

1
2 **Committee on World Food Security**

3
4 **High Level Panel of Experts on Food Security and Nutrition**

5
6 **Sustainable Agricultural Development**
7 **for Food Security and Nutrition,**
8 **including the Role of Livestock**

9
10 **V0 DRAFT REPORT**

11
12 **2nd October 2015**

13
14 Submitted by the HLPE
15 to open electronic consultation
16 until 31 October 2015

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18
19 This V0 draft is publicly available on the HLPE consultation platform:

20 <http://www.fao.org/fsnforum/cfs-hlpe/Sust-Agr-Dev-Livestock-V0>

21 ***Please read the consultation cover letter on pages 2 and 3 of this document***

22 Comments can be sent by e-mail to: cfs-hlpe@fao.org or to fsn-moderator@fao.org.

23
24 This consultation will be used by the HLPE to further elaborate the report, which will then be submitted
25 to peer review, before its finalization and approval by the HLPE Steering Committee.

26
27 *This V0 draft may be thoroughly corrected, modified, expanded and revised after the present
28 consultation.*

29 *For this reason we kindly invite you not to cite nor quote elements from this V0.*

Please only refer to the final publication for quotations.

1
2 **COVER Letter from the HLPE to this V0 Consultation**

3 **HLPE consultation on the V0 draft of the Report:**

4 **Sustainable Agricultural Development for Food Security and Nutrition,**
5 **including the role of Livestock**
6

7 In October 2014, the UN Committee on World Food Security (CFS) requested the High Level Panel of
8 Experts on Food Security and Nutrition (HLPE) to conduct a study on Sustainable Agricultural
9 Development for Food Security and Nutrition, including the role of Livestock. The findings of this study
10 will feed into CFS 43 Plenary session (October 2016).

11 As part of the process of elaboration of its reports, the HLPE is organizing a consultation to seek
12 inputs, suggestions, and comments on the present V0 draft. This open e-consultation will be used by
13 the HLPE to further elaborate the report, which will then be submitted to external expert review, before
14 finalization and approval by the HLPE Steering Committee.

15 HLPE V0 drafts are deliberately presented early enough in the process - as a work-in-progress, with
16 their range of imperfections – to allow sufficient time to give proper consideration to the feedback
17 received so that it can play a really useful role in the elaboration of the report. It is a key part of the
18 scientific dialogue between the HLPE Project Team and Steering Committee, and the rest of the
19 knowledge community. In that respect, the present V0 draft report also identifies areas for
20 recommendations at a very early stage, and the HLPE would welcome suggestions or proposals.

21 In order to strengthen the report, the HLPE would welcome submission of material, evidence-based
22 suggestions, references, and examples, in particular addressing the following important questions:

- 23 1. The report is wide-ranging and comprehensive in analyzing the contribution of sustainable
24 agricultural development to ensuring food security and nutrition (FSN), with a particular focus
25 on the livestock sector because of its importance for both nutrition and sustainable futures. Do
26 you think that the report is striking the right balance between agricultural development overall
27 and the livestock sector specifically with respect to their relative contribution to FSN?
- 28 2. The report is structured around context, trends, challenges and pathways/responses. Do you
29 think that these are comprehensive enough, and adequately considered and articulated? Does
30 the report strike the right balance of coverage across the various chapters? Are there
31 important aspects that are missing?
- 32 3. The report uses a classification to distinguish between four broad categories of livestock
33 systems, in order to better identify specific challenges and sustainable development pathways
34 for each of them. Do you find this approach useful for identifying specific policy responses and
35 actions in different socio-economic and environmental contexts?
- 36 4. The report has referenced key projections and scenario studies in identifying the drivers and
37 trends through to 2050. Are there other studies that the report needs to reference, which offer
38 different perspectives on the future outlook for the agriculture (including livestock) sector, in
39 particular those that focus on nutrition and diet?
- 40 5. The report has identified a wide range of challenges likely to be faced in the coming period to
41 which policy makers and other stakeholders will need to take into account so that SADL can
42 contribute to FSN. Do you think that there are other key challenges/opportunities that need to
43 be covered in the report, including those related to emerging technologies, the concentration
44 and intensification of production in livestock, and the implications for feedstuffs (crops and
45 oilseeds), and international trade?
- 46 6. A decision-making approach that could be useful for policy makers in designing and
47 implementing policies and actions has been proposed in Chapter 4 of the report. Is this a
48 useful and pragmatic approach?

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- 1 7. Chapter 4 also contains case studies/examples of evolutions of agricultural development
2 policies and actions in different contexts/countries. Could you offer other practical, well-
3 documented and significant examples to enrich and provide better balance to the variety of
4 cases and the lessons learned in agricultural development, including the trade offs or win-win
5 outcomes in terms of addressing the different dimensions of sustainability and FSN?
- 6 8. The social dimension of sustainable agriculture development has often been less well
7 described and understood, including due to lack of data. Examples and experiences on such
8 issues (livelihoods, gender, share and situation of self employed versus wage workers,
9 working conditions, etc.) would be of particular interest to the team.
- 10 9. The upstream and downstream sectors are playing an increasingly important role in respect of
11 the orientation of agricultural development, food choices and diets. Can you provide examples
12 of the role these sectors play in sustainable agricultural development and FSN?
- 13 10. What are the key policy initiatives or successful interventions to improve the sustainability of
14 food systems, in different countries and contexts that merit discussion in the report? Is there
15 evidence about the potential of economic incentives, and which ones (taxes, subsidies etc.),
16 regulatory approaches, capacity building, R&D and voluntary actions by food system actors?
- 17 11 The design and implementation of policies for FSN requires robust, comparative data over
18 time and across countries. Where are the data gaps that governments, national and
19 international organizations might need to address in the future in order to understand trends
20 and formulate better policies?
- 21 12 Are there any major omissions or gaps in the report? Are topics under-or over-represented in
22 relation to their importance? Are any facts or conclusions refuted or questionable? If any of
23 these are an issue, please send supporting evidence.

24

25 We thank in advance all the contributors for being kind enough to read and comment and suggest
26 inputs on this early version of the report.

27

28 We look forward to a rich and fruitful consultation.

29

30 *The HLPE Project Team and Steering Committee*

31

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47 *Experts participate in the work of the HLPE in their individual capacities, and not as representatives of*
48 *their respective governments, institutions or organizations*

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31
32
33
34
35
36
37
38
39
40
41
42
43

Contents

INTRODUCTION	7
1 CONTEXT AND CONCEPTUAL FRAMEWORK.....	11
1.1 What does “sustainable agricultural development for FSN” mean?	11
1.2 Projections	13
1.3 Revisiting the concept of sustainable agricultural development	13
1.4 “Sustainable agricultural development for FSN”: the key role of the livestock sector ...	17
1.5 Conceptual framework for this report	20
2 TRENDS AND DRIVERS	23
2.1 Projections and scenarios for agricultural development, focusing on livestock supply and demand	23
2.1.1 FAO projections.....	23
2.1.2 Other projections and scenarios.....	24
2.2 Role of livestock in agri-food systems	26
2.3 Typologies of livestock farm systems and their links to crop systems	30
2.4 Prices.....	37
2.4.1 Real prices follow the long-term declining trend	37
2.5 Social elements	39
2.6 From food supply chains towards sustainable food systems	40
2.7 Concluding comments.....	43
3 CHALLENGES TO ACHIEVING SUSTAINABLE AGRICULTURAL DEVELOPMENT THAT HELPS MEET FOOD AND NUTRITION OBJECTIVES	45
3.1 Social sustainability challenges	45
3.1.1 Employment and working conditions.....	45
3.1.2 Gender and equity.....	47
3.1.3 Viable rural communities	47
3.1.4 Ethics and values of production	47
3.2 Economic sustainability	48
3.2.1 Efficiency and yield gaps	48
3.2.2 Market performance	49
3.2.3 Risks in an interconnected world.....	50
3.3 Environmental sustainability	52
3.3.1 GHG emissions from the livestock sector	52
3.3.2 Land.....	52
3.3.3 Water	53
3.3.4 Climate change.....	55
3.4 Health and animal welfare	55
3.4.1 Food-borne diseases.....	55
3.4.2 Animal and human diseases	56
3.4.3 Antimicrobial resistance	57
3.4.4 Animal welfare	58

HLPE DRAFT V0 (2 Oct 2015) – DO NOT CITE OR QUOTE

1	3.5	Main challenges by types of systems	59
2	3.6	Conclusions	60
3	4	TOWARDS SUSTAINABLE AGRICULTURAL DEVELOPMENT: PATHWAYS	
4		AND RESPONSES	61
5	4.1	Introduction	61
6	4.2	The role of livestock.....	61
7	4.3	Pathways towards sustainable agricultural development	62
8	4.4	Responses	64
9	4.5	Approach to policy decision-making and actions	67
10	4.6	Trade-offs and synergies	68
11	5	CONCLUSIONS AND RECOMMENDATIONS.....	81
12		D R A F T Recommendations: Responding to critical challenges to SAD for FSN.....	83
13		REFERENCES	86
14			

15 List of Figures

16	Figure 1	Conceptual framework showing linkages between sustainable agricultural development	
17		and food security and nutrition.....	22
18	Figure 2	Relationship between meat consumption and per capita income in 2011	27
19	Figure 3	Increase in per capita consumption of perishables and pulses in developing countries with	
20		1963 as index year	28
21	Figure 4	Share of traded production in 2024 compared with 2012–2014	30
22	Figure 5	Relationship between intensification and diversification on livestock.....	34
23	Figure 6	Medium-term evolution of commodity prices in real terms	37
24	Figure 7	Ethanol, biodiesel and hydrotreated vegetable oil (HVO) global production 2004–2014	38
25	Figure 8	Foods implicated in food-borne disease in different countries.....	56
26	Figure 9	Decision making approach: the response cycle for policies to address FSN-SADL	67
27	Figure 10	Number of breeding ewes and total lamb meat production in New Zealand.....	69
28	Figure 11	Total sheep farming methane emissions per kg of processed meat	70

29

30 List of Tables

31	Table 1	Challenge matrix	59
32	Table 2	Productivity gains in the New Zealand sheep sector	70

33

34

1 **List of Boxes**

2	Box 1	Rural worlds – importance of agriculture in the economy	14
3	Box 2	Sustainable intensification: a useful guiding concept?	18
4	Box 3	The food sovereignty debate	20
5	Box 4	An overview of the diets in the Mediterranean area and their evolution during the last 50	
6		years	28
7	Box 5	Changing structure of the livestock sector in China	36
8	Box 6	Economic growth, demographic change and food security in China	39
9	Box 7	The challenge in Southern Cone of overcoming degradation, biodiversity loss and soil	
10		erosion on grassland systems with sustainable intensification	53
11	Box 8	The main challenges to Sahelian pastoralism	59
12	Box 9	Reforms in the New Zealand sheep meat sector	68
13	Box 10	Diversifying production in East Africa	71
14	Box 11	Actions on pastoralism in the Sahel and Sahara regions of Africa	71
15	Box 12	Engaging indigenous communities in the protection of northern Australia’s livestock and	
16		sensitive ecosystems	73
17	Box 13	Livestock and deforestation in Brazil	74
18	Box 14	Empowering rural women artisans through improved production, processing and export of	
19		value-added fiber in Tajikistan and Kyrgyzstan	75
20	Box 15	Boosting poultry production in Uzbekistan	76
21	Box 16	Small-scale cattle farming highly integrated with crop production in Uzbekistan	78
22	Box 17	Actions on animal welfare	79

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2 INTRODUCTION

3 *To be regularly revisited and revised as the work on the main text progresses. Sources to be added*
4 *and statistical data references checked – as will be the case throughout the report.*

5 Context

6 This report has been requested by the Committee on Food Security (CFS) in October 2014, in the
7 midst of heightened debate about how to tackle multiple pressures on the world's food and agriculture
8 systems and at the same time reinvigorate efforts to reverse persistent food insecurity and nutrition
9 problems.¹ The debate reflects a range of concerns about the world's capacity to provide effective
10 access to adequate, safe, healthy food for all in the face of rising projected demand for more and
11 different sorts of food. While there is encouraging progress in addressing many of these concerns, it is
12 now clear that much still needs to be done, including in the way our food and agriculture systems
13 perform economically, socially and environmentally, how they can restore and maintain the already
14 stressed natural systems that underpin food production now and into the future, and how they can
15 underpin decent livelihoods and sustainable development pathways.

16 This debate takes place at the time of the agreement by the international community, in September
17 2015, of a set of 17 Sustainable Development Goals (SDGs) for 2030, amongst which Goal 2 is
18 particularly relevant to the present report, namely to "end hunger, achieve food security and improved
19 nutrition, and promote sustainable agriculture". This also follows the 2014 Rome Declaration on
20 Nutrition², which recommended that the United Nations would declare 2016–2025 as a Decade of
21 Action on Nutrition.

22 After more than two decades of global engagement on the question of sustainable development - with
23 an impressive and growing body of research and data in national governments, intergovernmental
24 organizations, and in the scientific, private sector and NGO communities to draw on - there has been
25 an encouraging coalescence of views about the nature of tractable and emergent food security
26 problems, the goals to be attained and the imperative of broadly-based social, economic and
27 environmental approaches to them. It is widely recognized that these approaches need to be
28 sufficiently differentiated to be relevant to extremely diverse farm types across and within countries
29 with different agri-food production typologies, societal and consumer preferences, and reflecting
30 different economic, environmental, cultural and knowledge contexts. There is a vast amount of
31 information available and, unsurprisingly, on some subjects, a very wide spread of views about the
32 causal linkages between aspects of food production and consumption across different typologies, the
33 appropriate policies and actions, and the implications for food security and nutrition (FSN), the earth's
34 natural ecosystems, and society in general.

35 FSN³ encompasses the dimensions of availability, access, utilization and stability of food, all of which
36 interact and differ in terms of importance across countries at different levels and structures of
37 economic and agricultural development.

38 The complex interconnections between different crop and livestock systems, land and water
39 resources, and natural ecosystems prompt consideration about the sustainability of different
40 production systems, how they co-exist, and to what extent they contribute, and how, to FSN, in
41 particular the poor and vulnerable, and the creation of employment and income, in different contexts.

¹ The CFS, in its 41st Plenary Session (October 2014), requested the HLPE to prepare a report on *Sustainable Agricultural Development for Food Security and Nutrition, Including the Role of Livestock*, for its 43rd Plenary Session in 2016.

² Reaffirming the right of everyone to have access to safe, sufficient and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger consistent with the International Covenant on Economic, Social and Cultural Rights and other relevant United Nations instruments.

³ According to the CFS, food security exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. In 2009, the World Summit on Food Security stated that the "four pillars of food security are availability, access, utilization and stability". *Availability* is the supply of food through production, distribution and exchange; *Access* is the affordability and allocation of food, as well as the preferences of individuals and households requirements of each member of the household; *Utilization* is the metabolism of food by individuals; and *Stability* is the ability to obtain food over time.

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1 At the same time, the production, processing, distribution and consumption of food affect the
2 sustainability of the planet's natural resource base, social and gender equity, economic efficiency and
3 cultural values.

4 By 2050, agriculture will have to feed over 9 billion human beings – 2 billion more than in 2010 – most
5 of whom will be in developing countries and often in regions with least possibilities to increase
6 agricultural productivity. Around 800 million people still suffer from hunger, while over 2.5 billion are
7 affected by malnutrition, and 2.1 billion people are estimated to be overweight, of whom 671 million
8 are obese (Ng *et al.*, 2014). While the number of hungry people has fallen, there are serious and
9 growing problems of overnutrition (and not only in richer countries) and of nutritional deficiencies.
10 Changing diets in both poor and rich countries will have major implications for health, resource use,
11 sustainable agricultural development and FSN.

12 The livestock sector is of major importance in such considerations because of its critical position in the
13 food and nutrition status of billions, its role as an engine for the development of the agriculture sector
14 as a whole, its dynamic nature in the face of rapidly growing demand, and the challenging economic,
15 environmental and social choices required if the sector is to contribute more powerfully to food and
16 nutrition security.

17 Increasing future production to meet demand for livestock and associated animal feed production –
18 mostly sourced in from specialist arable farms – will further raise the pressure on natural resources
19 and heighten risks to the environment and to the health and welfare of animals and people. As current
20 and future production depends on maintaining a healthy natural resource base, it is crucial that crop
21 farmers and livestock keepers experience incentives to be able to manage production systems suited
22 to different agro-ecological conditions.

23 Livestock has often been given less attention than crops in agricultural development and FSN. Yet,
24 the meat and livestock sector is central to sustainable agricultural development. It accounts for 40
25 percent of global agricultural GDP and makes a huge positive contribution to livelihoods and nutrition
26 including for poor and vulnerable people in the developing world. An estimated 1 billion poor people,
27 many of them women, derive at least part of their livelihood from livestock. It has been one of the
28 fastest growing sectors in global agriculture, due to rapid demand growth in low-income and emerging
29 economies. That trend is set to continue to meet a 70 percent projected increase in demand for
30 livestock products by 2050, almost all of which will be in developing countries.

31 Globally, meat and other animal products such as milk and eggs provide 13 percent of total calories,
32 28 percent of dietary protein. They are also important sources of vitamins and key micronutrients,
33 several of which are not found in plant foods, contributing to optimal nutrition. Livestock products are
34 thus valuable in combating malnutrition and a range of nutritional deficiencies in particular for
35 disadvantaged and vulnerable people, including the elderly, lactating mothers and infants. Around 2
36 billion people, whose diet is mainly derived from crops, are deficient in these essential nutrients that
37 can be abundantly supplied by livestock products.

38 Along with the positive attributes, the livestock sector is implicated heavily in concerns about the state
39 of the earth's natural resources (greenhouse gases, land clearance, monocultures to generate feed,
40 biodiversity loss, water availability and quality). Livestock production and products also carry important
41 health risks, especially in terms of food-borne disease, emerging diseases and occupational hazards.
42 There are also social concerns such as human health, animal care and industrialization associated
43 with livestock, with attendant social and economic costs.

44 The wide diversity of livestock systems worldwide means that livestock keeping has varying impacts
45 on the socio-economic viability of communities, and on natural resources and the environment,
46 including climate change. In broad terms, at the global level, livestock accounts for around an
47 estimated 14.5 percent of greenhouse gas (GHG) emissions, when accounting for all direct and
48 indirect emissions along the production chain, including land use change, feed production and
49 transport (Gerber *et al.*, 2013) and is a major user of water resources, including irrigation water for
50 animal feed production, but this varies considerably across countries and production systems and
51 moreover estimates of impact are still subject to some dispute. Climate change is already impacting on
52 the agriculture sector, which will have to continue to adapt as well as to reduce its contribution to
53 greenhouse gas emissions.

54 While urbanization has continued apace, as many rural people have moved to cities, many poor,
55 vulnerable and landless people – especially in the transitional phase of urbanization – do not yet have

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1 access to sufficient nutritious food to maintain their health.⁴ (Despite this, urban citizens are better
2 nourished than rural⁵.) At the same time, across the world there is a rapidly growing incidence of
3 health problems linked to poor diets and overconsumption of food, including some livestock products.
4 Livestock products are also frequently implicated as the source of food-borne diseases in humans,
5 and livestock production has been responsible for the emergence of important zoonotic diseases such
6 as new variant Creutzfeldt-Jakob disease (“mad cow disease”) and highly pathogenic avian influenza
7 (“bird flu”). Moreover, losses and waste throughout the agri-food supply chain have drawn attention to
8 the gap between the potential and actual availability of food supplies.

9 **Issues**

10 In terms of food availability at the global level, agriculture, including livestock, has recorded impressive
11 progress in production over time, due to a combination of economic development, advances in
12 technology, knowledge and improved management along the supply chain. This increased production
13 has mostly occurred through specialization, intensification, industrialization and economies of scale
14 that depend increasingly on inputs often grown outside the farm, including animal feed from the crop
15 sector and non-renewable sources of energy. However, pasture-based extensive livestock and
16 pastoral systems that do not rely on inputs from outside the sector are also increasing. Over the long
17 run, world food prices in real terms have tended to fall, although that trend has masked much price
18 volatility, as a consequence of supplies increasing faster than demand. However, that tendency may
19 not continue in the future, both because of greater demand pressures and constraints on supplies
20 from competition for key resources (water, land, energy), technological uncertainties and the cost of
21 regulations. Such a development will have important consequences for achieving FSN for the most
22 vulnerable people.

23 Improving long-term food security, ensuring adequate nutrition and moving towards sustainable
24 development in the context of an increasing global population and incomes, dietary preferences,
25 pressure on scarce resources and climate change, will be very – even prohibitively – costly to achieve
26 under a continuation of recent trends, or a “business as usual” scenario. The evolution of the world’s
27 livestock systems and dietary changes – from the raising of animals through to the point of final
28 consumption – will have arguably the most critical impact of all efforts being made to secure more
29 sustainable agricultural development for FSN.

30 While a fundamental requirement to address the various challenges is that productivity in the crop–
31 livestock sector must grow, that is only one part of the equation. Productivity must be viewed within a
32 broad sustainability perspective in the long term, which implies that the natural resource and social
33 bases on which it depends are secure. In addition, addressing the sustainability of food consumption
34 draws attention to losses and waste as well as the ability of people to pay for food. Recognizing the
35 diversity of cultural and traditional values, and equitable access to production resources, are further
36 requirements that need to be taken into account to address the challenges.

37 Technically, the potential exists – even with existing technologies – to narrow the productivity or yield
38 gap between the highest and lowest performers in a region and thus increase agricultural production,
39 including livestock and animal feed production to meet expected food demand in the future and reduce
40 losses and waste along the food chain. A key question is how to incorporate well-understood
41 technologies and approaches to different scales and types of producers, considering, at the same
42 time, farmer innovation and knowledge, improving yields and diversifying production systems and
43 allowing poor producers to have access to land, water and biodiversity resources in order to improve
44 the design and management of their agricultural systems. The potential also exists to improve the
45 diets, nutritional status and health of poor and vulnerable people – as well as rebalancing the diets,
46 nutritional status and health of many people in rich and emerging economies.

47 But there are at least three key questions to address in actually realizing that potential. First, how can
48 the goals of FSN be achieved in ways and in systems that conserve natural resources, reduce
49 pollution and adjust to climate change, and respect social and cultural values? Second, how can
50 effective policies be designed and implemented to achieve food security and nutritional goals across
51 and within different countries and societal groups? Third, which are the ways and means to address

⁴ Currently, over 50 percent of the world’s population live in urban areas, which are projected to increase to nearly 70 percent by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2014).

⁵ Cross-country evidence consistently shows children in urban areas are better nourished than those in rural areas. For example, in 82 out of 95 developing countries for which evidence is available the proportion of underweight children is less in urban areas (UNICEF, 2013).

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1 the trade-offs involved in moving towards more sustainable agricultural development pathways to
2 improve FSN?

3 Policies across the world have had mixed effects on the sustainability of agricultural systems. Some
4 have been supportive of encouraging sustainable, efficient systems, but others have led to the
5 overexploitation of natural resources, diminished diversified and mixed crop–livestock farming
6 systems, and risked the viability of rural communities. Policies have contributed to the success in
7 reducing the number of hungry people globally and in targeting vulnerable people to consume more
8 nutrient-rich foods, but thus far only very limited success in steering people towards the adoption of
9 healthier diets. There is not one policy formula that is suitable in all situations, but there are lessons to
10 be learned from experience.

11 **The report**

12 This is the first HLPE report on sustainable agricultural development and FSN, although the issue has
13 been touched on in other HLPE reports, either with a sectoral focus or from a cross-cutting
14 perspective. The HLPE Note on *Critical and Emerging Issues for Food Security and Nutrition* (HLPE,
15 2014c) provided both some analysis of the livestock issues, and stressed the importance of a food
16 systems approach. The present report has drawn on previous HLPE reports as contributions to its
17 narrative. This aims to ensure consistency across reports, as well as adding value by giving
18 sustainable agricultural development a central role in the overall HLPE narratives.

19 This report explores how embracing sustainable agricultural development, which covers the crop and
20 livestock sectors, can contribute to achieving FSN by outlining the possible responses and pathways
21 to address the main challenges involved. It concludes by proposing a set of recommendations that
22 policy-makers and stakeholders should consider.

23 This is potentially a very broad and comprehensive issue. However, in recognizing the interactions and
24 linkages involved between agriculture and FSN, between agricultural development and increased
25 FSN, it points towards a systems approach in addressing the challenges. Moreover, given the
26 substantial work that has already been undertaken by the HLPE, appropriate cross references are
27 made to relevant studies without requiring exhaustive treatment in the present report.

28 The report is structured as follows. The first chapter describes the *context and conceptual framework* –
29 the overall developments in the agri-food sector, and the concepts and methodology used to analyse
30 the issues addressed in the report. This is followed by a discussion of the main *drivers and trends*
31 affecting the production of agricultural commodities and food consumption – with particular reference
32 to livestock – resulting from a variety of projection exercises that give a sense of what the world would
33 look like through to 2050, assuming “business as usual” and other scenarios. The next chapter
34 discusses the priority *challenges* facing livestock (and associated feedcrops) production and
35 consumption, at both the global and local levels, in contributing to the goals of sustainable agricultural
36 development to enhance food security and nutrition for all, in particular for the poor and vulnerable,
37 and highlights the hotspots, stresses, risks and tipping points that need to be addressed. This leads in
38 to a chapter outlining possible *pathways and responses* to address those challenges. Brief case
39 studies illustrate the variety of practical experiences in moving towards sustainable agricultural
40 development to achieve FSN. The report concludes with a set of action-oriented *recommendations*
41 addressed to policy-makers, international government organizations and other stakeholders, some of
42 which are applicable generally, others applicable in specific circumstances, but all with an emphasis
43 on feasibility.

44 In brief, as a contribution to address the role of livestock in improving FSN through sustainable
45 agricultural development, the report argues that business as usual is not an option in the future. It is
46 hoped instead that the report will offer policy-makers and other stakeholders realistic options to
47 achieve that goal.

48

49

1 CONTEXT AND CONCEPTUAL FRAMEWORK

This chapter explores the context in which views are evolving on the role of sustainable agricultural development as a driver of improved food security and nutrition. It adopts a global perspective across the agriculture sector as a whole, while foreshadowing a particularly close look later in the report at the livestock sector given its dynamism in the face of growing demand as well as its strong impacts – for good and bad – across the three dimensions (social, economic and environmental) of sustainable development. The chapter outlines key concepts and influential contributions to a now vibrant debate about challenges and pathways for sustainable agricultural development, which are taken up in more detail in subsequent chapters. Finally, this chapter provides a framework diagram that identifies the components and interactions in food systems relevant to actions to enhance sustainable agricultural development and food security and nutrition.

1.1 What does “sustainable agricultural development for FSN” mean?

The resurgence of interest in the “grand challenge” (Hertel, 2015) to sustainably feed the planet stems from the anxiety about the persistence of hunger and malnutrition and the fact that malnutrition is taking on new forms. Despite important advances in recent decades, with an estimated 795 million people (FAO/IFAD/WFP, 2015) suffering from chronic undernourishment, two billion suffering from nutrient deficiencies and two billion overweight or obese (FAO/IFAD/WFP, 2013), new approaches to achieving food and nutrition security are needed.

Undernourishment is the result of chronic calorie deficiency, typically less than 1 800 kilocalories a day, the minimum most people need to live a healthy, productive life. Hotspots are in sub-Saharan Africa (23.2 percent undernourished and in southern Asia (15.7 percent undernourished) (FAO/IFAD/WFP, 2015). Most of the undernourished are poor, earning less than USD 2 a day. The 959 million poor make up 15 percent of global population but up to 67 percent of the population of countries in sub-Saharan Africa (Kocchar, 2015; International Bank for Reconstruction and Development/The World Bank, 2015).

“Hidden hunger” or micronutrient deficiency concern not only hungry people but also those that can meet their energy needs but not their nutritional needs essential for human development, health and functioning, because of an unbalanced diet (such as monotonous diets based on staple crops with relatively low amounts of the vitamins and minerals), of lack of access to potable water (HLPE, 2015), or because of induced metabolic disorders, such as for overweight people. Much of sub-Saharan Africa and the South Asian subcontinent are again hotspots with high prevalence of hidden hunger.

The last decades have seen an unprecedentedly large and rapid transition across countries to the so-called “Western diet” (Popkin *et al.*, 2012), involving more refined sugars and carbohydrates, refined fats, oils and meat, with induced human health concerns including overweight – now directly affecting over one-third of the world’s adult population (Ng *et al.*, 2014) – and obesity,⁶ cardiovascular disease, diabetes and autoimmune diseases and some cancers (Murray *et al.*, 2013). This transition is linked to rising incomes and urbanization in the developing world as well as social, technological and economic changes in food systems. Overconsumption (particularly of some food groups) and associated obesity is mainly a problem of the rich in low-income countries and the poor in high-income countries; in middle-income countries there is a mixed picture, with a tendency for overconsumption and obesity to shift from the rich to the poor, especially in women (Dinsa *et al.*, 2012).

Although it was the food price spike of 2008 and its temporary reversal of positive trends in food security that initially stimulated renewed focus on the state of world food and agriculture, assessments of the issues have recognized that the task is about much more than simply “feeding the world”. That is not by any measure a trivial challenge and this report considers the most significant reviews and projections in recent years of the key drivers and trends in global food demand and supply. It should, nevertheless, be stressed that most people are hungry because they cannot afford food, not because there is not enough food in the world. It is the effective demand for food (meaning demand by people

⁶ Thirty-nine percent of adults aged 18 years and over were overweight in 2014, and among these 13 percent were obese (WHO, 2015).

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1 who can pay for it) and how food is distributed and accessed across countries and within households
2 and genders that ultimately matters (Quentin Grafton *et al.*, 2015).

3 Tackling the “grand challenge” to sustainably feed the planet means harnessing the food and
4 agricultural systems more powerfully towards sustainable agricultural development imperatives.
5 Agricultural development needs to be sustainable and lead to improved FSN. In fact, in line with HLPE
6 (2014a), agricultural development cannot be called sustainable if it does not lead to improved FSN of
7 one in three workers across the world that depend on agriculture, and the nearly 2 billion people who
8 depend of smallholdings for their livelihoods (HLPE, 2013), while at the same time ensuring, together
9 with global economic development and urban income growth, its contribution to urban food insecurity.

10 Today’s debates differ in nature and complexity from those of the 1970s when global efforts to tackle
11 hunger ushered in the “Green Revolution”, which centred on boosting food availability through
12 significant increases in yields of wheat, rice and maize, and was dramatically successful in Asia and,
13 to a lesser extent, Latin America. The approach drew from what is sometimes called the
14 “productionist” model of agriculture that emerged following the Second World War in developed
15 countries. Building on the work of crop scientists, it involved the use of high-yielding varieties,
16 expanded irrigation and application of chemical inputs (synthetic fertilizers and pesticides) as well as
17 improved management techniques, As a consequence, global agricultural production increased as
18 much as threefold in 50 years with an increase in farmed area of only 12 percent (FAO, 2014a),
19 although with significant variation across countries and regions.

20 At the same time, Green Revolution technologies established a strong link between agricultural
21 production and a fossil fuel-based energy system. Gains in productivity were accompanied by a
22 significant use of non-renewable sources of energy, particularly fossil fuels. Between 1945 and 1983,
23 corn yields increased three-fold in the United States of America but energy inputs increased five-fold.
24 By the mid-1990s, fertilizers, particularly nitrogen, accounted for nearly one-third of all energy used in
25 agriculture. Between 1950 and 1983, global fertilizer consumption per person increased by a factor of
26 five, from just over 5 kg in 1950 to 25 kg in 1983 (Stout, 1990). Overuse and mismanagement of
27 agricultural inputs resulted in serious water and soil pollution. According to FAO (2011), global
28 demand for fertilizers, including nitrogen, phosphate and potash is expected to continue to grow
29 annually by 1.7, 1.9 and 3.1 percent between 2011 and 2015 and long-term projections raise concerns
30 about the capacity of existing supply chains to meet the increasing demand for phosphorus in
31 agriculture. The rising cost of mining and processing phosphate rock (Cordell and White, 2011) is of
32 concern and growing demand and prices are also projected for potash. In both cases, supply capacity
33 is highly concentrated in terms of countries and suppliers. Haberl *et al.* (2011) also highlight the
34 feedback loop between the availability of fossil energy and agricultural yields, with global soil
35 degradation and high costs of fertilizers as important factors affecting productivity. Access to land,
36 water and other natural assets is crucial for the production of food, not only for self-consumption but
37 also to supply local and regional markets.

38 The challenges we now face in reorienting agriculture and agricultural development for improved
39 sustainability and FSN are in part a result of the pathways of the past, which carried huge productivity
40 and production achievements, but also introduced new problems. The intensification of agricultural
41 production has progressively weighed on the world’s natural resources and ecosystems, with critical
42 concerns around water availability and quality, soil degradation, air quality and greenhouse gas
43 emissions causing climate change. Less easy to measure and reverse, but now known to be vitally
44 important, are the economic, social and environmental implications, including remote impacts and
45 impacts on other production systems of the development of specialized large production units and
46 homogenized agricultural landscapes. This shift from the traditional smaller mixed crop–livestock
47 agricultural production units, now also under way in developing countries (see Chapter 2), is leading to
48 loss of natural and semi-natural habitats and the biodiversity dependent on them (Duru *et al.*, 2015).
49 Debates continue on the question of biophysical limits in these critical areas and the extent, but not
50 the direction, of change required, especially in the light of projected demand increases from a larger
51 and richer population in many countries in the world.

52 As well as these environmental pressures, concerns are mounting about the care and welfare of
53 farmed animals and the human and animal disease risk associated with agricultural production. Some
54 agreement about basic principles and standards in animal care has been developed through the World
55 Organisation for Animal Health (OIE) covering aspects such as ensuring animals are healthy,
56 comfortable, well-nourished, able to express innate behaviour and do not suffer unpleasant states
57 such as pain, fear and distress (see Chapter 3). It is more difficult to settle on the appropriate specific
58 policies and regulations required to meet these objectives across countries in different stages of

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1 economic development and production systems, and in a manner that respects scientific evidence,
2 cultural norms and community preferences. Achieving high standards of care can be costly and while
3 improved standards of care can generate productivity gains in less commercially developed systems,
4 this can be beyond the means of poorer producers in the absence of external support.

5 Growing intensification of production and expanded international trade with longer, more complex food
6 supply chains is also increasing risks (again, further detail is provided in Chapter 3). Food-borne
7 diseases resulting either from biological contamination (pathogens, microbes) or chemicals are a
8 significant cause of human health problems related mainly to fresh food products such as fruit and
9 vegetables, as well as animal-sourced foods. In relation to chemicals, the cause can be either illicit
10 additives, such as the melamine introduced into powdered milk in China, or additives introduced to
11 achieve specific properties such as taste, longer shelf-life or appearance. A related risk to human
12 health of growing concern is anti-microbial resistance linked to the use of antibiotics in farmed animals,
13 mainly in intensive systems. Surveillance and reporting systems have been improved in recent years
14 in developed countries but remain problematic in many developing countries where knowledge and
15 capabilities require attention and safety protocols are less well established, especially in informal
16 markets. New and resurgent zoonotic diseases (those transferred from animals to humans) are also a
17 key concern as reflected in outbreaks of avian and swine influenza, ebola, MERS and SARS, resulting
18 in deaths, serious illness and very significant costs for containment and eradication. Greater
19 involvement of wildlife in zoonotic disease outbreaks has also been detected recently.

20 There is greater scrutiny of the way in which food is now produced and consumed, increasingly in
21 larger, more formal and more intensive production systems, with longer supply chains, frequently sold
22 in global markets for distribution after elaborate transformation and packaging through supermarkets
23 and more often consumed outside the home. Consumers are increasingly remote from agricultural
24 production and often unaware of the processes by which their food is produced. Some also point to
25 the loss of “protective factors” in the shift from a more traditional diet to that emerging today, pointing
26 to loss of nutrients and dietary diversity, including microbial diversity (Miller, 2014).

27 With these multiple pressures and stresses in today’s food and agricultural systems, what is the
28 outlook for a world with a rapidly growing and richer population already struggling to extend food and
29 nutrition security to all while preserving the earth’s natural assets vital for the wellbeing of generations
30 to come?

31 **1.2 Projections**

32 Population growth, income growth, urbanization and changing diets are the main drivers of increased
33 demand for agricultural production over the coming decades. Chapter 2 provides an elaboration of this
34 situation, so suffice is to note here that, based on current UN projections of a global population of 9.15
35 billion in 2050, FAO estimates (FAO, 2012) global agricultural production in 2050 will be 60 percent
36 higher than in 2005/07. Some livestock products – in particular poultry – will show greater growth than
37 this aggregate figure. Because of a slowing in population growth, and because of more people
38 reaching a level of food satiety, the rate of growth in production will be less than was experienced over
39 the past 50 years. This projected increase in demand, and particularly for products with higher value
40 added such as animal sourced products, can present great opportunities for smallholders to escape
41 from poverty and improve their food security and nutrition.

42 Nevertheless, these absolute increases in production will not be without difficulty as land, water and
43 other resources come under greater pressure. Methods and approaches to meet these demands and
44 pressures are outlined elsewhere in this report. McKenzie and Williams (2015) argue that for the world
45 as a whole there are no biophysical limits to greater food production. It is also the view of the FAO
46 (2012) report that evidence cautiously suggests that, globally, there are sufficient resources to satisfy
47 the additional demand projected to 2050, but that resource availability, income and population growth
48 are unequally distributed and local resource scarcities are likely to remain a significant restraint in
49 pursuing food security (FAO, 2012). The needed increase in agricultural production (including
50 livestock) offers a huge opportunity to lift smallholders out of poverty.

51 **1.3 Revisiting the concept of sustainable agricultural development**

52 Concerns about the long-term sustainability of the development of the food and agriculture sector
53 have been building since the late 1960s and 1970s as evidence has mounted on the costs of

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1 inadequate attention being paid to the environmental and resource use consequences of production,
2 processing and distribution systems. Environment ministries were established across governments
3 and, following the Brundtland Report of 1987, the landmark United Nations Conference on
4 Environment and Development in 1992 agreed the Rio Declaration and adopted the concept of
5 sustainable development encompassing the economic, social and environmental dimensions.

6 While discussion and some policy actions to reduce the environmental externalities associated with
7 the food and agricultural systems began to take hold, global attention to the economic and social
8 development potential of the sector slipped as a priority until the food price rises of 2007–2008
9 reactivated concerns about hunger and distress in the developing world.

10 The World Bank's 2008 World Development Report (WDR), *Agriculture for development*, referred to
11 "years of policy neglect" in agriculture (International Bank for Reconstruction and Development/The
12 World Bank, 2007). The report argues that by remedying underinvestment and mis-investment in
13 agriculture the sector could be a vital tool for sustainable development and poverty reduction. The
14 WDR analyses the differentiated scope for revitalizing the agriculture sector to boost growth,
15 livelihoods and food security across the developing world, categorizing countries according to three
16 distinct "rural worlds" – agriculture-based, transforming and urbanized – depending on the importance
17 of agriculture in the country (Box 1).
18

Box 1 Rural worlds – importance of agriculture in the economy

Agriculture-based countries – Agriculture is a major source of growth, accounting for 32 percent of GP growth on average – mainly because of its large share in GDP – and most of the poor are in rural areas (70 percent). This group of countries has 417 million inhabitants, mainly in sub-Saharan African countries; 82 percent of the rural sub-Saharan population lives in agriculture-based countries

Transforming countries – Agriculture is no longer a major source of economic growth, contributing on average only 7 percent to GDP growth, but poverty remains overwhelmingly rural (82 percent of all poor). This group, typified by China, India, Indonesia, Morocco and Romania, has more than 2.2 billion rural inhabitants. (Ninety-eight percent of the rural population in South Asia, 96 percent in East Asia and the Pacific, and 92 percent in the Middle East and North Africa, are in transforming countries.)

Urbanized countries – Agriculture contributes directly even less to economic growth, 5 percent on average, and poverty is mostly urban. Even so, rural areas still have 45 percent of the poor, and agri-business and the food industry and services account for as much as one-third of GDP. Included in this group of 255 million rural inhabitants are most countries in Latin America and the Caribbean and many in Europe and Central Asia. Eight-eight percent of the rural populations in both regions are in urbanized countries.

19
20 While the situation varies according to countries' economic, social and agronomic circumstances, the
21 WDR highlights the fact that three out of four poor people in developing countries live in rural areas
22 and most depend on agriculture directly or indirectly for their livelihoods. In the "agriculture-based"
23 countries particularly, agriculture and associated industries are essential to reduce mass poverty and
24 food insecurity and will require a productivity revolution in smallholder farming, dominated in these
25 countries by women. In "transforming" countries, the WDR suggests extreme rural poverty must be
26 addressed by providing multiple pathways out of poverty, including through a shift to higher-value
27 agriculture, more rural-based non-farm economic activity and assistance to people transitioning out of
28 agriculture. In "urbanized" countries too, agriculture can help reduce the remaining rural poverty if
29 smallholders can be connected to modern food markets and good jobs created in agriculture and
30 agro-industry along with the introduction of markets for environmental services.

31 The WDR makes the case for liberalization of agricultural markets – domestically and globally – as an
32 important means of revitalizing the sector in support of development and FSN. It notes, for example,
33 that access to world priced imports of food staples can be pro-poor, including for smallholder
34 agricultural producers who are net buyers of food. Similarly, removal of export restrictions on food,
35 often intended to dampen prices in local markets, can hamper access of poor farmers to valuable
36 export market opportunities and noting two-thirds of agricultural value added is in developing
37 countries. In effect, these moves would continue the trend of reducing the burden on the agriculture
38 sector in many developing countries that have effectively taxed it for the benefit of other sectors with
39 lower potential to drive development and FSN improvements. At the same time, the report
40 acknowledges that there are losers from the liberalization process and targeted safety net provisions

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1 and transition arrangements would be essential to assist them. Similarly, serious concerns continue in
2 relation to recurrent price volatility in staple food markets, which can have disastrous effects on poor
3 and vulnerable communities with a range of interventions identified to minimize negative
4 consequences including improved price and market transparency, and public stockholding (HLPE
5 2011).

6 The WDR also stresses the development and poverty reduction costs of misdirected agricultural
7 subsidies in some developing countries, arguing that agricultural distortions and protection that
8 increases the price of food has damaging effects on agricultural productivity growth as well as
9 negative implications for food security. There has been a trend in recent years for these costs to be
10 mitigated in some developing countries through improved targeting of support and other interventions,
11 as well as agriculture focused development support from government, non-governmental
12 organizations (NGOs) and other sources. There has, however, also been a reverse trend in some
13 other countries including some large non-OECD economies such as Indonesia, the Russian
14 Federation and China, which are moving from effective taxation of agriculture to becoming significant
15 subsidizers, in some cases approaching OECD country levels, and with the potential for the same
16 damaging impacts on poorer countries' agricultural interests. Attention is also paid in the WDR to the
17 negative impacts on developing country agriculture of support and protection in developed countries,
18 with removal of these policy distortions estimated to be five times the value of aid flows to developing
19 country agriculture. The latest OECD report monitoring agricultural policies shows that while
20 agricultural support (subsidies) and protection has gradually been reduced over time in the OECD
21 area, it remains high (over USD 450 billion annually for OECD countries as a group), distorting
22 resource allocation, incurring environmental damage, being paid for disproportionately by poorer
23 consumers in OECD countries and damaging commodity market prospects for developing countries.

24 The role of trade and markets in fostering sustainable development and improved FSN remains at the
25 heart of highly contested policy discourse, including in the World Trade Organization, where the Doha
26 Round of trade negotiations remains stalled with differences over liberalization rules and their impact
27 on food security at the centre of the impasse. Alternative perspectives, including the concept of food
28 sovereignty, are also discussed later in this report.

29 Reflecting the evolution of thinking about environmental sustainability, the WDR notes that with rising
30 resource scarcity and mounting negative externalities, agricultural development and environmental
31 protection have become closely intertwined. "Agriculture's large environmental footprint can be
32 reduced, farming systems made less vulnerable to climate change, and agriculture harnessed to
33 deliver more environmental services. The solution is not to slow agricultural development – it is to seek
34 more sustainable production systems... but realizing on this promise also requires the visible hand of
35 the state – providing core public goods, improving the investment climate, regulating natural resource
36 management, and securing desirable social outcomes". There are important implications here, in
37 maintaining equilibrium between different farming systems and between local production and
38 international trade.

39 The refocusing of attention on the economic dimension of sustainable development in agriculture
40 since 2008 offers some grounds for optimism. Attention to the potential of the agriculture sector to act
41 as a motor for growth, poverty reduction and improved FSN has been reflected in some tangible action
42 of national governments, multilateral institutions, donors and other actors. Budgets for agriculture
43 sector initiatives have increased and innovative projects have captured attention and support with new
44 actors, including private philanthropists, rural peoples' movements and NGOs contributing along with
45 governments to the development of policies affecting agriculture. Nevertheless, agricultural
46 productivity in most agriculture-based countries remains well below potential and attention has been
47 focused on what can be done to reduce "yield gaps" between both developed and poorer developing
48 country production performance and between the best and worst performers in each system.

49 Sumberg (2012) notes that major analytical studies, including the InterAcademy Council's report
50 (2004), the *World Development Report* (International Bank for Reconstruction and Development/The
51 World Bank, 2007), the International Assessment of Agricultural Science and Technology (IAAST,
52 2009) and the United Kingdom Foresight report (2011) draw on yield-gap analysis as a framing device
53 for agricultural policy prescriptions aimed at making lasting agricultural productivity improvements in
54 the parts of the world where it could make the biggest difference to livelihoods and FSN (Sumberg,
55 2012; InterAcademy Council, 2004; Foresight, 2011). As Sumberg points out, yield- or productivity-gap
56 analysis, drawn from the disciplines of crop production ecology and micro-economics, can be a very
57 helpful framing device in focusing attention on the promise of what might be achieved to increase
58 agricultural productivity. He outlines a range of ways in which analysts have estimated the deficit or

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1 gap between potential and actual crop yield and explores the relative importance of factors and inputs
2 that explain the differences, highlighting the importance of the location specificity of the framework and
3 the fact that it favours long-term explorations. And while he sees great merit in yield gap analysis as a
4 framing device for policy debate about interventions to enhance agricultural productivity and FSN, he
5 notes that it is often used by policy advocates to support particular narratives or prescriptions that
6 might be poorly related to the yield-gap analysis without taking account of its nuances and limitations
7 (including location specificity). While it might help focus attention on opportunities, yield-gap analysis
8 in itself is unlikely to help disentangle “continuing debate and contestation about alternative visions,
9 objectives and instruments for agricultural policy (over) large or small farms; market engagement or
10 self-sufficiency; fertilisers and GMOs or agro-ecology; favoured or marginal areas” (Sumberg, 2012).

11 The *social* dimension of sustainable agricultural development, which is a key contributor to improved
12 FSN, has often been neglected or not given as much attention as it warrants. This is perhaps because
13 it covers a very wide range of disparate and complex issues – the role of smallholder enterprises and
14 rural communities dependent on agriculture; the working conditions of agricultural and food system
15 workers; nutrition, food-borne diseases and human health; poverty reduction; cultural preferences; and
16 animal care – that are very much country-specific and do not easily lend themselves to generalization
17 and are often difficult to quantify and compare. The social dimension of sustainable agricultural
18 development is thus one of the most challenging areas to address, although many of the issues are
19 often inextricably linked to the economic and environmental dimensions.

20 What is clear from the analyses and projections is the inescapable interconnections between crop,
21 livestock, energy, water and nutrient cycles. Equally clearly, they show that the way in which livestock
22 production and consumption evolves will bear disproportionately on the state of world food security
23 and nutrition as well as on the health of global ecosystems. This report, therefore, attempts to develop
24 ideas and options for encouraging a transition of our food and agriculture systems to conform more
25 effectively to sustainability requirements while meeting emerging and future food needs. It also
26 recognizes the opportunities to move the agricultural and food systems – especially livestock systems
27 – on to sustainable pathways focused on FSN by citing the many experiences of actions and policies
28 taken or under way in different country contexts, while stressing that choices have to be made given
29 the trade-offs involved.

30 There is now a well-established consensus about the need for a holistic framework for examining
31 appropriate guiding policies, institutions and actions, using the three dimensions of sustainability
32 (social, economic and environmental) that emerged from the Rio process. The FAO definition of food
33 security is also widely accepted – “*when all people, all of the time, have physical, social and economic
34 access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for a
35 safe and healthy life*” (FAO, 2009a) – and is generally characterized as having four essential
36 dimensions – food availability, access, utilization and stability.

37 Drawing on the established concepts of both sustainability and food security, a considerable amount
38 of literature has been developed about their application to the food and agriculture sector,
39 encapsulated in the notion of sustainable agricultural development.

40 In this broader context, in 2014 FAO building upon a 1988 definition,⁷ developed a “vision for
41 sustainable food and agriculture”: “*that of a world in which food is nutritious and accessible for
42 everyone and natural resources are managed in a way that maintain ecosystem functions to support
43 current as well as future human needs. In our vision, farmers, pastoralists, fisherfolk, foresters and
44 other rural dwellers have the opportunity to actively participate in, and benefit from, economic
45 development, have decent employment condition and work in a fair price environment. Rural women,
46 men and communities live in security, and have control over their livelihoods and equitable access to
47 resources, which they use in an efficient way*” (FAO, 2014a). Sustainable agricultural development is a
48 process of development that evolves through time and varies across countries with different agri-food
49 systems.

50 In September 2015, UN members agreed on a set of 17 Sustainable Development Goals for 2030, to
51 follow up on the Millennium Development Goals. Many of the goals are relevant to agriculture and food

⁷ Sustainable agricultural development is “the management and conservation of the natural resource base, and the orientation of technological change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Sustainable agriculture conserves land, water and plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable”.
www.fao.org/docrep/u8480e/u8480e0l.htm

1 system and the second goal is specifically to “*end hunger, achieve food security and improved*
2 *nutrition, and promote sustainable agriculture*”.⁸

3 Another important development, which links the concept of FSN and the social and economic
4 dimensions of sustainable agricultural development, was the adoption by governments of the Rome
5 Declaration on Nutrition in November 2014, held under the auspices of FAO and WHO. Governments
6 committed, *inter alia*, to “enhance sustainable food systems by developing coherent public policies
7 from production to consumption and across relevant sectors to provide year-round access to food that
8 meets people’s nutrition needs and promote safe and diversified healthy diets” (FAO, 2014b). The
9 Declaration acknowledged that current food systems are being increasingly challenged to provide
10 adequate, safe, diversified and nutrient-rich food for all that contributes to healthy diets and pointed to
11 resource scarcity, environmental degradation, unsustainable production and consumption patterns,
12 food losses and waste and unbalanced distribution as root causes. Recognition that diets link
13 environmental and human health is a clear acknowledgement of the need for stronger focus on the
14 relationship between sustainable agricultural development and food and nutrition security. Rising
15 incomes, driving dietary transition, contribute significantly to problems such as rising GHG emissions
16 and land clearing. At the same time these changes are greatly increasing the incidence of type II
17 diabetes, coronary heart disease and other chronic diseases. Alternative diets offer substantial health
18 benefits and if widely adopted could reduce global GHG emissions, land clearing and resultant species
19 extinction while helping prevent diet related health concerns (Tilman and Clark, 2014).

20 **1.4 “Sustainable agricultural development for FSN”: the key role of** 21 **the livestock sector**

22 In drawing together disparate trends, drivers and opportunities for harnessing sustainable agricultural
23 development (SAD) for FSN, this report places particular emphasis on the meat and livestock sector.
24 As a recent paper by the Global Agenda for Sustainable Livestock notes, there is a “much needed
25 unifying, evidence-based ‘all-in-one’ narrative on the role of livestock in sustainable development”
26 (GASL, 2014) given that livestock accounts for 40 percent of global agricultural GDP and makes a
27 huge contribution to livelihoods and nutrition including for poor and vulnerable people in the
28 developing world. An estimated 1 billion poor people, many of them women, derive at least part of their
29 livelihood from livestock. It has been one of the fastest growing sectors in global agriculture, due to
30 rapid demand growth in low-income and emerging economies. Delgado *et al.* (1999) stressed the
31 importance of livestock in sustainable agricultural development, which led to coining of the expression
32 “livestock revolution”. Per capita consumption of animal-sourced products in developing countries
33 increased by 50 percent between the early 1970s and the early 1990s and that trend is set to continue
34 to meet a 70 percent projected increase in global demand for livestock products by 2050, almost all of
35 which will be in developing countries. This has enormous implications for nutrition and health, as well
36 as for the crop sector on which so much of livestock, in particular feed for monogastrics, depends
37 (Sumberg and Thompson, 2013).

38 Nutritionally, meat and other animal products such as milk and eggs globally provide 13 percent of
39 total calories, 28 percent of dietary protein, and are sources of vitamins and key micronutrients,
40 several of which are not found in plant foods, thus contributing to optimal nutrition. They are valuable
41 in combating malnutrition and a range of nutritional deficiencies in particular for disadvantaged and
42 vulnerable people, including the elderly, lactating mothers and infants. Around two billion people suffer
43 from micronutrient deficiencies including at least half of children worldwide aged 6 months to 5 years
44 (Ahmed *et al.*, 2012). In particular, there is severe and widespread deficiency of iron, zinc, vitamin A,
45 iodine and folate, all of which are present in animal-sourced foods (ASFs). Indeed, ASFs are probably
46 the world’s most important source of nutrient-rich foods in diets and studies show the health benefits of
47 providing ASFs to undernourished populations (Gibson, 2011). Milk consumption is especially
48 associated with increased height, and meat consumption with increased cognitive development.

49 However, many studies show an association between meat consumption (especially red and
50 processed meat) and cardiovascular disease (including strokes), some cancers, diabetes and all
51 cause mortality (Micha *et al.*, 2012; Larsson and Orsini, 2014).⁹ There are also plausible mechanisms

⁸ <https://sustainabledevelopment.un.org/sdgsproposal>

⁹ Many nutritional studies have been based on observational data from studies that look at a group at a point in time or follow a group over a number of years to investigate links between diet and health outcomes, and dietary recommendations or mostly based on these. Unfortunately, these studies are prone to major biases including: self-

1 by which livestock products may have a causal role. For example, meat is a source of carcinogens
2 formed during high-temperature cooking of meat and ASFs are sources of saturated fat, associated
3 with higher risk of cardiovascular disease.

4 In brief, livestock is arguably the most dynamic agriculture sector, with socio-economic implications for
5 animal-feed demand, for concentration and intensification at the farm level, and for increased income
6 creation and nutritional status and health. Its functioning is also strongly linked to crop sectors, large-
7 scale or small-scale. The social and development impact of the sector is highly significant, accounting
8 for the employment of 1.3 billion people globally and supporting the livelihoods of around 1 billion of
9 the world's poorest people, two-thirds of whom are rural women according to FAO (2009b). As well as
10 direct livelihood and nutrition impacts from the production and sale of ASFs, livestock raising
11 generates by-products including manure, power, and acting as a store for capital, and is integral to the
12 traditions, values and landscapes of many communities across the world. Livestock also has
13 significant implications for the environment, both positive and negative, particularly when land-use
14 changes and feed crop production effects are taken into account. Livestock is therefore central to the
15 question of achieving sustainable agricultural development and FSN objectives.

16 In the following chapters, this report's closer look at the livestock sector aims to explore, in more detail
17 than would be possible in a food and agriculture sector-wide review, some of the critical challenges
18 and opportunities to achieve sustainable development of the livestock sector, maximizing its
19 contributions to the progress towards FSN goals. In doing so it draws from the rapidly expanding and
20 vibrant literature on pathways for transition for a more sustainable and FSN-oriented development of
21 the sector, illustrating through livestock sector trends, drivers, challenges and responses to them,
22 possible pathways to better SAD for FSN.

23 The report uses a categorization of four broad livestock production systems (pastoralist, smallholder
24 mixed, intensive and commercial ranching), which interact with crop systems (large-scale and small-
25 scale), in order to explore the nature of the different challenges facing the sector, the choices that
26 need to be made, and the possible pathways and responses to move towards sustainable agricultural
27 development. Thus this report attempts to illuminate critical issues in SAD for FSN both globally and
28 across different livestock systems and situations within and between countries – and to stress that
29 moving towards sustainable agricultural development needs to crucially reflect the diversity of farm
30 systems. It also examines the important linkages between the livestock and crop sectors and deals
31 with key cross-cutting issues affecting the food and agriculture system as a whole such as climate
32 change and other environmental externalities associated with food production and consumption, diet
33 and nutrition, research and technology and social protection.

Box 2 Sustainable intensification: a useful guiding concept?

This report attempts to capture key sets of relationships that need to be integrated into efforts to harness SAD for FSN. In this broad context, it is appropriate to touch briefly on the recent exploration by expert commentators on concepts attracting policy attention in thinking about sustainable transition pathways for food and agriculture.

The concept of "sustainable intensification" has gained considerable traction – and some critical reactions – as an approach to tackling the mutual challenges of producing more food to meet expected demand, while protecting the environment from the consequences of greater agricultural production, given increasing competition for natural resources. The broad logic of the approach is that if more food is to be produced to meet burgeoning demand in the face of evident stresses and constraints in the natural asset base, productivity has to be lifted while improving environmental performance. According to Petersen and Snapp (2015), the term "sustainable intensification" has its origins in work by Pretty in the 1990s but there has been a strong lift in interest in the idea since the food price crisis of 2008 and its accompanying renewed focus on food security. They note it has been embraced especially in international agricultural development by the work of FAO, the CGIAR system, the United Kingdom's Royal Society, government agencies such as USAID and non-government

reporting (people underreport consumption of unhealthy foods), displacement effects (when outcomes are due not to a food but because its consumption replaces another food), healthy consumer bias (people consuming a food differ systematically from those who do not) and confounding effects (failure to measure other factors that vary with both diet and health outcomes) (Maki *et al.*, 2014). The challenge of the weak evidence base for nutritional guidelines combined with overconfidence in association studies (confounding correlation with causation) is illustrated by recent major reversals in nutrition advice. In 2015, the American Dietary Guidelines Advisory Committee abandoned previous restrictions on cholesterol and fat and recommended that artificial sweeteners should not be promoted for weight loss. Other studies have created considerable ambiguity over appropriate recommendations on reducing salt, alcohol, coffee and increasing breastfeeding (O'Donnell *et al.*, 2014).

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actors including the Bill and Melinda Gates Foundation. Moreover, the term “sustainable intensification” is also being mainstreamed into thinking in the European Union in the context of agricultural policy reform (European Commission, 2015). A recent RISE report provided one definition of sustainable intensification – only focusing on land – as a “means simultaneously improving the productivity and environmental management of agricultural land” (RISE, 2014).

According to Godfray (2015) in a recent review of the concept, sustainable intensification is a process designed to achieve higher agricultural yields while simultaneously reducing the negative impact of farming on the environment. Sustainable intensification specifies a goal, but not a blueprint as to what it entails in terms of farming and food production and consumption practices, and how it might be achieved, as it acknowledges the diversity of farming and food systems across the world: it is context-specific. The notions of “sustainable” and “intensification” have been interpreted in many different ways, but the concept of “sustainable intensification” does not imply a path of industrial, concentrated high-input/high-output production systems in contrast to bringing more land into agriculture through extensive systems using a high ratio of land to other inputs – in the case of livestock this latter system would mean lower stocking rates. Conway (2012) has argued that there are three components of intensification: genetic, ecological and market intensification – all of which contribute to increased agricultural productivity. Godfray (2015) argues that sustainable intensification is essentially “sustainable increases in productivity from existing agricultural land in response to price signals”.

Critics of the term “sustainable intensification” argue that the starting point for thinking about what is needed for sustainable food and agriculture should place restoration and maintenance of natural ecosystems rather than yield increases at the centre of design for agricultural transition pathways and focusing more strongly on the social aspects of sustainability. Godfray observes that the word “intensification” is off-putting for some who associate it intrinsically with high input Western arable farming. He also suggests that some critics fear the term could be exploited by vested interests to nudge towards capital-intensive farming. A major area of concern to some commentators is the extent to which the term “sustainable intensification” fails to adequately address the need to reverse biodiversity loss, which is an aspect of the debate on “land sharing or land sparing”. Briefly, land sharing and land sparing sit at either end of a continuum. According to Acton (2014), “a land sparing system involves large, separate areas of sustainably intensified agriculture and wilderness, whereas land sharing involves a patchwork of low-intensity agriculture incorporating natural features such as ponds and hedgerows, rather than keeping agriculture and wilderness separate”. Other issues of concern to critics include the extent to which the term sustainable intensification would embrace genetic modification, support improved animal care or focus on social and community cohesion and equity objectives. Petersen and Snapp (2015) consider that differences have arisen over the merits of the sustainable intensification concept in part because of differences about the extent to which a profound shift is needed in agricultural production practices. “To some it represents making marginal changes to a system that continues to increase food production. To others it means dramatically altering an agricultural system that causes significant environmental damage and continues to leave billions mal- or under-nourished.”

Petersen and Snapp discuss a number of concepts and goals put forward by various proponents in debates about tackling the challenge of agricultural production and environmental protection – organic agriculture, conservation agriculture, agroecology/ecological intensification and sustainable intensification/sustainable farming systems. Petersen and Snapp suggest that the term ecological intensification may represent a more useful approach compared with sustainable intensification, and define ecological intensification as “using ecological principles to design sustainable production systems that are semi-closed systems, with efficient use of inputs and minimize harm to the environment. Improved genetics and management are utilized that rely on biological processes, to conserve and protect resources while supporting production”. They conclude, however, that both terms require further development, particularly to address the social dimension of land use.

These debates seem set to continue to play out and ultimately can only be settled in the context of specific national, regional and local decision-making about transition pathways linked to specific production and ecological dynamics. Guillou (2013) observes that there are no “off the peg” solutions. Rather, “dually efficient” farming systems, – efficient at both economic and environmental levels – need practices that are adapted to pedoclimatic (climate within the soil) and agro-ecological environments, as well as to the local economic and social context. Through efforts over time to design and implement specific local transitions to more sustainable food and agricultural systems some of the theoretical and terminological debate might be illuminated or even resolved. In the meantime, despite differences of interpretation or views on the boundaries of what constitutes improved practice the direction of reform efforts is clearly harnessed to enhancing the sustainability of systems.

Box 3 The food sovereignty debate

Lively debate also surrounds the idea of food sovereignty that emerged in the mid -1990s, with the term first used at the World Food Summit in 1995 by representatives of La Via Campesina, described on the organization's Web site as an "international movement which brings together millions of peasants, small and medium-sized farmers, landless people, women farmers, indigenous people, migrants and agricultural workers from around the world". The organization attracted attention and expanded from its origins in the Americas and Europe to become a broader transnational social movement and advocacy network through its strong opposition to the direction of agricultural trade liberalization embodied in the Uruguay Round Agreement on Agriculture and the establishment of the World Trade Organisation (WTO) in 1995 (Burnett and Murphy, 2014).

A commonly cited definition of food sovereignty by Wittman et al. (2010) is 'the right of nations and peoples to control their own food systems, including their own markets, production modes, food cultures and environments ... as a critical alternative to the dominant neo-liberal model for agriculture and trade. Another definition of food sovereignty from the Nyelini Declaration of the Forum for Food Sovereignty in Mali in 2007, is "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (Nyelini Declaration cited in Burnett and Murphy, 2014).

Bernstein (2014) encapsulates key elements that 'frame' the idea of food sovereignty as an attack on corporate industrialized agriculture for its environmental and social devastations; a restatement of the social, moral and ecological superiority of small-scale or peasant farming; and a programme for a new sustainable and socially-just world food order, reconnecting (in the words of Wittman et al., 2010) food, nature and community. Bernstein sums up the central criticisms of contemporary global food and agriculture by food sovereignty advocates as a system "that is increasingly global in its drivers, modalities and effects, that registers a 'changing relationship to food imposed by the industrialization of (agricultural) production and the globalization of agricultural trade' (Wittman et al.) and results in 'food insecurity, fossil fuel dependence and global warming' (McMichael, 2010)".

Positioned in substantial part as an advocacy movement, proponents of food sovereignty have called for a "radical democratization of the food system in favour of the poor and under-served" (Holt-Giminez and Shattuck, 2010) and to prioritizing local market exchange over global trade (Burnett and Murphy, 2014). Commitment to relocalizing markets and governance of food and agriculture has pitted the food sovereignty movement against trade liberalization initiatives for the sector and the WTO as an institution as well as the broad thrust of the economic analysis from inter-governmental economic organizations, notably the World Bank, and private development foundations active in agricultural development such as the Gates Foundation. As Pimbert (2009) puts it, citing both institutions: "This modernist development agenda and the corporate thrust for radical monopoly control over the global food system are mutually supportive elements of the same paradigm of economic progress... This notion of 'food sovereignty' is perhaps best understood as a transformative process that seeks to recreate the democratic realm and regenerate a diversity of autonomous food systems based on equity, social justice and ecological sustainability".

Strong differences are evident between commentators about the role of trade and agricultural support and protection in achieving development and FSN, the ecological merits of different scales and production techniques in food and agricultural production and the impacts on the poor of retaining by policy intent a small-scale subsistence-oriented agricultural system in the large areas of the developing world where it remains dominant (agriculture-based countries) or attempting to recreate it where it has already transformed. As in the debate on the concept of sustainable intensification, views about the notion of food sovereignty provoke equally sharply contrasting visions of the most effective pathways towards food security and nutrition through sustainable agricultural development. Here too resolution of differences is most likely only to be possible in specific circumstances within and between countries.

1

2 1.5 Conceptual framework for this report

3 The conceptual framework presented in this section builds upon the definition of sustainable food
4 systems provided by the HLPE in an earlier report (HLPE, 2014a) and tries to capture the complex
5 interactions between production, nature and society in the structuring of the current food system,
6 identifying system components and relevant dimensions of change in the transition towards
7 sustainable food systems. This framework is conceived as a conceptual device that tries to integrate
8 concepts and relationships considered relevant to the analysis, and to identifying possible areas for

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1 policy intervention. It is acknowledged that food systems encompass multiple levels, scales and
2 sectors, affecting and being affected by other systems (HLPE, 2014b).

3 FSN is addressed as a set of policy goals to be incorporated by relevant actors – including multilateral
4 organizations and institutions, state agencies, market actors, civil society organizations, producers and
5 consumers – and, at the same time, as an outcome of sustainable food systems arising from
6 interactions between economic, social and environmental processes related to food production and
7 consumption.

8 Transition to more sustainable food systems¹⁰ involves both qualitative and quantitative changes in the
9 relationships between society, nature, energy and material flows within the food system. Sustainable
10 agricultural development encompasses crop cultivation and livestock production, with links to forestry,
11 fisheries and aquaculture, practised across a wide diversity of ecosystems and landscapes.

12 The report pays particular attention to livestock sector interactions, as noted above, because of its
13 critical position in the food and nutrition status of billions, its role as an engine for the development of
14 the agriculture sector as a whole, its dynamic nature in the face of rapidly growing demand, and the
15 challenging economic, environmental and social choices required if the sector is to contribute more
16 powerfully to food and nutrition security.

17 Various authors (Altieri, 1999; Gliessman, 1997; Thrupp, 2000; Perfecto *et al.*, 2009) have noted that
18 biodiversity in agro-ecosystems, including the animal component, performs important ecological
19 services beyond food production, and conditioning such as recycling of nutrients, pollination, pest
20 control, regulation of microclimate and local hydrological processes, detoxification of noxious
21 chemicals, control of greenhouse gas emissions, risk reduction under unpredictable environmental
22 conditions and the conservation of surrounding natural ecosystems. Agricultural production itself
23 depends on healthy agro-systems. As suggested by FAO/PAR (2011), agricultural systems cannot be
24 reduced to simplified input–output systems: they function best when the interconnectedness of the
25 different ecosystems' components and functions is preserved and optimized (FAO/PAR, 2011) through
26 the promotion of positive synergies between crop, breeds and natural ecosystem diversity. And
27 animals are an essential part of these cycles.

28 Important challenges arise on the supply side that relate not only to meeting food demand but also to
29 the rising consumption of bioenergy and biomaterials, including biofuels (HLPE, 2013). Competing
30 demands for the use of land and water are critical factors shaping the organizational features of food
31 systems, raising important concerns in relation to the provision of stable and sufficient supplies of food
32 in the face of problems of land degradation, diminishing freshwater availability and quality, and
33 different sources of instability and stresses related to climate change. Environmental pressures affect
34 sustainability and FSN in different ways throughout the food chain, particularly vulnerable groups,
35 through rising and volatile prices of food and inputs.

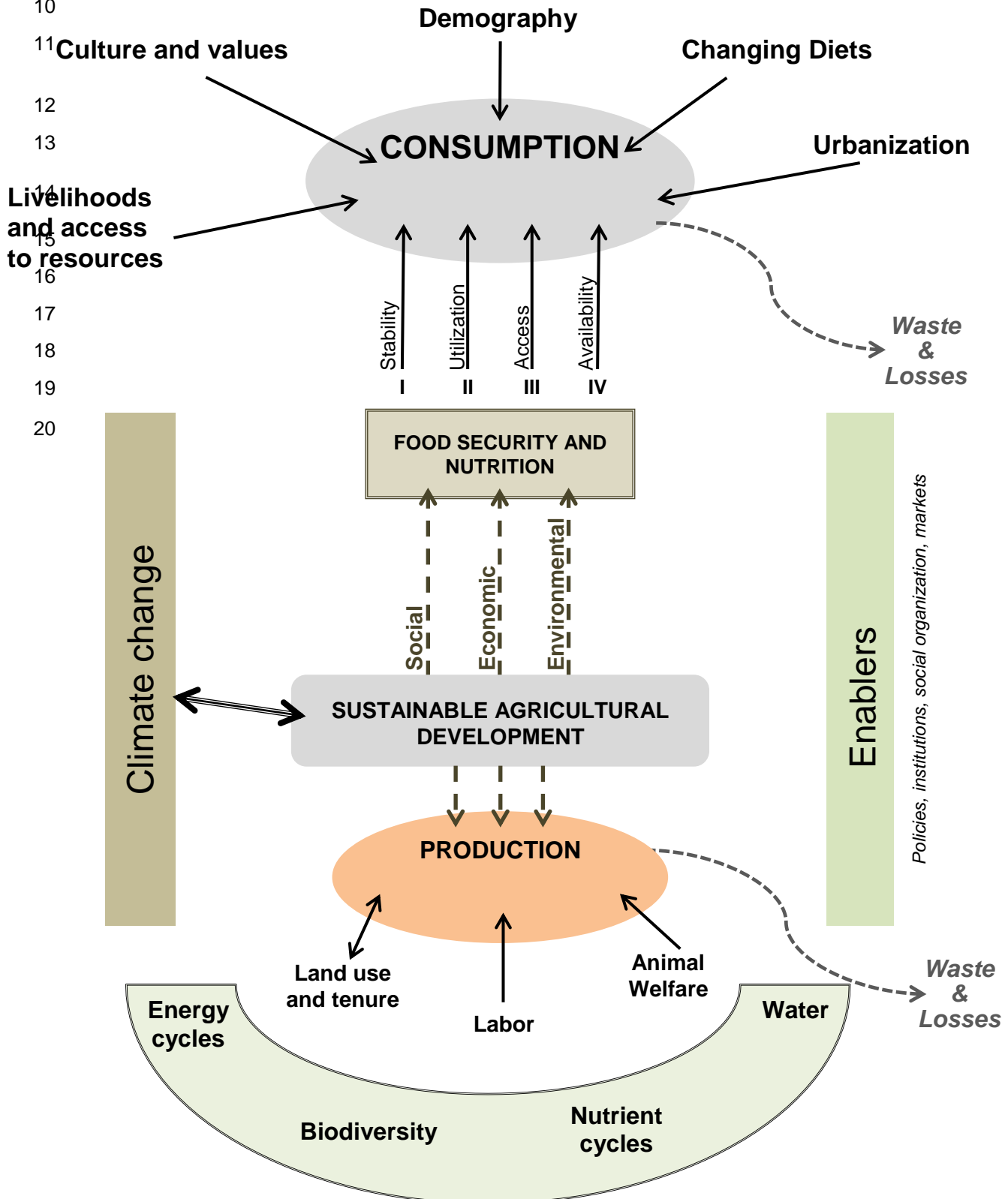
36 This report acknowledges the complexities of the food, environment and social interface and the
37 context specificity across and within countries and also the different impact of change on different food
38 system stakeholders, from farmers, market agents and along the supply chain as well as social actors.
39 In later chapters, through case studies, reviews of experience and policy proposals emerging from
40 research and analysis, possible forward directions are explored.

41 Figure 1 aims to capture linkages between different subcomponents of the system of agricultural
42 development and their relationship to other drivers and to FSN objectives. The complex structure and
43 interactions between components of the agri-food system also reflect different cultures and history.
44 Food production is affected by natural resource endowments, technology and farm management
45 practices. Processing and retailing as well as patterns of international trade are also key determining
46 factors along with land use and tenure arrangements and the organization of labour in agriculture,
47 influencing the interplay between the social, economic and environmental dimensions of sustainable
48 agricultural development. Food consumption is affected by demographic trends, levels and distribution
49 of incomes, urbanization and changes in policies and cultural values (including the cultural meaning
50 attached to food and diets). Constraints on access to food and adequate nutrition also reflect socio-
51 economic circumstances in different national and local settings as well as the nature of social policy
52 interventions aimed at addressing problems that arise for FSN as a consequence.

¹⁰ “Sustainable food systems are food systems that ensure food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised” (HLPE, 2014a),

1 Figure 1 does not aim to capture all these complex interrelationships; it is intended rather as a tool for
 2 exploring key decision areas within the food system and it could be relevant for thinking at the global
 3 level as well as for particular regional or local food and agricultural settings across production systems.
 4 The central objective of the report is to identify constraints to the achievement of sustainability of food
 5 systems worldwide and to propose possible pathways of sustainable agricultural development that can
 6 best contribute to current and future FSN that might be amenable to action by policy-makers and other
 7 stakeholders.

8 **Figure 1 Conceptual framework showing linkages between sustainable agricultural**
 9 **development and food security and nutrition**



1

2 TRENDS AND DRIVERS

3 This chapter examines the trends of recent decades, and the projections and drivers in the evolution of
4 the demand for and supply of livestock products.

5 Agriculture and agricultural systems, including livestock, are continually evolving and adjusting to meet
6 the increasing demand for food and changes in nutrition and diets, in a context of resource
7 constraints, technological developments, social considerations and, increasingly, the need to both
8 mitigate and adapt to climate change imperatives. The livestock sector is subject to influences of an
9 economic, social, technological and environmental nature, some bearing a historical perspective and
10 some of an emerging nature. Although not always explicitly stated but nevertheless ever-present is the
11 global requirement that agricultural development be sustainable (in its broadest interpretation) and that
12 it contributes to food security and delivers desirable nutrition outcomes. As a significant contributor to
13 these objectives, it is axiomatic that livestock should be developed in a manner consistent with these
14 imperatives. Examining the trends and describing and analysing the various drivers that will shape the
15 evolution of the livestock sector provides strong clues to the challenges to be faced (Chapter 3) and
16 the pathways (Chapter 4) that the livestock sector might take towards meeting these objectives.

17 The chapter begins with a section on projections, to understand likely future production requirements
18 as well as their drivers. This is followed by a brief overview of the importance of the livestock sector in
19 recent evolutions of agricultural systems, including a reference to the "livestock revolution" and a
20 typology of livestock systems. This informs the subsequent analysis including on the design of
21 responses/pathways for different farm systems in Chapter 4.

22 2.1 Projections and scenarios for agricultural development, 23 focusing on livestock supply and demand

24 *"If you don't know where you are going, then any road will get you there." (Anon.)*

25 Although there are few certainties when forecasting, informed analysis provides a valuable
26 assessment of likely levels of consumption and production. A broadly accepted expectation of future
27 requirements can provide for informed debate and give direction as a basis for determining the
28 challenges and potential pathways/responses in pursuing sustainable agricultural development. As the
29 best known and most widely quoted of the various agricultural projections, those of Alexandratos and
30 Bruinsma in *World agriculture towards 2030/2050: the 2012 revision* (2012) are used as the basis for
31 this chapter. They are supplemented with analysis from other sources.

32 2.1.1 FAO projections

33 FAO projects that global agricultural production in 2050 will be 60 percent higher than in 2005–2007,
34 in response to growth in global population and incomes. Upon disaggregation, FAO's broad projection
35 reveals some interesting regional, country or commodity particularities.

36 This 60 percent increase in production would come mainly from an increase in crop yields (80 percent
37 of the production increase at the world level), some increase in cropping intensity (10 percent) and
38 limited land expansion (10 percent). It is worth noting that within the overall 60 percent increase in
39 agricultural production, livestock's contribution to the total will rise slightly from its current 36 percent of
40 gross agricultural value to 39 percent in 2050. This reflects a projected increase in meat production by
41 76 percent, from 258 million tonnes in 2005–2007 to 455 million tonnes in 2050 (mostly occurring in
42 developing countries).

43 Noting that population growth, income growth, urbanization and changing diets drive the projected
44 production requirement in 2050 to meet expected demand (which nevertheless does not eliminate
45 food insecurity), Alexandratos and Bruinsma's analysis also contends that there are sufficient global
46 resources available to produce the increasing agricultural production by the amounts required to
47 satisfy the additional demand. This conclusion assumes that the necessary investments are
48 undertaken, and appropriate incentives and policies are in place.

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1 Downside risks include: greater than expected population growth (a recent UN revised projection of
2 9.7 billion in 2050 is greater than the 9.15 billion used by Alexandratos and Bruinsma); climate change
3 impacts on production (particularly in developing countries), none of which were explicitly modelled in
4 their projections; and greater than assumed use of crops in biofuels production. Concerning biofuels,
5 uncertainties – both in energy markets and in biofuels policies (mandates and subsidies) – make
6 forecasting difficult: Alexandratos and Bruinsma opt for the OECD-FAO outlook figures up to 2020
7 after which they assume no change in quantities.

8 Concerning the composition of food consumption, Alexandratos and Bruinsma draw attention to the
9 rapid increase in consumption of meat (particularly poultry), milk, eggs and vegetable oils. Animal-
10 sourced food and vegetable oils together now provide 22 percent of total calories in the developing
11 countries, up from 13 percent in the early 1970s. Their share is projected to rise to 26 percent in 2030
12 and 28 percent in 2050 (in the developed countries the share has been around 35 percent for several
13 decades now).

14 The major structural changes that characterized the historical evolution of the world livestock
15 economy, particularly in the 1990s, are likely to continue, though in somewhat attenuated form. The
16 growth of world milk production and consumption has been less buoyant than that of meat. World per
17 capita consumption is currently 83 kg, up from 77 kg 30 years ago. All of the increase in per capita
18 consumption came from the developing countries (from 37 kg to 52 kg), yet their per capita
19 consumption remains well below that of the industrial countries (202 kg).

20 Given the still low consumption levels in developing countries there is considerable scope for
21 nutritional gains from further growth in consumption of milk and dairy products, and these projections
22 foresee milk production rising from 664 million tonnes in 2005–2007 to 1 077 million tonnes in 2050.
23 This 1.1 percent annual growth will be greater in developing countries (at 1.8 percent per annum) than
24 in developed countries (0.3 percent per annum).

25 2.1.2 Other projections and scenarios

26 FAO's definition of food and nutrition security covering all of its dimensions (availability, access,
27 utilization and stability) was agreed at the 1996 World Food Summit. However, there is no global
28 scenario study dealing with these four dimensions of food security. Most studies deal with availability,
29 with access and stability sometimes analysed as co-products of availability (e.g. increased availability
30 contributing to decreased food prices and thus improved access to food, and contributing to less
31 volatile prices and more stability). The utilization dimension is rarely dealt with except through the
32 consideration of dietary adjustments that could contribute to reducing the prevalence of non-
33 transmissible diseases (obesity, diabetes and cardiovascular diseases, for instance).

34 Several recent scenario studies (e.g. Reilly and Willenbockel, 2010; van Dijk, 2012; Wise, 2013; von
35 Lampe *et al.*, 2014; van Dijk and Meijerink, 2014) focus, at least partially, on global food security.
36 Reilly and Willenbockel (2010) propose a typology of scenarios, which is very useful to classify
37 studies.

38 They distinguish three types of scenarios:

- 39 1. "Projections", which are usually used either to estimate the future of a system under "business
40 as usual" assumptions (baseline projections) or to assess the reaction of a system to a set of
41 "what if" assumptions (what if projections).
- 42 2. "Exploratory scenarios", which are designed to explore possible futures, allowing for changes
43 in the structure of the system and boundary conditions.
- 44 3. "Normative scenarios", which are designed to support vision building and develop narratives
45 for the agri-food system to meet specific targets.¹¹

46 Among the projection studies, the *FAO's World agriculture towards 2030-2050* (Alexandratos and
47 Bruinsma, 2012) is currently held as a reference for baseline projections of world agricultural supply
48 and demand in 2050 (see above).

49 Of the exploratory scenario studies, the Millennium Ecosystem Assessment (MEA) is probably the
50 most well known (Carpenter *et al.*, 2005). The MEA was undertaken by an international network of
51 scientists and other experts, under the auspices of the United Nations, with a procedure modelled on

¹¹ For further comments on the difference between normative and exploratory scenarios, see Iversen (2006).

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1 the Intergovernmental Panel on Climate Change (IPCC). The objective was to “assess the
2 consequences of ecosystem change for human well-being and the scientific basis for action needed to
3 enhance the conservation and sustainable use of those systems and their contributions to human well-
4 being”. The MEA proposes four exploratory scenarios developed along two axes: one describing
5 global governance for international cooperation and trade (globalized vs regionalized), the other
6 covering attitudes towards ecosystem management (pro-active vs reactive). Among the four
7 scenarios, global orchestration (globalized, reactive ecosystem management) was the reference
8 scenario in the *Agrimonde* study.

9 Among the normative scenarios, the *Agrimonde* foresight study, undertaken by INRA and CIRAD
10 (Paillard *et al.*, 2010), focuses on feeding the world in 2050. It considers two scenarios: a baseline
11 scenario (“business as usual”), which relies closely on the “global orchestration” scenario from the
12 MEA foresight study, and a normative scenario involving less food consumption inequalities and more
13 sustainable agricultural production across the world, implying breaks in both diets and agricultural yield
14 trends (a uniform diet worldwide up to 2050, resulting in reduced consumption of animal products in
15 developed countries and increased consumption in developing countries, and stagnating or slowly
16 increasing yields in most regions in the world).

17 From the “what if” projection scenarios, the International Assessment of Agricultural Knowledge,
18 Science and Technology for Development (IAASTD) study, *Agriculture at a crossroads* (MacIntyre *et*
19 *al.*, 2008), is probably one of the most well known. The IAASTD study is an international effort initiated
20 by the World Bank and FAO with the objective of assessing the impacts of agricultural knowledge,
21 science and technology (AKST) on food security and sustainable development. The IAASTD is
22 relatively close to the MEA regarding the process and method used. But both exercises differ as
23 regards the type of scenarios they propose: the IAASTD did not propose global exploratory scenarios
24 as in the MEA study, but a baseline projection and a set of “what if” projection scenarios. In the
25 baseline projection, current trends are projected to 2050. The baseline and the variant scenarios are
26 simulated with a wide set of quantitative models, in particular using the IMPACT model (IFPRI).

27 Another “what if” study, *Eating the planet* (Erb *et al.*, 2009) is of special interest for the present report
28 since it explores the consequences of combinations of various assumptions on land-use change
29 (massive change, or business as usual); on yields (intensive, intermediate, or organic); on diets ((i)
30 Western high meat, (ii) current trend, (iii) less meat, or (iv) far less meat, which goes beyond the ‘less
31 meat’ scenario, reducing the share of protein from animal sources to 20 percent, instead of 30 percent;
32 and on different livestock systems (intensive, humane or organic). It analyses the interrelationships
33 and possible trade-offs among the resulting 72 possible scenarios, the feasibility of which is tested
34 through a biomass balance model.

35 It appears that, with current methods of production, the “Western high meat” diet is not a feasible
36 option whatever the increase in crop yields, the land-use change and even the livestock system. One
37 possible – and probably feasible – exception for the extension of the Western diet could be for a
38 combination of massive land-use change, intensive livestock production systems and intensive use of
39 arable land (such as FAO’s “Save and grow” proposal for sustainable production by smallholders).¹²
40 Otherwise, the feasibility of the scenarios seems to depend, in order of importance, on first, the
41 evolution in animal protein consumption, then on the increase in crop yields, and finally on land-use
42 change.

43 It is interesting to note that, more generally, the feasibility analysis indicates that the additional costs of
44 humane and organic livestock rearing systems, in terms of feeding efficiency and demand for
45 additional area, seem to be relatively low. Differences in the livestock systems assumed in the
46 scenarios play only a minor role in determining whether a scenario was feasible or not. However, the
47 study also shows that the data uncertainties and the current limited scientific understanding of the
48 feeding efficiency of humane farming systems demonstrate the need for better data to enable more
49 robust conclusions to be drawn on that issue.

50 In conclusion, several pathways are possible to feed the global population of over 9 billion people in
51 2050. These pathways can be seen as changes in diet (including fish), increases in agricultural
52 productivity, changes in land use, greater reliance on trade, reduction in food losses and waste, and
53 reduction of inequalities. Among these pathways, livestock has a key role to play and is part of the
54 solution (Erb *et al.*, 2009).

¹² <http://www.fao.org/ag/agp/save-and-grow/>

1 The broad story of the various projections, which is becoming a common global narrative, is that over
2 the next three decades or so population increases and (particularly) income growth (and both being
3 more pronounced in developing countries) will drive increased demand for livestock products. This
4 increase can affect FSN positively in many ways. First, by providing opportunities for increasing the
5 incomes of smallholders. Second, by facilitating the correction of nutrient deficiencies and addressing
6 undernutrition. For this increase in access to animal-sourced foods, livestock numbers need to
7 increase, but so too will the productivity of these animals, the latter being particularly important if
8 natural resources (particularly water) are to be used wisely, and environmental pressures and
9 greenhouse gas emissions are to be mitigated. Feeding these extra animals will require more grain
10 and fodder, to be produced alongside crops for direct human consumption and for biofuels (depending
11 on the uncertain trajectory that this energy source will take).

12 **2.2 Role of livestock in agri-food systems**

13 Livestock production is central to food systems. The livestock sector and the related supply chains
14 employ 1.3 billion people globally and support the livelihoods of 1 billion of the poorest people of which
15 around two-thirds are rural women (FAO, 2009). Livestock keeping is also strongly influenced by
16 values and ethics and livestock has a key role in shaping many landscapes and communities.

17 The world's livestock headcount is estimated to 33 billion – among which, 19 billion chickens, 1.5
18 billion cattle, 1.7 billion sheep and goats, and 1 billion pigs¹³. Estimates, based on data for 2001–2003,
19 indicate that grazing systems supply 9 per cent of the world's meat and 12 per cent of milk; mixed
20 crop–livestock systems contribute 46 per cent of meat, 88 per cent of milk, and 50 per cent of cereals;
21 while intensive systems provide 45 per cent of meat (Steinfeld *et al.*, 2006; Thornton and Herrero
22 2009). Among milk-producing livestock, cows have an important significance, and sheep, goats,
23 buffaloes and camels produce milk of particularly high nutritional value. Livestock also has an
24 important role in providing manure, power, hides, fibre and medicines, as well as being important
25 assets for livestock owners.

26 The main animal products and animal sourced food (ASF) : meat, dairy products (milk, cheese and
27 other dairy products) and eggs provide around 13 percent of the energy and 28 percent of protein
28 consumed globally, with a higher share in developed countries (20 percent and 40 percent
29 respectively) (FAO, 2009). In developing countries, the demand for ASF has escalated over the past
30 few decades and is projected to continue to rise strongly.

31 Over the last two decades, there has been an ongoing re-structuring and transformation of the
32 agricultural and global food system, which differs regionally, nationally and locally (McMichael, 1993;
33 Goss *et al.*, 2000; Busch and Bain, 2004; Konefal *et al.*, 2005; Thompson and Scoones, 2009).

34 Often associated with processes of globalization, economic development, technology, policies, and
35 commercial and other stakeholder interests, this restructuring is evident in transitions in relation to
36 scale, production systems, concentration, governance and technology. While delivering more food,
37 and often at lower prices, in some places these changes have engendered a degree of resistance
38 reflected in new interest in "local food", quality, social and environmental certification, provenance and
39 food sovereignty. The dominant transitions in scale, concentration, technology, etc. have nevertheless
40 had, and will continue to have, important implications for rural livelihoods, poverty, food security, social
41 justice and the environment in both developed and developing countries (Sumberg and Thompson,
42 2012).

43 Local food has been the subject of government policy in recent years as consumer interest in and
44 demand for local foods has grown (Low *et al.*, 2015). Local foods have been linked to a full suite of
45 priorities including enhancing the rural economy, the environment, food access and nutrition, informing
46 consumer demand, and strengthening agricultural producers and markets.

47 These processes of restructuring have affected the production, processing, distribution, sale and
48 consumption of meat and livestock products. With a particular focus on the developing world, ongoing
49 and projected transitions in the consumption and production of livestock products have been termed
50 the 'livestock revolution' (LR) (Delgado *et al.* 1999c). In a nutshell, the LR highlights accelerated
51 growth in demand for livestock products in parts of the developing world, tied to human population
52 growth, rising incomes, continuing urbanization and changing food preferences. The notion of the LR –

¹³ <http://faostat.fao.org/site/573/default.aspx#ancor>

1 with its promise of diet diversity, better nutrition and health, and also economic opportunities for small-
2 scale producers – is one of the most powerful ideas to emerge in the areas of food, nutrition and
3 agricultural development over the last decade (Sumberg and Thompson, 2012).

4 Analysis by Delgado *et al.* (1999c) identified seven "characteristics" of the LR:

- 5 1. rapid worldwide increases in consumption and production of livestock products in developing
6 countries;
- 7 2. a major increase in the share of developing countries in total livestock production and
8 consumption;
- 9 3. ongoing change in the status of livestock production from a multipurpose activity with mostly
10 non-tradable output to food and feed production in the context of globally integrated markets;
- 11 4. increased substitution of meat and milk for grain in the human diet;
- 12 5. rapid rise in the use of cereal-based feeds;
- 13 6. greater stress put on grazing resources along with more intensive production closer to cities;
- 14 7. the emergence of rapid technological change in livestock production and processing in
15 industrial systems.

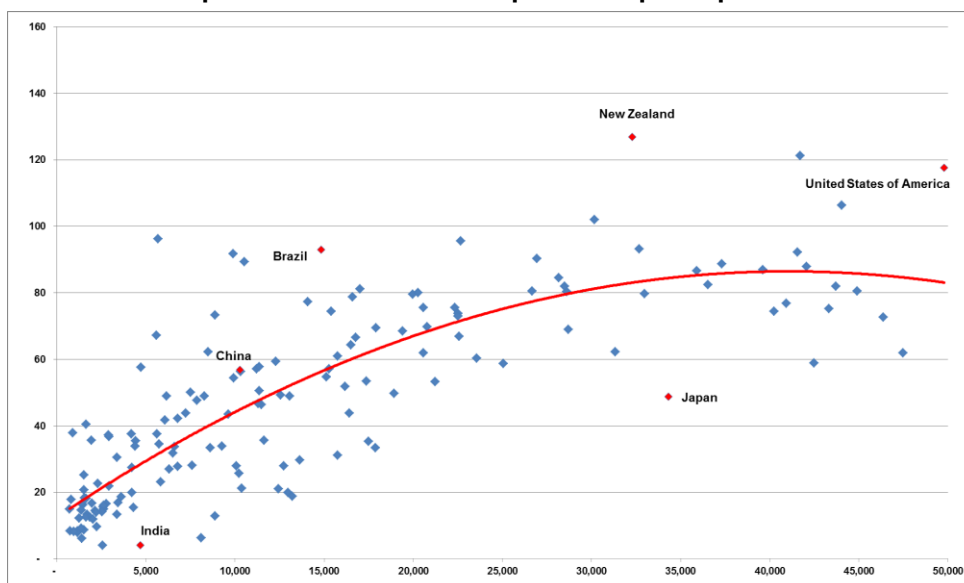
16 Livestock is the world's largest user of land resources with 26 percent of the earth's ice-free terrestrial
17 surface used for grazing. Pasture and land dedicated to the production of feed represents almost 80
18 percent of total agricultural land. The sector uses 3.4 billion hectares for grazing and one-third of
19 global arable land to grow feed crops, accounting for more than 40 percent of world cereal production.
20 Almost one-third of total agricultural water is used by the livestock sector directly (FAO, 2013).

21 Demand for animal-sourced food (ASF)

22 In recent years, the growth in the demand for ASF has come from rapidly expanding economies in
23 developing countries. It is projected that by 2050 per capita consumption of meat and milk in
24 developing countries will have increased by more than 57 percent and 77 percent, respectively (FAO
25 2011a). Yet even at those rates of increase, consumption levels of meat and milk will still be less than
26 half of those found in developed countries. Currently, global average meat consumption amounts to 43
27 kilograms/capita/year, with developing countries accounting for 33 kg/capita and developed countries
28 for 76.2 kg/capita. Milk consumption is 85 kg/capita/year globally, with a greater difference between
29 developing and developed countries than in meat, 53 and 210 kg/capita/year respectively.

30 Global trends in consumption of animal products vary considerably by region. It is estimated that food
31 demand for livestock products will nearly double in sub-Saharan Africa and South Asia, from some
32 200 kcal/capita/day in 2000 to around 400 kcal/capita/day in 2050. In OECD countries (currently at
33 1000 kcal/capita/day or more) consumption levels will barely change, while in South America and
34 countries of the former Soviet Union it is expected to increase to OECD levels (Van Vuuren *et al.*,
35 2009).

36 **Figure 2 Relationship between meat consumption and per capita income in 2011**

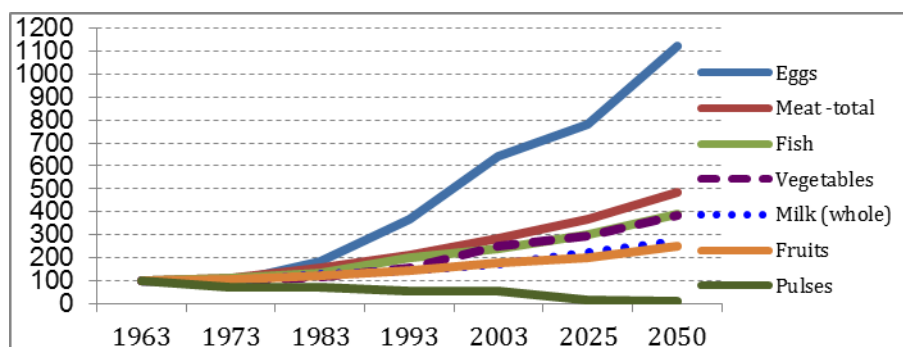


37
38 Note: GDP per capita is measured at purchasing power parity (PPP) in constant 2011 international US dollars.

1 Source: Adapted from FAO 2009b: Livestock in the balance (FAO, 2009). Based on data from FAOSTAT (FAO,
2 2015) for per capita meat consumption and the World Bank for per capita GDP.

3 **Figure 3 Increase in per capita consumption of perishables and pulses in developing**
4 **countries with 1963 as index year**

5



6

Source: FAO (2009b).

7

8

9 Over the past 50 years, global meat production has almost quadrupled from 78 million tonnes in the
10 1960s to a current total of 308 million tonnes per year. Much of this growth has been concentrated in
11 East Asia and revolved around poultry and pigs. In developed countries, production and consumption
12 of livestock products are now growing only slowly or stagnating, although at high levels. Even so,
13 livestock production and processing in developed countries account for 53 percent of agricultural GDP
14 (World Bank, 2009).

15 As diets become richer and more diverse, the livestock sector offers improvements to the nutrition of
16 the vast majority of the world. Livestock products not only provide high-value protein but also are
17 important sources of a wide range of essential micronutrients, in particular minerals such as iron and
18 zinc, and vitamins such as vitamin A. By providing essential nutrients, especially in the critical first
19 1 000 days from conception, animal-sourced foods can help ensure normal physical and cognitive
20 development. Well-nourished and well-educated children can grow up to be healthy young adults who
21 are able to realize their full potential and contribute to family income-earning and national
22 development. On the other hand, diets rich in livestock products, in particular red meats, are
23 implicated in rising health concerns in some countries, although the scientific evidence and nutritional
24 guidance has often changed through time and can be confusing to consumers.

25 In recent years much of the advice given by nutritionists has centred on adopting the so-called
26 “Mediterranean diet”, which is arguably better for health and the environment, as shown in Box 4.

Box 4 An overview of the diets in the Mediterranean area and their evolution during the last 50 years

According to Willett *et al.* (1995), who proposed the first “Mediterranean diet pyramid” (MDP), the highly publicized MDP defines a model for healthy eating. Based on epidemiological evidence, the MDP is related to high life expectancy, low rates of coronary heart disease and certain forms of cancers, and other diet-related chronic diseases. It reflected the food habits of habitants of Crete and Southern Italy in the early 1960s described by Keys (1970). This diet is characterized by abundant food from plant sources (fruits, vegetables, cereals, potatoes, beans, nuts, seeds), olive oil as the principal source of fat, some dairy products, low to moderate amounts of fish and poultry (including eggs), low and infrequent amounts of red meat, and wine consumed in low to moderate amounts, principally with meals.

Soon after, and although different regions in the Mediterranean basin have their own specific diets, Trichopoulou and Ligiou (1997) proposed that these be considered as variants of a single entity, namely, the Mediterranean diet, based on the observation of the many common characteristics of these variants, among which olive oil occupies a central position in all of them. Olive oil is important not only on account of its own consumption, but also because it is associated with the consumption of large quantities of vegetables in the form of salads and equally large quantities of vegetables in the form of cooked foods. Thus, it was considered convenient, if not wholly accurate, to define the Mediterranean diet as the dietary pattern found in the olive-growing areas of the Mediterranean region in the late 1950s and early 1960s, when the fast-food culture had not yet taken hold in the area.

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Since then the MDP has been adapted to the different nutritional and socio-economic contexts of the Mediterranean region, with updated recommendations considering the lifestyle, dietary, socio-cultural, environmental and health challenges that the current Mediterranean populations are facing (Bach-Faig *et al.*, 2011). The Mediterranean diet has also been recognized as an “Intangible Cultural Heritage of Humanity” by UNESCO (2010).

The evolution of the food system of the North Africa–Middle East Region has been studied recently by INRA-DEPE (INRA’s Office for Scientific Expertise, Foresight and Advanced Studies), on behalf of the PluriAgri association: “Le système alimentaire de la Région Afrique du Nord - Moyen-Orient à l’horizon 2050 : projections de tendances et analyse de sensibilité” (The food system in the North Africa–Middle East Region in 2050: trend projections and sensitivity analysis).

Much of the data gathered for this retrospective study described the evolution of food availability (kcal/capita) of countries around the southern (Morocco, Algeria, Tunisia, Egypt) and eastern (Israel, Lebanon, Syrian Arab Republic, Turkey) edges of the Mediterranean. These “food availability” data serve as popular proxies for actual consumption at the national level ([http://www.ers.usda.gov/data-products/food-availability-\(per-capita\)-data-system.aspx](http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx)). The aggregated data provided in the synthesis report (Marty *et al.*, 2015) of the INRA-PluriAgri study for the period 1961–2012 provide an approximate picture of the evolution of the diet in the region for that period.

The two main trends noted over time in the diet are a radical change in the types of consumed oil, and a strong growth in the consumption of sugar products. In the early years of the study period, the highest consumption of oils was traditional and local: olive and cottonseed oils. These were replaced, in the 1970s, by palm oil, soya oil and sunflower oil, which are increasingly imported. Concerning sugar products, consumption almost doubled over the period. The share of sugar products in plant food availability amounted, by the end of the period studied, to around 10 percent in all subregions of North Africa and the Middle East Region.

These various trends in dietary change are consistent with a “Westernization” of diets. However, the region still seems to follow, at least to date, a particular pathway of nutritional transition, by maintaining the strong characteristics of the Mediterranean diet: the share of plant products remains high (circa 90 percent on average), and cereals continue to play a leading role (wheat accounts for 40 to 50 percent of total food availability). Another characteristic of the Mediterranean diet that has been important over the period is the high level of fruits and vegetables consumed. The share of animal products in food availability has remained almost constant, at around 10 percent on average. The main feature is the substantial increase in poultry meat consumption: its share in the animal food availability increased from 4 to nearly 20 percent on average in the region over the period.

In summary, the North Africa–Middle East Region has undergone a nutrition transition (increase of daily calories and increase in the share of oil and sugar in food availability), but the changing diet differs from the “Western” model by virtue of the very low growth in the share of animal products and the persistence of high levels of plant products, including cereals, fruits and vegetables, in diets.

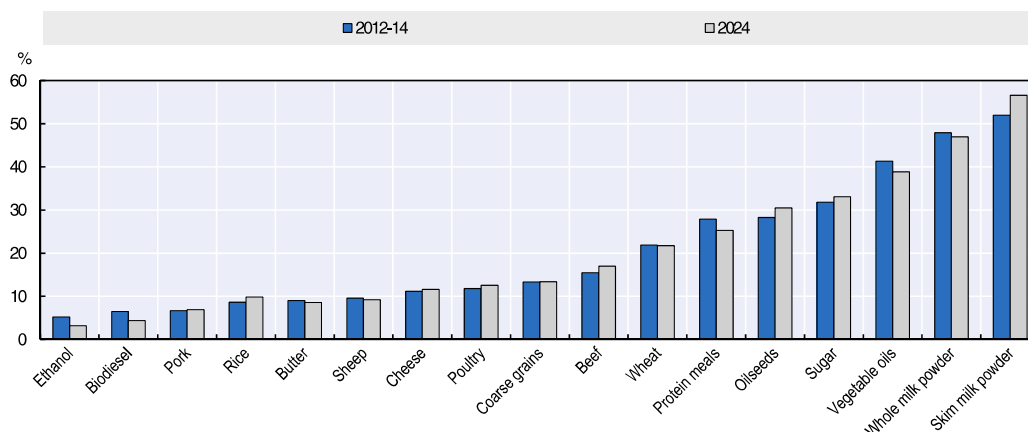
Marty *et al.* (2015) noted that: “These two developments in the average diet are largely responsible for the significant increase in non-communicable chronic diseases and obesity in the region (Popkin *et al.*, 2012), increase which is all the more worrying as nutritional deficiencies persist in the region (Fahed *et al.*, 2011)”.

- 1
- 2 While a very high proportion of ASF is produced and consumed locally, the importance of trade is
- 3 increasing. According to the OECD–FAO outlook 2015–2024, international trade volumes of most
- 4 agricultural commodities are projected to expand over the next ten years, as shown in Figure 4.

5

1
2

Figure 4 Share of traded production in 2024 compared with 2012–2014



3 Source: OECD/FAO (2015), “OECD-FAO Agricultural Outlook”, *OECD Agriculture Statistics* (database), <http://dx.doi.org/10.1787/agr-outl-data-en>.

4 Staple dairy products (milk powder) are the most traded livestock products, with more than 50 percent
5 of total production currently exported. According to the OECD–FAO projections, beef will continue to
6 be the most traded meat.

7 The growth in livestock production is closely associated with the demand for feed grains and oilseeds,
8 with trade of coarse grains for feed having risen faster than the trade in some ASF products. For
9 some producers, such as in the European Union and China, availability of imported feed is vital for
10 their livestock sectors.

11 Exports of livestock products are concentrated in fewer than ten countries, in particular Australia and
12 New Zealand (dairy and sheep), the European Union (dairy and pork), United States of America (beef,
13 poultry, pork and dairy products) and Brazil (beef and poultry).

14 National trade-related policies such as some subsidies and support measures provided mainly by
15 developed countries (but increasingly also in developing countries, including India and China) and
16 tariffs have a major impact not only on national agricultural and food systems but also on the
17 agricultural performance of other countries. Dairy and beef products are among the most protected
18 commodities by developed countries and are becoming more significant in developing countries.

19 2.3 Typologies of livestock farm systems and their links to crop 20 systems

21 Because moving towards sustainable agricultural development will vary considerably across countries,
22 among different farming systems and through time, there will be a range of possible pathways and
23 responses to deal with the challenges facing agriculture. Capturing the diversity of farming systems
24 and the possible implications of different modes of organization of agricultural production for SADL
25 and FSN, at different levels and scales, is an important step in the construction of a solid base for
26 policy proposals and action. The analysis and recommendations presented in this report are thus built
27 upon the recognition of the diversity of crop and livestock systems worldwide, through a simplified
28 classification of farming system types.

29 Diversity in agriculture is the result of the co-evolution, in time and space, of human societies and
30 ecosystems, through the practice of farming, unfolding in different patterns of resource use and
31 development trajectories (Ploeg and Ventura, 2014). The heterogeneity of farming systems reflects, in
32 many senses, the diversity of social, economic and ecological responses to changing adaptive
33 conditions in different settings (Ploeg, 2010). Biological and cultural diversity embedded in farm
34 systems and the knowledge associated with the practice of agriculture in different agro-ecological
35 settings is here considered as an important asset in the construction of sustainable agricultural
36 development trajectories. It’s important to highlight, at the same time, that agricultural practices alter
37 ecosystems in different ways, but are part, at the same time, of a global process of environmental,
38 economic and social change.

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1 It is widely recognized that agriculture is currently marked by the coexistence between, at one end of
2 the range, the highly industrialized farm systems, with strong connections to the markets and heavily
3 dependent on external inputs and, at the other end, diversified multipurpose production systems,
4 managed by smallholders according to a combination of market and non-market needs and pressures,
5 with intensive use of natural resources locally available. Between these two extremes, there is a great
6 variety of farm systems located in different agro-ecological zones, with different development
7 pathways.

8 According to Ploeg (2008), contemporary agriculture can be described as a confluence of three
9 different constellations of development trajectories including:

- 10 ▪ *Peasant agriculture*, where labour is mostly provided by the family or mobilized within the rural
11 community, with sustained use of ecological capital. Land and other means of production are
12 family or community owned. Production can be oriented towards the market but aims, also, at
13 the social and economic reproduction of families and or communities.
- 14 ▪ *Entrepreneurial agriculture* strongly based upon financial and industrial capital within
15 specialized farming systems. Scale enlargement is an important feature in this development
16 trajectory.
- 17 ▪ *Large-scale corporate farming*, where the labour force is mostly based in salaried workers
18 and the maximization of profits is an important driver in the functioning of agricultural systems.

22 This categorization reflects different modes of organizing agricultural activities. Other frameworks can
23 be developed incorporating the agro-ecological features of farm systems, dominant patterns of farm
24 activities, livelihood strategies, relationships to markets or multiple category systems.

25 The Farming System Knowledge Base, a joint project of FAO and the World Bank (Dixon *et al.*, 2001),
26 aims to document trends, emerging constraints and strategic priorities for a range of 72 farming
27 systems in six developing regions of the world. Five key biophysical and socio-economic determinants
28 were taken into account in the construction of the study framework: (i) natural resources and climate;
29 (ii) science and technology; (iii) trade liberalization and market development; (iv) policies, institutions
30 and public goods; and (v) information and human capital. According to the authors, these categories
31 represent, “major areas in which farming systems characteristics, performance and evolution are likely
32 to be significantly affected over the next thirty years” (Dixon *et al.*, 2001). At the household level, five
33 major strategies to improve livelihoods, all of them closely related to food security, were identified:
34 intensification of existing production patterns; diversification of production and processing; expanded
35 farm or herd size; increased farm income (agricultural and non-agriculture) and a complete exit from
36 the agriculture sector within a particular farming system. An important contribution of this work is to
37 highlight constraints and opportunities of the identified farming systems and livelihood strategies.

38 The diversity of livestock production systems, at the global level, has been captured through different
39 classification schemes (Seré and Steinfield, 1996; Herrero *et al.*, 2009; Robinson *et al.*, 2011). In most
40 cases, livestock systems are treated as a subset of farming systems. The livestock classification
41 system proposed by Seré and Steinfield (1996), encompasses all the cases in which livestock
42 contributes “*more than 10 percent to total farm output in value terms or where intermediate*
43 *contributions such as animal traction or manure represent more than 10 percent of the total value of*
44 *purchased inputs*”. Subsequent studies, such as Robinson *et al.* (2011), called attention to the fact that
45 this general classification includes features that cannot be measured using available spatial datasets,
46 particularly at a global scale. It is important to highlight, as well, that the concept of the farm unit, which
47 structures the definition as a spatial reference, may not be the best way to describe the spatial context
48 of livestock systems, considering not only the mobile character of many livestock systems, particularly
49 in the case of pastoralists, but also the fact that, for many of these systems, communal forms of land
50 use are highly important.

51 In general terms, as suggested by Robinson *et al.* (2011), the classification proposed by Seré and
52 Steinfield (1996) can be used as a starting point as it “*provides a relevant stratification through which*
53 *to describe, visualize and explore livestock and livestock-related issues, and constitutes a useful*
54 *baseline that can be refined, improved upon, and adapted through time*” (Robinson *et al.*, 2011). In the
55 same direction, Notenbaert *et al.* (2009) also agree that the Seré and Steinfield (1996) classification is
56 a useful starting point and base line that can be illuminated by complementary information and
57 different system cuts. The broad classification of livestock systems as a subset of farm systems

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1 provided by the authors encompasses a wide range of variation, considering different agro-ecological
2 zones, distinct possible combinations of crops systems and livestock systems, and different economic,
3 social and cultural foundations.

4 The four-category classification presented below was constructed for the purpose of this report, in
5 order to present an as simple as possible descriptive tool dealing with the diversity of livestock
6 systems at the global level. In the construction of these categories three guiding principles were
7 considered: (i) the proposed classification system would have to be consistent with the body of
8 scientific evidence, acknowledging that the precise definition of boundaries can vary considerably
9 according to different contexts and conditions; (ii) as suggested by Robinson et al. (2012), the
10 proposed classification should allow room for investigation of future developments in response to
11 global drivers; and (iii) the classification should be relevant to exploring FSN issues such as the
12 access to food, markets and means of production.

13 Therefore, the report distinguishes four main categories of livestock keepers:

14 1. *Pastoralist and agro-pastoralist systems.* Pastoralist systems are the result of a co-evolutionary
15 process between populations and the environment, developing different modes of land tenure and
16 management, strongly associated with mobility, the use of common pool resources and the ability
17 of animals to convert local vegetation into food and energy.

18 Pastoralism is globally important for the human populations it supports, the food and ecological
19 services it provides, the economic contributions it makes to some of the world's poorest regions,
20 and the long-standing civilizations it helps to maintain (Nori and Davies, 2007).

21 Pastoralism is a livestock production system that is based on extensive land use and often
22 some form of herd mobility, which has been practised in many regions of the world for
23 centuries (WISP, 2008). Pastoralism occurs on about 30 percent of the earth's ice-free land
24 area, mostly in the developing world, from the drylands of Africa and the Arabian Peninsula to
25 the highlands of Asia and Latin America where intensive crop cultivation is physically not
26 possible (FAO, 2001). Worldwide, according to the International Fund for Agricultural
27 Development (IFAD), there are an estimated 200 million pastoralists (but this is an
28 approximation) and herds total nearly a billion head of animals including camel, cattle and
29 smaller livestock that account for about 10 percent of the world's meat production (FAO, 2001),
30 and significant milk production. In different contexts, extensive livestock rearing can be
31 combined with crop production, mainly for household consumption.

32 Pastoralists developed, over time, different strategies in order to keep an optimal balance between
33 pastures, livestock and people, such as: raising a variety of species and breeds in order to make
34 an optimum use of different ecological niches; controlling access to water in order to manage the
35 use of pastures; investing in animals, particularly in fertile females, as an insurance against
36 drought, diseases and other extreme events (Hesse and MacGregor, 2006; ODI, 2009). The
37 distribution of assets according to social arrangements based on systems of reciprocity stands,
38 also, as an important strategy in the social and economic continuation of pastoralist forms of
39 livelihood. The conversion of grasslands to croplands and urbanization can, in certain cases, lead
40 to the violation of people's rights to traditional land. As noted by de Haan *et al.* (2010), "*population
41 pressure, arable farming encroachment and government policies to settle mobile pastoral groups
42 are also major sources of soil degradation*".

43 2. *Smallholder mixed farming systems.* In developing countries, most farms are mixed crop–
44 livestock, often managed by smallholders. This usually family-based system is producing up to 80
45 percent of the food consumed in developing countries. Farm sizes are typically small and only few
46 animals are kept. The diversification of these systems enables positive synergies between crops
47 and livestock systems and a multifunctional use of livestock. Rainfed mixed farming systems occur
48 in the temperate zones of Europe and America and in the subhumid regions of Africa and Latin
49 America (de Haan *et al.*, 2011). Globally, these systems are producing 48 percent of beef, 53
50 percent of milk and 33 percent of mutton production (FAO, 2006). In East and South Asia, in areas
51 with high population density, it is possible to observe the prevalence of mixed irrigated farm
52 systems. These systems contribute to about one-third of pork, mutton and milk production, and
53 one-fifth of beef production (de Haan *et al.*, 2011). Smallholder mixed farming systems can be
54 associated with a great variety of livelihood strategies with different levels of integration to the
55 markets. The diversified agricultural systems developed by these smallholders are often
56 characterized by the presence of different species of animals and the holding of multipurpose
57 breeds. Under certain circumstances, both in developed and developing countries, mixed farming

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1 systems can evolve into specialized farming systems highly dependent on the use of external
2 inputs.

- 3 3. *Intensive livestock systems.* According to Bruinsma (2003), large-scale intensive operations,
4 where animals are raised in confinement, account for three-quarters of poultry supply, 40 percent
5 of pork and two-thirds of all eggs. The study conducted by Robinson *et al.* (2011) reported that 58
6 percent of the total number of pigs, globally, are raised in intensive systems, with the largest
7 proportion in China, East Asia and Pacific and high-income countries. In relation to poultry
8 production, 70 percent of the poultry production, worldwide, is raised in intensive systems with a
9 leading role of China, high-income countries, East Asia and Pacific and Latin America and the
10 Caribbean. Intensive production is not restricted to pigs and poultry but reaches beef production
11 and the dairy industry. Intensive landless systems can be found around urban conglomerates of
12 East and Southeast Asia, Latin America or near the main feed-producing or feed-importing areas
13 of Europe and North America (de Haan *et al.*, 2011). Intensive livestock production systems are
14 strongly associated with economies of scale, but also to the reduction of the genetic diversity of
15 livestock. The FAO document, *The State of the World's Animal Genetic Resources for Food and*
16 *Agriculture*, highlights the relationship between the rapid spread of intensive livestock production
17 and the decline of genetic diversity in livestock production systems (FAO, 2007).
- 18 4. *Commercial ranchers.* In different agro-ecological zones commercial ranching assumes great
19 importance in beef and sheep production. Commercial ranchers (or graziers) can be found both in
20 developed and developing countries in areas covered by grasslands but, also, in forest frontiers
21 where pastures expand into forests and woodlands such as in the Amazon Forest in Brazil. As
22 ranching intensifies, producers can increase production by sowing exotic pasture species. The use
23 of high-yielding animal breeds can also be an important feature of these systems with different
24 levels of dependency upon external inputs. An important distinction between pastoralists and
25 commercial ranchers relates to the links established by commercial ranchers to global value
26 chains. The levels of intensification and the environmental impact of these systems can vary
27 significantly across different biomes.

28 The classification described above calls attention to the fact that the role of livestock as a provider of
29 different products and ecological services cannot be extended to these four categories of livestock
30 systems. Specialized intensive livestock systems are basically concentrated in the production of
31 specific commodities. Ecological interactions between crop and livestock systems are more evident in
32 mixed smallholder farm systems.

33 Beyond these four categories of livestock keepers it is possible to add two other types of systems that
34 are not encompassed in the previous typology:

- 35 ▪ *Intensive crop farming* – this category comprises large areas of land cultivated with a small
36 number of crops using, quite often, methods that imply the intensive use of external inputs. In
37 the case of grain monocultures, particularly maize and soybean, the connection with intensive
38 livestock systems is mostly established through global commodity chains. According to Weis
39 (2013: 69), “since 1961 the volume of maize exports grew seven-fold and world soybean
40 exports grew eight-fold; more than one-third of all soybean production is now exported”.
41 Environmental problems associated with the intensive production of feed crops are addressed
42 in other sections of this report.
- 43 ▪ *Smallholder systems where animals represent less than 10 percent of the total farm output in*
44 *value terms* – the specialization of smallholder systems in crop production can be a result of
45 agro-ecological conditions more suitable to farm strategies based on a combination of different
46 crops or the result of market specialization. The intensive production of fresh vegetables for
47 the market by specialized smallholders, depending on the use of fertilizers – very common in
48 peri-urban settings – can be a good example of a farm system where the contribution of
49 animal production can be negligible.
50

51 Along the report, the typology here presented will be used as a tool in order to highlight the constraints
52 and opportunities of different types of systems in the pathway towards SADL for FSN. The aim here is
53 to avoid a reductionist approach to agricultural systems and “one size fits all” solutions. The biological
54 and cultural diversity of farm systems stands here as an important asset in the strengthening of FSN,
55 at different levels, in the adaptation of agricultural production to climate change and in the
56 diversification of diets.

57

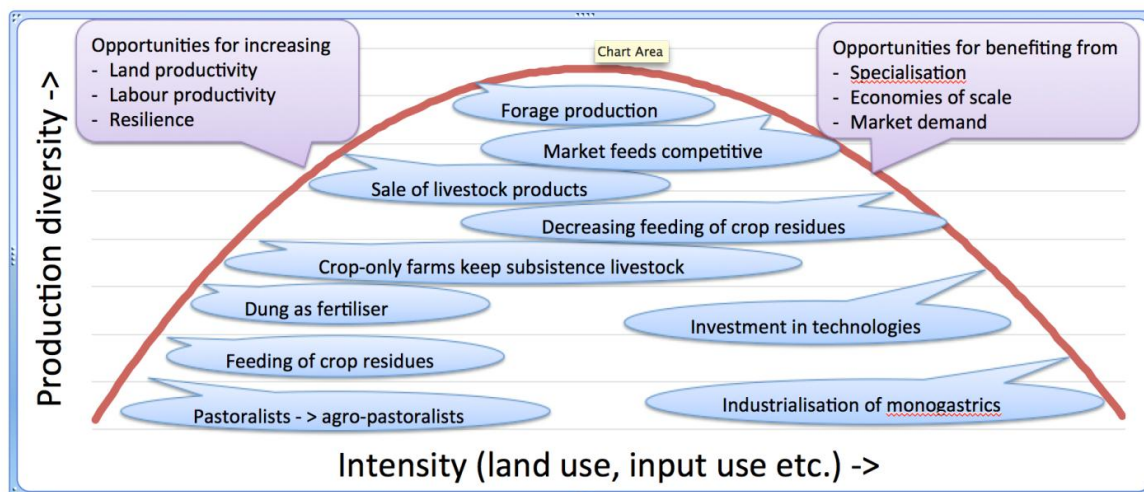
1 Changes in farm systems

2 Meeting the substantial increases in demand for food will have profound implications for livestock
 3 production systems over the coming decades. Estimates indicate that between 2000 and 2050 the
 4 global cattle population should increase from 1.5 billion to 2.6 billion, and the global goat and sheep
 5 population from 1.7 billion to 2.7 billion (Rosegrant *et al.* 2009). Thus, while crop production growth in
 6 the future will come mostly from yield increases rather than from area expansion, the increases in
 7 livestock production will be mainly the result of expansion in livestock numbers, and will be largely in
 8 developing countries (Thornton, 2010).

9 Arable and pasturelands have expanded considerably since the early 1960s to provide crops for
 10 livestock feed and grasslands for cattle raising. The demand for protein sources for animal feed has
 11 led for instance in Latin America to a considerable increase of cropland planted with soybean in the
 12 past three decades. Extensive cattle raising in the Amazon region accounts for at least 65 percent of
 13 the deforestation and up to 600 000 hectares per year are reported to be cleared for crop production
 14 to produce feed for pigs, poultry and dairy. Deforestation has also occurred in Southeast Asia and
 15 Central and West Africa, some of which has directly or indirectly been driven by livestock production.

16 Over the last 20 years, livestock production has responded to increasing demand primarily through a
 17 shift from extensive, small-scale, subsistence, mixed crop and livestock production systems towards
 18 more intensive, large-scale, geographically-concentrated, commercially oriented, specialized
 19 production units (Robinson *et al.*, 2011). Figure 5 shows a path of intensification in the use of
 20 resources when farmers specialize in the production of a single commodity.

21 **Figure 5 Relationship between intensification and diversification on livestock**



22 Source: ILRI, unpublished.

23
 24
 25 The intensification of animal production, however, is not necessarily associated with the
 26 industrialization process but also with increasing diversification. Small-scale livestock keepers may
 27 intensify their production by, for example, increasing labour productivity, using improved managing
 28 practices such as feeding with crop residues or using dung as fertilizer, by procuring services, or by
 29 adopting improved breeds, among other actions. Diversification generates opportunities to increase
 30 land productivity and more resilience of the system. The dairy sector in India is a good example, where
 31 large numbers of smallholders contribute to the provision of milk for the surrounding urban markets:
 32 production increased from 74 million tonnes in 1999 to 105 million tonnes in 2009 (an increase of 42
 33 percent over ten years), with an average herd size (cows and buffaloes) of only 3.3 (Wright *et al.*,
 34 2011).

35 Intensification may further lead to a degree of mechanization of operations on the farm, at which point
 36 production may become industrial. This enables farmers to invest in more targeted technologies and
 37 enables greater market integration, which will lead to improved economies of scale. Monogastric
 38 species (pigs and poultry), in particular, due to their high feed conversion ratios and short generation
 39 intervals, are well suited to rapid intensification of production.

40 Developed countries have experienced considerable specialization and intensification of agriculture,
 41 driven by economic growth, policies directed at increasing production, application of technology and a

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1 substitution of capital for labour. This has led to a decrease in mixed farming systems: most cereals
2 are produced on specialist arable farms, and large-scale industrial units dominate the monogastric
3 livestock sector. The dairy sector, especially in North America, and to some extent in Europe, is also
4 rapidly moving towards industrial-style production systems.

5 On the other hand, in developing countries, mixed crop–livestock systems produce 65 percent of beef,
6 75 percent of milk and 50 percent of lamb, the vast majority from smallholder systems. Thus, mixed
7 crop–livestock farming systems are crucial to global food security and the livelihood of almost 2 billion
8 people in developing countries half of whom are poor (Wright *et al.*, 2011).

9 With limited land and water resources and environmental concerns relating to the impact of agricultural
10 practices, more production in developing countries will come from increases in productivity from
11 existing resources (intensification). A key question is whether this intensification in developing
12 countries will result in more specialization and industrialization, such as in developed countries, or in
13 the intensification of smallholder mixed systems. This depends very much on countries situations and
14 trajectories (see HLPE, 2013).

15 This shift towards more intensive livestock production systems has had marked implications for the
16 composition of agricultural land use (Taheripour *et al.*, 2013a, b). Globally, the area devoted to maize
17 and oilseeds – key inputs into concentrated livestock diets – has risen by about 60 million hectares
18 over the first decade of the twenty-first century, reaching nearly 400 million hectares. Meanwhile, the
19 area devoted to permanent meadows and pastures – typical of extensive livestock production – fell by
20 about roughly the same amount, with animal feed crops such as hay and fodder falling as well
21 (Taheripour *et al.*, 2013a, b). In turn, ruminant grazing intensity in the rangelands is projected to
22 increase, resulting in more intensification of livestock production in the humid and subhumid grazing
23 systems of the world, particularly in Latin America and the Caribbean.

24 Nearly half the biomass (48 percent) eaten by livestock is grass, which is mostly grown on land
25 unsuitable for crops, and in developing countries stovers (fibrous crop residues) are a key feed
26 resource, comprising sometimes up to 50 percent of the diet of ruminants in these regions (Herrero *et*
27 *al.*, 2013). Many smallholder mixed systems in developing countries rely on local crop residues to
28 provide the basal diet for livestock, resulting in a very low-cost feed but these feeds, especially cereal
29 straws, have low nutrient values. Hence there is a requirement to improve the nutrient content and
30 digestibility in a cost-effective manner (Wright *et al.*, 2011). Attempts have been made to upgrade the
31 fodder quality of crop residues by chemical, biological and physical treatments, but few of these
32 interventions have been widely adopted.

33 As production systems intensify and become more efficient, less feed is needed to produce a given
34 unit of livestock product, with positive effects on the environment. Consequential changes in stover
35 production will occur, but vary widely from region to region. It is expected that large increases will
36 occur in Africa mostly as a result of productivity increases in maize, sorghum and millet. Yet stover
37 production will stagnate in areas such as the ruminant-dense mixed systems of South Asia (Herrero *et*
38 *al.*, 2009).

39 The case study of China, below, illustrates some of the positive and negative impacts of rapid
40 structural change in the crop–livestock sector.

41

Box 5 Changing structure of the livestock sector in China

China's livestock has been dominated by pig production in agricultural regions, with a small contribution from non-pig production in pastoral areas. In 1980, total meat production was 12.05 million tonnes, of which pork accounted for 94 percent at 11.34 million tonnes. However, the relative importance of pork production has gradually decreased while total meat production showed strong growth for more than three decades. Total meat production stood at 85.4 million tonnes in 2013, of which the share of pork was 64 percent. The relative decline of pork production can be explained by the role of pig-raising, and demographic change in rural areas.

Pork production was dominated by backyard pig-raising, with almost every farm household raising one or two pigs each year. Backyard pig production was essential to the survival of small farm holders, as it was not only the main source of badly needed cash income, but also the main source of manure necessary to grow crops. The agricultural worker to arable land ratio has been extremely high in China, at about three workers to 1 hectare in the 1980s, slightly declining to 2.5 workers to 1 hectare recently. Backyard pig production provided small farm holders with probably the only productive way to use their spare time when off-farm employment opportunities were not available. Backyard pig production was cost efficient, not only because the opportunity cost for labour was low or even negligible, but also as the use of commercial feed was very limited due to wide use of domestic wastes.

More importantly, manure generated from backyard production was crucial to growing field crops in the past. Even during the communal era backyard pig production was one of the household "sideline" production activities allowed because of its role in providing manure. In the 1960s and 1970s, rural households received their income allocated by the production team for their labour inputs and for manure from backyard pig-raising. The rewards to labour inputs were often only able to cover the value of food and fuel distributed to them, and cash income was basically to compensate for the manure they contributed to collective production of field crops. In many cases, the value of manure from backyard production was as much as the value of the income from labour to a prime agricultural worker for a whole year.

The situation has changed dramatically in the last three decades. More than 300 million rural workers have found off-farm jobs, often far away from their homes, and the level of chemical fertilizers used per hectare of sown areas increased from 86 kg in 1980 to 359 kg in 2013. Backyard pig production has lost its importance to small farm holders: they have found better opportunities in using their labour, and they no longer depend on manure. Following the huge rural–urban migration, opportunity costs in raising pigs, in collecting plant materials for manure and in application of manure, have all increased dramatically. According to the Survey of Farm Production Costs, the wage rate in agricultural production in 2013 was four times as high as that in 2004. And as household size has fallen with some members working at least partially away from home, the quantity of domestic wastes has also decreased and become uneven, so the feed efficiency in backyard pig production has also declined.

As a result, pig production has shifted from backyard-based to large-scale commercial production. According to the Animal Husbandry Yearbook, the number of households/farms with annual production of more than 50 000 pigs increased from 16 in 2001 to 187 in 2012, and those with annual production of 10 000 to 50 000, increasing from 747 to 4 363, during the same time period. By way of comparison, the number of households that raise less than 50 pigs in a year was only 51.9 million, less than 20 percent of the total rural households. It could reasonably be assumed that the number of households engaged in traditional backyard pig production – raising one or two pigs a year in their spare time and using domestic waste – is much less than that figure, although the statistics are not available.

The changing structure of the livestock sector in China has led to more production, with an exodus of workers earning higher incomes outside agriculture and a greater reliance on imported feed, and has contributed to better nutrition for the population. But it has led to serious problems of non-point pollution, as manure is no longer used as fertilizer. The proper treatment of manure is very costly, and hard to monitor when tens of millions of pig farms are scattered over a vast arable land area. At the same time, domestic wastes are no longer used as feed and have turned from being a resource to a pollutant.

Sources: tbd

1 2.4 Prices

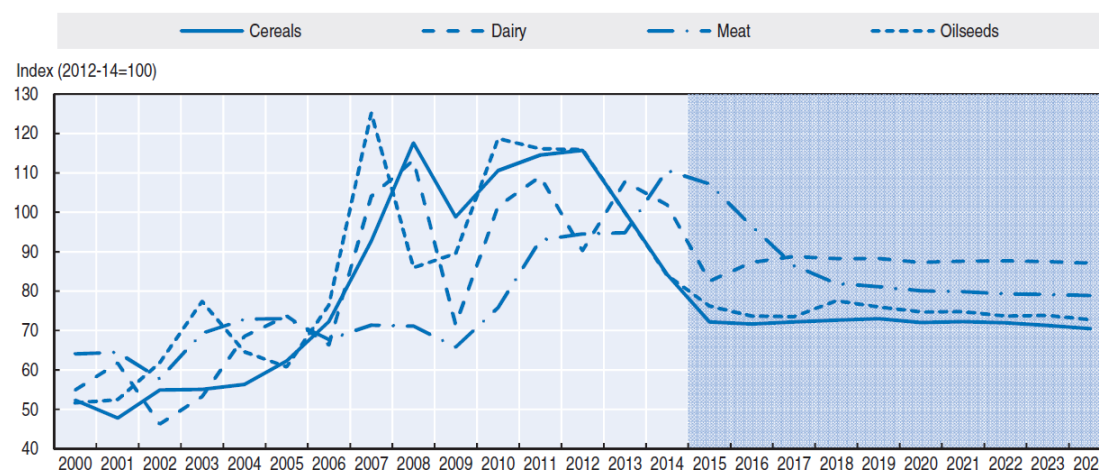
2 Production decisions and consumption levels and patterns both influence and are influenced by
 3 relative prices of inputs and products, with these prices being also affected by income levels,
 4 population growth, weather, policies, exchange rates and macro-economic conditions. The annual
 5 OECD–FAO Outlook provides an assessment of prospects in agricultural commodity markets for the
 6 coming decade. The latest edition (OECD/FAO, 2015), covering the years 2014 to 2024, gives an idea
 7 of the drivers and trends influencing agriculture in the medium term.

8 In real terms, prices for all agricultural products are expected to decrease over the next decade, which
 9 is consistent with the tendency for long-term secular decline.

10 2.4.1 Real prices follow the long-term declining trend

11 Over the next ten years, real prices are projected to decline from their 2014 levels but remain above
 12 their pre-2007 levels. When considering only the last 15 years, projected prices appear to be on a
 13 higher trend (Figure 6). The period of low prices in the early 2000s was followed by a period of high
 14 and volatile prices starting in 2007. Prices started to moderate in 2013, but are not expected to drop to
 15 the levels witnessed in the early 2000s.

16 **Figure 6 Medium-term evolution of commodity prices in real terms**



Note: Index calculated by a constant weighting of commodities within each aggregate. The weight is calculated by the average 2012–14 production value.

Source: OECD/FAO (2015), “OECD–FAO Agricultural Outlook”, OECD Agriculture Statistics (database), <http://dx.doi.org/10.1787/agr-outl-data-en>.
 StatLink  <http://dx.doi.org/10.1787/888933228861>

17
 18 However, whether real prices are on a higher or lower trend depends on the period over which prices
 19 are examined. When analysing the evolution of real prices over the last century, the projected prices
 20 continue a trend of long-term decline. Prices during the early 2000s were below the trend, while
 21 current and projected prices are more on trend. Even though real prices are projected to decline, this
 22 does not preclude the likelihood that prices will experience bouts of volatility, including upward price
 23 spikes, in the next ten years.

24 The major changes in demand are in developing countries, with rising incomes prompting consumers
 25 to diversify their diets by increasing their consumption of animal protein relative to starchy staples. For
 26 this reason, the prices of meat and dairy products are expected to be high relative to the prices of
 27 crops, while among crops the prices of coarse grains and oilseeds used for animal feeds should rise
 28 relative to the prices of food staples. These structural tendencies are in some cases offset by specific
 29 factors, such as a flat demand for maize-based ethanol. Lower crude oil prices are a source of
 30 downward pressure on prices, principally through their impact on energy and fertilizer costs. Moreover,
 31 under the projected lower crude oil prices, the production of first generation biofuels is generally not
 32 profitable without mandates or other policy incentives. While policies are not expected to lead to
 33 significantly higher biofuel production in either the United States of America or the European Union, a
 34 rise in the production of sugar-based ethanol in Brazil is expected to flow from the increase in the
 35 mandatory blending ratio in gasoline and the provision of tax incentives, while biodiesel production is
 36 being actively promoted in Indonesia.

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1 Within developing regions, almost 60 percent of total cereal use was consumed as food between 2012
2 and 2014, in contrast with the developed world, where food use accounted for only 10 percent of total
3 cereal disappearance. Rising demand for animal feed remains the core driver of cereal consumption
4 growth. Widely considered to be an affordable and healthy meat, with low fat content and few
5 religious and cultural impediments, poultry dominates meat consumption with an average annual
6 growth rate of 2 percent. Poultry will be half of the additional meat consumed in 2024.

7 Meat output is expected to respond to an improvement in margins, with lower feed grain prices set to
8 restore profitability to a sector that has been operating in an environment of particularly high and
9 volatile feed costs for most of the past decade. Although the emergence of biofuel and other industrial
10 uses was an important driver of rising demand for cereals throughout the past decade (coarse grains
11 use for biofuels almost tripled from 2004 to 2014), stagnation in biofuel demand will give way to feed
12 use as the significant driver of cereal demand.

13 Favourable meat to feed price ratios over the outlook period will support production growth, particularly
14 in industries such as poultry and pork, which rely on intensive use of feed grains. A short production
15 cycle allows the poultry sector in particular to respond quickly to improved profitability and,
16 underpinned by robust demand, production is projected to expand by 24 percent over the outlook
17 period. In 2024, developing countries (but excluding the least developed among them) will account for
18 58 percent and 77 percent of the additional global poultry and pigmeat production, respectively. Within
19 many developed regions, environmental regulations combined with more stringent animal welfare
20 regulations limit the potential for further expansion and hence production growth is slower.

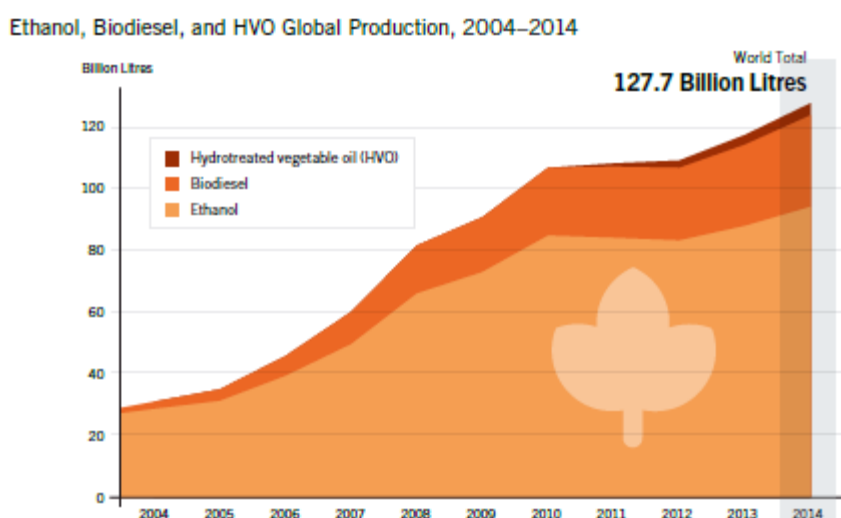
21 Consumption of dairy products has expanded rapidly over the past decade and constitutes an
22 important source of dietary protein. At a global level, the demand for dairy products will expand by 23
23 percent over the ten-year projection period. Growth remains strongest in the developing world and in
24 light of the preference for fresh dairy products within these regions, almost 70 percent of additional
25 dairy production will be consumed fresh.

26 Rising milk production throughout the past decade was a result of dairy herd expansion, as average
27 yields declined by an annual average of 0.2 percent, due to a fast increasing dairy herd in low yield
28 regions. Over the outlook period, milk production is projected to increase by an annual average of 1.8
29 percent, with the bulk of the additional milk produced in developing countries, notably India, which
30 overtakes the European Union to become the largest milk producer in the world. Within developing
31 countries, growth in milk production will result from both herd expansion and productivity gains. In
32 contrast, dairy herds are projected to decline in most developed countries, reflecting productivity gains
33 as well as constraints in water and land availability.

34 **Biofuels**

35 In the period from 2001 to 2014, world biofuel production increased six times to nearly 130 billion litres
36 (HLPE, 2013; REN21, 2015).

37 **Figure 7 Ethanol, biodiesel and hydrotreated vegetable oil (HVO) global production 2004–**
38 **2014**



39 Source: tbd

1 A pertinent question is whether such high growth (from a small base) will continue, and under what
2 circumstances. Particularly within the developed world, the emergence of biofuel and other industrial
3 uses was an important driver of rising demand for cereals throughout the past decade. The use of
4 coarse grains (predominantly maize) for biofuels almost tripled from 2004 to 2014, with almost 40
5 percent of additional coarse grains consumed over the past decade processed for biofuels. Over the
6 OECD–FAO 2015–2024 Outlook period however, significantly lower crude oil prices result in biofuel
7 demand being closely tied to policies mandating their use (OECD/FAO, 2015). The International
8 Energy Agency (IEA) forecasts global biofuel production of 139 billion litres in 2020 (IEA, 2014).
9 Although the first commercial advanced biofuel plants (using ligno-cellulose as feedstock) opened in
10 2014, food-crop based feedstocks are expected to continue to dominate ethanol and biodiesel
11 production over the coming decade, with the inherent competition for land, water and crops that have
12 alternative uses directly as food and as feedstuffs for livestock production.

13 Producing biofuels creates valuable by-products, such as distillers' dried grains (DDGs) and oilseed
14 meals that can be used as animal feed and can substitute for grain in animal rations. Dairy and beef
15 producers traditionally use DDGs in their feed rations, as it is palatable to cattle and well digested.

16 2.5 Social elements

17 Urbanization, employment, social and cultural traditions

18 Rapid urbanization has posed enormous challenges in many countries, especially as it proceeds
19 quickly while policies and structures only adjust slowly. Urbanization stimulates improvements in
20 infrastructure, including cold chains, which permit trade and transportation of perishable foods.
21 Compared with the less diversified diets of rural communities, city dwellers have a varied diet rich in
22 animal proteins and fats, characterized by higher consumption of meat, eggs, milk and dairy products.
23 The links between economic growth, demographic change, and food security are illustrated in the case
24 study of China (Box 6).

25

Box 6 Economic growth, demographic change and food security in China

China's economy has experienced fast and continuous growth for more than three decades, with GDP growing at an impressive annual rate of 9.8 percent from 1978 to 2013. It is widely acknowledged that the "demographic dividend" has been one of the major contributors to growth: while population increases the labour force base, the extension of life expectancy increases the share of workers in the population. However, there has been another form of demographic dividend: relocation of a large portion of the total labour force from the low-productivity sector to high-productivity sectors, i.e. massive migration from rural/agriculture to urban/non-farm sectors.

Total employment in China increased at about 3 percent per year during the 1980s, but employment in non-farm sectors increased at about 6 percent per year during the same period because of the rural-urban migration. The growth rate of the total labour force declined to about 1 percent per year during the 1990s, and has turned negative since 2014. However, due to rural-urban migration, the growth rate of non-farm employment has still been positive at around 2–3 percent annually.

The rural-urban migration of more than 300 million people (the largest during peacetime in human history) has contributed greatly not only to economic growth but also to the welfare of immigrants themselves and their families. Income from agricultural sources accounted for about 75 percent in rural households' net income during the mid-1980s, declining to about one-third in recent years, while the share of wage increased to about one-half of household net income in rural areas. Partly due to the increase of income from non-farm sources, per capita income in rural households has been able to grow at an annual rate of 7.5 percent from 1978 to 2012.

The joint effect of income growth and out-migration of labour is a dramatic shift of the supply curve in the rural labour market, which has a pronounced impact on food production. Obviously, increases in income will translate into increases in labour costs, while a decrease in the labour supply will lead to further increases in labour costs. As a result, the rural wage rate increased by more than four times in 13 years (from 20.8 yuans in 2000 to 109.8 yuans in 2013 per day, in grain production on average). Compared with increases of annual per capita income from 6280 yuans to 24565 yuans and from 2253 yuans to 7917 yuans, in urban and rural areas, respectively, the rural wage rate has increased relatively faster, indicating an inward shift of the labour supply curve in rural areas. As the wage rate is an annual average, the actual wage during peak season must be much higher, considering the seasonal nature of labour demands in agriculture.

Farmers facing a large and continuous increase in labour costs have two options: input substitution or product substitution. If they wish and are able to continue the same production, they may substitute other inputs, such as machinery, for labour, provided such substitution is both technically and economically feasible. Alternatively, if substitution of machinery for labour is not feasible either technically or economically, they may shift their production to high-value produce. The first option is largely determined by topography and the second by market demand.

Due to strong demand resulting from income growth in urban areas, the areas sown to vegetables increased from 2 to 12 percent in the total, basically at the cost of grain production, despite labour inputs required in vegetable production being about 5–6 times that of grain production and labour costs are rapidly rising. However, grain production has been the least profitable among all crops due to the relatively low price, determined largely on world markets and which could not increase with labour costs. Therefore, one major option for farmers to continue growing grain crops is to substitute machinery for labour. One of the major technical constraints is topography, which determines the feasibility of machinery services.

Among the four southeastern coastal provinces, grain production fell by 45 percent in Zhejiang, and between 25 and 30 percent in Fujian and Guangdong, while kept at the same level in Jiangsu during the last 20 years. The four provinces have experienced the same dynamics: relatively faster economic growth and demographic change, and higher income and labour costs compared with other provinces. However, while the crop-sown area accounts for about half of the total land surface in Jiangsu, the share of sown areas in the other three provinces is less than 20 percent, implying a large portion of the arable land is likely to be located in hilly regions, not easily accessible for machinery.

Economies of scale also determine the feasibility of substituting machinery for labour. It is not economically viable to own and operate a tractor and associated machinery on a farm as small as half a hectare, and small farmers may not be able to raise enough funding to purchase machinery. As the profitable scale of farm machinery is much larger than the size of family farms, China's mechanization of agricultural production actually started in the 1960s under the collective farming system. It was relatively easier for a production team, consisting of 25–30 households, to allocate adequate money to buy a "hand tractor" (walking tractor) and select a talented young person to learn how to operate it on the collective farm, usually of 30 hectares.

The past experience and accumulated human resources enabled Chinese farmers to innovate a new system to operate bigger farm machinery on small family farmland: specialized households buy and operate big farm machinery, while the majority of small farm households receive machinery services for a fee. The service providers move from south to north, tracking sowing and harvesting seasons across the country. As they provide cross-region services, each tractor is able to operate on areas larger than typical farms of the United States of America, and hence benefits from greater economy of scale. Those service providers are often organized into a small cooperative consisting of about ten tractors, in order to minimize information costs and coordinate more efficient services. And farmers tend to reduce their sourcing and negotiation costs through collective bargaining with service providers.

The importance of machinery services could be measured by their relative increase in the costs. The total direct material costs in rice production increased by 170 percent from 2000 to 2013, but the payment of farm machinery services increased by 6.5 times during the same time period. The trend was the same in maize production: total material costs increased by 2.1 times, while the payment of farm machinery services increased by 7.1 times, forcing small Chinese farmer holders to give up grain production.

1

2 The next few decades will see unprecedented urban growth, particularly in Africa and Asia where
3 urbanization rates today stand at less than 30 percent. It is expected that nearly 70 percent of the
4 world population will live in cities by 2050.

5

6 **2.6 From food supply chains towards sustainable food systems**

7 The food supply chain, which encompasses all those activities that lie between on-farm production and
8 the point of consumption, has experienced fundamental changes during the last two decades. It has
9 become more globalized and marked by upward trends in scale of production and economic
10 concentration. Three-quarters of food sales in most industrialized countries are now sold through
11 supermarkets, and 90 percent of the global grain trade is undertaken by four agribusiness firms

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1 (Murphy *et al.*, 2011). This has drawn critics to highlight the environmental and social implications of
2 extended supply chains designed to achieve year-round provision at the lowest cost.

3
4 From the governance perspective, the locus of power and decision-making has moved steadily from
5 farmers to retailers and traders, and from the state to the corporate entities whose power within the
6 food supply chain and intergovernmental policy regime is growing (Lang and Barling, 2012).

7
8 This introduces a shift in the control of food systems. The state, or government, is no longer
9 predominant. Corporations now have an overarching influence in the industry. The governance of food
10 supply chains has consequently become more complex and multiscalar, involving many public, private
11 and civil society actors (Lang *et al.*, 2009).

12
13 The life cycle assessment and other technical measures are being used to evaluate energy, carbon,
14 water footprints and other environmental, social and economic impacts, focusing on the potential
15 trade-offs in the development of more sustainable food systems (van Hauwermeiren *et al.*, 2007;
16 Edwards-Jones *et al.*, 2008).

17
18 Agro-food industries produce, sell and promote products responding to market-driven incentives,
19 consumer behaviour and policy signals and regulations. Current incentives tend to favour: the
20 production of poultry and pig meat and milk from intensive farms relying on feed; selection of varieties
21 for high and consistent yield rather than nutrition or health properties;¹⁴ processing that increases
22 palatability (which often entails increases in the amount of fat, sugar and salt, although the industry
23 has recently responded to criticism by marketing foods with lower fat, sugar and salt content),
24 extending shelf life, and reducing food preparation effort; and vigorous marketing especially to
25 children. This, in turn, contributes to overconsumption and increased consumption of less healthy
26 foods.

27 While studies in high-income countries generally support a link between higher ASF consumption,
28 overnutrition and chronic disease, the exact role of specific foods is highly contested and prone to
29 revision. There is also considerable controversy over the role of the agri-food industries with some
30 emphasizing their role in feeding more people at less cost than ever before while others draw parallels
31 between the food and tobacco industries and conceptualize overconsumption as a “profit driven”
32 disease (Buse and Hawkes, 2015). Despite isolated areas of improvement, there has been little overall
33 progress in shifting Western diets to healthier alternatives or decisively reversing trends in overweight
34 (Roberto *et al.*, 2015). Poor diet and non-communicable disease are increasingly associated with
35 poverty in both developed and developing countries but it is not clear whether this is driven by food
36 availability and price or by consumer preferences for tasty, convenient and cheap food.

37 38 **Food losses and waste**

39 The HLPE report on food losses and waste in the context of sustainable food systems (HLPE, 2014a)
40 covers food losses and waste (FLW) in a generic fashion and quotes the often reported figure that
41 nearly one-third of food produced for human consumption is lost or wasted globally (approx 1.3 billion
42 tonnes per annum (Gustavson *et al.*, 2011)). Due to a variety of definitions, methodologies, metrics and
43 protocols, compounded by data problems and unreliability of broad estimates derived from point-
44 based estimates, it is difficult to quantify food losses and waste. Nevertheless, a study reported in
45 2011 shows that for meat/meat products and milk the percentage of losses and waste, at about 20
46 percent, is lower than for other agricultural products. Further, this appears to hold true for all regions,
47 although losses are somewhat higher in sub-Saharan Africa.

48 In general, in middle- and high-income countries, most FLW occur at distribution and consumption; for
49 low-income countries, FLW are concentrated at production and post-harvest stages. Attention to
50 losses and waste in the livestock sector will make useful contributions to sustainable development,
51 and have some flow-on effects to food security and nutrition. Moreover a significant part of FLW is or
52 can be used as feed. However, there is a dearth of systematic quantity estimates of the nature of the
53 problem, or of implementable mitigation measures.

¹⁴ Whereas a chicken carcass used to be 2 percent fat, it is now 22 percent.

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1 The HLPE report notes (HLPE, 2014a) that “there is today no large-scale scoping study on the list of
2 existing, adopted measures/investments for FLW reduction, with details on cost–benefit among those
3 measures/investments along the food supply chain for the specific products and actors, and by
4 location in both developed and developing countries”.

6 **Trade, Policies and Markets (to be further developed and revised in light of any further** 7 **progress in WTO negotiations)**

8 The multilateral negotiations under the WTO, known as the Doha Development Round, have been the
9 dominant force shaping the international policy environment for agricultural commodity trade during
10 the past three decades. The process of integration of agriculture into the multilateral trading system is
11 not yet complete, and the stalled Doha Round negotiations as well as developments in the emerging
12 web of overlapping bilateral and regional trade agreements, add new uncertainties to the likely
13 evolution in some of the drivers and trends in agricultural markets explored above..

14 There has been vibrant debate between WTO member governments as well as in the academic
15 literature and stakeholder groups about the impact of the existing trade rules in agriculture on
16 sustainable agricultural development and on food security and nutrition. Some argue that the
17 multilateral trading system has yet to respond adequately to sustainable development and food
18 security and nutrition or other agriculture-related concerns such as declining terms of trade,
19 diversification and market concentration at the global level (McCalla and Nash, 2007). Nevertheless,
20 as described in chapter 1, others see the deepening of trade liberalisation in agriculture as a powerful
21 force for sustainable development especially in rural areas (International Bank for Reconstruction and
22 Development/The World Bank, 2007).

23 The WTO Agreement on Agriculture, adopted in 1995 as part of the Uruguay Round of trade
24 negotiations, was conceived in an international agricultural market of oversupply and low prices. The
25 shift from a demand-constrained market environment towards a more supply-constrained one subject
26 to greater price volatility has also shifted the emphasis in the food security debate, bringing the issues
27 of food access and affordability to the fore. In parallel there has also been controversy around the
28 compatibility of world trade rules and policies designed to facilitate environmental protection, for
29 example on the question of exemption of public funding of environmental programs from agricultural
30 subsidy disciplines.

31 The Doha round floundered in 2009 when negotiators were unable to narrow differences in
32 contentious issues over agricultural trade rules, including the extent to which developing countries
33 should be able to shelter certain products from tariff reductions, including in response to sudden import
34 surges or price falls. The Bali package, which the WTO agreed at the end of 2013, aimed to resolve
35 the impasse by ushering in an agreement on a limited number of issues, including five elements of the
36 agricultural negotiations: export competition; tariff rate quota administration; cotton; a revised list of
37 “green box” exempted subsidies; and a peace clause on above-market rice purchases of food for
38 public stockholding programs for food security. This would represent the first multilateral trade deal in
39 nearly two decades and would allow agreements to proceed on development oriented matters where
40 WTO members seem likely to reach consensus. The Green Box element of the Bali package is more
41 far-reaching than trade liberalisation, recognising that some environmental sustainability general
42 services programs like land rehabilitation, soil conservation, and drought management could be
43 exempted from reduction or discipline under the WTO rules. A more controversial element in the Bali
44 package however, is the search for a permanent solution to the issue of public stockholding of
45 subsidized agricultural products for food security programs. The Bali package remains under
46 negotiation and will be considered in Nairobi (where the next WTO conference will take place on
47 December 15-18).

48 Globally, the international community has not historically considered trade a sustainable development
49 tool. However, the issue of trade is more prominent in the negotiations for new SDGs than it was in the
50 MDGs, although the proposed SDG trade goals currently focus only on the multilateral trading system
51 and not on the large-scale regional agreements that are likely to have a major bearing on the future of
52 the world trading system

53 Meanwhile, local food has been the subject of government policy in recent years as consumer interest
54 in and demand for local foods has grown (Low *et al.*, 2015). Local foods have been linked to a full
55 suite of priorities including enhancing the rural economy, the environment, food access and nutrition,
56 informing consumer demand, and strengthening agricultural producers and markets.

1 Information and communications technology for agriculture

2
3 The application of information and communications technology (ICT) in agriculture is increasingly
4 important. E-Agriculture is an emerging field focusing on the enhancement of agricultural and rural
5 development through improved information and communication processes.

6 Traceability is an increasingly public and private investment for monitoring compliance with quality,
7 environmental and other product and/or process attributes related to food.

8 **2.7 Concluding comments**

9 Population growth has been the main demand driver in agriculture and food systems, but its relative
10 weight is declining, influenced by increasing per capita incomes, urbanization and changing dietary
11 preferences. This creates considerable challenges – but also opportunities – to identify pathways to
12 sustainable agricultural development, including the livestock sector, in contributing to FSN.

13 Much of the increased crop output required over the period to 2050 will be in the form of feedstuffs for
14 livestock as consumers seek to enrich their diets based on increased purchasing power, almost
15 entirely in developing countries.

16 Livestock feeding strategies will increasingly focus on the production of milk and meat rather than
17 other functions of livestock (such as provision of manure, traction and store of wealth), with regular
18 and higher-quality feedstuffs and more specialized livestock production units. The speed at which
19 these developments will take place in different locations will be highly dependent on market
20 fundamentals, local conditions and resource availability.

21 While not all of the increase in grain and oilseed production has been used directly by livestock, the
22 portion going to biofuels has contributed indirectly to feedstuffs through the livestock consumption of
23 biofuel by-products including dried distillers grains and oilseed meal. This increase in grains and
24 oilseeds area has been especially notable in South America.

25 Livestock can be produced through extensive production practices (e.g. grazing in the case of
26 ruminant livestock, or foraging in the case of poultry and pigs) or intensive practices (in which
27 thousands of animals are fed concentrated feed rations in confined facilities). Each of these production
28 models has significantly different implications for production, environmental quality, resource use, and
29 animal and human health. Over the last 20 years, there has been a shift, worldwide, towards more
30 intensive livestock production techniques, with marked implications for the composition of agricultural
31 land use, including deforestation.

32 Globally, increases in livestock productivity in the recent past have been driven mostly by scientific
33 and technological developments in breeding, nutrition/feeding and animal health. However, there is
34 still a big yield gap to be addressed that holds the potential to increase production and efficiency in a
35 sustainable way.

36 Sustainability challenges and the possible contributions to FSN are quite different for each livestock
37 production system. So far, there is no consensus on the trajectories required to address FSN through
38 SAD, including livestock. The evolution of livestock systems in the coming decades is inevitably going
39 to involve trade-offs among economic development, poverty reduction, food security and nutrition and
40 environmental sustainability.

41 Smallholder mixed crop/livestock systems will not provide all the food that will be required to feed a
42 global population of over 9 billion people by 2050: specialized cropping systems and intensive
43 livestock systems will play their part. However, there is sufficient evidence to support the conclusion
44 that small-scale mixed systems in the tropics and subtropics have a significant role to play in global
45 food and nutrition security, provision of livelihoods and poverty reduction.

46 Livestock production is likely to be increasingly affected by carbon constraints, and environmental and
47 animal welfare legislation. Demand for livestock products in the future could also be moderated by
48 socio-economic factors such as dietary and human health concerns and changing socio-cultural
49 values. There is considerable uncertainty as to how these factors will play out in different regions of
50 the world in the coming decades.

51 A combination of policy, market and institutional approaches is needed to strengthen the viability and
52 resilience of farming systems to steer them on to sustainable pathways, but the approaches will be

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1 context-specific given the wide range of agro-ecological conditions, socio-economic development, and
2 historical and cultural traditions.

3 The trends, drivers and projections outlined in this chapter give an assessment of the trajectory of the
4 demand and supply of animal-sourced food, and the impacts that will ensue. The chapter serves as a
5 useful basis for debate and for planning of investments and policies, but has only hinted at the
6 economic, social, environmental and institutional challenges that these projections imply. That is grist
7 for the next chapter.

8

3 CHALLENGES TO ACHIEVING SUSTAINABLE AGRICULTURAL DEVELOPMENT THAT HELPS MEET FOOD AND NUTRITION OBJECTIVES

This chapter focuses on identifying and outlining the sustainability challenges that agricultural development needs to address for improved food security and nutrition (FSN) with a focus on livestock production.

Given that two billion people are currently malnourished and that world population is growing, achievement of food security and nutrition goals will go along with increasing food availability (for example, by increasing productivity or reducing waste), increasing access to food (for example, by reducing price, increasing entitlements or by improving distribution) and/or with changing demand for food (e.g. changing consumption patterns). Current projections are a starting point for understanding likely demands and these suggest there will be an especially rapid escalation in demand for animal-sourced foods (ASF) as well as edible oils, farmed fish and fresh fruits and vegetables (Chapter 2). This implies that increasing food availability and access will be important strategies for meeting FSN objectives.

Meeting these increased demands is challenged by the undesired social, environmental and economic impacts of agricultural production and food consumption. The agriculture sector must mitigate these challenges if it is to sustainably provide food that meets FSN objectives. This chapter, like others in the report, focuses on the livestock sector as many unwanted effects or negative externalities (such as GHG emissions or pollution) are more pronounced in livestock than crop production. Other challenges (such as emerging disease and animal welfare) are unique to the livestock sector.

- The priority social challenges that agriculture must address are: improving the poor working conditions associated with agriculture as well as job opportunities; reducing gender and other inequities in food systems; **fostering liveable rural communities; and producing food in ways compatible with values.**
- The priority economic challenges are: improving economic and environmental efficiency; improving market performance; limiting risks in an interconnected world; **and reducing food loss and waste.**
- The priority environmental challenges are: reducing greenhouse gas production; reversing land degradation and biodiversity loss; reducing water pollution; and adapting to climate change.
- Other challenges, unique to the livestock sector, are: reducing livestock associated human disease (especially food-borne diseases, emerging diseases and occupational hazards); and achieving animal welfare.

These challenges are discussed in the context of the farming typologies identified in Chapter 2 (that categorize livestock producers as: traditional pastoralist; small-scale producers; diversified crop–livestock systems; and intensive large-scale commercial livestock), taking account of threats to the sustainability of these systems and identifying the “hotspots”, limits, stresses, risks and tipping points. We then discuss the challenges generated outside the agriculture sector that food production systems must adapt to, while continuing to mitigate the internal challenges.

3.1 Social sustainability challenges

3.1.1 Employment and working conditions

Agriculture plays a major role as a provider of employment and livelihoods, especially in developing and emerging economies. Sustainable agricultural development would aim to provide adequate working conditions and employment opportunities.

Agriculture accounted for 31 percent of global employment in 2013, down from 45 percent in 1991, and over 1 billion people are currently employed in agriculture, representing one in three of all workers. There are an estimated 600 million smallholder livestock farmers and around 1.3 billion people are employed in livestock value chains (Thornton, 2010). In developed countries, most of those

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1 in livestock value chains are engaged in activities beyond the farm-gate. However, for many people,
2 working conditions are far from satisfactory. Among the most vulnerable groups are:

- 3 • **Wageworkers:** Around half a billion women and men are employed as agricultural workers.
4 Especially in developing countries, many are employed on a seasonal or casual basis: they do not
5 receive any employment benefits and have long periods (often one-third of a year) enforced
6 joblessness. Wages are often low and working conditions unsafe. The share of women waged
7 agricultural workers has also been rising in all regions, accounting for 20–30 percent of total
8 agricultural wage employment (Hurst, 2007).
- 9 • **Migrants:** Temporary workers who are not settled permanently in a population are considered
10 migrants. Recent decades have seen huge increases in migrant labour, and in some regions, such
11 as California, the proportion of migrant agricultural workers is close to 90 percent. People move
12 because they perceive migrant labour to be preferable to their alternative options, but migrant
13 agricultural labour has for long been associated with poor working conditions (Svensson *et al.*,
14 2013). In the Republic of Korea, the number of migrant workers in livestock agro-industry is higher
15 than the numbers in construction or fisheries. In the United States of America, industrial farms and
16 the slaughter and meat-packing industry are heavily reliant on migrants and recent immigrants.
- 17 • **Child workers:** Of the 215 million child labourers worldwide in 2008, about 60 percent, or 129
18 million, were engaged in the agriculture sector. Children are often involved in herding; for
19 example, in Lesotho one in five boys are herders, starting at the age of three or four, and never
20 going to school (FAO, 2013). In Ghana, boys herding cattle worked 10–12 hours a day, seven
21 days a week. Children are also involved in dairying and in some countries even work in intensive
22 poultry production and slaughterhouses.

23 The sector is facing significant changes in available workforce: Two billion people will be over 60 years
24 of age by 2050 and nearly 70 percent are expected to be born and live in low- or middle-income
25 countries (UN, 2014). Even today, greater numbers of older people live in rural areas as younger
26 generations migrate to cities, and in many countries many of those living in rural areas are older
27 women who survive predominantly by farming. In China, in just ten years, the average age of working
28 farmers will be over 60 years of age, while 70 percent of members of Mozambique's Small Farmers'
29 Union are over the age of 45 years, while the median age of members of the Zimbabwe farmers'
30 Union is also 45 years, with many in their 60s and 70s (Gorman, 2012). In the United States of
31 America, the average age of farmers is 58 years, in Kenya 60 years and 67 years in Japan (Jöhr,
32 2012). Feeding a growing population will require either radical changes in production technology or
33 making farming more attractive to young people.

34 Concentration and intensification of agriculture change the nature of work. Fewer people are
35 employed, and work is often in less pleasant environments and of lower status and autonomy than
36 equivalent jobs in traditional enterprises. This challenge can be partially offset by increased potential
37 for improved workers' rights and protection, and opportunities for those displaced to shift to higher-
38 valued and more rewarding jobs outside the sector.

39 Participation in livestock value chains is associated with a relatively high level of occupational disease,
40 especially traumatic injuries and infections. Farm machinery, livestock and falls are reported to be the
41 main causes of occupational injuries on farms (Doupbrate *et al.*, 2009). For example, during a five-
42 year period, 20 percent of Finnish farmers suffered injuries and 2 percent infections severe enough to
43 report to a doctor (Karttunen and Rautiainen, 2013). Occupational hazards occur along the food value
44 chain. Slaughterhouse and packing plant workers are also exposed to high levels of occupational risk
45 and suffer elevated rates of injury and even mental disorders (Hutz *et al.*, 2013). In the United
46 Kingdom in 2014, food manufacture had a rate of reported injury more than twice that of
47 manufacturing as a whole (HSE, 2014).

48 Structural transformation in agriculture is a broad development trend in which agricultural productivity
49 grows while its share in GDP and employment declines. This is accompanied by rural-to-urban
50 migration, development of an industrial and service economy, and a demographic transition from high
51 rates of births and deaths to low rates of births and deaths (Timmer, 2007). While this trajectory was
52 historically common, this may no longer be the case in poorer countries (especially in Africa). In
53 contrast to countries that underwent structural transformation, these countries have not completed
54 demographic transition, off-farm opportunities are limited and substantial agricultural productivity gains
55 remain elusive (HLPE, 2013). A recent review found evidence for "premature de-industrialization", that
56 is, de-industrialization starting at a relatively low level of GDP and industrialization in many countries.
57 As a result, manufacturing has shrunk in Latin America and economy- wide productivity has suffered,

1 while in Africa urban migrants are crowding into petty services instead of manufacturing (Rodrick,
2 2015),

3 Countries that have undergone structural transformation increasingly rely on a shrinking and aging
4 agricultural workforce while countries with slowed agricultural transformation increasingly experience
5 rural to urban migration, with the same result. In China, in just ten years, the average age of working
6 farmers will be over 60 years of age, while 70 percent of members of Mozambique’s Small Farmers’
7 Union are over the age of 45 years, while the median age of members of the Zimbabwe farmers’
8 Union is also 45 years, with many in their 60s and 70s (Gorman, 2012). In the United States of
9 America, the average age of farmers is 58 years, in Kenya 60 years and 67 years in Japan (Jöhr,
10 2012).

11 **3.1.2 Gender and equity**

12 The last few decades have seen growing recognition of the importance of livestock to the poor, and
13 especially poor women, and that sustainable agriculture should promote gender equality. Indeed,
14 almost two-thirds of the world’s 925 million poor livestock keepers are rural women (Staal *et al.*, 2009).
15 Despite this, women have lower access to technologies, extension and inputs than men (Herrero *et*
16 *al.*, 2012). The 2011 FAO *The State of Food and Agriculture* report highlights that women almost
17 everywhere “face more severe constraints than men in accessing productive resources, markets, and
18 services” (FAO, 2011b). This gender gap in assets is likely to constrain agricultural productivity growth.

19 In many cultures, men and women may differ in the types of rights they have to livestock and generally
20 women have fewer rights, especially over valuable animals. Guèye (2000), in a review of backyard
21 poultry in Africa, found that women generally owned and cared for poultry, but could rarely take sole
22 decision over the use of the birds or eggs. There is strong evidence that men and women do not use
23 income or assets in the same ways and that the inequitable access of women to resources also
24 constrains the nutritional status and health of children (Quisumbing and Maluccio, 2003).

25 Although livestock are important to women, the landless rural and marginalized groups, views vary as
26 to whether livestock are more an expression of poverty or a pathway out of it (Perry and Grace, 2009),
27 with implications as to whether livestock keeping by the poor and marginalized is peripheral and
28 temporary or can be an important engine for poverty alleviation and food production. Livestock
29 keeping is more prevalent among the rural rich and the urban poor, suggesting that, with urbanization
30 and modern lifestyles, keeping livestock becomes less attractive (Pica-Ciamarra *et al.*, 2011).

31 **3.1.3 Viable rural communities**

32 *The roots of most rural communities are in agriculture, and sustainable agriculture should contribute to*
33 *liveable and thriving communities.* Maintaining viable rural communities was one of the three strategic
34 aims for the Common Agriculture Policy set out by the European Union in 2010, and agriculture has
35 important roles in creating employment, bringing services to rural areas, maintaining landscapes and
36 providing recreational spaces. The total value of EU landscape in 2009 was estimated at €25.8 billion,
37 representing around 7.5 percent of the total value of EU agricultural production (Ciaian *et al.*, 2011).
38 The social benefits of agriculture can be eroded as production becomes more concentrated, intensive
39 and technology dependent. In the United States of America, a review of studies over the past 50 years
40 found industrialized agriculture resulted in lower relative incomes for farm workers of the community
41 and greater income inequality and poverty, a less active “Main Street”, decreased retail trade and
42 fewer stores in the community (Pew, 2008).

43 **3.1.4 Ethics and values of production**

44 *Increasingly, agricultural systems are required to produce food in ways that are compatible with*
45 *values.* These concerns cluster around novel technologies, the humane and ethical use of animals,
46 and production compatible with cultures and values. Use of animals is covered in a later section, as an
47 issue unique to the livestock sector.

48 Consumers generally have a greater fear of novel technologies used in ASF value chains than most
49 experts consider warranted by the actual health risk. These technologies include chemicals in food,
50 genetically modified organisms (GMOs), antimicrobial residues and irradiation for food preservation.
51 For example, 88 percent of scientists in the United States of America agree that GMOs are safe to eat,

1 but this position is only shared by 37 percent of the general public (Pew Commission Report on
2 Industrial Animal Agriculture, 2008). Risk perception is complex and driven only partly by factual
3 evidence. Food technologies often involve “fear factors” or emotional characteristics that make them
4 seem more worrisome than other risks (for example, riding a bicycle) (Slovic, 2010). These include
5 distrust of large companies, dislike of “unnatural” processes and uncertainty over unfamiliar dangers.

6 Recent decades have seen a growth in ethical consumerism whereby people’s purchasing habits
7 reflect their beliefs, values and preferences. In response to this, various initiatives have arisen to
8 provide, advertise and sometimes certify ASF, which meet required criteria. These include: fairly
9 traded; locally produced,; welfare friendly; organic; GMO-free; antibiotic free; deforestation moratorium
10 and verified sustainable. Most people agree there is a fundamental ethical obligation to inform the
11 public about issues that are of concern to them. At the same time, if labelling goes in advance of public
12 understanding, this may have negative effects; for example, when famine-stricken countries rejected
13 offers of maize because it could not be certified free of genetic modification or consumers ended up
14 with fewer choices after GMO labelling because retailers preferred to eliminate biotechnology foods
15 (GM foods) (Carter and Gruère, 2003).

16 The world is only able to support its present population because of the “green revolution”, which was
17 driven by innovations in plant breeding, including mutation breeding¹⁵, fertilizer and pest control.
18 Proponents of biotechnology foods argue they have potential to increase agricultural productivity,
19 increase nutritional quality of food, reduce environmental impact, rehabilitate degraded lands and
20 reduce waste, and impact studies have been largely positive. At the same time, opponents are
21 concerned about currently unknown harmful effects, the escape of genetically modified organisms into
22 the environment and the transfer of allergens into new foods (Buiatti *et al.*, 2013).

23 **3.2 Economic sustainability**

24 **3.2.1 Efficiency and yield gaps**

25 *In a world of increasing competition for the scarce natural resources on which agricultural production*
26 *depends, meeting future demands for FSN requires improving the efficiency of current use of inputs*
27 *rather than expanding land and water inputs.* Given that the food system of today is undermining the
28 natural resources on which food systems of the future rely, it is also necessary to improve
29 environmental efficiency: that is, food systems’ performance in terms of minimizing undesirable
30 outputs such as pollution and GHG.

31 Given the very large differences in yield obtainable within countries and especially between developed
32 and developing countries (Tittonell and Giller, 2013), policy recommendations often highlight improving
33 the efficiency of production (for example, by increasing productivity) (Garnett *et al.*, 2015). Regionally,
34 livestock yield gaps are most pronounced in sub-Saharan Africa and by system gaps are largest for
35 dairy cattle and poultry. Indeed, milk yield in sub-Saharan Africa is only 6 percent of that in developed
36 countries – the figure for South Asia is 14 percent (Staal *et al.*, 2009). The yield gap has been
37 attributed to suboptimal use of genetic resources, inadequate feed and high animal disease burdens.
38 These deficits in turn are driven by the lack of prerequisites (services, inputs such as fertilizers, crop
39 care products, machinery and credit, infrastructure, management skills, scale) and incentives (lack of
40 access to markets and government support). The economic yield gap is accompanied by a similar
41 environmental efficiency gap: numerous studies have shown that ASF from animals reared in more
42 intensive and specialized systems have a relatively lower carbon footprint than those from extensive
43 systems, and dairy products, eggs and meat from monogastrics have a lower footprint than meat from
44 ruminants (Garnett *et al.*, 2015).

45 However, economic and environmental efficiency assessments are based on narrow metrics, which
46 often do not include non-food outputs (manure, power), animal welfare or non-tangible social assets.
47 These unmeasured outputs are often generated at higher levels in less intensive systems. For
48 example, a study found that smallholder dairying in Kenya had lower GHG efficiency than intensive
49 systems when just milk production was considered but, when other economic and livelihood functions
50 of smallholder systems (e.g. manure, insurance) were taken into account and were attributed part of
51 the footprint, the carbon footprint related to milk were similar (Weiler *et al.*, 2014).

¹⁵ The process of exposing seeds to [chemicals](#) or [radiation](#) in order to generate mutants with desirable traits, to be bred with other plant cultivars.

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1 Moreover, increasing the productivity of agricultural systems can be associated with a decrease in
2 their stability and resilience. For example, studies in Viet Nam found that smaller pig farmers, who
3 made use of household labour and feed resources grown on farm, were less vulnerable to changes in
4 market prices than larger farmers reliant on market inputs (Tisdell, 2010). Increases in productivity
5 have also been associated with: de-coupling of livestock from the local ecosystem and consequent
6 negative externalities of absolute increases in resource use (energy, water, crops, antibiotics);
7 pollution (water, soil, air); zoonotic disease (e.g. salmonella, Highly Pathogenic Avian Influenza,
8 toxigenic *Escherichia coli*); rate of genetic resource loss; and concerns over animal welfare.

9 Improvements in efficiency may not be sufficient to close the disconnect between increasing scarcity
10 of resources and rising demands for ASF. In Sweden, for example, GHG per kg of chicken fell by 22
11 percent between 1990 and 2005, but consumption increased by 180 percent during the same period,
12 with a resultant total emissions increase of 150 percent (Cederberg *et al.*, 2009).

13 Cheap, acceptable meat substitutes would lead to a complete restructuring of the livestock industry
14 and a massive reduction in numbers of livestock kept and farm employment. Dutch researchers
15 presented their USD 330 000 burger grown from *in-vitro* cattle stem cells in 2013. Since then
16 production costs have been cut to USD 11 (Dorsey, 2015). Major advances in robotics (e.g. fully
17 automated milking or meat packing) could lead to job losses, but at the same time would reduce costs
18 and ease problems of labour shortage and unattractive working conditions.

19 A more fundamental challenge to the efficiency of livestock food systems comes from the argument
20 that eating animals rather than edible plants is inefficient in terms of calories harvested per hectare.
21 Currently, 36 percent of the calories produced by the world's crops are being used for animal feed,
22 and only 12 percent of those feed calories are eventually eaten as ASF. However, this does not take
23 into account the higher micronutrient levels, better protein quality and higher palatability and consumer
24 preference for ASF. Likewise the carbon footprint of ASF per gram is somewhat higher than other
25 foods (although somewhat lower per calorie consumed) (Drewnowski *et al.*, 2014). Indeed, orange
26 juice has a higher carbon footprint than milk (Smedman *et al.*, 2010).

27 **3.2.2 Market performance**

28 *Well-performing markets should lead to the efficient use of resources in the production of agricultural*
29 *commodities to meet consumer demands for food.* But the way in which the price system works in
30 agricultural and food markets often does not give signals that lead to sustainable agricultural
31 development and improved food security and nutrition status, for three main reasons: (a) markets are
32 imperfect and often non-competitive, property rights and regulations are not well defined or enforced,
33 while many smallholders are not connected to supply chains; (b) government policies distort price
34 signals through subsidy, trade restrictions and tax policies; and (c) – of major importance –
35 environmental externalities (both positive and negative) of agricultural production and food
36 consumption, as well as the natural resources used in production, are either not priced or underpriced
37 (OECD, 2005, 2012).

38 One of the major challenges is thus getting a well-functioning price system so that the prices of
39 commodities produced and inputs used will enhance sustainable agricultural development for FSN.
40 This issue has been extensively discussed with respect to agricultural development, food security and
41 nutrition objectives (see for instance HLPE, 2011, 2012, 2013, 2014b).

42 High crop prices (relative to input prices) benefit producers who can respond to those prices, including
43 a good majority of the food insecure. Those who live from crop agriculture and are able to produce and
44 sell more produce, increasing household income, are thus able to buy more food (albeit at a higher
45 price). But high feed-crop prices mean higher input prices for livestock producers – in particular of pigs
46 and poultry – and can reduce profits if animal product prices do not also increase.

47 High domestic food prices have an impact on food security and nutrition, including both rural poor
48 people, many of whom are net food buyers, and the urban poor. High meat and dairy product prices
49 are a burden for the food insecure in general, except those who own livestock. High prices cause
50 people to consume less food and, indirectly, less animal feed. But in general, the evidence indicates
51 that people in the world's wealthier countries cut back little on food consumption when prices rise (food
52 only accounts for around 10–15 percent of household expenditure), while the world's poorer people
53 reduce their food consumption more significantly (HLPE, 2011), compromising their food security and
54 nutritional status.

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1 High prices for commodities favour investment and technological development, which in turn favour
2 production increase and subsequent lower prices, as highlighted by Prakash (2011): “The essence of
3 the price system is that when a commodity becomes scarce its price rises, thus inducing a fall in
4 consumption and signalling more investment in the production of that commodity”. In contrast,
5 persistence of low prices leads to a slowdown of investment (HLPE, 2011). But in agriculture – and in
6 particular livestock – there is often a large time lag between prices, investment and production
7 responses, such that production can come on stream when prices have changed. This is one factor in
8 the risk-averse behaviour of some farmers, leading to resource use that is suboptimal from a
9 sustainable development and FSN perspective.

10 In agriculture, due to the effects of natural conditions, especially weather, and time lags between
11 decision-making and production shifts, prices tend to vary considerably and impact adversely on many
12 farm enterprises. While large farm enterprises can often hedge against volatile prices, have financial
13 resources to cushion a downturn in prices and can enter into longer-term contracts with food
14 processors, this is difficult or impossible for small-scale farmers. Excessive fluctuations in commodity
15 prices, whether in situations of price increases or price depressions, create uncertainties for crop and
16 livestock farmers. This affects decisions regarding agricultural investment and as such has a long-term
17 impact on world food security (HLPE, 2011).

18 But the overall level of economic development and incomes are also critical factors determining the
19 importance of prices in sustainable agricultural development and food security and nutrition. The level
20 and volatility of prices have a much greater impact on the livelihoods of poor farmers and consumers
21 than of richer ones, especially where poor farmers are not financially viable to farm sustainably and
22 poor consumers do not have the means to buy nutritious food. On the other hand, farmers that are not
23 connected with supply chains are less vulnerable to the vagaries of market prices.

24 Accessibility of ASF, including fish (HLPE, 2014a), is a major determinant of ensuring nutrition
25 security. The increasing drive from retailers and consumers for ASF being as accessible and cheap as
26 possible risks in the long run undermining food security objectives by jeopardizing the profitability of
27 the meat and dairy sector and by encouraging competition on the basis of economic rather than
28 environmental efficiency. In the food supply chain, many farmers face few processors and retailers
29 competing to ensure consumer prices are as low as possible. This has important implications for the
30 future structure of the livestock and meat sector, and on the relationships between producers and the
31 rest of the chain. With downward pressure on producer prices, farm incomes and debt, a situation
32 often encountered in the industrial livestock sector (Zijlstra *et al.*, 2012), the result is that it is the larger
33 farms that tend to survive, with increasing concentration in the sector. This can have important socio-
34 economic implications through triggering depopulation in rural areas.

35 A crucial challenge is to get price signals working effectively to play their role in well-functioning crop
36 and livestock agricultural systems. Producers seek remunerative farm-gate prices; consumers want
37 prices that are low enough to satisfy their needs for food security, quality and variety, especially in
38 terms of fulfilling their basic nutritional needs; and food processors, traders and retailers need to
39 balance those opposing interests with respect to prices. There are frequent calls for a fair distribution
40 of value added within the food supply chain (HLPE, 2013).

41 The agri-food chains in all countries are evolving. The tendency in recent decades has been for a
42 downward trend in international agricultural commodity and food prices, creating two major issues: (i)
43 the viability and means of survival of production models that cannot structurally compete in
44 international markets in terms of producer prices for similar quality products; and (ii) the convergence
45 in terms of technologies and scales of production – a movement similar to the ones experienced in the
46 industrial and manufacturing sectors, with economic, social and environmental implications. Therefore,
47 a key question is: to what extent should policies intervene in the organization of food systems and
48 food chains to influence prices so that the value added generated along the food chain remunerates
49 labour, farms and rural areas (HLPE, 2013)? The further question is, how will the response differ if the
50 future is a world of rising agricultural commodity prices?

51 **3.2.3 Risks in an interconnected world**

52 *An important dimension of price formation and developments in agricultural markets is international*
53 *trade. As shown in Chapter 2, a small, but increasing, proportion of livestock and ASF is traded. Trade*
54 *and trade liberalization is often a key element in achieving food security and nutrition, but trade in*
55 *livestock and livestock products may also bring health, nutrition, livelihood and equity risks. High*

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1 commodity prices not only benefit efficient agricultural productive and exporting countries, but also
2 provide incentives to net food-importing countries to exploit their potential in agricultural production
3 (HLPE, 2011). As trade in livestock products increases, so does the challenge of assuring the benefits
4 of trade while limiting the exposure to and impacts of risks.

- 5 • **Disease risks:** Increased food trade may introduce new diseases, revive previously controlled
6 diseases and spread contaminated food more widely (Thow, 2009). Developing countries with
7 weaker food governance may be most vulnerable: for example, despite the national import
8 prohibition of Chinese milk products and unlabelled milk powder in the United Republic of
9 Tanzania, 6 percent of milk powder samples were contaminated with melamine (Schoder, 2010).
- 10 • **Nutrition risks:** While overall food availability has increased with globalization, there may be
11 fewer benefits, or even declines in the poorest countries (Thomas, 2006). Moreover, changes in
12 the types of food available may have nutritional costs as well as benefits. For example, imports of
13 high-fat meats in Pacific Island Countries led directly to increased consumption of fatty meats and
14 indirectly to decreased availability of traditional root crops, high rates of obesity and non-
15 communicable disease (Thow *et al.*, 2010).
- 16 • **Livelihood risks:** In principle, trade leads to world prices of agricultural commodities that reflect
17 comparative advantage and more competitive markets, which is to the advantage of consumers
18 who buy food but may disadvantage less-efficient local producers. At the same time, reducing
19 import barriers increases the exposure of domestic agricultural prices in markets previously
20 protected to price volatility. Overall, however, with more production traded, price volatility is
21 reduced by a wider sharing of the risks. A particular concern that also needs attention is the risk of
22 changes in the food supply chain leading to a powerful transnational trader gaining monopolistic
23 market power, resulting over time in price rises (Reardon *et al.*, 2010).
- 24 • **Equity risks:** In developing countries, access to export markets tends to present greater hurdles
25 to smaller farmers than the traditional informal markets where most livestock products are bought
26 and sold. Recent decades have seen major declines (60 percent and 40 percent, respectively) in
27 small farmers participating in the export of fruit and vegetables, as they lack the human and
28 financial capital needed to sell to markets that impose high demands in terms of quality,
29 consistency and timeliness (Unnevehr and Ronchi, 2014)
- 30 • **Systemic risks:** A further concern emerges from the increasing connectedness and globalization
31 of food supplies. Disruptions at any one point could have far-reaching consequences. For
32 example, under one scenario, an extreme El Nino event could lead to quadrupled commodity
33 prices and commodity stock fluctuations, coupled with civil unrest, followed by significant negative
34 humanitarian consequences and major financial losses worldwide (Lloyd's, 2015). In this context,
35 the effects of oil price and financial shocks (or a major animal disease pandemic) are also as
36 important as extreme climatic events to the agri-food sector.

37 The experience over many years and many countries demonstrates that the benefits of trade
38 liberalization and globalization clearly outweigh the risks. At the same time, many commentators,
39 including several important non-governmental organizations, have cautioned that trade liberalization
40 (that leads to higher global income) can be associated with widening inequality, job losses following
41 rapid technological change, excessive power to multinationals, greater natural resource extraction and
42 environmental harm than would otherwise have been the case with lower global income – unless other
43 flanking measures and policies are also in place, including to properly price environmental and social
44 externalities.

45 Nearly all the predicted growth in livestock production is predicted to occur in developing countries,
46 which are categorized by heterogeneous and fragmented food systems with large numbers of actors,
47 many small-scale actors, large informal sectors and relatively little organization. In China, for example,
48 food production is said to be dominated by “elephants and mice”; in other words, a great majority of
49 informal sector actors who are difficult to monitor and a few large companies that have incentives to
50 escape or capture regulation (Alcorn and Ouyang, 2012). These structural challenges are
51 compounded by generally poor capacity to enforce regulation in many developing countries. As
52 regards food system regulation, stakeholders cite the following governance challenges: inadequate
53 policy and legislation; multiple organizations with overlapping mandates; outdated, fragmented or
54 missing legislation; inappropriate standards; lack of harmonization and alignment of standards; failure
55 to cover the informal sector.

3.3 Environmental sustainability

3.3.1 GHG emissions from the livestock sector

Greenhouse gases (GHG) from human activities are driving climate change since the mid-twentieth century; sustainable agriculture must mitigate as well as adapt to climate change. Within the agriculture sector, livestock production is more GHG emissions-intensive than any other form of food production. Feed production and processing, and enteric fermentation (a natural part of the digestive process for ruminant animals), are the two main sources of emissions, representing 45 percent and 39 percent of sector emissions respectively, while manure storage and use represent 10 percent of emissions. The remaining 6 percent is attributable to the processing and transportation of animal products.

GHGs from enteric fermentation (the main source of livestock emissions) are trending upwards in developing countries while in developed countries they have decreased (Tubiello, 2013). (This is the result of increase in livestock numbers in developing countries and increase in efficiency of production in developed countries). Ruminant systems operating at low productivity in Africa, South Asia, Latin America and the Caribbean are more emissions intensive. Emission intensity varies among species, by product and according to the system of production. Extensively grazed ruminants are more GHG-intensive (emissions per unit of production) than other sources of animal protein such as poultry, pigs or fish; emission intensity and resource use efficiency for eggs and dairy products tend to be less GHG intensive than meat. At the same time, extensive ruminant systems produce less waste and pollution, have higher use of by-products and lower use of cereal grains, and may have more acceptable welfare than the high-intensity production systems that are more efficient in terms of reduced GHG emissions.

3.3.2 Land

Sustainable agriculture relies on the natural resource of land and the ecosystem services that enable land to support plants and animals. Livestock systems are major users of land and natural resources. For marginal lands without viable alternative uses, livestock are a good way of converting biomass to human food, and in agro-pastoral systems livestock contribute to food production by utilizing agricultural by-products as well as providing power and manure for soil fertility. However, in other livestock systems, trade-offs between livestock production and food and nutrition objectives may be more salient.

Currently, land degradation (such as soil erosion, drought, salinization, waterlogging and desertification) affects more than 20 percent of all cultivated land. Globally, some 20 000–50 000 km² of potentially productive lands are lost annually through soil erosion and degradation, and 2.9 million km² are considered at very high risk of desertification, much of it in developing countries. This degradation and conversion of cropland for non-food uses could reduce the available cropland by 8–20 percent by 2050 according to UNEP.¹⁶ Projections indicate that less water may be available and more droughts and other extreme weather events may occur in coming decades.

Estimates of the extent and severity of rangeland degradation caused by overgrazing remains – despite decades of research – variable and contested. Probably, around 20 percent of the world's pastures and rangeland have been degraded to some extent, and the proportion may be as high as 73 percent in dry areas (FAO, 2009). However, the official perception that pastoralists cause widespread environmental damage undermines the rights of pastoral communities to manage their own resources and can be another challenge. Lal *et al.* (2012) estimate that 20 percent of the world's native grasslands have been converted to cultivated crops and almost 80 percent of the South America *cerrado* has been converted to cropland and urban uses (White *et al.*, 2000). Assessing and managing grasslands is complicated by the absence of an international mechanism or organization responsible for the assessment and reporting on their global state, unlike other biomes (e.g. forests by FAO, wetlands by Ramsar).

The extent of rangelands has changed over time due to conversion of forested land into human-made grasslands, the conversion of rangeland into cropland, and the replacement of abandoned rangeland with forests. Recent assessments expect little increase in pastureland (Bruinsma, 2003; MA, 2005). Most land use models show a minor increase (10 percent or less) in grazing land needed by 2050

¹⁶ Geo-3: Global Environmental Network – Land Degradation. <http://www.unep.org/geo/geo3/english/141.htm>

1 (Smith *et al.*, 2010). This is less than the anticipated increases in cropland of 10–20 percent by 2050,
2 mainly in Africa and Latin America. However, because of growing demand for ASF, much of the
3 increased crop output over the period to 2050 will be for livestock feed.

4 Some intensification in production is likely to occur in the humid and subhumid zones on the most
5 suitable land, through the use of improved pastures and effective management of livestock production.
6 In arid and semi-arid areas, population increases are fragmenting rangelands, making it increasingly
7 difficult for pastoralists to gain access to the feed and water resources they have traditionally used.
8 This is associated with a decrease in biodiversity. Ranching-induced deforestation is a common
9 feature in Central and South America (Wassenaar *et al.*, 2006)

10

Box 7 The challenge in Southern Cone of overcoming degradation, biodiversity loss and soil erosion on grassland systems with sustainable intensification

Historically, natural pastures have been considered as low productive extensive systems. The pressure for the use of sown pastures (sometimes foreign species) by commercial seed enterprises, jointly with the predominant research view of national research institutions, often leads to replacement of natural grassland systems as the main technical intervention being proposed. The *Cerrado* vegetation in Brazil and the Pampa natural grasslands are well-known cases.

For most of the natural grassland ecosystems around the world, with a more or less constant stocking density, there is a clear tendency to overgrazing and then to degradation of vegetation (Carvalho *et al.*, 2011). Grassland degradation, often accompanied by soil degradation and erosion, results in a decline of the production and ecological function of grassland ecological systems (Zhang, 1995). Such degradation leads to a decline of biodiversity (Wu, 1997), grass and animal production in pasture, deterioration of human living environments and soil erosion (Zhang, 1995).

In Brazil, from the 14.1 million ha with natural grasslands in 1970, only 10.5 million ha survived in 1996 (IBGE, 1996). Current estimation places the remaining natural vegetation cover at around 34 percent of the original cover, so natural grasslands now comprise less than 6 million ha (Hasenack *et al.*, 2007). Bilenca and Miñarro (2004) indicated that natural grasslands are also decreasing in Argentina and Uruguay, at rates of 11.9, 3.6, and 7.7 percent, respectively. Considering the census data from 1996 to 2006, the average reduction has reached an incredible 440 000 ha per year (Nabinger *et al.*, 2009).

Source: Livestock production opportunities based on Pampa natural grasslands with different levels of anthropogenic intervention (adapted from Carvalho, 2001 and Carvalho *et al.*, 2008)

11

12 The majority of the world's population now live in cities, around one-third of them in informal
13 settlements or slums. Recent studies suggest there are 450 million people in urban livestock keepers
14 homes and most of the 2.5 billion people who live in developing country cities depend on urban live
15 animal markets, wet markets and slaughterhouses, which bring live animals into cities for sale and
16 processing (Grace *et al.*, 2015). Urban livestock keeping can make important contributions to FNS and
17 livelihoods but requires careful management to mitigate pollution, diseases, accidents or social
18 tensions (Correa and Grace, 2014).

19 3.3.3 Water

20 *Farming accounts for around 70 percent of water withdrawals in the world today, and sustainable*
21 *water management is critical for food production as well as maintaining other social, economic and*
22 *environmental benefits of waters systems (HLPE, 2015). Globally, freshwater resources are relatively*
23 *scarce, amounting to only 2.5 percent of all water resources (MA, 2005). Groundwater also plays an*
24 *important role in water supply: between 1.5 and 3 billion people depend on groundwater for drinking,*
25 *and in some regions water tables are declining without being recharged (Rodell *et al.*, 2009). By 2025,*
26 *64 percent of the world's population will live in water-stressed basins, compared with 38 percent today*
27 *(Rosegrant *et al.*, 2002).*

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1 Until recently, livestock and water were considered almost exclusively from the perspective of the
2 impact of livestock on water pollution (Steinfeld *et al.*, 2006). Yet, almost one-third of total agricultural
3 water is used by the livestock sector: feed from cropland uses 37 percent of the water used for crop
4 production, and biomass grazed by livestock represents 32 percent of the evapotranspiration from
5 grazed lands; direct consumption for livestock drinking represents 10 percent of total usage (Herrero
6 *et al.*, 2013).

7 Increasing livestock numbers in the future will add to the demand for water, particularly in the
8 production of livestock feed. Several entry points for improving global livestock water productivity exist,
9 such as increased use of crop residues and by-products, managing the spatial and temporal
10 distribution of feed resources so as to better match availability with demand, and managing systems
11 so as to conserve water resources (Peden *et al.*, 2007).

12 The water footprint of livestock products is much higher than for crop products in terms of calories
13 produced (although when biological value of protein is compared, no plant protein is significantly more
14 efficient at using water than protein produced from eggs, and only soybean is more water-efficient than
15 milk and goat and chicken meat (Mekonnen and Hoekstra, 2012; Shlink *et al.*, 2010). Animal products
16 from industrial, feed-based systems are generally more water intensive and generally consume and
17 pollute more ground- and surface-water resources than animal products from grazing or mixed
18 systems.

19 While the majority of livestock production is in backyard, integrated or extensive systems that do not
20 make large contributions to pollution, recent decades have seen rapid growth of industrial farms
21 clustered around major urban centres in developing countries. Many of these are also located near
22 lakes, rivers or coasts. Large concentrations of animals and animal wastes close to dense human
23 population and far from crops create considerable pollution problems. Wastes are also discharged
24 from livestock feed processing plants, agri-chemical plants, tanneries, slaughterhouses, livestock
25 processing plants and wet markets, all of which in developing countries are also often close to urban
26 centres.

27 Water pollution from livestock activities related to the entire value chain includes:

- 28 • Sediment load due to overstocked grazing lands leading to degraded vegetation cover and
29 erosion.
- 30 • Manure leakages from animal rearing (non-point nutrients, organic matter and biological
31 contamination), from manure storage (point nutrients, organic matter and biological
32 contamination and non-point e.g. nitrogen active gases evaporating from manure, later settling
33 on lands and in water bodies), and from manure application to different types of agricultural
34 lands (non-point nutrients, organic matter and biological contamination).
- 35 • Abattoir and animal product processing with inadequate management or treatment of waste and
36 process water released to water bodies (point source biological, organic matter, and any
37 chemicals used in processes, such as in the leather tannery industry).
- 38 • Water pollution associated with cultivation of feeds for livestock (including crop residues and
39 different by-products used as animal feeds): management of crops and soil on cultivated land
40 (sediments, nutrient load, agrochemicals including pesticides), processing and production of
41 feed crops, or parts of food crops, any losses from this management, and water pollution related
42 to the chemical fertilizer industry.

43 Major problems associated with pollution identified by FAO (2006) include:

- 44 • eutrophication of surface water;
- 45 • leaching of nitrates and pathogens;
- 46 • release of pharmaceuticals including antimicrobials and anabolic steroids;
- 47 • build-ups of excess nutrients and heavy metals;
- 48 • release of ammonia methane and other gases;
- 49 • degradation of rivers, lakes, coral reefs and coast areas.

50 Another problem of concentrated (point source) pollution is the concentrated animal feeding
51 operations¹⁷. These are often located in rural areas and typically have better systems from managing

¹⁷ The US Environmental Protection Agency (US-EPA) defines a concentrated animal feeding operation (CAFO) as an animal feeding facility that houses more than 1 000 animal units (AU), has 300 to 1 000 AU but meets certain conditions, or is designated a CAFO by the state (US-EPA, 2005).

1 and storing waste, but still experience challenges. For example, a lagoon collapsed at a western New
2 York dairy, sending 3 million gallons of waste into the Black River. As many as 250 000 fish were
3 killed, and residents of Watertown had to suspend their use of the river as a water supply and
4 recreation area (Food and Water Watch, 2007). Concentrated animal feeding operations (CAFOs) in
5 developing countries have lower capacity to manage waste and less enforcement of standards.

6 **3.3.4 Climate change**

7 *Climate change has potential to severely impact on agriculture, especially in the tropic and subtropic*
8 *regions of the world; sustainable agriculture will need to be resilient in the face of change.* Livestock
9 systems may be significantly affected by climate change but livestock are more mobile and hence less
10 vulnerable than standing crops, thus contributing to resilience to climatic variability and change.

11 Climate change affects plants, animals and natural systems in many ways. Most poor livestock
12 keepers live in Africa and South Asia – regions especially vulnerable to climate change. Climate
13 change may affect livestock systems through: adversely affecting the quality and quantity of feed;
14 exposing livestock to heat stress and extreme events such as droughts and flooding; reducing water
15 available for livestock; and increasing livestock pests and diseases (Thornton *et al.*, 2009). Among the
16 livestock diseases that most affect poor communities, more than half could be spread farther and
17 faster by climate changes (Grace *et al.*, 2015). At the same time, other processes are driving rapid
18 changes in land including population increase, population movements, conflict, urbanization and land-
19 grabbing, and these may result in changes in orders of magnitude greater than those due to climate
20 change

21 The recent study by Havlik *et al.* (2015) provides the most detailed global assessment of climate
22 change impacts on the livestock sector available so far, accounting not only for changes in crop yields
23 but also for changes in grass productivity. The authors combine a biophysical and economic model to
24 project the effects of climate change scenarios on the agriculture sector as a whole, with detailed
25 consideration of the livestock sector. The results of this simulation study are considered under three
26 aspects: climate change impact on livestock; land management adaptation; and livestock sector
27 adaptation. The main messages from this analysis are that:

- 28 • Climate change impacts on crop and grass yields are projected to have only small effect on
29 global milk and meat production by 2050, which remains under any climate scenario within +/-2
30 percent of the projected production without climate change.
- 31 • Depending on the scenario, the climate change effects can be more pronounced at the regional
32 scale. In sub-Saharan Africa, the effects are both the most uncertain and potentially the most
33 severe; e.g. ruminant meat production could increase by 20 percent but it could also decrease
34 by 17 percent.
- 35 • The effects on regional consumption are less pronounced because the impacts of climate
36 change are mostly buffered through international trade. Virtually all the negative effects are
37 smaller than 10 percent.
- 38 • Adjustment in the production systems structure will be an important adaptation measure. Grass
39 yields benefit more (or are hurt less) from climate change than crop yields. Climate change
40 would hence favour the grazing systems, leading potentially to a change in the current trend
41 towards more intensive systems.
- 42 • Depending on the impact scenario, optimal adaptation strategies can go in opposite directions.
43 Efforts to decrease this uncertainty must go hand in hand with the search for robust strategies
44 effective under many different climate futures.

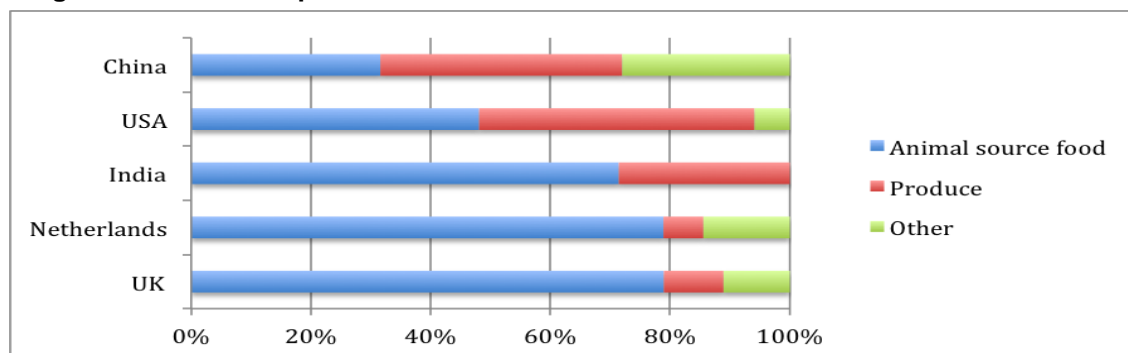
45 **3.4 Health and animal welfare**

46 **3.4.1 Food-borne diseases**

47 *Food security implies food safety and sustainable agriculture must deliver food that is not only*
48 *nutritious but also of acceptable microbiological, chemical and physical safety.* The burden of food-
49 borne disease (FBD) has become better quantified in recent years. In developed countries, most FBD
50 results from consuming fresh livestock products and produce (i.e. fresh fruits and vegetables). In
51 developing countries, less fresh food (ASF and produce) is eaten on a per capita basis, but the fresh

1 food eaten is more contaminated (Grace, 2015). Livestock products have been the most important
 2 causes of food-borne disease in a range of studies, as in Figure 8 (Painter *et al.*, 2013; Sudershan *et al.*,
 3 *et al.*, 2014; Bouwknegt *et al.*, 2014; Tam *et al.*, 2014; Sang *et al.*, 2014). Biological food hazards such
 4 as microbes and pathogens impose a health burden of around 30 million disability-adjusted life years
 5 (DALYs) a year – more than twice the burden of breast cancer or Alzheimer’s disease (Grace, 2015).
 6 FBD is not just a health issue. Already a major determinant of export market access, it is increasingly
 7 affecting domestic markets.

8 **Figure 8 Foods implicated in food-borne disease in different countries**



9
 10 Source: Grace 2015.

11
 12
 13 Although the known health burden due to chemical contamination of food is considerably less than the
 14 burden due to pathogens (O’Neill, 2014), public concern is often higher. (This is an example of where
 15 lay perception differs from expert opinion and is probably due to psychological factors that make
 16 chemical hazards more frightening for many [Slovic, 2010].) In China, recent years have seen: the use
 17 of melamine to increase the apparent protein level of baby milk; ink to colour noodles; and sodium
 18 borate used to make cheap pork resemble beef (GFSF, 2011). A meta-review of studies of acute food
 19 poisoning sourced from Chinese academic databases for the period 2000–2010, covering 2 387
 20 individual incidents of acute food-borne illnesses, found food additives were responsible for 9.9
 21 percent of incidents, 3.5 percent of illnesses and 11.6 percent of deaths attributed to food (Xue *et al.*,
 22 2013).

23 Inadequate surveillance and reporting systems make it difficult to assess the impact of food-borne
 24 disease. Although interventions to improve food safety have been successful in developed countries,
 25 there is limited evidence on effective, sustainable and scalable food safety interventions in developing
 26 countries, which bear the brunt of food-borne disease.

27 3.4.2 Animal and human diseases

28 *Diseases of animals, and diseases that pass from animals to humans (zoonoses), reduce efficiency of*
 29 *production and are important causes of shocks that can disrupt food production; better management is*
 30 *thus integral to sustainable production.* Animal diseases impose costs on the livestock industry and
 31 threaten human health. These costs are large, and often run into billions of dollars for particular
 32 diseases or particular outbreaks. Just a few major diseases cause most of the costs imposed by
 33 animal diseases. Animal diseases appear to be decreasing in wealthy countries but static or
 34 increasing in poor countries (Perry *et al.*) Animal diseases can lead to costs in different ways,
 35 discussed below.

36 *Livestock sector impacts:* There have been many studies on the economic costs of disease as the
 37 result of losses from mortality, reduced productivity and control costs. However, only a few studies
 38 have attempted to systematically assess the impacts of livestock disease across species or countries.
 39 The cost of 32 important diseases in the United Kingdom livestock sector was estimated at USD 1 178
 40 million, or 8 percent of the value of the sector (Bennett and Ljplaar, 2005). In Australia, the top 21 beef
 41 and sheep diseases cost the livestock sector AUD 979 million, or 16 percent of the value of the sector
 42 (Sackett and Holmes, 2006). A study covered four different species and looked at the costs of five
 43 important diseases in Nigeria.¹⁸ All five were diseases of a transboundary nature listed by the OIE (see

¹⁸ Newcastle disease (ND) in local poultry, peste des petits ruminants (PPR) in sheep and goats, contagious bovine pleuropneumonia (CBPP) in cattle, African swine fever (ASF) in pigs and trypanosomiasis in cattle and pigs.

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1 below); together, the diseases cost USD185 million (Fadiga *et al.*, 2013). A recent OIE survey in Africa
2 estimated the 35 highest priority diseases cost nearly USD9 billion a year, equivalent to 6 percent of
3 the total value of the livestock sector in Africa (Grace *et al.*, 2015).

4 *Human health impacts:* Animal diseases can have a direct effect on human health in the case of
5 zoonoses (i.e. transmitted from animals to humans). Around 60 percent of all pathogens that cause
6 disease in humans are zoonotic. Moreover, their impact in terms of human illness differs between
7 high- and low-income countries. In 59 low-income countries, zoonoses accounted for 13 percent of the
8 infectious disease burden while in rich countries zoonoses were responsible for less than 1 percent of
9 the infectious disease burden (Grace *et al.*, 2012). Farmers, veterinarians and other livestock workers
10 are directly exposed to zoonoses; consumers of livestock and fish products are exposed through food.

11 Many important human diseases were originally zoonotic, such as measles, tetanus, smallpox, HIV
12 and diphtheria. Moreover, “emerging” diseases (defined as diseases that have newly appeared in
13 populations or are rapidly increasing in frequency or range) are mostly zoonotic. Currently, one new
14 human disease is emerging every four months; three-quarters of emerging infectious diseases are
15 zoonotic. The costs of these emerging zoonotic diseases are estimated at USD 6.7 billion per year
16 (World Bank, 2012). Historically, most zoonotic diseases emerged in the intensive animal industries of
17 the western United States of America and Europe but more recently there has been a shift to
18 developing countries (Grace *et al.*, 2012). Most emerging zoonoses have a wildlife component, and
19 the study of disease emergence has a strong focus on wildlife. However, the most important emerging
20 diseases often involve livestock: for example, since 1997, eight major emerging diseases have cost at
21 least USD 100 billion and, in six of these,¹⁹ livestock have been a reservoir or a bridge to carry disease
22 to people (World Bank, 2012). But although the drivers of disease emergence have been identified
23 (Jones *et al.*, 2013), there is little evidence on what practical strategies could be best employed to
24 reduce disease emergence from or through a livestock system.

25 Animal operations also produce waste, especially manure, which contaminates air, soil and water with
26 pathogens and toxins. Adverse health effects related to exposure to these contaminants among CAFO
27 workers have been well-documented; impact on the health of residents in nearby communities is less
28 documented but neighbouring residents appear to be at increased risk of developing neurobehavioural
29 symptoms and respiratory illnesses, including asthma (Greger and Koneswaran, 2010).

30 *Impacts on welfare and wildlife:* Animal diseases affect animal welfare by causing suffering and death.
31 Diseases of wildlife can have impacts by acting as reservoirs for human or livestock disease, by
32 reducing the value derived from wildlife by activities such as tourism or harvesting, and by reducing
33 the ability of ecosystems to regulate disease.

34 **3.4.3 Antimicrobial resistance**

35 *Agriculture has a potentially important role in contributing to the emerging problem of antimicrobial*
36 *resistance.* This is considered one of the major public health challenges faced by humanity this
37 century. Antimicrobial-resistant infections currently claim at least 50 000 lives each year in Europe and
38 the United States of America (Laxminarayan *et al.*, 2013) and some estimate that drug-resistant
39 infections will cause 10 million extra deaths a year and cost the global economy up to USD100 trillion
40 by 2050 (Review on Antimicrobial Resistance, 2014). Beyond the abuse of antibiotics in medicine, the
41 burgeoning use of antimicrobials in agricultural production is exacerbating this problem. Antibiotic use
42 in agriculture probably exceeds use in human medicine and demand is growing rapidly, especially in
43 emerging economies of Brazil, India and China. China’s livestock industry by itself could soon be
44 consuming almost one-third of the world’s available antibiotics (van Boeckel *et al.*, 2015). There is very
45 little information on the use of antimicrobials in livestock in developing countries and even among
46 developed countries (Italy, Cyprus, United States of America) some have markedly high amounts of
47 antibiotic used per animal while others (Norway, Iceland, Sweden) have very low use (Grace, 2015).

48 In developing countries, resistant pathogens are commonly found in animals, animal food products
49 and agro-food environments, but the lack of surveillance systems means there are no reliable national
50 data on the level of antimicrobial residues or resistant pathogens in animals and their products. While
51 antimicrobial resistance in animals and their products undoubtedly contributes to the burden of

¹⁹ Nipah virus (pigs, Malaysia), West Nile fever (horses, United States of America), SARS (farmed civet, Asia, Canada), avian influenza (poultry, Asia, Europe), BSE (cattle, United States of America, United Kingdom), Rift Valley fever (ruminants, United Republic of Tanzania, Kenya, Somalia), Middle East respiratory syndrome (camels, Saudi Arabia, Republic of Korea); costs from World Bank.

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1 resistant infections, the evidence from the literature is insufficient to draw firm conclusions on the
2 extent of this contribution, which is likely to vary in different contexts.

3 **3.4.4 Animal welfare**

4 *Animal welfare is increasingly recognised as an important issue, and as a characteristic of sustainable*
5 *agricultural development* (Reisch *et al.*, 2013). An animal is in a good state of welfare if (as indicated
6 by scientific evidence) “it is healthy, comfortable, well nourished, safe, able to express innate
7 behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress” (OIE,
8 2015). Animal welfare is of concern in all livestock systems, from extensive and small-scale to
9 intensive and large-scale operations, as well as transportation of live animals and slaughtering
10 practices.

11 Many livestock producers find that it is in their interest to maintain the health and welfare of their
12 animals. In addition, in many countries, legislation provides for a minimum standard of animal welfare,
13 and consumers are often willing to pay more for livestock products that go beyond minimum standards
14 of welfare.

15 Maintaining and improving animal welfare can incur higher costs to livestock producers but higher
16 returns to producers from more productive animals and ultimately through to consumer prices for
17 livestock products – where livestock producers are integrated into supply chains. At the same time,
18 consumers and retailers in many countries are exerting increasing pressure on livestock producers,
19 transporters and slaughterhouses to raise animal welfare standards. But many livestock producers in
20 developing countries are not integrated into supply chains, while others do not have the knowledge or
21 resources to raise animal welfare standards. Cultural and religious practices related to the rearing and
22 slaughtering of livestock, and the consumption of some livestock products, also involve considerations
23 of animal welfare and can come into conflict with animal welfare standards.

24 Especially in developed countries, the livestock sector is challenged to produce ASF without
25 compromising the welfare of livestock, especially in the situation of poorly-regulated, intensive
26 industrial systems.

27 When husbandry conditions are very poor, improving animal welfare can also increase productivity
28 and profits but, as husbandry improves, maintaining and improving animal welfare can incur higher
29 costs to livestock producers, which will be passed to consumers. This is a challenge, especially where
30 there is not a level playing field. Exporters of livestock products do need to meet the standards set by
31 importing countries and if not then some potential exporters are excluded from international trade
32 through inability to comply with welfare standards.

33 Poor and vulnerable consumers may not have the means to pay for the higher cost of livestock
34 products that meet higher animal welfare standards. In addition, cultural and religious practices related
35 to the rearing and slaughtering of livestock, and the consumption of some livestock products, can
36 come into conflict with animal welfare standards. As demonstrated by Schröder and McEachern
37 (2004), behaviour in relation to animal welfare is sometimes conflicting; as citizens, people support the
38 notion of animals being entitled to a good life, but as ASF consumers they may avoid the cognitive
39 connection with the live animal.

40 The specific challenges are to establish: (i) the degree of animal welfare that is appropriate under
41 different production systems and socio-economic and cultural settings across and within countries, to
42 ensure sustainable agricultural development, food security and improved nutritional status; (ii) the
43 experiences of countries and livestock production systems in addressing animal welfare issues; and
44 (iii) the respective role for governments, the livestock supply industries and consumers in developing
45 and implementing the mix of policies and practices that will best facilitate moving towards desired
46 animal welfare standards.

47 The use of animals by humans is controversial. Some do not accept that humans should use animals,
48 even if treated humanely; others believe that animals should *only* be used if treated humanely; and still
49 others do not believe that animals have moral value and see no obligation to treat animals humanely.
50 In practice, there is a wide variation on acceptable ways to treat farm animals within and across
51 cultures, which makes it difficult to develop a consensus on global standards.

3.5 Main challenges by types of systems

Following the pillars of sustainable development, we have categorized challenges as social, economic and environmental. However, challenges are often linked (either positively or negatively) and in any given system multiple challenges are found. Box 8 gives the example of challenges identified by stakeholders in the Sahel.

Box 8 The main challenges to Sahelian pastoralism

The main constraints faced by African pastoralism are summarized by the N'Djamena Symposium, 27–29 May 2013.

Equity and culture: Previously pastoralism was often regarded as "backward" and policies promoted sedentary, ranching and "modern farming" (Doutressoule, 1947; Hesse and MacGregor, 2006; Collective, 2010). Failure to consider the needs of pastoralists meant previous investment programmes in state ranches (Niger, Mali, Chad) were often prejudicial to pastoralists. For example, the major irrigation schemes for rice production have excluded pastoralists from valuable fall-back grazing areas near rivers (Corniaux *et al.*, 2012).

Market distortions: Meat produced by pastoralists has been subject to strong competition from products imported from Europe or South America, which may receive substantial subsidies for production and distribution. During the 1970s and 1980s, international food aid was the main response to the Sahelian food crisis leading to destabilization of markets and increasing dependency.

Land use: As a consequence of demographic change (population growth coupled with an acceleration urbanization), there is increasing incursion of crops into rangelands, which can create problems for the movement of animals and access to resources such as surface water.

Climate change: The Sahel will be one of the regions most affected by climate change, with significant impacts on the availability of water and forage resources. The risks, frequency and severity of droughts will increase, with an impact on the evolution of transhumance routes and sources of conflict, while price volatility of agricultural products continues.

Table 1 summarizes some of the challenges integral to current production systems that must be overcome if agriculture is to be sustainable and meet FSN goals. These are categorized by the nature of the challenge, the geographies and scale of those affected, the extent to which the livestock sector is responsible for the problem, and the livestock systems most at risk.

Table 1 Challenge matrix

	Challenge	Most affected	Importance and priorities	Role of livestock	Main livestock system of relevance
Social	Micro-nutrient deficiency	Lower and middle income countries	Billions seriously affected	Moderate	Smallholder mixed; intensive (S, I)
	Undernutrition	Lower-income countries; poor in middle-income	Billions seriously affected	Moderate	Smallholder mixed systems (S,P)
	Overnutrition	Poor in rich countries; middle class in middle-income	Billions seriously affected	Moderate	Intensive poultry, pork, and dairy (I)
	Food-borne disease	Middle-income countries; emerging economies; richer in poor countries	Millions seriously affected; billions mildly affected	High	Peri-urban and urban dairy; smallholder mixed (S,P,I)
	Occupational and environmental disease	Poor in rich countries; middle-income in others	Hundreds of thousands seriously affected	High	All (P,S,R,I)
	Emerging zoonotic disease	Global	Thousands seriously affected; potentially millions	High	Intensive pig and poultry (I)
	Antimicrobial resistance	Global	Tens of thousands seriously affected;	Unknown	Intensive pig and poultry (I)

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		potentially millions			
Economic	Animal welfare	Global, with most support in rich countries	A moderate concern of millions of people	High	Intensive pig, poultry, dairy (I)
	Fear of technologies (e.g. GMO)	Global, with most concern in rich countries	A moderate concern of millions of people	Moderate	Intensive pig, poultry, dairy (I)
	Unviable rural communities	Global	A moderate concern of billions of people	Moderate	All
	Low productivity	Lower income and poor in middle-income	Billions seriously affected	High	Smallholder mixed; urban & peri-urban (S,P)
	Poor work conditions	Middle income and poor	Around one billion moderately affected	High	All (P,S,R,I)
	Competition for resources	Especially emerging economies	Billions moderately affected	Moderate	Especially intensive and urban (I)
	Trade and connectedness risks	Global	Billions potentially seriously affected	Moderate	Dairy, intensive poultry and pig, rancher (I,R)
	Food waste	Mainly rich countries	Billions mildly affected	Moderate	Especially dairy (I)
	Market access barriers	Middle-income, emerging economies	Millions affected	Moderate	Pastoral; smallholder (P,S)
	Greenhouse gas emissions	Global	Billions potentially seriously affected	Moderate	Smallholder mixed and extensive grazing (S,P,R)
Environmental	Water and soil pollution	Especially emerging economies	Billions moderately affected	High	Intensive production (I)
	Decoupling production from ecosystem services	Rich, emerging countries	Millions moderately affected	Moderate	Intensive livestock (I)
	Overgrazing and land degradation	Emerging economies; poor countries in Africa	Millions moderately affected	High	Extensive grazing (P,R)
	Loss of ecosystem services	Global	Billions potentially moderately affected	Moderate	Intensive and grazing (P,S,R)
	Natural resource depletion, tipping points, X risks	Global	Billions potentially seriously affected	High	All systems (P,R,S,I)

1
2 **Systems typology:** P=pastoralist; S=smallholder; I=intensive; R=rancher
3 Red=higher priority
4

5 3.6 Conclusions

6 There is a broad consensus that while the livestock sector generates many health, livelihood,
7 economic and environmental benefits, it also contributes to many nutrition, health, social and
8 environmental problems. Because livestock is produced in so many ways – from backyard chicken to
9 intensive dairy – and because it generates benefits that are valued as well as harms that need to be
10 mitigated it is not easy – nor indeed appropriate – to develop global conclusions on the merits and
11 demerits of livestock production. In recent decades, there has been much emphasis on the “long
12 shadow of livestock”, that is, the environmental and other trade-offs of livestock production. Different
13 stakeholders have different views, based on their perceived interests and often-unique insights but
14 also on their culture, values and their interpretation of uncertain and often ambiguous evidence. But it
15 is clear that the livestock sector faces many challenges at present and, more so, in the coming period,
16 and the most pressing question is whether problems are tractable, what kinds of responses have been
17 undertaken, with what results, and which ones will be necessary, feasible and effective in the future.

18

19

4 TOWARDS SUSTAINABLE AGRICULTURAL DEVELOPMENT: PATHWAYS AND RESPONSES

(This chapter is in the process of development, including further references)

4.1 Introduction

This chapter discusses the pathways and responses that look to be the most promising approaches to address the challenges to move towards sustainable agricultural development and contribute to achieving food security and nutrition goals.

There has been significant progress on reducing the number of hungry people in the world in terms of calorie intake, but many, including the poor, women and children, and the elderly remain deficient in essential nutrients, while the overnutrition phenomenon is a recent but rapidly growing concern. In the 1950s and 1960s, the challenge of increasing crop yields created opportunities that led to a boost in research and development culminating in the “green revolution”, although that was focused primarily on enhancing production in developing countries – the “availability” dimension of food security - rather than pursuing sustainable agricultural development.

The social dimension of sustainable agricultural development, which is a key contributor to improved FSN, has often been neglected or not given as much attention as it warrants. This is perhaps because it covers a very wide range of disparate and complex issues – the role of smallholder enterprises and rural communities dependent on agriculture; the working conditions of agricultural and food system workers; nutrition, food-borne diseases and human health; poverty reduction; cultural preferences; and animal care – that are very much country-specific and do not easily lend themselves to generalization and are often difficult to quantify and compare. The social dimension of sustainable agricultural development is thus one of the most challenging areas to address, although many of the issues are often inextricably linked to the economic and environmental dimensions.

It is only since the 1980–1990s that governments have accorded a higher priority to address the natural resource and environmental impacts of agriculture and the agri-food sector, although the policy measures put in place have been mainly targeted to local, not global, problems, and have had mixed results. McKenzie and Williams (2015), in an extensive review of research on the natural resource potential for sustainable food production for food security, concluded that there is in the world “*enough resources and the potential to produce all the food needed for the population of the future*”, but that the dominant trajectory that the world is currently on is “business as usual” in which, by and large, more food is being produced with more resources and with more environmental impacts, concluding that “*If we want to take a different path, we will have to make the choice to do so*”. Producing more food, without a corresponding increase in resource use and fewer harmful environmental impacts requires an increase in productivity. To increase productivity that translates into better food security and nutrition for all requires a shift in focus by policy-makers and stakeholders to outline goals and strategic sustainable agricultural development pathways, and a start to implement concrete actions as a matter of urgency to achieve those goals.

More recently, concerns of over-nutrition and the associated health problems have come to the fore, and there is much controversy over who to target and which policy measures might be effective.

All of this requires exploring different models, to shift from an only productivity-focused agricultural development model (with environmental and social issues seen as constraints) to a sustainability and FSN-focused agricultural development model that is concomitantly ecologically, socially and economically productive.

4.2 The role of livestock

The report addresses many of the key concerns surrounding the issue of sustainable agricultural development for FSN, in particular with respect to the role of livestock. These include: the intensification, industrialization and concentration of agriculture and their impacts on resource use and access, the environment, animal care, and smallholders and pastoralists; the respective roles of biotechnology, wider adoption of existing and emerging conventional technologies and production practices; the role of women in livestock production; the issue of local versus global production and

1 access to markets, with implications for scale and efficiency of production, food sovereignty and trade;
2 changing and sometimes conflicting dietary guidelines; and the levers and institutions available in the
3 public and private domains to trigger actions to help achieve desired outcomes.

4 Different livestock systems prompt different questions regarding their sustainability, and highlight
5 potential trade-offs between achieving the economic, environmental and social goals of sustainable
6 livestock in the future. A range of conclusions about productivity and sustainability emerge across the
7 wide diversity of livestock systems, from small-scale livestock keepers, mixed crop–livestock systems,
8 extensive pastoral systems, to intensive large-scale commercial enterprises. These systems involve
9 differences in production practices, inputs and land use. Thus with significant variations in agricultural
10 productivity and sustainability across and within countries, there are consequential implications for
11 FSN, the well-being and livelihoods of smallholders, landless hired workers, families and rural
12 communities dependent on agriculture, including livestock systems.

13 Technically, the potential exists – even with existing technologies – to narrow the productivity or yield
14 gap between the highest and lowest performers in a region and thus increase agricultural production,
15 including livestock and animal feed production. A fundamental question is how to scale up the well-
16 understood technologies and approaches to improving yields that are massively underused by poor
17 producers. The potential also exists to improve the diets, nutritional status and health of poor and
18 vulnerable people – as well as rebalancing the diets, nutritional status and health of many people in
19 rich and emerging economies.

20 The livestock sector has a large potential to reduce the intensity (ghg/kg of product) of greenhouse
21 gas emissions, although it is much less likely for total emissions given the projected increase in
22 livestock production. Mitigation (reduction or prevention) of the sector's emissions could be achieved
23 by a reduction in production and/or consumption, by an increase in production efficiency, or by shifting
24 the structure of production towards less emission-intensive animal food types. Many technical options
25 to reduce emissions exist, including feed supplements and feed management, grazing land and
26 manure management, health management, improvements in genetics and animal husbandry
27 practices. In more intensive systems, progress could be made by introducing technological
28 innovations to increase efficiencies in production and shift towards monogastric species.

29 FAO estimates that applying, in each type of livestock system, the already established and used
30 practices with the lowest emission intensity could reduce emissions by 18–30 percent without reducing
31 overall output (Gerber *et al.*, 2013).

32 Given the projected increase in the demand for ASF in developing countries and the trends in livestock
33 GHG emissions, many developing countries have expressed interest in – or are already –
34 implementing GHG mitigation policies in the livestock sector. Most of the proposed policies can be
35 implemented through Nationally Appropriate Mitigation Policies (NAMAs).

36 Promoting production and consumption of less resource- and GHG-intensive livestock types can
37 change the emissions trajectory of the livestock sector. Soil carbon sequestration is also an important
38 option that shows potential for mitigating net emissions from grazing livestock. For instance, restoring
39 degraded soils, better adjusting stocking density and using legumes has a significant potential
40 worldwide for mitigation in the livestock sector (Henderson *et al.*, 2015; IPCC, 2014).

41 **4.3 Pathways towards sustainable agricultural development**

42 Many of the biggest and most urgent challenges facing the agri-food system are global, or cross
43 boundaries, and in each country there are priorities that reflect the particular farm systems, socio-
44 economic and agri-ecological conditions, history and culture, and public preferences. From the
45 previous chapter, the priority challenges, which are broadly shared across the world, are:

- 46 • The priority *social* challenges are to contribute to livelihoods and viable rural communities,
47 promote gender equality and provide better conditions for livestock sector workers.
- 48 • The priority *economic* challenges are to enhance productivity to reduce yield gaps, especially for
49 small-scale producers in poorer developing countries, reduce risks and uncertainties of farmers
50 and traders, improve the efficiency of markets and reduce food loss and waste.
- 51 • The priority *environmental* challenges are to meet FSN objectives while reducing greenhouse
52 gas production, reduce pollution, reverse land and soil degradation and biodiversity loss,

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1 conserve water resources, and enhance the provision of ecosystem services and aesthetic
2 landscapes.

- 3 • The priority *health and animal welfare* challenges are to reduce livestock’s contribution to
4 human disease especially food-borne diseases, improve animal care and improve its
5 contribution to nutrition by facilitating adequate and healthy diets.

6
7 The possible pathways (the broad strategic directions to achieve goals over time) that could be
8 envisaged can be defined in terms of giving priority to the particular dimensions of sustainable
9 development (Leach *et al.*, 2010). Thus, a pathway emphasizing the “economic” dimension would give
10 priority to agricultural production, technology, structures, scale and trade to achieve increases in food
11 production and consumption. A pathway emphasizing the “environmental” dimension would give
12 priority to conserving natural resource systems and cycles, with production and farming livelihoods
13 better integrated with agro-ecological conditions, such as is encapsulated in agro-ecological
14 intensification. A pathway emphasizing the “social” dimension would give priority to production and
15 consumption systems that engage with stakeholders and involve participatory approaches, and would
16 give priority to meeting food consumption from local – and often small-scale – production, and to food
17 sovereignty.

18
19 The model of past pathways and the associated institutional structures have tended to strongly focus
20 on the economic or “productionist” approach, because the priority had been to produce more food to
21 meet a growing world population (such as encapsulated in the “green revolution”). But increasingly, as
22 we have seen in earlier chapters of the report, the environmental and social aspects have been
23 afforded increasing attention so that there is growing interest in sustainable intensification (or similar
24 concepts, such as green growth, integrated, low external input or climate-smart agriculture).

25 There is a range of possible responses to reduce pressure over land for agriculture (Herrero *et al.*,
26 2010). Intensification and the continued shift from ruminants to monogastrics (especially poultry) are
27 continuously improving land-use efficiency, helping to reduce the land area used per unit of output.

28 However, these pathways have been framed in a national context, whereas many of the big and
29 urgent challenges that are global or cross-boundary, - in particular climate change, biodiversity and
30 animal diseases, - are areas have the characteristics of global public goods (and bads). Incentives (or
31 disincentives) for individual countries to take action are often lacking and thus create a “free rider”
32 problem. Global and cross-boundary challenges require an approach that both involves cross-country
33 cooperation and provide incentives for individual countries to take action. Integrating or linking
34 pathways and specific responses to address national farm systems and global challenges will
35 inevitably involve both win–win outcomes and trade-offs.

36
37 In considering alternative pathways to sustainable agricultural development, there are many hurdles to
38 overcome, not least the vested interests and the inertia of institutional framework that can favour
39 status quo. Alternatives may also be constrained by path-dependency and technological lock-in. To
40 change direction is costly, with uncertain results, and takes time. Moreover, the direction of change
41 can be controversial, in part because it shapes the patterns of distribution of the benefits, costs and
42 risks associated with innovation. Different pathways also imply different requirements of knowledge
43 and resource needs, and the resilience of systems (Thompson and Millstone, 2011).

44 There are very different “rural worlds” coexisting in countries across the planet, which have been
45 identified in earlier chapters of this report, and which have evolved to best reflect the socio-economic
46 and agro-ecological conditions, and policy priorities. There is no one pathway that is the “silver bullet”
47 for all countries and farm systems. But in thinking about alternative pathways that offer the potential to
48 move towards sustainable agricultural development, there are key issues that help to determine the
49 orientation of pathways and policy responses to address the challenges identified in Chapter 3. In the
50 most general of terms, the choice is often characterized as between “industrial” or “agro-ecological”
51 agricultural systems, with corresponding implications for the sources and intensity of resource use,
52 and the environmental and social impacts. In reality, there is, as has been shown, a range of farm
53 systems and even gradations and variations within those farm systems in different contexts.

54
55 The following lists some of the key issues or choices that need to be taken into account by countries in
56 considering alternative agricultural production pathways, which may include elements of the following,
57 to varying degrees (to be elaborated in subsequent versions):

- 1
- 2 • **Utilization of land: land sharing or land sparing?** (Land sharing *integrates* agricultural
- 3 production with ecosystem services, such as biodiversity, hedgerows, trees, ponds and green
- 4 buffer zones, in a patchwork of low-intensity agriculture on a given area of land, whereas land
- 5 sparing *separates* agricultural production from these ecosystem services and involves large,
- 6 separate areas of sustainably intensified agriculture and wilderness [Fischer *et al.*, 2014]).
- 7 • **Carbon-intensive or low carbon agricultural production systems?** (Influenced from
- 8 outside the sector by the price of fossil fuels)
- 9 • **Scale of production: big or small farming operations?** (Economies of scale at the expense
- 10 of labour and viable rural communities?)
- 11 • **Integration or specialization?** (Crop–livestock integrated operations or purchasing feed for
- 12 outside the farm, often from imported sources?).
- 13 • **Connecting to food supply chains or local production for local consumption?** (Economic
- 14 and social trade-offs)
- 15 • **Self-sufficiency or international trade?** (Economic and social trade-offs, implications for
- 16 viability of some farm systems and rural communities)
- 17 • **Agriculture as an economic activity or social support system?** (Economic and social
- 18 trade-offs)
- 19 • **Adoption of new or existing technologies and practices?** (Risk taking: precautionary
- 20 principle or risk regulation?)

21
22 Rarely is there a stark choice – either between *large-scale industrial* or *intermediate* or *small-scale*

23 *backyard* – as models for sustainable agricultural development. The reality on the ground is altogether

24 different, as there are significant flows, dependencies and complementarities between these three

25 broad systems. For example, intermediate commercial and small-scale backyard producers often

26 depend on the large-scale integrated operations for their supplies of day-old-chicks and quality feed.

27 Without the large-scale operations the very existence of the small and intermediate operators would

28 be in question (as would the sustainability, livelihood and other benefits that are claimed to be

29 associated with these systems). Similarly, the pathways of these systems are also linked,

30 interdependent and co-evolving (and this linking and co-evolution extend to the global scale). While

31 stylized constructions (such as the large-scale commercial, intermediate commercial and small-scale

32 backyard systems) have their place in distinguishing between different systems and their associated

33 co-evolutionary pathways, they can oversimplify complex and dynamic relationships.

34 4.4 Responses

35 Given the complexity and multidimensional nature of FSN and sustainable agricultural development,

36 and the range and variety of agri-food systems and livestock species, responses are often designed to

37 simultaneously address multiple challenges. In fact, those responses that have the potential to deliver

38 win–win solutions across the dimensions of sustainable agricultural development are to be preferred,

39 but in most cases trade-offs have to be made, implying difficult choices. Those choices and trade-offs

40 will clearly vary across countries and farm systems, depending on the priorities for policy, as well as

41 the situation in each country or region. Moreover, there is the important question of timing and

42 durability of responses. The urgency of many of the challenges demands that policy responses and

43 actions by stakeholders need to be taken as soon as possible, recognizing that it will take time for the

44 agri-food chain to adjust, and to avoid the risk of reverting back to non-sustainable practices.

45 Many of the responses needed to address the challenges lie within the agri-food sector. But,

46 increasingly, it is from outside the sector that responses will be found, including better (and more

47 equitable) economic performance, trade policy, broad-based social safety nets, education, R&D, and

48 environmental regulations, which apply to all economic sectors and are not agri-food-specific.

49 The farm and livestock practices actually adopted will be primarily driven by the need for financial

50 viability, survival and compliance with regulations and norms of behaviour. However, when the impacts

51 of farm practices are not taken into account by farmers and livestock keepers, because there is no

52 financial remuneration for the provision of public goods (such as carbon sequestration in soils or

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1 habitats for wildlife), or penalties for polluting water courses or harming biodiversity for example, or the
2 social consequences are not factored in to producer decisions, then sustainability is compromised,
3 with potentially negative effects on FSN.

4 For example, industrial, intensive livestock operations tend to be efficient in production, but sometimes
5 at the expense of water pollution and the welfare of animals, and depend on feedstuffs from the crop
6 sector, with knock-on environmental effects. Extensive livestock operations tend to depend on pasture
7 and conserve land at risk from erosion vulnerability, but sometimes at the expense of productive
8 efficiency. Nevertheless, great care is needed in making generalizations, as there are wide ranges of
9 impacts within given farm systems.

10 There is evidence that resilience (to climate change) and efficiency can be positively correlated,
11 according to case studies reported in a FAO–OECD workshop (FAO/OECD, 2012). While large-scale
12 farms tend to be more efficient in their use of resources – of which they have more than small-scale
13 farms – technologies for sustainable agriculture cover the whole spectrum of farming systems. “All
14 farming systems, from intensive conventional farming to organic farming, have the potential to be
15 locally sustainable. Whether they are in practice depends on farmers adopting the appropriate
16 technology and management practices in the specific ago-ecological environment within the right
17 policy framework. There is no unique system that can be identified as sustainable, and no single path
18 to sustainability. There can be a co-existence of more intensive farming system with more-extensive
19 systems that overall provide environmental benefits, while meeting demands for food. However, it is
20 important to recognise that most sustainable farming systems – even extensive systems – require a
21 high level of farmer skills and management to operate“ (OECD, 2001).

22 A checklist of possible responses, grouped according to the dimensions of sustainable agricultural
23 development, with a particular focus on the livestock sector, and crosscutting issues, are outlined
24 below. This has drawn on a number of sources (Eisler *et al.*, 2014; McKenzie and Williams, 2015;
25 FAO, etc) .

26

27 **Social challenges**

28 **Responses:**

- 29 • Support smallholders and agriculture for development to ensure a better livelihood for farmers
- 30 • Apply social safety nets
- 31 • Ensure equal pay for equal work
- 32 • Set and enforce minimum standards for workplace safety
- 33 • Increase rural job opportunities in small and medium enterprises and related activities
- 34 • Provide and disseminate science-based evidence on novel technologies

35

36 **Economic challenges**

37 **Responses:**

- 38 • Improve resource-use efficiency, including through adoption of new technologies
- 39 • Balance and tailor precision animal feeding and nutrition
- 40 • Use animal feed varieties with higher digestibility and nitrogen content in crop improvement
41 programmes
- 42 • Increase farmers' access to markets through capacity building, credit and infrastructure
- 43 • Respond to market volatility by encouraging flexibility in production systems and savings
- 44 • Reform trade policy to reap benefits from comparative advantage in production while ensuring
45 coherence between sustainable agricultural practices and trade policies, and to spread market
46 and other trade-related risks
- 47 • Assess the impact of trade policies on food security and food security policies on trade
- 48 • Open new channels to integrate small farmers into domestic and global food supply chains
- 49 • Reduce food losses and waste

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Environmental challenges

Responses:

- Prepare for and adapt to climate change
- Use best farmer practices for reduced GHG emission intensity, including through reduced
- Conserve animal genetics *in situ* and *ex situ* and diversify crops and breeds
- Protect the ecological foundation of food – to preserve the ecosystem services on which food production depends
- Use grassland for biodiversity, carbon storage and water services
- Implement contingency planning for droughts, floods and pest outbreaks
- Protect water from pollution through animal waste management
- Apply the “polluter pays” principle to address negative environmental externalities
- Set payments for using and for providing environmental services that are not remunerated through the market

Health and animal welfare challenges

Responses:

- Provide better information/labelling of foods for consumers
- Use subsidized public procurement programmes to provide nutritious meals for children, the elderly and vulnerable groups
- Consider using taxes and subsidies to boost regulations to influence healthy food choices
- Encourage a diversified diet to ensure micronutrients are available (boost processed foods with micronutrients where they are lacking)
- Improve rural nutrition: production of more and affordable nutritious and diverse foods, including fruits and vegetables
- Design, implement and showcase pilot demonstration projects on healthy diets
- Set minimum standards for animal care and implement codes of good practice for animal care
- Provide financial and in-kind capacity in developing countries to adopt good animal care practices
- Improve surveillance, control and eradication programmes, and monitoring of animal and food-borne diseases

Crosscutting challenges:

Response:

- Generalize risk assessment/management and communication
- Increase and redirect agricultural investments that are targeted to achieve sustainable development goals
- Close collaboration between crop and animal scientists and national plant variety screening and research authorities
- Increase effective participation and multistakeholder involvement in policy
- Encourage formation of voluntary associations in the agri-food chain
- Increase frequency and content of consultations among stakeholders, including development of multistakeholder partnerships
- Develop decentralized capacity for policy-making and implementation
- Design and enforce property rights, policies and laws, through appropriate institutions.

- 1 • Limit agricultural expansion – to release/conservate land for ecosystem services/forests/nature
2 – by increasing the productivity of scarce land sustainably
- 3 • Integrate farming systems – to enhance both productivity and environmental performance
4 through mixed crop and livestock systems

5 4.5 Approach to policy decision-making and actions

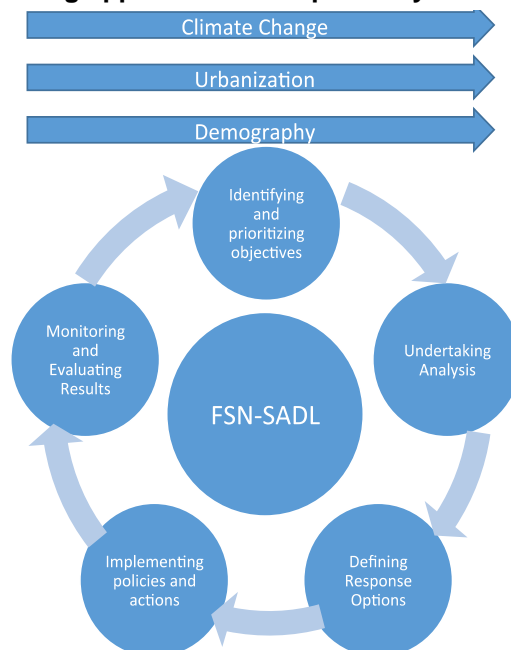
6 An approach that could be useful for identifying and evaluating responses is to develop a decision-
7 making response approach, which can be adapted for specific contexts, reflecting the importance and
8 urgency of the challenges. It is imperative, in first identifying the priority *challenges*, to articulate them
9 as clear, measurable objectives, then undertake analysis based on sound data and evidence in order
10 to define the potential *response* options as a prelude to design and implement chosen policies and
11 actions and, finally, to monitor and *evaluate* the results, which, in turn, could generate another round in
12 the response cycle.

13 The context (agro-ecological conditions, agricultural structures, socio-economic environment,
14 externalities, consumer and citizen preferences, and trading stance) is crucial and thus the responses
15 will be specific to particular situations. However, in some cases, such as climate change, biodiversity
16 loss, water and soil quality and availability, and animal diseases, the challenges often cut across farm,
17 regional and country boundaries. Moreover, the agriculture sector impacts on other sectors and
18 groups and is likewise impacted by developments outside the agri-food sector. The responses
19 therefore need to reflect the realities of the externalities generated, the unintended consequences and
20 the provision of public goods. These also raise institutional issues of governance, legal enforcement,
21 trust and stakeholder engagement, as well as the coherence with other policies (such as health, social
22 security, rural development, anti-trust, education and research).

23 The process is not necessarily sequential: the exact succession of actions will differ according to
24 location and scale (community, national or global level). Coordination and consistency among the
25 different scales – from global to local levels – is thus an essential requirement.

26 Figure 9 depicts a stylized approach to such decision-making. The arrows in the circle indicate the
27 stages of decision-making; the arrows heading the diagram illustrate key developments and policy
28 areas that are external to the agri-food decision-making process, and thus provide the overall context.

29 **Figure 9 Decision making approach: the response cycle for policies to address FSN-SADL**



30
31

1 4.6 Trade-offs and synergies

2 Experience shows that the transition to sustainability will involve both trade-offs and synergies, and
3 that at different scales of production those trade-offs or synergies will differ. For example, preserving
4 a way of life for smallholders may be at the expense of economic efficiency, while switching from red
5 to white meat consumption could result in health benefits, cheaper sources of protein and a reduction
6 in greenhouse gas emissions.

7 It is increasingly recognized that successful transitions to sustainability will involve a range of
8 multistakeholder partnerships (MSPs). One such MSP is the Global Agenda for Sustainable Livestock,
9 which brings together the engagement of the public sector, the private sector, NGOs, social
10 movements and community-based organizations, academia and research, and donors, as well as
11 international organizations. This partnership promotes policy dialogue, generation of evidence and
12 knowledge sharing, and concerted action by livestock sector stakeholder groups to support livelihoods,
13 long-term food security and economic development by simultaneously addressing global food security
14 and health, equity and growth, and resources and climate. As such it is becoming the “recognized
15 platform” for discussion and initiation of actions related to global livestock sector issues, and a spur to
16 the attainment of the Post-2015 Sustainable Development Goals.

17 **Case studies – to be supplemented with additional case studies (including some on intensive**
18 **industrial systems in developed countries) and integrated into the chapter in subsequent**
19 **versions**

20 Box 9 illustrates the case of a change in policy in the New Zealand sheep meat sector, which is
21 dominated by extensive, commercial, grass-based enterprises (**livestock farm system typology xx**). It is
22 an example of a case where policies, which were contributing to unsustainable production, were
23 reformed so that the sector had to respond to market signals, since complemented by environmental
24 flanking policies. The economic and environmental aspects of sustainability were the dominant
25 challenges in this case.

26

Box 9 Reforms in the New Zealand sheep meat sector

Sheep numbers in New Zealand peaked in 1982, boosted by various government policies and support measures, which included Supplementary Minimum Prices (SMPs), sheep retention grants (Livestock Incentive Scheme), Land Development Encouragement Loans (LDEL), and fertiliser transport and spreading subsidies.

Thus, the New Zealand sheep farmer was shielded from the market by these measures, which were policy-driven rather than market-led.

From 1984, with low world prices for sheep meat and high budgetary costs to the government, a reforming government removed these financial support measures (including to other agricultural commodities and other economy-wide reform measures). Farmers were thus faced with exposure to market forces, without artificial support measures. This market-orientation forced farmers to make changes in their farm practices and marketing.

Identifying objectives

The objective of farmers very quickly became “to restore profitability to the sheep meat sector in a market-oriented environment”.

Analysis

Analysis showed various ways in which farmers could improve the profitability of their operation, mainly by adjustments to their management system to improve productivity of their sheep flock. The new market-oriented regime revealed that many sheep were being farmed on land that was too marginal to be economic. Also, in many areas the stocking rate (sheep per hectare) was too high to provide optimum performance: this overstocking led to lower lambing percentages, lower growth rates in lambs, lower carcass weights at slaughter, soil erosion on fragile land and contributed to pollution of watercourses. Experience revealed that improved grazing management could have positive effects on these performance measures.

Responses and actions

Responses did not require policy guidance – farmers were driven to change by their own economic

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interest and survival. The industry used several or all of the following responses, depending on their situation, at both the individual producer and industry levels:

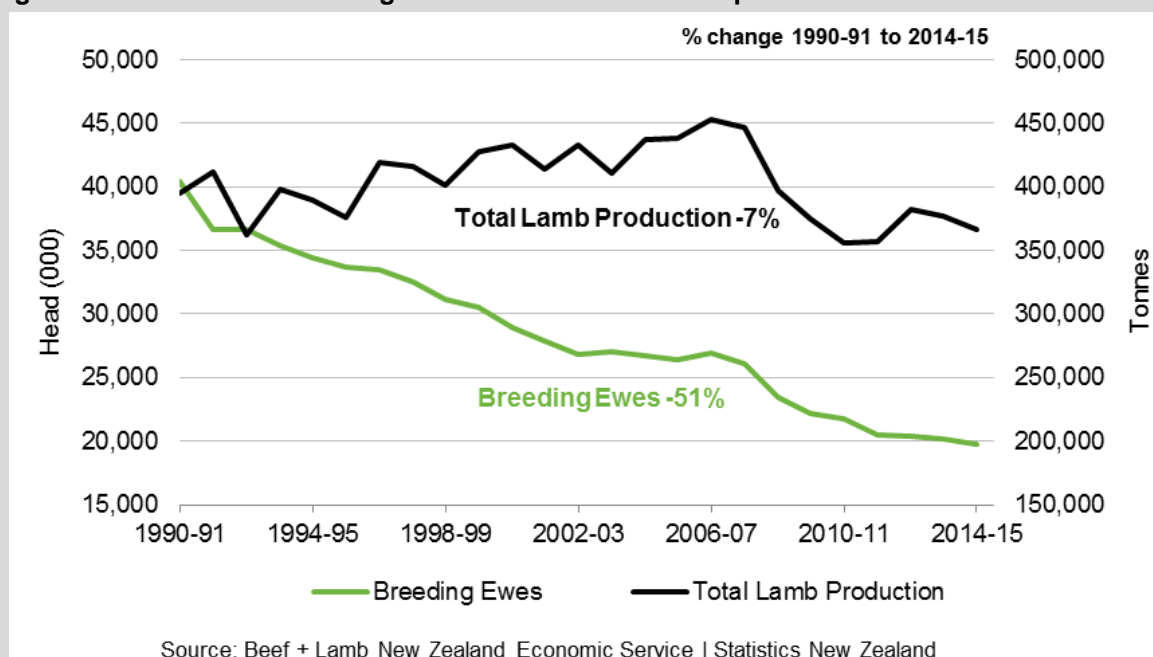
- reducing sheep numbers, at the unprofitable margin;
- ceasing farming on marginal lands (too steep, too remote, too dry or low fertility soils);
- improving performance of the flock (fertility, growth rate, slaughter weight), by:
 - improved pasture content and production
 - improved grazing management (fencing, rotational grazing)
 - genetic improvement
 - reducing stocking rates (to an optimal level)
- at the industry level:
 - greater efficiencies in abattoirs and processing
 - improved marketing (by the industry body, the then New Zealand Meat Producers Board).

Monitoring and evaluating results

Production performance improved: this was clear to each farmer, for their own enterprise, and farm records were used by farmers to make further refinements to their farming operation. At a sector level, the Meat and Wool Board Economic Service annually surveys sheep farmers' flock size, production results and financial performance, and then publishes this information. Results showed a return to profitability for most farmers in most years, after the initial and, in some cases, difficult transition period.

Figure 1 shows that despite the decrease in breeding ewes in the last quarter century, lamb production has increased, demonstrating significant gains in productivity.

Figure 10 Number of breeding ewes and total lamb meat production in New Zealand



Sheep numbers in New Zealand reached a high point of 70.2 million in 1982, bolstered by a range of subsidies and support to farming at that time. From 1984, in a widespread economic reform process, these assistance measures were fully removed, so that by 1990 the effects of support had essentially dissipated. At this point the national sheep flock had adjusted to 57.9 million. Over the following 25 years sheep numbers have halved (to 29.8 million in 2014), but the total production levels of lamb meat have reduced only marginally (minus 7 percent).

The area of land dedicated to sheep farming was reduced due to conversions to forestry, dairy, viticulture and horticulture, by urban encroachment, and some land was closed for conservation or left to revert to scrub and native trees.

The table provides more detailed data on the productivity increases. The large increase in lambing percentage (lambs born per ewe), faster growth rates in lambs and an increase in lamb carcass weights resulted from increased genetic merit of sheep for growth and reproduction, enhanced pasture production and quality, improved grazing techniques and optimising stocking rates to fit pasture growth.

Table 2 Productivity gains in the New Zealand sheep sector

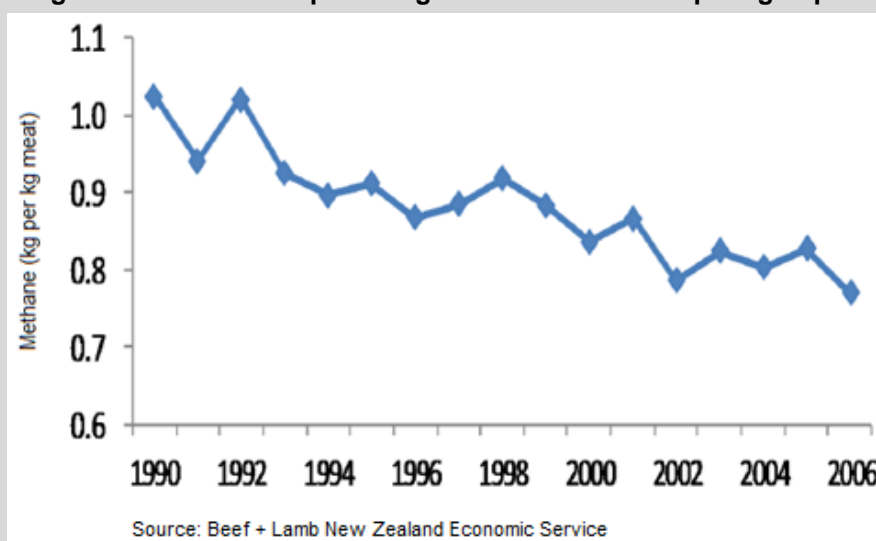
		1990–91	2013–14	Change
Lambing percentage (lambs born per ewe)	%	100.4	118.6	+18 (18 lambs)
Lamb carcass weight	kg/head	14.4	18.3	+27 %
Lamb sold (carcass weight)	kg/ewe	9.8	18.7	+91%
Wool production	kg/head	5.28	5.33	+1%

Source: Beef + Lamb New Zealand Economic Service

Sustainability gains in the New Zealand sheep sector

The reduced stocking rates contributed to improved environmental performance. And as climate change concerns became more widespread in recent years, the sheep meat industry wanted to assess their GHG emissions performance, and seek ways in which to improve performance. The industry body (Beef + Lamb New Zealand) commissioned an agricultural research institute (AgResearch) to conduct a life cycle assessment study (LCA) that would estimate the emissions of GHGs from sheep production. The results are graphed in Figure 2, showing that methane (a major GHG from ruminant animals) emissions per kilogram of lamb meat processed reduced over a 16-year period, due to the productivity improvements outlined above. This cradle-to-grave life cycle analysis showed that 80 percent of the GHG emissions occurred at the farm production stage, consisting mainly of enteric methane and nitrous oxide. Methane contributed 57 percent of the total carbon footprint of lamb meat. A time series analysis shows the significant fall in methane emissions (kg methane per kg meat) in lamb meat production.

Figure 11 Total sheep farming methane emissions per kg of processed meat



New Zealand sheep farmers are also implementing practices directed at environmental improvement and hence enhanced sustainability of production. Beef and Lamb New Zealand, an industry organization, has developed an environmental strategy to enable sheep and beef sector efficiency and profitability, while

sustainably managing air, soil and water, and natural resources. Mechanisms include provision of tools and services that assist sheep and beef producers, and development of an on-farm measurement tool to track the effectiveness of initiatives directed at achieving environmental goals.

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Box 10 Diversifying production in East Africa

Diversifying production on smallholder farms is often perceived as a promising strategy to improve dietary quality and diversity. This hypothesis is tested with data from smallholder farm households in Indonesia, Kenya, Ethiopia and Malawi. Higher farm production diversity significantly contributes to dietary diversity in some situations, but not in all. Improving small farmers' access to markets seems to be a more effective strategy to improve nutrition than promoting production diversity on subsistence farms.

Source: Sibhatu *et al.* (2015).

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Box 11 Actions on pastoralism in the Sahel and Sahara regions of Africa

In the Sahel-Sahara region, pastoralism is a unique and ancient system adapted to an agro-climatically constrained landscape and threatened by socio-economic, agro-ecological and institutional changes, requiring policies and actions to enhance the resilience of these systems. The expansion of agriculture and a shift to agro-pastoralism has pushed nomadic pastoralists into more marginal regions. African Sahel-Sahara pastoralism is not only a production system, it is a way of life based mainly on livestock, especially small ruminants, cattle and camels.

In this region, about 16 percent of the population depends on pastoralism, and in some countries, such as Somalia or Mauritania, pastoralists constitute the majority of the population. Pastoralism is a central activity of the Sahelian economy providing income to 80 million homes. Half of the meat and more than two-thirds of the milk consumed in the coastal cities of West Africa are from the Sahel (However, in the markets of major cities, Sahelian (pastoralist) meat is subject to strong competition from imports, from Europe or South America).

In general, pastoralism represents 10 to 44 percent of agricultural GDP in African countries. In North Africa, pastoral communities are living on marginal drylands, which cover 22 million ha in Libya and 32 million ha in Algeria. For Africa, it is in Algeria that the livestock subsector makes the largest contribution (50 percent) of agricultural GDP. This shows the socio-economic importance of pastoralism in this part of the continent (Union Africaine, 2010).

Sustainability challenges

The region is characterized by the variability in rainfall, and uncertainties related to the spatial and temporal distribution of water resources and pasture for animals. Some experts believe that pastoralists will be the first to feel the effects of climate change, while others consider that, since pastoralism is an adaptation to climate change, pastoralists will be among the best equipped to deal with such a threat. The challenge of climate change seems insignificant to many pastoralists who are faced with extreme political, social and economic marginalization: relax these constraints and pastoral adaptive strategies might enable pastoralists to manage climate change better than many other rural inhabitants. The vulnerability that is associated with climate change in some pastoral environments has its roots in the restriction of tried and tested pastoral coping strategies, including the ability to move through different territories, to access critical livelihood resources, to trade across borders, to benefit from appropriate investments, and to participate in relevant policy decision-making. As is so often the case in developing regions, the main concern for pastoralists is the accessibility, rather than the availability or variability, of resources.

The Sahel will undoubtedly be one of the regions most affected by climate change, with significant impacts on the availability of water and forage resources. The risks, frequency and severity of

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droughts will increase, with an impact on the evolution of transhumance routes and sources of conflict, while price volatility of agricultural products continues.

The Sahara-Sahel zone is marked by natural resource use rights on rangelands (Bernus, 1991), based on different legitimacies – customary, state and religious (Baroin, 1985). There is a wide variety of natural resource management systems ranging from a shared use path between social groups to a near-exclusive use of a "pastoral territory" by a lineage recognized by all as the "owner" of natural resources (wooded meadows, shrub or herbaceous and water). The nomadic and pastoral lifestyles require the guarantee of the presence of water to allow the movement of herds. Access to water remains crucial to access pasture. It constitutes therefore a central element of the necessary mobility. Access to these water points is negotiated and the subject of social agreements, tacit or formal, acquired and carefully maintained with local groups who exercise control over land routes for use of a grazing right, more or less prolonged, for animals (PSSP, 2009; Briggs, 2011).

There are social tensions over the use of natural resources (water, pasture for agriculture/pastoralism) to in face of demographic and income changes. The frequency of social conflicts over land has increased (irrigated perimeters, managed ponds, etc.). Meanwhile, the conflict settlement ways (customary, religious, administrative, modern) leads to many abuses and promotes the escalation of violence. The mechanisms of alliances between groups have been undermined, both as prevention mechanisms or to simply find amicable resolution.

Responses

The approaches adopted in the Sahel to address these challenges include:

- enhancing access to veterinary services and improved husbandry practices, often combined with the pastoral water development activities. A set of best practices has been derived from these experiences (mobile veterinary services, for example);
- enhancing the ability of farmers to take advantage of market opportunities: access to market and product quality;
- improving natural resource and land management conservation practices and management of rangelands and improved access to water;
- strengthening the capacity of pastoralists to be involved in decisions affecting them, particularly through the establishment of local development funds, including a broader set of needs such as access to education and health care and crisis management;
- strengthening the resilience combining the establishment of monitoring and early warning systems, conflict prevention, diversification of revenue sources pastors, plans for Emergency Action and the establishment of readily accessible reserves. Since the early 2000s, support systems based on financial transfers ("safety nets") in various forms have multiplied. Meanwhile, information devices have undergone profound transformations. Early warning systems are based mainly on the combination of agro-meteorological data (derived from field observations and satellite images) and market information;
- breeders have developed management systems based on strategic mobility, which are well adapted to the difficult conditions. Although African pastoral ecosystems are ancestral lands for a large part of the population for which pastoralism is a traditional way of life, farming is far from static. Breeders are now adapting to new economic opportunities and better access to modern means of communication (Union Africaine, 2010).

Evaluation

For a long time, states have favoured intensification of livestock policies promoting sedentary, ranching and "modern farming" (Doutressoule, 1947; Hesse and MacGregor, 2006; Collective, 2010). For 15 years, though, the awareness of governments, technical and financial partners as well as civil society have supported the development of pastoral areas and consequently herd mobility. The policy of liberalization of land tenure in Algeria seems to have given rise to a race for private land ownership and operation without any follow up and supervision required by the technical services. Consequently, natural resources in the Saharan zones have suffered (Brac, 1993; Bedrani, 1991).

Dong *et al.* (2011) concluded that for pastoral systems in the Sahel: (i) changing pastoral systems into agricultural systems enhanced the fragility of the agro-ecosystem; (ii) pushing pastoralists into more marginal regions with the expansion of agriculture increased the risk of limiting livelihood assets; and (iii) promoting current development models aimed at delivering economic growth and marginalizing traditional resource management lowered the institutional capacity to respond to crisis.

Moreover, it appears that the specific pastoral systems are still insufficiently taken into account in early warning systems and interventions of prevention/mitigation of food crises. This is due to many factors, including lack of financial and human resources of national research systems to have a thorough understanding of pastoralism, on one hand, and the focus for many years, food safety policy on grain

production, on the other.

Analysis of the various responses to crises in the Sahel since the great drought of 1973 to 1975 demonstrates the development from the negative effects of dependence on food aid in favour of "Food-against-work" (SWAC-OECD/ECOWAS, 2008) and actions aimed at boosting food crop production and markets.

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Box 12 Engaging indigenous communities in the protection of northern Australia's livestock and sensitive ecosystems

Sustainability challenges

The vast and sparsely populated northern coastal regions of Australia incorporate many of the country's most precious natural assets of high conservation value (Allen Consulting Group, 2011). The area is also particularly vulnerable to biosecurity threats because of its close proximity to countries that harbour pests and diseases not present in Australia. Of particular concern are biosecurity threats that could have serious consequences for Australia's livestock industry such as foot and mouth disease (FMD) and classical swine fever. A study by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) estimated the cost of a large FMD outbreak in Australia at more than AUD50 billion (USDxx) over ten years, potentially devastating producers of sheep, beef, dairy and wool who would be excluded from important export markets (Commonwealth of Australia, 2013).

The Australian Government's Northern Australian Quarantine Strategy (NAQS) operates over approximately 10 000 km in coastal regions from Broome in Western Australia to Cairns in Queensland, including the islands of the Torres Strait. Special attention is paid to routes for possible movement of exotic pests, weeds and diseases carried by feral animals, migrating birds, water currents and monsoon winds as well as through movements of people (including of traditional inhabitants of the Torres Strait islands), vessels and aircraft to mainland Australia (Commonwealth of Australia, 2012).

Indigenous peoples own some 20 per cent of the Australian continent and are more likely than other Australians to live in remote or very remote parts of the country where employment opportunities are limited (Australian Bureau of Statistics, XXXX). The land has deep cultural and spiritual meaning for indigenous communities and indigenous knowledge relevant to environmental and heritage conservation underpins a number of programmes that employ or consult with people from these communities, especially in northern areas (Australian Department of the Environment, XXXX).

Responses

Australian Governments at national and state level have worked closely for many years with Australia's indigenous communities to conserve and protect the environment. Indigenous ranger groups are engaged by the Australian Quarantine and Inspection Service (AQIS) on a fee for service basis to undertake critical biosecurity activities for NAQS, including monitoring the coastline for illegal foreign fishing vessels and marine debris, mapping plant and bat colonies and monitoring fruit fly and mosquito traps. Rangers also facilitate access to indigenous-held land and build relationships with local communities who cooperate with quarantine authorities, for example alerting them to the presence of illegally imported animals or high quarantine risk materials. Some 38 ranger groups were engaged in 2011–2012 providing coverage almost the entire northern coastline (Commonwealth of Australia, 2012). Further inland, the ranger groups monitor sentinel cattle herds in four separate locations taking blood samples to test for the presence of targeted exotic diseases such as strains of the blue tongue virus, surra (*Trypanosoma evansi*) and other pests such as screw worm fly. Plant health surveys are also conducted in a range of locations.

Publicly funded programmes cover a wide suite of indigenous activities supporting natural resource management, carbon storage farming and biodiversity and heritage protection on land and sea. Some 680 indigenous rangers are now engaged in around 95 ranger teams across Australia. Indigenous groups such as the North Australian Indigenous Land and Sea Management Alliance (NAILSMA) complement official activities, supporting the involvement in these and related privately sponsored environmental and heritage protection activities and facilitating the exchange of ideas among communities. NAILSMA was admitted as a member organization of the International Union for the Conservation of Nature (IUCN) in 2013.

Evaluation

As well as the environmental and heritage benefits for the nation, these activities have provided important employment and social benefits to indigenous rangers and their communities. Many aboriginal and Torres Strait islander people suffer substantial disadvantage with significant gaps between their living standards, educational achievements, health and employment and those of other Australians. Since 2007 a programme of the Department of the Environment called *Working on country* has consciously targeted the dual objectives of environmental protection and sustainable employment opportunities for indigenous people. This programme was evaluated positively in an independent review in 2011 (Allen Consulting Group, 2011). It found that the true cost of *Working on country* was up to 23 percent lower than its budget cost due to reduced welfare payments and increased tax revenue, reflecting the large pool of unemployed labour in the remote and regional areas supported by the programme. It also noted the programme had produced benefits beyond those quantified – for example through improved health, well-being and social attributes flowing from the employment of indigenous rangers and engaging their communities. It particularly highlighted the preservation and passing on of indigenous knowledge as a powerful force in fostering social capital.

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Box 13 Livestock and deforestation in Brazil

Sustainability challenges

Cattle ranching in the Amazon region is one of the most important sources of deforestation in Brazil due to its low productivity. Extensive areas of pastures are needed due to the low productivity of land, while weakly controlled and monitored pasture management practices also lead to increased forest clearing. Amazonia represents a major sustainability challenge: as well as being the world's largest remaining tropical forest, the entire Amazon biome is home to more than 30 million people and provides locally, regionally and globally significant human-welfare benefits, including economic goods (e.g. timber and agricultural products) and non-market ecosystem services, such as climatic regulation and biodiversity conservation. Over the past 20 years, about 10 percent of the Brazilian Amazon forest has been lost, and more than half of this loss was due to the conversion of the forest to cattle pasture (Faminow and Vosti, 1998). Brazil is the second largest producer of beef in the world. According to the Ministry of Agriculture, Livestock and Food Supply (MAPA), Brazil will account for an estimated 44 percent of global meat production by 2020.

Responses

During the last decade, there have been two key areas of intervention in Brazil:

(i) Public policies for reduction and monitoring of deforestation to enhance environmental governance (Forest Code Compliance) and improvement of governmental technical capacity (federal, state and municipal) in order to help cattle ranchers, retailers and others stakeholders in the beef value chain in the preservation of the natural ecosystems and thus to improve the productivity of cattle production.

(ii) Development and adoption of new technologies to intensify production and improve pasture quality to increase the efficiency of cattle ranching and consequently to reduce deforestation.

Since 1965, Brazil's Forest Code requires Amazonian landowners to set aside between 50 to 80 percent of their property under natural vegetation cover. With the approval of the new Brazilian Forest Code in January 2010, and the mandatory environmental registry of rural farms (Cadastro Ambiental Rural, CAR Forest Code), compliance has increased. The new system requires landowners to participate in a registry, which enables monitoring of legal and illegal deforestation and to track compliance with environmental regulations and more responsible production. As of 2014, most ranchers in the Amazonia are at or very close to the 20 percent limit that the legislation permits to be converted into pasture.

At the 2009 Copenhagen Climate Conference (COP15), Brazil pledged to voluntarily reduce GHG emissions in the range of 36–39 percent by 2020. The actions include, among other measures, the reduction in deforestation in the Amazonia (80 percent) and the *cerrado* (40 percent), restoration of degraded pastures (about 80 million ha), wide implementation of Brazilian good agricultural practices, reduction in energy consumption, stabilization of the share of renewable energy sources in the energy matrix, and increased use of biofuels.

To fulfil its commitment of reducing GHGs, Brazil launched the ABC programme in 2010 to fund low-interest loans for those activities including promotion of more sustainable cattle ranching practices, with three specific credit lines to support rehabilitating degraded pastureland, crop–

livestock–forestry integration and treating cattle waste to generate energy.

The Brazilian Roundtable on Sustainable Livestock (GTPS – *Grupo de Trabalho da Pecuária Sustentável*), a multistakeholder partnership initiative, is promoting principles, standards and common practices to be adopted by its members to contribute towards sustainable cattle ranching systems that are environmentally friendly, economically viable and socially acceptable.

Currently, the GTPS involves seven projects that cover 900 farmers in one million hectares of five Brazilian States (Mato Gosso, Mato Grosso do Sul, Pará, Rondonia and Bahia) that are part of the Amazonia and *cerrado* bioma (Brazilian savannah) The GTPS is committed to zero-illegal deforestation. In order to address the economic and social challenges, four key actions have been adopted by GTPS:

- promoting intensive beef production by aligning best practices that are economically viable;
- training farmers to adopt best sustainable practices;
- improving forage and cattle genetics through partnership with universities and research institutes;
- providing economic incentives through loans with specific targets and in coordination with the Ministry of Agriculture.

Evaluation

GTPS members have already fulfilled the commitment of zero-illegal deforestation. The group is also working on increasing beef productivity, mainly in the Amazon that is very low (100 kg/ha/year) in terms of the maximum potential with positive outcomes that would lead to a social and cultural change in favour of sustainable beef production.

There are still other environmental impacts associated with beef production that have not yet been implemented systematically by GTPS, such as reclamation of degraded pastures (environmental liabilities) and key mitigation actions to tackle GHGs emissions (other than those produced by deforestation), cattle waste and water pollution.

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Box 14 Empowering rural women artisans through improved production, processing and export of value-added fiber in Tajikistan and Kyrgyzstan

Sustainability challenges

Tajikistan and Kyrgyzstan have much in common. With more than two-thirds of the total populations (xx million) living in rural areas (IFAD/World Bank, 2010), rural poverty is a pressing issue in these two countries. Agriculture plays an important role in Tajikistan's economy. But less than 7 percent of the country's land area is arable. In Tajikistan about 50 percent of the population depends on agriculture for a livelihood. Most farmers lack access to adequate resources, technology and markets. Poverty mainly affects rural people who are landless and earn a living on small household plots, as well as subsistence farmers and those who are unemployed or self-employed. However, most of the farmers are poor because their productivity is low. They cannot make an adequate income from their agricultural activities as the land is degraded, irrigation facilities are lacking, and access to improved technologies, inputs and markets is poor.

It is a similar picture in Kyrgyzstan. More than half of its population works in agriculture, which is still the backbone of the economy. About two-thirds of Kyrgyzstan's population live in rural areas, and most rural households depend on livestock breeding for a livelihood, except for those in a few major valleys. The rural population includes three-quarters of the country's poor, who live mainly in remote and mountainous areas and are subsistence farmers and livestock breeders (IFAD/World Bank, 2010).

While large numbers of male workers from rural areas of Tajikistan and Kyrgyzstan are migrating to seek employment in the Russian Federation and other countries of the former Soviet Union, it is women who run the household and maintain their families. According to figures from IFAD and the World Bank (2009), women make up 44 percent of the total labour force in Tajikistan and 42 percent in Kyrgyzstan.

Responses

Many rural women are engaged in processing wool and mohair and making handicrafts from them. These are then sold at local markets and sometimes abroad. This creates employment opportunities for others too. For instance, in northern Tajikistan, thousands of households are engaged in the production of mohair, tens of thousands of women are engaged in processing,

and hundreds of people are engaged in sales of raw material and semi-finished products. Thus, there are opportunities for livestock breeders, women artisans and handicraft sellers.

But they face constraints ranging from insufficient skills to lack of access to marketing channels. In 2009, IFAD launched a four-year project aiming to help rural populations in Tajikistan, Kyrgyzstan and Iran. The project, implemented by the International Center for Research in the Dry Areas (ICARDA), targeted specifically rural women artisans and small livestock breeders, and aimed to improve their livelihoods and income through improved production, processing and export of value-added fibre in these three countries.

A functional chain is now in place that is focused on value-added fibre goat breeding and fibre harvesting, processing and marketing. Besides women artisans and livestock breeders, local researchers also participated in and benefited from this work. They were trained in modern breeding technologies to ensure sustainable breeding populations and improve their interaction with livestock farmers. Farmers in Kyrgyzstan and Tajikistan were encouraged to work with artisan women to see what kind of quality of raw materials they want. Through cross-breeding with new genetic material introduced from the Russian Federation and the United States of America, farmers supported by researchers managed to improve the quality of their animal populations, which will produce fibre that increases the profits from selling mohair and cashmere.

Evaluation

Women's contributions to the total household income are usually meagre in monetary terms. This is so because the price and quality of traditional yarn and products are very low. Yarn sells at USD10–15 per kg on local markets in northern Tajikistan. Products that women make also have low margins. And women lack access to technology and foreign markets.

Improving the quality of wool and mohair and adding value to finished products can boost rural women's earnings. If livestock breeders supply quality wool and mohair, and women produce more marketable handicrafts, exports and profits increase. Tens of thousands of rural dwellers could lift themselves out of poverty.

Better quality raw materials also add value to hand-knitted products by women. An improved system of mohair processing allows women to produce high-quality yarn for export. Artisan groups now see the benefits of value-added production and are keen to produce handicrafts for export.

Sources: <http://www.cac-program.org/fiber/>; <http://cac-program.org/news/detail/368>

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Box 15 Boosting poultry production in Uzbekistan

Sustainability challenges

Providing nutritious, affordable food and employment opportunities in Uzbekistan is an important challenge. Poultry production, which is currently mainly oriented to the production of eggs and meat, is one of the fast-developing niches of the livestock sector in Uzbekistan. The Government supports the expansion of the production of eggs and chicken, because of its cost-effectiveness and short payback period. As poultry products are rich in protein, the poultry sector is seen as a real contributor to the national food security policy and its development is considered essential for a healthy diet. The sector also provides job opportunities, thereby reducing unemployment. In Samarkand province of Uzbekistan, the production of eggs is more than twice the local consumption. Poultry farmers of Samarkand province supply eggs to neighbouring provinces, as well as to the republic's capital, Tashkent.

Responses

The rapid development of poultry is favoured by the well-developed organizational structure of the poultry value chain, which brings together all actors. Success in boosting poultry production in the Samarkand region is largely due to the initiatives of key actors in the value chain. The Regional Government provides the required institutional framework that creates an enabling environment for the development and effective functioning of the poultry sector (more detail needed).

A special role is played by the Agalyk-Lohmann-Parranda agricultural (poultry) enterprise, a joint venture between the German multinational livestock company Lohmann and a privatized former state farm, which in the Soviet days had imported the crosses and production technologies developed by the Russian Poultry Research Institute (VNITIP).

Having the status of a breeding farm, Agalyk-Lohmann-Parranda imports parents of high

reproductive crosses from Germany into Uzbekistan and to date produces more than 70 percent of the incubation eggs and final hybrids supplied to incubators, other large poultry enterprises and professional farms producing eggs and meat for commercial purposes in the Samarkand region.

The poultry enterprises and large poultry farms are organized in the Association of Poultry Producers of Samarkand Region, which represents their interests and facilitates cooperation between actors in the poultry value chain and with other actors of the innovation system.

Another key influencer of poultry value chain is the Regional Government (Khokimiyat) of Samarkand region and its relevant departments. As indicated, it attaches high policy priority to the development of the poultry sector, because of its important contribution to achieving national food security, as well as to the regional economy and employment. In view of this, the Regional Government not only creates an enabling policy, regulatory and legal environment for the development of the sector, (such as through....) but also provides the necessary physical and institutional infrastructure and ensures access to resources.

Perhaps even more importantly, the Regional Government acts as a broker by bringing the different actors in the value chain together and facilitates the joint formulation of the annual "Programme for the implementation of measures to develop poultry farming in the Samarkand Region" at regional level. This programme results from intensive bilateral and multilateral communication between the various actors in the poultry innovation system to define consumer demand and assess the producers' needs and the support they require for better farming and improved livelihoods. The programme is approved at the governmental level and involves all aspects of the sector: the premises for breeding birds, cages, feed, preventive measures and protection of birds. Thus, the steering role of the Regional Government is an important factor in the efficient and effective functioning of the poultry innovation system and its sustainability.

The system examined effectively combines a strong steering and facilitating role of the Regional Government, with private initiative of actors in a value chain operating in a partly liberalized market economy. A further specific interest of this case is the mutually beneficial relationship between professional farms and privately-owned commercial *dehkhans* farms on the one hand and large private poultry enterprises on the other, with a key role for large-scale breeding enterprise, which imports technology from abroad. This configuration also stimulates the development of an impressive and dense local knowledge infrastructure and attracts a wide range of public and private service providers, which supports the continuous improvement of the poultry sector.

Evaluation

Both foreign suppliers of technology and local partners are guided by the requirements of the technology rather than by the requirements of the socio-economic and other specific conditions under which the different types of producers are operating and under which the technology has to be applied. The focus is on achieving technical optima. Therefore technology development is biased towards the (technically more favourable) conditions of large enterprises. This bias seems to be compensated by a range of measures to adapt the socio-economic and other conditions of professional farms and *dehkhans* farms in such a way that they can obtain technically satisfactory results. There does not seem to be a strong orientation toward adapting technology to fit the specific socio-economic and other conditions of professional farms and *dehkhans* farmers as is attempted in other parts of the world. Nonetheless, this does not exclude smallholders from benefiting from this development.

The combination of strong public steering and private sector initiative, as well as the combined participation of smallholders and large industrial poultry enterprises, is perhaps specific for countries with formerly collectivized economies that obtained their independence from the Soviet Union after 1990. The practical applicability of some of the good practices illustrated in this case study may well be highly relevant for more established market economies as well, especially those regarding the advantages of a strong role of public agencies as broker and facilitator. There is a growing consensus in the literature on innovation (references) that even where strong market incentives for multi-actor collaboration in innovation exist, such collaboration often does not happen spontaneously, but requires a strong broker, a role which the public sector plays

Box 16 Small-scale cattle farming highly integrated with crop production in Uzbekistan

Sustainability challenges

Mixed crop–livestock farming systems in Central Asian countries, namely, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan, still struggle to adapt to the major changes caused by the breakdown of the Soviet Union in 1991. With the collapse of previous arrangements on trade and economic linkages for production and marketing of farm products, the five countries face the challenge of developing agricultural systems for food security and improved livelihoods including for the newly emerged, small-scale farms that are financially viable without state aid. In contrast to other countries of the former Soviet Union, the transition period to a more market-oriented economy in Uzbekistan was not accompanied by a drastic decrease in the number of ruminants, and cattle numbers remained apparently rather stable.

The decline in cattle productivity after independence (1990–1998) was due to a decline in milk production per cow. This in turn was influenced by the deterioration of supporting services to the livestock sector and the lack of skilled livestock farmers who had not been prepared to change to independent farming entrepreneurs.

The agriculture sector of Uzbekistan contributes substantially to GDP (22 percent in 2007), from which almost half was generated by the livestock sector. Historically, in Uzbekistan most of the cattle stock was reared on household farms and this tendency continued after the reforms and irrespective of the regions in the country. For example, in 2011, about 90 percent of cattle in the Khorezm region of Uzbekistan were reared by household farms and not more than 10 percent by privately-managed “livestock peasant farms”, and similarly for horses, sheep and goats, and poultry of which respectively 83, 80 and 60 percent are kept by household farms.

A USDA report (2011), for example, underlined that insufficient feed resources and lack of land areas and turnover are key factors negatively affecting the livestock sector in Uzbekistan. Nevertheless, the generalization of such bottlenecks on livestock or cattle production is insufficient for shaping and developing policies to improve livestock management, production and productivity.

Recent research results show that while livestock farms produced more metabolizable energy and crude protein than required by their own ruminant livestock, the feeds produced by family farms covered only one-third of the requirements. Despite their limited farm size, family farms took an active part in the commercial farming sector, for example, through the purchase of inputs for cattle and crop production, and product sales. These farms generated higher relative crop yields than their livestock counterparts, while cattle productivity of both was comparable, albeit low.

Although family farms generated higher crop revenues per ha, cattle reproductive parameters were comparably low in both livestock farming systems, as were total products derived per cattle livestock units. The research reveals the low milk yields due to the low genetic potential combined with the little scope for selection within the relatively small herds, and little use of artificial insemination due to an apparently weak organization of breeding. Another important reason for the low cattle reproduction is the imbalance and deficiency in the diet, e.g. the lack of mineral supplementation (USDA, 2011). Indeed, the quality of the cattle feed in the region is notoriously low and the high proportions of untreated maize stover, and wheat and rice straw in the diet, undoubtedly has limited dry matter intake.

Responses

The aims of the Uzbekistan Government's livestock development programmes (more detail needed) are to increase the number of farms keeping livestock, to improve livestock productivity and to raise rural family incomes. The reforms are aimed primarily at reforming medium-scale livestock farms.

In Uzbekistan, both livestock and household farms are currently benefiting from measures to improve infrastructure such as the establishment of accessible agricultural input shops. Facilitating access to specialized machinery could be a further relevant measure to support small-scale farming.

Evaluation

Though family farms are still the backbone of this sector, private plots are simply insufficient in size to produce the necessary quantity and quality of feed, which often resulted in farmers using the sparse halophytic vegetation on fallow land for a free-of-charge roaming, underlining that cattle production is hampered by a lack of feed (USDA, 2011). On the other hand, livestock is one of the most important economic subsectors within the agricultural production sector, with

almost 50 percent of agricultural value generated in the livestock sector, and an increase in livestock productivity is likely to increase incomes.

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Box 17 Actions on animal welfare

Financial mechanisms for agricultural funding have begun to endorse the importance of animal welfare: The European Bank for Reconstruction and Development included animal welfare (equivalence with EU animal welfare legislation) in its lending standards in 2014, while the UN Committee on Food Security's Responsible Agricultural Investment Principles also highlight the importance of animal welfare. The World Bank/IFC's Good Practice Note on Animal Welfare provides detailed recommendations (World Bank/IFC, 2006).

Reducing loss and waste through humane handling and slaughter

Improving animal welfare throughout production and slaughter makes good economic sense, especially where handling and transportation impact on meat quality. In Uruguay, research showed that 48 percent of carcasses ended up with at least one lesion, with bruising leading to losses of 2 kg of meat per carcass. If extrapolated across the country, this equated to USD100 million annually, or 3000 tonnes of meat. In a similar Brazilian study, better handling reduced carcass bruising from 20 percent to 1 percent (Appleby and Huertas, 2011).

World Animal Protection has worked with major multinational producers to introduce humane slaughter methods in Brazil, training over 5 000 professionals to date. Joint partnerships between World Animal Protection and the Brazilian Ministry of Agriculture (MAPA) have been recognized by the European Commission as enabling capacity building to meet European import standards for trade. Tailored humane slaughter projects with major producers have revealed the benefits for industry. In one Brazilian slaughter plant, a multinational processor was able to significantly reduce risk of injury and damage and exceed its targets.

In China, by working with World Animal Protection, the industry is beginning to adopt humane slaughter as a means of modernization and standardization of industry practice. Data from one of the largest-scale Chinese producers showed the impact of humane slaughter practice on reducing production losses from 12 percent to 8 percent and fractures reduced from 1.7 percent to 1.0 percent of animals. The loss of damaged meat was reduced from 0.5 kg per carcass to 0.2 kg on average.

Delivering animal welfare

NGOs including World Animal Protection have been engaged for more than a decade in working closely with industry to build animal welfare components into future livestock practices, lending their animal welfare expertise and working pragmatically with farming industries to develop good welfare solutions and promote them within the wider international community.

The OIE Animal Welfare Working Group

The OIE is developing a non-prescriptive, scientific, outcome-based ISO Technical Specification to: help avoid animal welfare legislation negatively impacting on trade; provide a route for those agri-food businesses seeking to demonstrate compliance through additional assurance by an external party, without requiring independent third party certification; and deliver a technical specification that is simple and easy to apply on small- and medium-size farms that do not have the capacity to develop their own animal welfare system to meet OIE standards.

The International Dairy Federation

The International Dairy Federation (IDF) is providing input into the OIE draft standards on animal welfare and dairy cattle production systems (reference), providing guidance for organizations in the food supply chain on animal welfare management, collecting data on government regulations and industry certification programmes for animal welfare, and commencing work on scientific evidence on welfare assessment of dairy cows in small-scale farming systems.

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Globally, progress has been made on integrating animal welfare into intensive systems, with the greatest attention to close confinement systems such as moving pregnant sows from highly confined sow stalls (gestation crates) to group housing systems, and moving away from battery cage production of laying hens. Alongside legislative requirements for group housing of sows in the EU, many large food companies are now requiring commitments to phase in improved animal welfare in their supply chains, including major food service multinationals such as McDonald's and producers such as Smithfield. This area of work provides large-scale potential for integrating animal welfare in production systems.

A number of common points can be highlighted with respect to animal welfare, sustainable agricultural development and food security and nutrition: it is in the interest of the livestock industries to take good care of animals, because quality and price premiums suffer with stressed and ill animals, but this applies to producers integrated into supply chains and can have a negative impact on poor consumers. Animal welfare is complex and multidimensional but standards and regulations need to be based on strong scientific foundations and robust data, and be verifiable; it is necessary to address animal welfare on a global basis in order to minimize animal welfare as a trade barrier, and there is a need to closely involve livestock businesses in framing and implementing animal welfare standards.

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5 CONCLUSIONS AND RECOMMENDATIONS

Food and agriculture systems globally play a vital role in providing essential products, and supporting the livelihoods of over two billion people, but are currently under serious stress:

- Anxiety about how to produce food to meet projected demand as population increases and incomes grow is leading to calls for more food but of a different mix to meet changing diets;
- Particular concerns about the health of natural ecosystems that underpin food production now and for future generations as well as supporting farm systems for biodiversity and human well-being.
- Great concern about diet transition triggering some human health problems on an unprecedented scale, as well as exacerbating ecosystem pressures (land clearance, water and air pollution including GHGs, etc); in this sense, health and environmental goals of FSN are well aligned.
- Concerns about the role of the downstream sectors (food retailing, processing and biofuel industries) in relation to farming (bargaining power in price formation, determination of production practices) and consumers (marketing and promotion of unhealthy diets/foods?), and in terms of the use of resources for food or feed or fuel.
- A range of social, ethical and development concerns about the risks in marginalization of smallholders and livelihood opportunities (in particular concerning the role of women), animal care/animal diseases, narrowing of production species and “homogenization” of more highly-processed products, the role of biotechnology and, as farming is increasingly moving towards a larger scale, concentrated, high external input systems and less diverse farming landscapes.

These stresses and concerns vary greatly across and within countries depending on stage of development, agricultural production system (scale, practices) and their impacts on different ecosystems and society, although there are some global or cross-boundary concerns such as GHG, water availability/quality and biodiversity/ecosystems.

On the basis of current food and agricultural production systems, and even more when taking account of demand projections, the future production pathways for livestock will have great bearing on likely outcomes for FSN and for future agriculture sector sustainability in all three sustainability dimensions.

Projected demand for agricultural products need not be taken as a “given” and can be dampened with interventions to reduce food losses and wastes and unhealthy overconsumption of animal-sourced foods (especially red meat) in some populations. Nevertheless, experts consider significant increases in food production will be required to meet increased demand in developing and emerging economies.

This suggests that to minimize encroachment on remaining natural landscapes critical for biodiversity and social well-being, best use must be made of existing agricultural land by both improving productivity (land sparing), and reversing to the extent possible negative impacts from established agricultural land on ecosystems – such as through policies and practices that focus on sustainable/ecological intensification.

From a development and FSN perspective, greatest gains could be made from enhancing productivity in developing countries where yield gap analysis indicates the greatest potential exists. This would generate enhanced food availability in regions where it is most needed (especially sub-Saharan Africa and South Asia) and provide momentum to the agriculture sector, considered to be one of the most powerful vehicles for enhancing growth and livelihoods in countries that are home to the largest numbers of poor people.

The livestock sector has a particularly important role to play in this:

- Accounting for 40 percent of total agricultural output and contributing to the livelihoods of 20 percent of the world’s population, 1 billion of the poorest and large numbers of women – food, cash from ASF sales, draught power, manure, store of wealth, etc.
- Currently providing 28 per cent of dietary protein and 13 per cent of calories

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- 1 • Providing critical nutrients for healthy diets including from self-consumption and sales through
2 informal markets.
- 3 • Transforming feedstuffs that are otherwise inedible to humans and occupying land that is
4 unsuitable for crops, on much of the world's terrestrial land area.

5 But, on the other hand, livestock generates:

- 6 • A heavy impact on the environment – water and air pollution including GHGs/climate change,
7 encroachment into natural landscapes.
- 8 • Exacerbated in some situations by poorly managed confined intensive systems generating
9 excessive nutrient loads, risks to animal health and well-being (and zoonoses) and exerting
10 pressure in other (often remote) locations from monoculture cropping for animal feed and
11 deforestation, with consequences for competition for staple foods and losses of biodiversity.
- 12 • Demand for feed grain for intensive systems in transition countries driving environmentally risky
13 monoculture cropping, often in other countries.
- 14 • Excessive consumption by some people creating a sharp rise in key non-communicable human
15 health problems – diabetes, some cancers and obesity – mainly in rich countries but
16 increasingly in emerging and poorer economies.

17

18 Much knowledge exists about ways to tackle the burden of negative externalities and to raise
19 productivity and yields of the worst performers towards those of the best in given countries for specific
20 production systems. In some cases, intensification can be managed along with improved
21 environmental performance if suitable investments are made by national governments, multilateral
22 institutions, donors and other actors in areas such as FSN-oriented R&D, infrastructure, skills training,
23 information dissemination and appropriately adapted and enforced regulation and attention to food
24 safety and animal care. In other cases (for example some pastoral areas), de-intensification will be
25 needed to avoid permanent environmental degradation and alternative livelihood solutions will be
26 needed. This might also be true for some intensive confined systems in emerging/transition countries
27 where significant environmental and health (animal and human) problems are growing.

28 While intensification typically leads eventually to commercialization and specialization in production,
29 pathways for sustainable development of the livestock sector should also be attentive to opportunities
30 to engage and retain where possible the involvement of smallholder mixed crop–livestock systems –
31 generating a lighter environmental footprint with higher positive FSN impacts as crop residue and
32 manure is re-used and water productivity is higher, while allowing for flexible use of family labour and
33 spreading of risks across a diversified range of commodities. Reducing waste and losses at the farm
34 and distribution stages of the food supply chain potentially offers a contribution to meet food demands,
35 but requires incentives and infrastructures for this to occur.

36 Scope remains in developed countries (though more limited) for sustainable intensification of existing
37 and alternative production practices that will weigh less heavily on natural assets and ease the
38 environmental burden. A number of experts (notably in Europe) suggest a return to more mixed and
39 fewer large specialized production systems to enhance the diversity of production, landscapes and
40 diets. But projections and scenario analyses show that it would be impossible for global ecosystems to
41 sustain the generalization of Western dietary patterns across the world. At the same time, more
42 diverse diets higher in plant content would enhance human health outcomes. This suggests merit in
43 encouraging some *diversification – of diets, production mix and scale* – adapted specifically to the
44 local ecosystem and social needs, opportunities and preferences, while acknowledging that large-
45 scale, intensive production will still be necessary to meet food availability requirements. More attention
46 needs to be paid to the role of often-powerful downstream sectors in the agri-food chain in respect of
47 relationships with farm suppliers and consumers. Reducing waste and loss at the consumer end of the
48 food supply chain potentially offers a source of supply towards meeting demands and possibly lower
49 food prices for the vulnerable and poor.

50 Trade has an important role to play in facilitating the supply of food at competitive prices to where it is
51 needed and to reduce the impact of seasonal and market volatility on food prices and hence FSN in all
52 its dimensions. At the same time, there are concerns about possible negative impacts through trade
53 of sudden price rises on those whose FSN depends on access to affordable food, or the effect of
54 import surges on those whose livelihoods depend on being able to sell their products in local markets.
55 Moreover, the global trading system still suffers from significant distortions caused by agricultural
56 support and protection policies that limit opportunities for producers in some (in particular developing

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1 and emerging) countries to gain access to valuable markets. The situation deteriorated further in
2 response to the 2007–2008 food price rises when a number of food-exporting countries imposed
3 export restrictions and some importing countries embraced self-sufficiency policies that have the effect
4 of raising prices (and lowering the efficiency) of food in local markets. Some confidence has been
5 rebuilt through transparency mechanisms such as the AMIS (Agricultural Market Information System)
6 initiative but more remains to be done. Debate continues on the most effective ways of enhancing
7 trade rules to support improved FSN. There is an understandable concern when food chains are long
8 and remote, agricultural and food prices are volatile, and uncertainty about the future is prevalent, to
9 resort to a reliance on local production, and shorter food supply chains, often encapsulated in the
10 notion of “food sovereignty”. But this can be a costly strategy and does not eliminate risk. Trade-offs
11 need, inevitably, to be made. Debate continues too about the extent to which exemptions should be
12 made to agricultural trade rules that restrict support measures intended to improve environmental
13 sustainability interventions that might have the effect of distorting markets. Efforts to resolve the
14 current impasse in WTO negotiations engage these issues and stronger efforts are needed to bridge
15 differences.

16 At both national and international levels, a much more determined push is needed to focus the
17 attention of states and other actors in the agri-food system on the urgency of the challenges in SAD for
18 FSN. Much evidence is available to point towards positive pathways to improved sustainability.
19 Interestingly, many of the suggested responses – for example enhanced dietary and agricultural
20 production diversity – would simultaneously have beneficial effects on agricultural development and
21 FSN. The larger challenge is to find innovative and effective ways to engage governments,
22 communities, businesses and NGOs to decide on and prioritize action.

23 **D R A F T Recommendations: Responding to critical challenges to** 24 **SAD for FSN**

25 *(This section of the report is presented now only in broad outline and will be developed further during*
26 *the next stage of drafting, in parallel with additional work on Chapter 4 - Pathways and Responses –*
27 *and in light of contributions from the open consultation)*

28 **Cross-cutting**

29 1. Governments to put in place an inclusive and evidence-based process, using the findings of this
30 report and CFS recommendations, to determine the priority issues to be considered and addressed,
31 and the way forward by all actors. This process should consider the following:

- 32 a) Engaging the attention of states and other key actors on the urgent need for transformative
33 actions to better embed SAD and FSN objectives in agricultural and related policies.
- 34 b) Highlighting the positive FSN outcomes and synergies resulting from targeted investments in
35 agricultural development, including in infrastructure, knowledge and markets; focused
36 initiatives to improve access to essential nutrients and to encourage healthier diets; and both
37 global and locally applied changes in agriculture’s interaction with the natural environment.
- 38 c) Reviewing the institutional arrangements for agriculture and nutrition policies to identify the
39 appropriate level and vehicles for policy action.
- 40 d) Revitalizing institutions to boost the effective participation of multiple stakeholders throughout
41 the agri-food chain, community groups and public authorities in the design and execution of
42 more sustainable, food and nutrition security oriented agricultural development policies,
43 including through public–private partnerships.
- 44 e) Providing the necessary institutional and financial support to the range of multistakeholder
45 partnerships that will be instrumental in supporting implementation of the SDGs
- 46 f) Addressing the need to fill critical data gaps on key areas for SAD, in an integrated way,
47 building open databases or platforms linking social, economic and environmental data on
48 sustainable agricultural development for food security and nutrition.

49 **Social**

50 2. Enhance efforts to harness the agriculture sector (and associated occupations) for development
51 opportunities that underpin livelihoods for poor and marginalized people, focusing especially on
52 the working conditions, situation and safety net needs of :

- 53 – smallholders;

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- 1 – wage workers and migrant workers;
- 2 – children and vulnerable or disadvantaged women.
- 3 3. Focus special attention on the benefits and needs of pastoralist and traditional communities in
- 4 exploring policy interventions in areas such as enforceable property rights, land access and
- 5 tenure, provision of niche products and services to society (including ecosystem services) and
- 6 explore better engagement into growing markets
- 7 4. Intensify efforts to rebuild and revitalize rural communities including through rural non-agricultural
- 8 initiatives and infrastructure enhancement.
- 9 5. Invigorate public and private institutions to engage populations, using evidence-based information
- 10 where possible, to establish acceptable policies in areas of controversy such as animal care, novel
- 11 technologies and trade-offs between competing economic, social and environmental objectives.
- 12 6. Enhance data collection and sharing on key social issues, in a gender-sensitive way, such as on
- 13 employment, especially regarding the informal sector and on working conditions.

14 **Environmental**

- 15 7. In the light of existing and projected pressures on the capacity of natural ecosystems to serve as
- 16 an adequate base for future food production and human well-being, re-set priorities to take
- 17 adequate care of challenges including:
 - 18 a) Climate change – devise policies aimed at adaptation to climate change and at mitigation by
 - 19 reduction in emission intensity and promotion of carbon sequestration.
 - 20 b) Water availability and quality – prioritize actions to improve water-use efficiency and manage
 - 21 access to groundwater in keeping with sustainable limits; establish policies to regulate and
 - 22 enforce standards on water quality including eutrophication of surface water, build up of
 - 23 nutrients and heavy metals, and degradation of rivers, lakes, coral reefs and coastal areas;
 - 24 pay particular attention in the livestock sector to intensive operations including those close to
 - 25 urban areas.
 - 26 c) Soil pollution and degradation – promote actions to reverse where possible and prevent
 - 27 further degradation including soil erosion, salinization, desertification.
 - 28 d) Loss of ecosystem benefits and biodiversity – rebuilding resilience and diversity including in
 - 29 the location, production mix and scale of agricultural enterprises, and through conserving plant
 - 30 and animal genetics *in situ* and *ex situ* and encouraging diversification of farmed crops and
 - 31 breeds.
 - 32 e) Resolving competing pressures for agricultural land and other natural resources with a view to
 - 33 preserving adequate prime arable land for food production while meeting other land-use
 - 34 needs, including to protect fragile ecosystems and support biodiversity.
 - 35 f) Incorporate wherever possible incentives (to reward public goods provision) and disincentives
 - 36 (polluter pays principle) including appropriate pricing to support sustainable use of natural
 - 37 resources.
 - 38 g) Establish or enhance environmental monitoring and reporting systems

39 **Economic**

- 40 8. Focus attention and investments on achievable actions to reduce “yield gaps” between the best
- 41 and worst performers in specific systems and locations as well as exploring scope for raising
- 42 productivity to best practice benchmarks in remote locations with similar characteristics; facilitate
- 43 investments in sustainable yield-increasing technologies.
- 44 9. Enhance data collection and availability on yields, especially on areas of major gaps, such as
- 45 grassland extent and productivity.
- 46 10. Undertake further analysis on the sustainability aspects of biofuel production, including impacts on
- 47 food security, land and water use, efficiency of production (energy out/energy in) and net
- 48 greenhouse gas effects
- 49 11. Facilitate investment in sustainable yield-increasing technologies.

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- 1 12. Improve market functioning at local, national and global levels through reducing impediments to
2 access, especially for smallholders, improving transparency and competition, especially in the face
3 of market power imbalances in food supply chains.
- 4 13. Increase farmers' access to markets, focusing especially on non-distorting measures such as
5 capacity building, credit and market infrastructure.
- 6 14. Reinforce efforts to engage the benefits of global trade in agricultural products, especially to
7 provide opportunities for developing country producers to access high-value markets, while taking
8 account of income and FSN risks in situations of volatile prices and import surges; enhance efforts
9 to establish acceptable world trade rules that give appropriate attention to FSN and SAD
10 imperatives.
- 11 15. Maximize opportunities to reduce food losses (especially in developing countries) and waste
12 (especially in developed countries) through initiatives in infrastructure, education and information,
13 and new technologies.
- 14 16. Initiatives or processes to reduce food losses and waste should be designed to ensure a level of
15 disaggregation to identify and describe problems and solutions particular to livestock products
16 (milk, meat, eggs)
- 17 17. Empower consumers to make informed decisions about their food choices and provide them
18 appropriate information in a useful format on the environmental, social and economic impacts of
19 their choices.

20 **Health and animal care**

- 21 18. Extend and prioritize actions aimed at tackling the world's most serious nutritional challenges
22 through action to:
 - 23 a) Lift the level of access of targeted interventions to reduce the incidence of undernutrition (and
24 micronutrient deficiency) including through appropriate access to animal-sourced foods (ASF).
 - 25 b) Redouble efforts to foster healthier diets including through information campaigns tailored to
26 different problems in different countries (e.g. encouraging lower consumption of ASF in some
27 populations and increased ASF consumption in populations suffering undernutrition and
28 micronutrient deficiencies)
 - 29 c) review the scope for a range of interventions including labelling(covering nutrition as well as
30 sustainability indicators) , advertising restrictions, taxes and public procurement for targeted
31 feeding programs
 - 32 d) Tackle food-borne disease challenges, especially in developing countries, with appropriate
33 technologies, information and infrastructure, to reduce the nutritional losses that impose great
34 human health and cost burdens.
 - 35 e) Increase efforts to improve analysis and indicators on malnutrition and overnutrition, in
36 particular to disaggregate data on vulnerable groups.
- 37 20. Increase efforts in animal disease surveillance and treatment, both to improve livestock sector
38 productivity and to reduce dangers associated with the spread of pests and outbreaks of animal
39 diseases and zoonoses.
- 40 21. Revisit policies, including the use of antibiotics in the livestock sector, to reduce the growing health
41 risks associated with anti-microbial resistance.
- 42 22. Give higher priority to establishing and enforcing agreed standards of animal care developed for
43 different livestock production systems and species, especially in intensive systems: include
44 financial and technical support for improved animal care in agricultural development funding
45 initiatives.

46 **Institutional**

- 47 23. Foster greater engagement of policy-makers with stakeholders in the design and implementation
48 of policies, including through public–private partnerships.
- 49 24. Increase efforts to improve analysis and indicators on malnutrition and overnutrition, in particular
50 to disaggregate data on vulnerable groups
- 51 25. Review the institutional architecture with a view to identifying the appropriate level of policy
52 intervention.

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