Australia)

and University College Dublin. From the private sector there were agribusiness partners from some of the top four global strategic consulting firms; managing directors of investment and development banks in the United Kingdom, Brazil and South Africa; C-suite executives of numerous agribusinesses from different countries (including Canada, Peru, Ukraine, Egypt, India and China); and current and former presidents of national associations (e.g. the National Turkey Federation, the American Animal Science Society, etc.).

Interviews were typically 25 to 40 minutes long, and were designed to allow for spontaneous responses through open-ended questions. As in the original GLIMPSE research, respondents were asked for their opinion on the biggest challenges facing agribusiness in feeding a growing, and increasingly affluent, global population. Additional directed, but still open-ended questions based on the original GLIMPSE findings were also asked. The follow-up questions were used to test whether the original GLIMPSE findings were both collectively exhaustive and mutually exclusive.

Using a grounded theory approach (Glaser and Strauss, 1967), the collected data was evaluated using a coding analysis process (Bryman, 2012). This produced a consolidated grouping of challenges that were then tested in Phase 2.

Phase 2: survey

The findings from Phase 1 were tested through a survey of 527 experts. Given the list of 22 challenges derived from the expert interviews, the respondents were asked to select the five biggest challenges and rank order them. The challenges were introduced in a randomized order to avoid any anchoring from the first list of challenges. Respondents were also given the option of adding their own challenge(s). To allow for segmentation analysis, demographic questions were also included.

The survey was offered in English, Spanish, Portuguese and Chinese. Invitations were sent to industry leaders and academicians, who were identified through the International Food and Agribusiness Management Association network, as well as attendants from an international industry symposium and attendants at a leadership level industry gathering.

Executives comprised 25% of the respondent pool; 23% were managers, 17% agribusiness owners, and the remaining were independent, retired professionals, and others. The respondents were distributed nearly evenly across industry activity groups, with about a third in academia, research or consulting; 23% in farm inputs; 19% in primary production, and the remaining quarter in downstream activities, government, non-governmental organizations (NGOs), financial markets, or the press. To ensure that respondents used the same terms of reference when identifying their place in the agribusiness value chain, an illustrated value chain (with examples) was provided. The respondent sample was also evenly distributed across years of experience in agribusiness and by the size of firm with which they were associated.

Phase 3: social media

The first two phases involved expert opinion drawn from the agribusiness sector. The third phase sought to capture public perception of agribusiness in general and the challenges of feeding the world in particular. Analyzing social media content to support business decisions is a relatively new, and underutilized, research tool. Social media captures information in an unprompted manner, allowing responses to reveal what is truly top of mind to consumers.

The focus of Phase 3 was on identifying and evaluating discussions about the challenges of agribusiness, and to look for trends and patterns across the data. Using an artificial intelligence (AI) system known as Crimson Hexagon, the frequency of particular words and topics were automatically identified and classified. Using publicly available sources, content from Twitter, Facebook, blogs, forums and others social media platforms posted during a three-year period (2012-2015) were analyzed. Primary keywords such as 'food production'

or ‘agribusiness’ were used to identify the industry subject to discussions; secondary or auxiliary keywords, such as ‘challenge’ or ‘barrier’ were used to identify themes and topics within industry-related discussions. Posts containing ‘http’ were excluded from the search to keep the focus on discussions, not referrals to third party websites and/or advertisements.

3. Results

Phase 1: interviews

A careful data coding process (including searching for common words or phrases that could be applied to a broader range of subjects) yielded two main groups of challenges: those related to optimal use of production factors to improve input efficiency and output productivity; and those challenges related to coordination between agribusiness and key stakeholders.

There was a consensus that regional low productivity is a result of constraints on factors of production that are readily available elsewhere in the economy or in the world. In particular, respondents noted technology, labor, and capital (fixed or financial) as being top challenges. These factors can often be transferred from one area to another. While land and natural resources, including water and climate, are not easily transferable from one place to another, they often are not the most limiting factor in low productivity. Moreover, even in places where land or natural resources is indeed the limiting factor, the respondents felt that the larger challenges are still related to the use of other factors of production, and that the overall increase in productivity can only be achieved by the increase in productivity of technology, labor or capital. Production output in any industry is constrained by the most limiting factor of production.

The challenges not directly linked to factors of production relate to coordination between agribusiness and key stakeholders, whether the stakeholders were those involved in food processing or the larger community (consumers, governments, creditors, investors, etc.). Again, there was a strong consensus among interviewees, in this instance regarding the challenge of aligning the efforts and priorities of these disparate stakeholders towards ensuring that there is enough food, at the right time and place, for the growing global population.

The 22 challenges identified in Phase 1 are consistent with those from other studies. For example, all of the challenges found in the PwC Agribusinesses Insights Survey 2014/2015 are represented within the challenges identified in this study. Similarly, the challenges most likely to affect agribusiness through 2030 included water scarcity, increased demand for individualized nutrition and local foods, and increased consumption in developing countries (Lakner and Baker, 2014) are also found in this study.

Phase 2: survey

A survey including shared closed groups containing agribusiness experts in professional social media networks, Alltech customers and IFAMA members yielded responses from 527 agribusiness professionals, with the responses relatively evenly distributed across the defined demographic groupings. The findings were analyzed both by the respondent characteristics and by the challenge group. Although there were variations in the frequency, all 22 challenges derived from Phase 1 were ranked among the top 5 challenges, validating the GLIMPSE findings.

Moreover, just 2% of the respondents provided unique additional challenges, which were added to the original dataset for analysis in Phase 3. These additional challenges account for only 0.5% of the total, which can be seen as validating the theoretical saturation described in Phase 1, confirming that the range of experts’ opinions gathered were indeed representative of the industry, and that the coding and categorization process was representative of the data set.

Interestingly, the challenges relating to the use of production factors and those relating to interactions with stakeholders were noted nearly equally. Production related challenges (those under Infrastructure, People, Science and Environment) accounted for 49% and stakeholder related challenges (Government, Loss and Markets) for 51%. The relative rankings are discussed further, below.

The relative frequency with which population segments listed each challenge was analyzed, providing useful insights in the way that different segments of the agribusiness value chain perceive the challenge, as well as a useful way to both confirm the broad validity of the challenge list and to eliminate any unintended bias in the process.

The data was analyzed against five variables: region, years of experience in agribusiness, size of the firm, activity (where the respondent is in the value chain), and the nature of the respondents role along with the relative weighting assigned to the challenge by the respondent.

■ Region

Regional analysis confirmed that the full range of challenges is felt globally, with results evenly distributed across regions. The highest level of responses was for the Consumer Marketplace, which was ranked in the top 5 by all regions, and was the most mentioned overall. However, while it was seen as important in all regions, it was not ranked as one of the most serious challenges.

The most variability was found in Investment and Infrastructure. There were strong variations in regional importance, ranging from a low of 3.35% in North America to a high of 12.68% in Africa. Environmental challenges, on the other hand, had the least regional variability, with all regions similarly. Oceania, Africa and Latin America were notably more concerned than average with Science & Innovation challenges (15.42, 10.56 and 11.16%, vs an overall average of 4.26%).

Other regional variations were found between occupations: professionals in Asia were notably more concerned about the challenges relating to human capital than professionals in Europe and Latin America (14.44%, vs 7.45 and 7.30%, respectively), while professionals in Europe, and to a lesser extent Oceania, ranked Food Losses as more of a challenge than other regions (9.36 and 3.74%, respectively). On the other hand, professionals in North America and South America were the most likely to cite Government & Policies challenges (24.89 and 24.46%, respectively).

■ Experience

Overall there was less variability in the frequency of responses as analyzed against years of experience in agribusiness. The two notable exceptions involved respondents with less than 10 years of experience, and those with more than 40 years of experience. The less experienced respondents see Consumer Markets as more of a challenge than those with more experience (28.95 vs 22.02% for respondents with over 50 years of experience). Professionals with more than 40 years of experience in agribusiness see Government & Policies as a somewhat bigger challenge (22.10%) than the newer people to the industry (16.96%).

■ Size

Analysis based on company size also demonstrated little variability, with the exception of those professionals from large companies (over 5,000 employees), who saw the Environment and Food Losses categories relatively more important than respondents from other segments (20.83 vs 19.61% average and 9.60 vs 7.35% average, respectively), and saw the Government & Policies category as less critical a challenge (16.76 vs 18.71% average).

■ Activity

Analysis of responses by activity within the agribusiness value chain produced the largest variations between respondents. Although the findings must be considered with some caution, due to some segment sample sizes being rather small, the responses do appear to correlate with the respondent's position in the value chain. Entities closer to end consumers (such as Food Retail and Press) were much more likely to rank Consumer Markets as a significant challenge than the industry at large (25.88 vs 1.89%). Similarly the Food Retail, and Trading & Processors segments are more concerned about Food Loss than the industry as a whole (16 and 11.58 vs 7.11%, respectively). At the other end of the value chain, NGOs are more concerned with production factors (especially scarcity and optimal usage), particularly in three categories: People (15.56 vs 9.84% average), Science & Innovation (15.56 vs 9.28% average) and Environment (24.44 vs 19.11% average). Government professionals see the Government & Policies category as being the most important obstacle (33.33 vs 19.81% average), but do not consider Food Losses or issues relating to Consumer Markets as critical obstacles (20.00 vs 25.88% average). Self-employed professionals were less concerned about the challenges involving People (6.31 vs 10.01% average) and Science & Innovation (9.01 vs 13.54% average), but more concerned about Environment (26.13 vs 19.61% average) and Food Losses (9.91 vs 7.35% average).

Phase 3: social media

The AI application retrieved 1,395,652 posts meeting the search criteria, primarily from blogs and forums, as well as Facebook and Twitter. Over 250,000 posts had an identifiable location, the majority of which were in English speaking countries (64% from the United States), which was expected as the keywords used were all in English. The largest proportion of responses came from California (7%) and Texas (6%), followed by New York (5%), Florida and the District of Columbia (4% each).

■ Analysis of content

The major data analysis examined the frequency with which specific words are used. Obviously, the most frequent words are the keywords used within the search criteria, and these are excluded from the analysis. The associations between the remaining words relating to the challenges were analyzed for patterns.

About a third of the most frequently used words can be easily associated to GLIMPSE categories, including 'water' (Environment), 'government' (Government & Policies) and 'health' (Consumer Markets).

Some words such as 'industry,' 'business,' 'company,' and 'management' transcend many categories. To get a better understanding of the context, the full posts from which the words were drawn were sampled. From these samples it appears that the posts relate to the challenges of doing business in the private sector as a whole; these challenges can and do inhibit the overall inability to rise to the challenge of feeding the world, but are not specific to that issue. Some of these elements are already included within the challenge categories, (particularly Infrastructure & Investment, People and Science & Innovation). However, as the objective of GLIMPSE is to evaluate the external challenges to the industry, the general challenges of being in business are not put forward as a separate challenge category.

There are no other obvious categories for the remaining words that do not clearly link to a GLIMPSE category. Thus, the associations confirm the comprehensiveness of the GLIMPSE framework, both in the areas captured and by the lack of any other required categories.

Moving from analyzing single words to analyzing clusters of words adds more depth to the analysis. The AI sorting program is first trained to recognize related words by having data samples manually categorized; the system then uses an algorithm to aggregate the remaining data based on content similarities from the sample. For this work, 350 posts were manually classified according to a set of criteria drawn from the GLIMPSE

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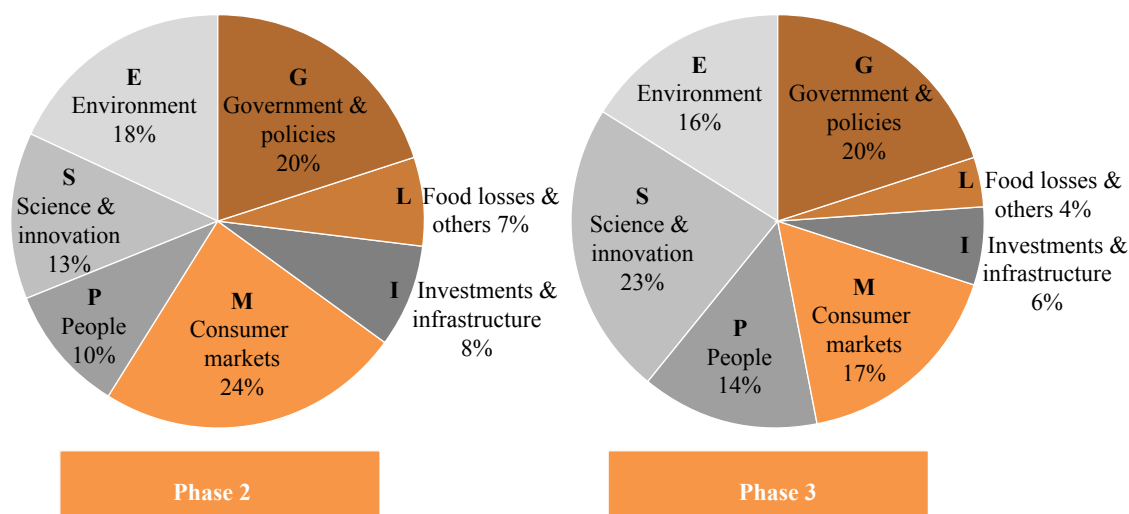


Figure 4. Comparison of the frequency of challenge categories under GLIMPSE obtained in Phase 2 (survey) and Phase 3 (social media).

4. Discussion

The findings from the three phases of new research were evaluated in the context of the original GLIMPSE acronym, testing the alignment between the new data and the GLIMPSE framework, expanding the understanding of each of the challenges, and integrating the new consumer element. In reviewing the findings, it was apparent that the overlap between Government and Politics & Policies was such that it made sense to combine. It also became clear that people, in particular the availability of appropriately skilled workers is emerging as a significant challenge. Accordingly, the GLIMPSE acronym has been amended to reflect these findings. The discussion below uses the revised framework (Table 1).

Government and policies

Although Government & Policies covers many areas, there were four aspects that particularly stood out: corruption and self-interest; environmental regulations; trade-distorting subsidies or quotas; and poor quality government infrastructure.

Table 1. New and original (2012) GLIMPSE frameworks.

New GLIMPSE framework, aligned with 2012 categories						
G	L	I	M	P	S	E
Government & policies	Losses	Infrastructure & investments	Markets: consumers	People	Science & innovation	Environment
2012 GLIMPSE categories						
Government	Losses in the food and ingredient supply chain	Infrastructure	Markets	Politics & policies	Science & innovation	Environment

■ Corruption and self interest

Professionals working with governments (5.00%), along with those from academia, research (5.86%) and ‘others’ (5.15%) expressed the most concern with corruption and self-interest politics, while agribusiness experts generally did not spontaneously bring up corruption. Regionality is significant here: the majority of interviewees consider corruption to be embedded in their societies. Professionals in Africa and Asia indicated the most direct concern with the impact of corruption (~7% put it among the top 5 challenges), while the professionals from Latin America indicated less concern about corruption than the global average (4.05 vs 5.07% average). Despite the current corruption scandals in Brazil, a managing director from an investment bank in Brazil noted that corruption was inherent in the society as a whole and thus was not seen as a particular, direct, barrier to agribusiness. The perception is that corruption and self-interest is omnipresent and inextricably linked to doing business. This acceptance of corruption as inevitable is itself a constraint on developing solutions.

■ Environmental regulatory changes

Climate change was the challenge most frequently mentioned in the open-ended question in Phase 2. Agribusinesses have to prepare for regulations arising from concerns about climate change, as well as changing regulations involving other environmental elements (such as waste disposal and water management). Both region and role affected the responses regarding these challenges. Across all regions, regulatory concerns were the second most commonly cited (6.26% average), but regionally regulatory changes were particularly noted as a challenge by professionals in Latin America (9.87%). By role, professionals from trading and processors and very large companies (over 10,000) (4.21 and 4.26%, respectively) were more sanguine about regulatory changes than government respondents and farm producers, who considered environmental regulations a significant challenge (11.6 and 9.39, respectively, vs 6.90% average). As a respondent from a major Irish feed brand noted, they know that ‘Governments will play a role in regulatory changes [to] offset emissions by changing production methods. [...] 10% of emission in EU comes from agriculture’.

■ Subsidies and quotas

Professionals from Oceania (4.21%) and Latin America (3.86%) saw the issue of subsidies as more problematic than those from Europe (1.49%) and North America (2.17%), which seems to correlate with the history of subsidies between the regions. Professionals working in the government attributed a much higher level of importance to the Government & Policies challenge within GLIMPSE (5.00 vs 2.52% average).

There were numerous quotes about the levels of subsidies in other markets, including from an agricultural company, an Irish farm input retail firm (who noted that approximately 80% of farmers ‘lose money operationally and survive on government subsidies’), the American Feed Association (China’s subsidies for inefficient agriculture) and so on. A leader of Harvard’s agribusiness program argues that ‘Countries want to be self-sufficient to better respond to rise in prices’. But the consensus among a significant majority of the experts interviewed is that protectionism fosters inefficiency and diminishes worldwide food output. ‘It is politics more than efficient resource allocation,’ noted a partner of a strategic consulting firm.

■ Poor government infrastructure

The importance of poor government infrastructure (that is politically unstable governments, poor law enforcement, and excessively high bureaucracy) seems to be affected more by the respondents’ role within the agribusiness community than by the region that they are from. Regionally, the level of concern is fairly evenly distributed, with an average around 6%. However, government professionals saw the challenges of poor government infrastructure as a significant challenge, and were significantly more likely than the average respondent to cite it as a challenge for agribusiness (11.67 vs 6.90% average). An advisor to the Ministry of Agriculture in Ukraine noted that an ‘unstable and poor legislation system’ is their number one

challenge in agribusiness. A frequently cited concern is a lack of rule of law, and that enforcement of both laws and regulations especially in rural areas is at best uneven, frequently chaotic, and often absent altogether. Examples offered included not following vaccination protocols and illegal deforestation.

Failure to enforce regulation is matched as a challenge by excessive regulation. As an executive of a large food company in Thailand noted 'regulations delay the release of new products' and that government should be more active in solving the issue. Producers worry about the delays in getting agricultural products to processors or market.

Loss and waste

Food loss (that is, waste that occurs in the upstream, or production part of the value chain), and food waste (which occurs in the downstream, or retail and consumption part of the value chain) are estimated to result in the loss of 24% of the calories contained in all the food that is produced (Lipinski *et al.*, 2013). Although food loss is more of an issue in less developed regions, and food waste in more developed regions, there is both loss and waste globally.

■ Food loss: upstream

In developing regions, food loss occurs primarily through the production and logistics process, and is linked to a number of GLIMPSE factors, notably Infrastructure, Technology, and Government. A lack of workforce skills was also noted by as a significant number of respondents. Food loss also contributes to issues in the Environment, particularly where the waste or pollution of natural resources affects the environment. Respondents suggested that improvements in the coordination of agents such as governments, consumers, or factors of production, would lead to the reduction of waste in the supply chain.

Regionally, food loss along the supply chain is considered a greater challenge in Africa (5.63 vs 3.59% average), Europe (4.68%) and Latin America (4.72%). Similarly, when segmenting by activity within agribusiness, Food Retail Trading & Processor (4.74%) and Academics & Research (4.69%) demonstrate more concern about food loss. When examining the data by role, self-employed professionals and those from larger companies (over 5,000 employees) (4.50 and 4.17%, respectively, vs 3.41% average) are most concerned about food waste.

The social media analysis indicates that there is limited awareness of food waste and losses among the general public. A Harvard agribusiness expert argues that economics suggest that waste will be reduced as resources become scarce, but there is no evidence that point has been reached yet.

■ Food waste: downstream

Food waste at the consumption and retail level is more prevalent in developed regions. There is a clear regional divide with regard to the perceived importance of food waste at the consumer or retail level: professionals in Europe (4.68%) and North America (4.07%) rank it as a much more serious challenge than those in Africa (1.41%) and Oceania (1.40%). Unsurprisingly, those working in food retail (10.00, vs 3.79% average) and trading and processors (6.84%) are more concerned about food waste at the consumer level as well. While the majority of the interviewees consider food waste at the consumption level a challenge, some do not relate it directly to agribusiness.

In 2014 the European Commission set a goal of reducing food waste in Europe by 30% by 2025 (EC, 2014a,b), but is already working on a more ambitious target to 'transform Europe into a more competitive resource-efficient economy ... including waste' (EC, 2015).

A partner in a strategic consulting firm sees food waste as an opportunity: solving it would save enough food to eliminate hunger – if the logistics of getting the food from the places where it is in to where there are shortages could be resolved. The managing director of a Dutch horticultural trading company pointed to closed loop cycle systems and the need for new technologies that will allow the use of food waste.

Infrastructure and investments

Infrastructure & investment addresses the capital necessary for agricultural production, from capital (fixed and financial) for all stages of the value chain, to the infrastructure needed for production, storage and transportation.

■ Infrastructure

The respondents identified Infrastructure as one of the most limiting factors of food production and distribution across several regions. Professionals from Latin America and Africa were particularly concerned, citing poor infrastructure as their second biggest challenge (6.87 and 6.34%, respectively, vs 4.51% average). Respondents from larger companies (over 5,000 employees), food retail and the press (4.95, 4.0 and 3.68%, respectively vs 3.42% average) also see poor infrastructure as more of a challenge than those from other segments.

On the African continent, getting goods to market can be difficult for farmers, as only a minority of the rural population lives within two kilometers of an all-weather road: 32% in Kenya, 31% in Angola, 26% in Malawi, 24% in Tanzania, 18% in Mali and just over 10% in Ethiopia (Juma, 2012). A number of respondents specifically noted the lack of cold storage and transportation infrastructure among the major challenges for agriculture delivering enough food to feed the world in the future.

■ Investments

The respondents noted a number of investment and finance issues. Lack of access to finance or investors was ascribed to the lack of credit lines for agribusiness and the lack of financial sophistication of players within the sector, while government instability was noted as making investors concerned about long-term gains. For both the private and public sector, the ability to access existing or new lines of credits is a particular challenge, especially in developing regions. A director involved in African business schools notes that 'capital investment financing is much more of a problem than working capital financing,' though he notes that both limit industry growth.

There is significant regional variation in the responses concerning finance: among professionals in Africa the frequency of finance being cited as a challenge was almost twice the global average (6.34 vs 3.51%), and it was cited as the most significant challenge by 10% of the respondents from Africa. Unsurprisingly, the respondents working in financial markets also consider it significantly more important than respondents from other industry segments (6.78 vs 2.70% average).

Markets

Market related responses, especially those referring to consumers, were amongst the most frequently cited. Though individually they were not generally ranked as the most challenging issues, combined they represent a substantial challenge. These challenges can be grouped into three categories: capacity, industry structure, and consumer expectations.

■ Industry capacity

A partner in an Indian consulting firm noted that the younger generations in India are not as concerned with religious prohibitions on eating meat. This is consistent with the global trend: as countries get wealthier they tend towards more protein based diets. In turn, protein-based diets require more factors of production, whether technology, natural resources, or capital (including human capital). As a challenge, the capacity of the industry to produce enough protein requires a fresh look at how current and potential protein sources can be developed to feed the world. Consumer preferences will matter: as an Irish agricultural entrepreneur asked, 'Would the world be prepared to eat protein from insects that have been fed on food waste?'

The head of a large Spanish producer pointed out that the practicalities of producing meat in the volume that the market requires, in ways that consumers demand (for example, treated humanely, with traceability and without antibiotics) requires the development of better technologies and environmentally friendly practices.

Nonetheless, although the respondents recognize it as a challenge, they seem to have confidence in the capacity of the industry to produce enough protein. When adjusted for regions, the shift in consumer preference towards more protein was the lowest ranked challenge in this study. Curiously, one of the least concerned sectors was professionals in Asia, where much of the growth in demand is expected (0.63 vs 2.21% average). The self-employed and professionals in small firms respondents didn't note it as a challenge at all, while professionals working in the financial markets and food retail were the most concerned about the challenge (5.08 and 4.00% respectively, vs 2.72% average).

■ Industry structure

The structural problems to growth within the agricultural sector are both external (access to consumer markets) and internal (poor coordination within the industry). Access to consumer markets was a particular concern for respondents from Asia and Africa (4.18 and 5.63%, respectively, vs 2.77% average). Respondents noted that fragmented markets and lack of transparency lead to inefficient pricing; multiple intermediaries in many markets reduces efficiency and squeeze margins for primary producers; and the lack of a standardized pricing system makes it difficult for smaller producers to compete successfully. A respondent from a development bank in South Africa also noted that inconsistent quality, a lack of volume and other limitations make marketplace access difficult.

Some experts, including the partner of a top consulting firm, argue that the advent of urbanization and technology, particularly smart phones, has diminished the magnitude of these challenges, and a director of an industry association notes that new retailing structures are arising in cities in emerging countries, so that over the next two decades opportunities should improve for farmers.

However, getting better access to the consumer marketplace is only half the equation: poor coordination within the industry, between producers, processor, and retailers also hampers growth. Moreover, fluctuations and changes in consumers demand can aggravate the challenge.

The lack of coordination is an issue both with players operating in one economic activity of the industry and those working across different activities (e.g. coordinating producers with processors with food retail). In both cases there is a zero-sum approach to transactional relationships rather than cooperation for mutual benefit.

There was considerable disagreement among respondents as to where in the value chain the problem lies. Some producer and processor respondents noted that food retailers responding to consumer expectations have substantially increased requirements from their supply chain (upstream accountability and documentation, ingredient changes, packaging, etc.) but are not willing to adjust prices. Large processors in both Italy and Sri Lanka noted that these demands by retailers are reducing their margins to unsustainable levels.

Other participants argued that it is large transnational companies that are not connected with other players (particularly producers) in the industry who have required suppliers to squeeze their margins below sustainable levels. Still others attribute the problem to the producers, saying that the producers are not well connected to one another and frequently are not capable of responding effectively to supply chain requirements.

Although one food processor argued that companies are only competing for the same consumers and this is the natural dynamics of a free and competitive market, a European investment advisor pointed out that ‘contradictory information driven by different lobby groups may be detrimental to the industry as whole’.

This disparity of views is emblematic of the lack of coordination of players within agribusiness. When the data is adjusted for region, it was the second highest ranked challenge (6.25% average), with the least variability across different regions (2.27%).

■ Consumer expectations

Consumer expectations of agribusiness in general and food preferences in particular have been changing rapidly, along with the platforms for expressing those views. A demand for more natural and healthy food options, concurrent with consumer opposition to genetically modified organisms (GMOs) and other forms of biotech innovation has created considerable communication challenges for agribusiness. CRISPR-Cas9 may offer some alternatives to classic transgenic options (Waltz, 2016).

The demand for more natural food options can be seen in a recent Food Label Survey (Consumer Reports National Research Center, 2015) in the US that found that consumers say they search for foods that are locally grown (66%), natural (59%), free from artificial growth hormones (50%), pesticide free (49%), or organic (49%).

However, most of the respondents agreed that, given the currently available technology, the planet does not have the resources to produce enough food to feed everyone using only non-GMO, natural and organic production techniques. Some noted that economics will play a role in preventing these requirements from becoming stricter, as food produced meeting all of these requirements will become more and more expensive. Although the population segments requiring food to be non-GMO, organic and natural are small, they tend to be more educated, wealthier and more voluble, thus more likely to affect policy making. Some of the experts noted that if policies shift further in those directions, it will make feeding the world of the future –especially the poorer segments – even more challenging.

Professionals in North American, Latin American and Africa were more concerned about this challenge (5.52, 5.15 and 4.93%, respectively, compared to 4.15% average), along with professionals with fewer years of experience in agribusiness (6.14 vs 4.28). Finally, retail food and press professionals were more concerned with changing consumer expectations (10.00 and 6.67%, respectively, vs 4.81% average). On the other hand, NGO professionals were notably less concerned (2.22%).

Many of the approaches that agribusiness is using to try and improve the availability of food, including biotechnology innovations in GMOs, feed additives, clones, etc. have been met with active resistance in the market place. Professional respondents from North America were markedly more concerned with consumer acceptance of biotechnology than those from other regions (9.14 vs 5.22% average) and it was the most frequently mentioned concern, with more than 10% ranking it their top concern. On the other hand, none of the professional respondents from Africa noted acceptance of biotechnology as a primary challenge, and less than 1% mentioned it at all. Professionals working with farm inputs, academics, and researchers (who are responsible for much of the new biotechnology of the industry), are somewhat more concerned than average (7.58 and 7.87% respectively, vs 5.77% average) with how consumers accept or resist/delay new technology.

The opposition to GMO foods amongst consumers is widespread. A recent survey (Pew Research Center, 2015) published in collaboration with the American Association for the Advancement of Science (AAAS) concluded that the 57% of the general public says genetically modified (GM) foods are unsafe to eat while only 37% claim it is safe. In contrast, 88% of AAAS scientists assert GMOs are safe to eat. At least one third of the interviewed experts, from around the world, spontaneously mentioned opposition to GMOs among the top 3 challenges. An expert with experience in Ghana noted that there is a 'huge anti-GMO' movement in Africa, and an expert from U.C. Davis noted that varieties of GM cassava that would improve harvest rates substantially are available in Africa, but have not been approved by regulatory authorities because of fears over safety.

A director from an investment bank suggested that 'if the first GMO products directly benefited consumers, with higher nutritional values, instead of farmers, with higher yields and lower costs, the outcome of public opinion might have been different'. As it is, consumer groups have managed to dominate the conversation and agribusiness has failed to deliver its own message clearly. To some extent this reflects agribusiness' low level of credibility with consumers, who see some well-known names in the industry as having a conflict of interest, and motivated solely by profit, with little regard for possible risks, and benefits to consumers as secondary priority. Some respondents object that many of the loudest consumer voices are poorly informed and share inaccurate or misleading information. Whatever the truth of these claims, it is clear that communication between consumers and agribusiness has not been successful.

One of the interviewees, a food retail owner and television show host, invited a large biotechnology company to their televised food show to participate in a debate about GMO foods, but the firm declined to participate. Respondents from an industry association, a major US food retailer, a large Latin American food processor and a French cooperative all noted that the agribusiness sector has not done a good job communicating with consumers regarding the use and constraints around factors of production such as new technologies, resource, available infrastructure and others.

Other interviewees, including a director of an international institute, and a former CEO of an international food NGO, argue that the industry has done a good job communicating with consumers but that given the lack of credibility within the industry there is not much that can be done to affect consumer attitudes.

The advent of CRISPR-Cas9 may offer new options for agriculture, the ability to edit genes in a manner which is perceived as consumer friendly and similar to the mechanisms used by the organism in nature to correct gene deficiencies (Connolly, 2016). CRISPR offers producers the potential to achieve similar or better responses to GMO technologies without the regulatory hurdles (Waltz, 2016).

Farm input and press professionals are more concerned about the challenge of consumer communications (5.27 vs 3.89% average), while NGOs and government professionals are less concerned about inefficient communication (2.22 and 1.67%, respectively). When segmenting for company size, professionals from companies with fewer than 200 employees identify communication as more of a challenge than those from companies with more than 5,000 employees or the self-employed (5.01, 3.85 and 1.80%, respectively, vs 4.14% average).

Governments are realizing that communications with consumers is an important issue and are trying initiatives to bridge the gap, such as the 'know your farmer, know your food' program for supporting local food systems to create jobs and boost economic growth created by the USDA in 2009 (USDA, 2016).

People

The biggest difference between the first and second GLIMPSE studies is the emphasis on people. In the original study adequate qualified workers were noted as a potential problem for the future, but were not seen as a particularly significant challenge. In just four years it has become an important challenge. There are

two related aspects: a shortage of an adequate, qualified workforce, and the difficulty in attracting talented young people to agribusiness.

■ Lack of qualified workforce

The majority of respondents view the challenge of having a qualified workforce as significant: approximately 20% of the respondents put the challenge of getting qualified workers in their top five challenges (though rarely as the top challenge). Variability across regions is low (1.5%). A researcher from a South African agricultural council noted 'there are a lot of people who are willing to work on farms but who are not qualified'. An executive from a large Brazilian cooperative concurred saying, 'There is a significant contingent of people (in agriculture) demanding training'. The president of a US poultry company argues that farming requires a broad set of skills, and that set of skills is becoming more specialized as new technologies are transforming all segments of the agribusiness value chain. A study from Rezende *et al.* (2009) found that the lack of qualification in the workplace derives from informality, seasonality and high turnover of employees.

■ Attracting young people to agribusiness

The head of an industry association, and owner of a large poultry operation, commented that it has never been so difficult to hire people to work in agriculture. He noted that the greatest challenge in a recent new project was to find 800 people to work in it, because 'people don't want to work in agriculture'.

Some experts argue that agriculture and food production are going through a 'talent renaissance' with the increase in use of technology and the growing awareness of the sector by population at large. They believe that the rise of automation in agriculture will require more jobs indoors than in fields, attracting a greater number of new and young people than in the past. However, although a US professor has seen a sharp increase in college applications to agriculture-related degrees, there is still a significant shortage of qualified people to fill jobs in agriculture in North America. There is an agreement among experts that agribusiness still demands more talent than what is available.

People with less than 10 years of experience in agriculture find the challenge of attracting new talent substantially more important than those with more than 50 years (7.16 and 3.67%, respectively, vs 5.72% average). Overall it was the seventh highest ranked challenge, with more than 20% of respondents mentioning it. While more than one in eight professionals working in farm input companies ranked the challenge as most significant, self-employed professionals did not see the challenge as relevant.

A subset of this challenge is business succession. Many farmers and agribusiness owners are facing difficulties in the succession of their business as the younger generations are not as attracted to the industry. According to Rabobank's analysis (2015), the average age of farmers in the USA increased from 45 in 1974 to 58 in 2007. The same study found that in the USA there are seven times as many farmers over age 75 as there are under age 25. Australia is seeing similar demographic changes: the average age of farmers in Australia increased from 44 to 56 over the past 30 years.

Experts from South Africa, Ireland, Brazil, the USA and several other countries spontaneously mentioned succession as a significant challenge of the industry. A counter argument, presented by the head of a Chinese biotechnology company, is that succession issues will be resolved by changes in ownership structures.

Science and innovation

Although the category of Science and Innovation covers a broad spectrum, for the respondents the challenges presented can be generally categorized as challenges of access to needed technology, resistance to innovation, and needed innovations.

■ Access to technology

Poor productivity was blamed in part on a lack of access to technology, particularly in Asia and Africa (6.90 and 5.63%, respectively, vs 4.32% average). Reducing the gap between high performers and low performers is key to increasing food production. Low performers typically have land, natural resources and sometimes people, but are less likely to have access to technologies such as crop or animal genetics, nutrition and management, irrigation, automation, and many other resources. The lack of access can be attributed to insufficient expertise (the producer may not even be aware of technological resources), local availability, an adequate ecosystem, finance, government limitations and others.

Experts from Peru, South Africa, Ukraine and India commented on the lack of access to technology in their countries. A partner from a strategic consulting firm commented that India, China, Niger, Ethiopia, and Ukraine, among others are all producing at 25 to 30% of the developed world yields. Another study concluded that the average irrigated and rain-fed maize yield in China has about half the yield achieved using technology typically used in other countries (Meng *et al.*, 2013).

■ Resistance to innovation

The range of views about the importance of this challenge was particularly high. Many of the respondents considered the challenge irrelevant while others saw it as a significant issue. One banking executive in Brazil noted that expenditure in food production research globally is about the same today as it was in 1970, with no adjustment for inflation. The president of an animal feed company in the USA commented, 'Some farmers in the Midwest have not been farming for 20 years. They farmed once and repeated themselves for another 19 years'. The director of a development bank in South Africa argued that if technology is economically available, agribusinesses will adopt it. Others believe that current levels of technology and adoption are acceptable.

The views of respondents who believe that the current rate of new technology evolution is not sufficient to support the needed growth in agricultural production and productivity were compared to those of respondents who believe farmers are not willing to adopt new technology or do so in a slower than optimal manner. People with less than 10 years' experience in the industry believe that adequacy of technology is less of an issue than resistance, while those with more than 50 years of experience see the issue as being more about the adequacy of the technology (2.78 and 3.76%, respectively). Of the professional respondents, those associated with NGOs were notably more concerned about the adequacy of with technology production and adoption (6.67 vs 3.43% average).

■ Needed innovation

Disease outbreaks and pest infestations are chronic challenges in agribusiness that have been exacerbated by both agricultural practices and the globalization of the food chain. Avian Influenza is a striking example of the challenge: the H5N1 strain was first identified in Asia in 2003 and by 2005 it had reached Europe and the Middle East, followed by Africa by 2006. In one week in 2015, outbreaks were reported in Taiwan, Vietnam, Indonesia, Ghana, Ivory Coast, Nigeria, Palestinian Territories, Mexico, and the USA (National Wildlife Health Center, 2015). The outbreak in the USA killed more than 48 million birds, representing 10% of total national turkeys, and 40% of Iowa's laying hens (USDA, 2015). Examples of other high profile outbreaks include bovine spongiform encephalopathy (BSE, or mad cow disease), pig virus, *E. coli*, and foot and mouth disease. One respondent, a member of the World Agricultural Forum and former executive of a major poultry processor, cited these sorts of biosecurity threats as the number one treat to agribusiness in the future.

Many of these outbreaks result from current production methods and technologies, as well as expanded trade of living animals. Effective control and response mechanisms depend on implementation by people

throughout the food value chain, and regulatory reaction to a single incident can change the larger operating environment. The president of a large poultry operation noted that *Salmonella* contamination of one producer's birds lead the US government to change policies for the entire country.

Crop protection, particularly rapidly evolving resistance to pest control products is another issue. A Brazilian executive noted that there have been few innovations in crop protection. Overall, biosecurity was one of the top 5 biggest challenges cited by respondents, particularly those from Oceania, the USA and Canada (7.48 and 7.42, vs 6.17% average). Professionals working in trading companies (7.89%) and consulting (8.13%) also consider it relatively important (5.95% average).

Environment

Scarcity and depletion of natural resources (especially, but not only, land or water) as well as changing regulations and population patterns all present challenges to the agribusiness sector.

■ Water

The World Economic Forum's Global Risks 2015 Report (WEF, 2015) lists water crises as the top global risk in terms of impact, and eighth in terms of likelihood of severe crises occurring. Water scarcity is, by a substantial margin, the most frequent challenge listed and discussed by study respondents. One third of the interviewees in Phase 1 spontaneously mentioned water as being one of the greatest challenges for agribusiness. 20% of the respondents listed scarcity of fresh water as the number one challenge, and nearly half considered it among the top 5 challenges.

However, there is some regionality in the responses. Professionals from North America and Oceania are relatively more concerned with the challenge (12.04 and 11.21%, respectively, vs a global average of 9.10%). Indeed, a third of the professionals with experience in Oceania listed water as the number one challenge. On the other hand, professionals from Asia and Latin America (6.69 and 6.44%, respectively) were comparatively less concerned with water scarcity.

In contrast to the concerns about innovation, it was the more experienced respondents (those with more than 40 years of experience) who were more concerned about water, than those with less experience (under 10 years) (11.31 and 7.89%, respectively, vs a 10.38% average). NGOs, financial markets and press professionals were more concerned about water than other sectors.

Although most participants agree that technology will be the solution to overcome water scarcity, they do not believe that solutions will be developed in the near future. A partner from a consulting firm gave the example of desalinization facilities in Australia that remain unused due to high operating costs. Other interviewees suggested that water pricing is a viable short-term solution, and not just at the producer end. Consumers could be charged for the water cost of foods, which would in theory increase demand for more efficient production methods.

■ Land

For professionals involved in primary production, land availability is second only to water scarcity as a challenge, with professionals newer to the industry the most concerned. Overall, availability of additional land for food production was ranked as the third most serious challenge. Professionals from Asia and Africa were more concerned than those from Latin America.

Land availability challenges in Asia are generally related to population, while those in Africa are more often related to land ownership and land reform. One respondent from South Africa noted that land is mostly in

the hands of people who are not looking into further developing agricultural productivity. These owners have been granted the access to the land and do not have any particular incentive to increase their productivity.

According to the Sustainable Europe Research Institute (2013) more than 75% of the land on earth (excluding Greenland and Antarctica) is already being used by humans, including urban areas (1%), cropland (12%), forestry (27%) and grazing land (36%). About half of the remaining land is unproductive land. Unless agricultural productivity increases, to meet the growing demand for food approximately 6 million additional hectares of land need to be converted to agricultural production every year until at least 2030 (ELD, 2013). However, respondents noted that conversion of land to agriculture faces a number of obstacles, including concerns about deforestation and release of carbon.

■ Other environmental challenges

Respondents cited scarcity of fertilizers, energy costs, poor waste management that contaminates and/or depletes other natural resources amongst other environmental challenges. An Australian expert in seafood retail noted that availability of salt water reserves for seafood farming is a challenge.

Few respondents from Phase 2 (2.96%) specified 'other' challenges, but professionals from Europe were more likely to specify concerns than those from other regions (4.26 vs 3.00% average), as were respondents with fewer than 20 years in the field (3.37 vs 2.40% average).

5. GLIMPSE: revisited and revised

The updated research largely validated the original GLIMPSE work, but found areas where updating or expansion was appropriate, as well as some opportunities for realignment. Drawing on the results from Phase 1 some adjustments were made to the category definitions.

The most significant difference from the original GLIMPSE framework revolve around challenges related to people: the 'lack of qualified or educated workforce' and 'new and young talents not being attracted by the industry'. Human capital was implicitly encompassed under various other challenges in the original study, but the present research prompted the creation of a new People category. The original GLIMPSE framework treated Policies and Government as separate categories, but the findings from the current work confirmed how interdependent these two categories are, so they have been consolidated into one category.

The second significant adjustment is the specific inclusion of Consumers into the Markets element, reflecting the increasing importance of consumer interaction. Consumers' preferences, expectations and requirements are changing, and the flow of information between them and participants in the food chain is stronger and more public than in the past.

Other minor adjustments are the inclusion of Investments to Infrastructure under the letter I, to account for the fixed or financial capital needed for improvements in production, and the specific inclusion of food loss, reflecting the magnitude of the loss as a proportion of agricultural production is affected.

These adjustments bring the GLIMPSE framework into alignment with the findings from the current research and incorporate all of the major challenge categories identified through the research.

6. Conclusions

Through an iterative, grounded theory methodology the original research that led to the GLIMPSE framework was validated, deepened and expanded. The key challenges were identified through open-ended interviews with industry experts, then confirmed and classified across industry segments, with interview and survey input from almost 600 agribusiness professionals from 53 countries. The challenges identified and refined in

these steps were then tested for relevancy and accuracy through the analysis of more than one million social media posts. The findings from this work were then reviewed against the original GLIMPSE framework, and some adjustments made to the framework to reflect both the changes over time and the findings of the larger study.

The current research improves the characterizations of the GLIMPSE categories and confirms that the challenges encompassed by the acronym are comprehensive. It also confirms the complexity of the challenges: the challenges are so interlinked that they cannot be analyzed on a standalone basis. The framework offers industry participants a useful tool for identifying those areas over which they have influence, thus helping to reduce uncertainty and measure risk.

The challenge of feeding a population that is rapidly increasing both in numbers and income is complex and contradictory. It will require aligning factors of production, agribusiness and society. Four of the GLIMPSE challenges relate to production factors: Infrastructure & Investments, People, Science & Innovation, and Environment. The other three challenges reflect the challenges of coordination between agribusiness and key stockholders such as governments and consumers. GLIMPSE offers a framework for identifying and understanding these challenges and provides the agribusiness sector with identification tools for addressing these problems.

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