Introduction

This book is about the work that Wageningen University & Research centre (Wageningen UR) has been carrying out under the research programme, *Global Food Security: Scarcity and Transition* (also known as the Knowledge-base 1 programme). It tells a story about how multidisciplinary teams of scientists and action researchers have come together to better understand the global-to-local underlying processes that lead to food insecurity and how the agricultural domain can make the transition to a brighter future. One of the main intentions of the book is to raise awareness about the programme's projects, their results and implications for future action. The programme has served to strengthen the resolve and commitment of researchers within the specialised research institutes of Wageningen UR to work with the private sector, government and civil society in finding alternative pathways to enhancing food security.

The food and nutrition challenge: More sustainable production and consumption

Food is essential to the sustenance of life, but the world's food systems and natural resource base are under increasing strain to provide food for all. Food security exists 'when all people at all times have access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.' (World Food Summit 1996)[1]. It is very much linked to agricultural production as well as issues related to 'food access and use' (Wageningen UR 2013)[2]. Nutrition security refers to everyone having access to not only food, but also to health care and hygienic conditions.

For many people, having access to a safe nutritionally adequate diet on a daily basis is a challenge, making it difficult for them to lead active, healthy lives. Population growth, urbanisation, diet change, the pressure on the ecosystem and climate change are among the factors contributing to greater uncertainty about future food and nutrition security.

Food and nutrition security is therefore increasingly being addressed as a global public good, and needs to be supported for the sake of security and stability for the global population. An estimated 842 million people or 12 percent of the global population in 2011-2013 (FAO 2013)[3] suffer from chronic hunger, and 2 billion people around the globe suffer from malnutrition due to insufficient or unbalanced diets (IFPRI 2014)[4]. And although the global supply of food is sufficient to feed the population and significant gains have been made in tackling the hunger problem, considerable differences in the level of undernourished people across regions remain.

Flat-out famine is now largely confined to regions of conflict, as recently seen in Sudan and now in pockets of Syria. Most of the countries where the state of food and nutrition security is 'alarming' are in sub-Saharan Africa and South Asia, where protracted hunger crises occur and most of the world's undernourished people are found[5]. Sub-Saharan Africa has the highest level of undernourishment, with one in four people estimated to be undernourished. Sub-Saharan Africa is not expected to achieve the Millennium Development Goal (MDG) hunger target[6].

The broader food and nutrition challenges are not only confined to the developing world but also appear in high-income countries. The agricultural production base has expanded enormously over the past decades, but this has come at a human and environmental cost. Maintaining agri-food's beneficial services in the face of ever-changing economic, social, political and environmental conditions will be increasingly challenging.
Food access is not guaranteed for all consumers. An added complexity is the double burden of malnutrition, where paradoxically undernutrition coexists with the obesity epidemic[7]. Food quality and safety have sometimes been compromised, and environmental concerns have grown. Further, short-term food crises (e.g., due to extreme weather conditions or disease outbreaks) and geo-strategic positioning will appear more frequently in global markets, which will affect vulnerable food consumers and producers, partly through unbalanced trade rules that favour agricultural exporters.

Both developing and developed countries stand to gain if there is strong commitment and a willingness to work together towards developing a food system that supports more sustainable production and consumption.

Scarcity: A wake up call?

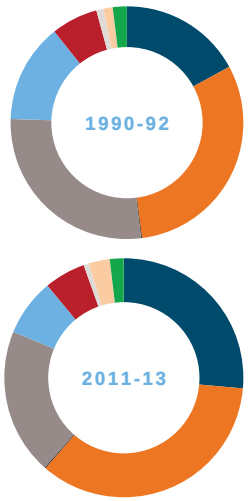
Many decision-makers are now aware of the fact that agriculture needs a strong push towards greater productivity. The most advocated pathway

Table 1 The changing distribution of hunger in the world

Number and prevalence of undernourished by region, 1990-92 and 2011-13

	Number (millions)		Prevalence (%)	
	1990-92	2011-13	1990-92	2011-13
Sub Saharan Africa	173	223	32.7	24.8
Southern Asia	314	295	25.7	16.8
Oceania	1	1	13.5	12.1
Eastern Asia	279	167	22.2	11.4
South-Eastern Asia	140	65	31.1	10.7
Latin America and the Caribbean	66	47	14.7	7.9
Caucasus and Central Asia	10	6	14.2	7.0
Western Asia and Northern Africa	13	24	5.1	6.3
Developed regions	20	16	1.7	1.3
Total	**1015**	**842**	**18.9**	**12.0**

Source: FAO, IFAD and WFP (2013) State of food insecurity in the world. Rome: FAO



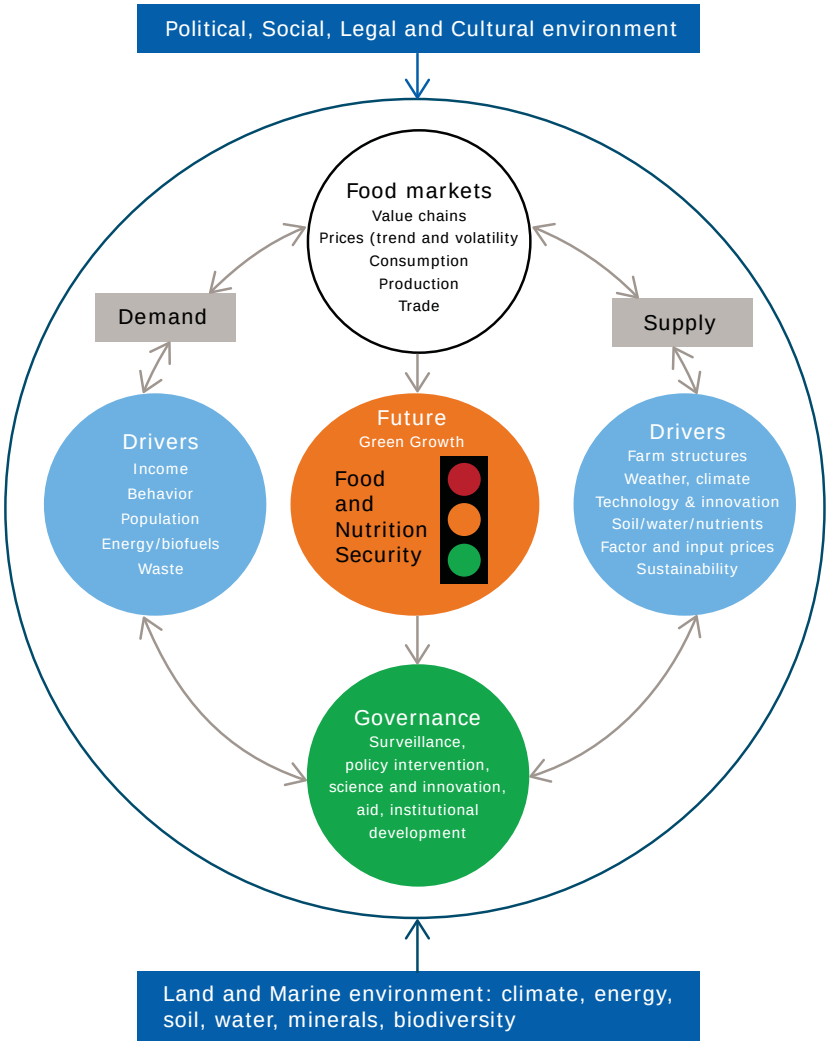


Figure 1 The broader picture

Source: Based on the FOODSECURE project

is to improve resource efficiency without increasing land area used for agriculture. This requires devising creative ways to make use of the available resources without depleting them or disrupting higher scale natural processes. A wide range of innovations will be required for a sustainable production base and for food systems to support adequate food consumption. The rising probability of market shocks may lead trading nations like the Netherlands to take action to pre-empt the risk of discontinuities in global sourcing. Sustained efforts are needed from policy-makers and the private sector to address agriculture's role in today's nexus around food security and scarcity.

Annual growth in demand for food, in terms of calories, is expected in the range of 1-2% per year until 2050 – quite comparable or even lower than what has been experienced over the past four decades (van Ittersum 2011[8]; Alexandratos and Bruinsma 2012[9]). But food systems have become very dynamic, and this adds to the challenge of sustaining the output growth that is required to meet the expanding demand. Factors affecting the demand have to do with population growth, rising affluence and changing consumption patterns, including the call for convenience or processed foods. On the production side, farmers face problems such as low productivity, extreme weather conditions, poor market access, missing markets for farm inputs, land and environmental degradation. Poverty and food insecurity have become deep-seated problems in developing countries, contributing factors include, soil depletion, nutrition insecurity, food losses and waste, and the ambiguous role of policies, land and environmental degradation, the land grab problem, climate change and the growing demand for renewable energy and biofuels. Figure 1 shows how some of these factors are inter-related.

Food prices
World food markets are increasingly interconnected, and shocks ripple swiftly through the system. For example, political instability in Ukraine, the third largest exporter of wheat, has brought some measure of uncertainty to the world's cereal markets, resulting in raised feed costs for Dutch livestock. Commodity prices have also increased, compounded by the fact that some agricultural crops are being used as a source of energy. So, in general, food prices have become more volatile. The recurrence of high prices of staple crops over the last decade have, in part, been responsible for social unrest and riots across the globe – most notably in North Africa where some autocratic governments have been toppled, giving rise to the so-called *Arab Spring*.

Land and environmental degradation
Since the middle of the 20th century, agricultural intensification with land-saving technologies has been the main engine of the growth in global farm output – between 1955 and 2005, arable land increased by around 15% whereas agricultural production tripled[10]. This has come at some cost to the environment – there is substantial degradation of land resources in many parts of the world – increasing desertification, soil erosion, salinisation and waterlogging serve to limit land productivity. Despite higher yields on land, there has been wide-scale clearing of forests over the last 40 years to make way for large, industrialised farms, which have led to a loss of biodiversity.

Land and water grabbing
While investments in agriculture are needed, large-scale acquisition of prime agricultural lands by foreign investors particularly in Africa and South America is expected to adversely affect agricultural production and food security. Land and water grabbing is a reaction to ever increasing scarcity and it is a way in which countries, communities and corporations try to secure raw materials. This is generally at the expense of local populations and small farmers who can be displaced and forced on to marginal lands to eke out a living. Strengthened land tenure systems are required, along with more comprehensive investment and research and development (R&D) policies based on local development needs. Improved governance mechanisms for natural resources will be required to address trade-offs, for example, landscape management has emerged as a new platform to address the trade-offs in public and private interests around land and water resources.

Climate change
Climate change is visible in the form of widening fluctuations in temperature and rainfall patterns. These changes are expected to hamper development processes and increase the vulnerability of already marginalised people and regions. The recent assessment report by Working Group II of the Intergovernmental Panel on Climate Change states that climate change is a threat to global food stocks, human security and will affect all sectors, regions

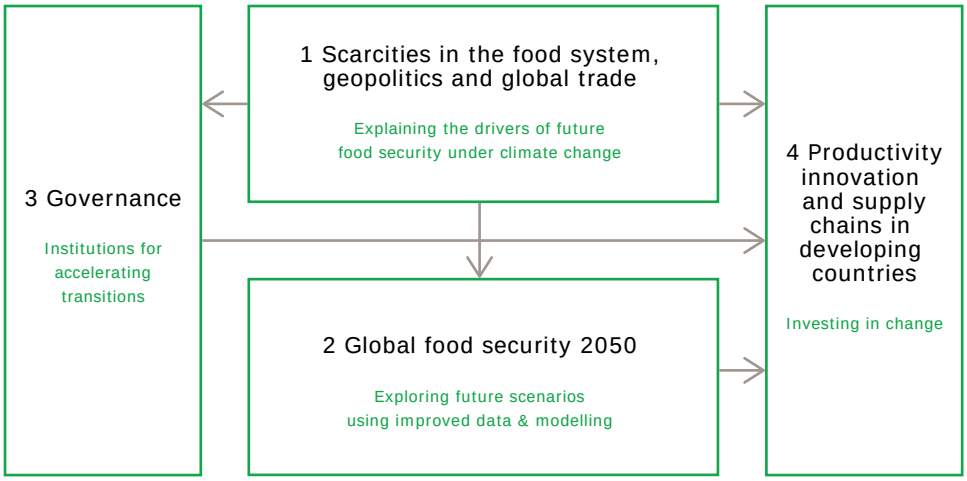


Figure 2 Global food security: Scarcity and transition research programme

and people. In Africa, the adaptive capacity of climate-sensitive sectors such as agriculture and fisheries is considered low, because of limited access to finance, knowledge, technology, and governance setting. More data and analysis are needed to examine the vulnerability of African regions and communities. Adapting to these changing conditions is inevitable. A climate-smart agriculture, combining food security and climate change goals, will be essential for future food security.

The bio-based economy

Developing bio-based economies or 'greener' economies based on bio-mass as the main raw material seems to be a plausible, even strategic alternative. According the EU's Research and Innovation and Science Commissioner, the bio-economy in the EU is worth Euro 2 trillion, and has already created 22 million jobs[11]. Nevertheless, big questions remain about the sustainability of this alternative, particularly regarding biofuels because of the large tracts of agricultural land used to grow crops for the non-food sector, and the increased pressure on land markets and forest resources that is associated with producing sugar or palm oil as a biofuel feedstock.

Urbanisation

UN projections suggest that the world's urban population will grow by more than 10 billion between 2010 and 2025, while the rural population will hardly grow at all[12]. Although the rates of urbanisation slowed down in most sub-regions of the world during the 1990s, and most metropolitan areas have not shown the expansion that was expected some decades ago, the majority of world's population is now urban. Urbanisation creates challenges for food supply because urban consumers typically consume less uniform diets and more processed food products. Also, the provision of safe and nutritious food into cities will often push transformations within the food distribution and marketing systems, and contribute to rising supermarkets and modern supply chains. Particular attention is required to ensure that local producers can benefit from the emerging market outlets.

Making the transition to a more food secure world

Although the challenges seem almost overwhelming, there is now an immense global effort involving national governments and the international community to support the agricultural sector. Following the food price hikes of 2007-2008 and 2011-2012, food security is increasingly being addressed as a global public good, which supports security and stability for the global population. The Committee on Food Security has been strengthened, and an agricultural monitoring and information system (AMIS) is now in place for greater market transparency in the face of volatile food prices and guidelines for responsible investment in land and agriculture have been tabled. There is also a renewed sense of commitment and considerable financial support has been made available to develop the sector. Concrete agreements like the Aquila Food Security Initiative (AFSI)[13] to address hunger and poverty, endorsed by 27 countries and 15 international organisations at the G8 Summit in 2009 and the Comprehensive Africa Agriculture Development Programme (CAADP)/ New Partnership for Africa's Development (NEPAD)[14] where several African governments agreed to set aside at least 10 percent of public funds to develop the agriculture sector are important steps in the right direction.

UN estimates call for an average annual net investment of US$83 billion to support expanded agricultural output in developing countries, an amount equivalent to double the current development assistance.[15] Donor governments (including the Netherlands) and governments in developing countries have focused more on leveraging investments from private companies. The private sector sector is consistently regarded a critical player in the shift from subsistence agricultural activities toward well-functioning commercial systems, where farmers can afford needed inputs and reach cash markets.[16] Private-sector engagement is also essential for 'scaling up' government-financed development projects, and for sustaining these projects after government funding is reduced or withdrawn. It has been suggested by the World Wildlife Fund that a mere 300 to 500 companies control 70% of food supply for the world's 7 billion consumers, which makes these companies major agents for change in the food system. Several companies, in particular the leading food and beverage corporations, have pledged their commitment to smallholder inclusion, sustainable sourcing and the strengthening of rural economies.

In the Netherlands, food security has become a spearhead of international cooperation in the agri-food, horticulture and propagation materials sectors and in development policy – this is intricately linked to the position the country holds as a key player in world markets, as exporter, importer and innovator. The Dutch government is therefore keen to promote a 'safe and stable world characterized by fair international relationships' (HCSS 2013)[17], by supporting global frameworks for agricultural investments, climate change and agriculture, and strengthening governance at various levels (e.g., the chairmanship of the Committee on Food Security and the various round tables for sustainable production).

In addition, the Dutch government has been facilitating companies that want to invest in agricultural development through its Private Sector Investment programme (PSI), Food Security and Sustainable Development Fund (FDOV) and its Dutch Good Growth Fund (DGGF), and its support to the Global Agriculture and Food Security Program (GAFSP) of the World Bank. Bilateral programmes on food security have been launched with China, Indonesia, Vietnam and several other countries. Through the Sustainable Trade Initiative, the government facilitates sustainable sourcing of agricultural commodities.

One particular way that the Dutch government has been strengthening food security is through the development of a knowledge environment to support decision- and policy-making in this area. For example, the government has been spearheading knowledge themes: climate smart agriculture, research alliance for greenhouse gas emissions, and the Oceans for food security conference. Substantial knowledge investments, particularly in the Consultative Group on International Agricultural Research (CGIAR), have also been made. Some of the knowledge challenges to support this transition pathway include how to: raise farm production while reducing the ecological footprint, maintain ecosystem services, develop climate-smart food systems, effectively promote good governance on the competition for scarce resources, upgrade smallholder farming systems and support innovation and upscaling successes in value chains.

The food puzzle: Finding solutions

The *Global Food Security: Scarcity and Transition* research programme, with the support of the Dutch Ministry of Economic Affairs, has been grappling with these food security issues and has been working on providing decision- and policy-makers with the 'right' tools and knowledge based on quality-assessed data to make sound decisions and formulate evidence-based policies. A primary concern of the programme has been the development of knowledge, expertise and methods that can underpin policy and action that can contribute to agricultural development and the finding of solutions to food and nutrition security. More specifically, the programme is contributing to the understanding of complexities and it is helping to make a more specific agenda for action. Special attention is being paid to countries in Africa and the role that the Dutch agri-food and horticulture sector can play in developing the agricultural sector in these countries.

The research programme comprises four main areas, focussing on concepts and theory, monitoring and data systems, and methods and modelling tools for foresight (Figure 2). One area explores geopolitical dynamics of scarce resources and climate change and how this impacts on global trade and the food system. The insights gained here support the work being carried out under Global food security 2050, where the focus is on developing an integrated framework to quantify scenarios as well as evaluate the potential effects of policies on food security.

The research programme also examines governance mechanisms aimed at improving the understanding of institutions and mechanisms for decision-making on innovation in agricultural supply chains and the upscaling of successful initiatives. The fourth area of focus has a strong international dimension, and examines agricultural production in developing countries, in particular. Key questions include: how can sustainable production systems be developed and maintained, what place is there for innovation and how to strengthen supply chains. Running themes throughout the research programme are learning and participation to support the establishment of a strong network.

An important aspect of the research programme Global Food Security is that it positions the food security debate in a unique way, where research groups form strategic alliances with the government, the private sector and local communities (in some cases) and can discuss and exchange ideas and collaborate closely in a public-private partnership (PPP). Crosscutting themes on biodiversity, climate change, and institutional change foster a multidisciplinary approach, and contribute to the understanding of complexities that can help shape transition and the creation of impact pathways to a more food secure world.

Putting the pieces together: The success stories

A concept that underpins the programme is the bringing together of science, action research and stakeholder participation to create the evidence-base for transition and change needed to solve the many food puzzles. Some of the flagship projects under the programme are briefly highlighted.

FOODSECURE addresses the question of future pathways for food and nutrition security and the role of policy in general and EU policy strategies, in particular. *More food on smaller foot* establishes sustainability thresholds for green growth with entrepreneurs in the Limpopo river basin in Southern Africa, and supports the Africa Union's CAADP agenda on agricultural development. In *Innovations and scaling*, Wageningen UR staff worked with farmers and entrepreneurs to gain valuable insights into how and when innovations can be stimulated and scaled. Each of these research efforts builds strongly on the knowledge support of the interdisciplinary research programme.

Partnerships are essential to the programme. Strong consortia have been established with other centres of excellence, particularly to work on European-funded projects. This has meant that research meets the highest standards, and that key research results are disseminated in the wider research and policy community. Programme results feed, for example, into other programmes such as the Water Agenda in Agriculture, which also dovetails into the CAADP agenda. The ability to connect different players along the knowledge is a major strength of the research programme, which has resulted in multiple public-private partnerships. Two examples illustrate this – the interest generated by the private sector and farmers in the vegetable seed project in Tanzania and partnership with Friesland Campina on the expansion of local sourcing of good quality milk in Africa and Asia, which required critical information from the programme on strengthening the services in the value chain. Other public-private partnerships under the Netherlands-African Business Council and under FDOV also benefitted from the research programme's ability to link the understanding of scientific concepts and evidence, and technical content with institutional processes.

Future action

The impact of the Global Food Security research programme is captured by the following vision:

To build the cooperation and the knowledge base that will help establish Wageningen UR as a knowledge partner in connecting global players to those at the local level, by linking basic science with action-oriented work and connecting technical work with economics and sociology – it's in the combination that Wageningen UR is strong.

Much work still remains to be done. The momentum gained from the multidisciplinary approach taken by the programme to address the many issues should be kept alive to ensure the continuation of the research agenda. Concepts and advances made by the *Global Food Security: Scarcity and Transition* programme have already had spin-off effects in terms of attracting funds for new projects under various investment facilities and subsidy programmes (e.g., the Netherlands Organisation for Scientific Research (NWO) and Horizon 2020). The scientists, action researchers and programme management team welcome the opportunity to continue collaboration with their funders, the private sector, and research community for solving the many food puzzles.

About the book

Knowledge Contributions to Solving the Food Puzzle represents an intense process of collaboration with a wide range of stakeholders. Seventeen chapters are presented under four themes. Individual chapters can be the result of more than one project. They also reflect an exciting mix of action and strategic research, which have spawned a range of perspectives and added rigour to the research. It is also important to note that some of the results presented are based on case studies, which have been used for learning and developing a conceptual framework. In other chapters, case studies have been used to test the methodologies developed. There is also an additional chapter on *Policy and partnerships* highlighting the networking role of the programme. A list of references is provided at the back of the book.

The book is aimed at all those concerned with food and nutrition security. The chapters are written in such a way so as to make them accessible to a wide range of stakeholders: funders, decision- and policy-makers, researchers and development practitioners. Each chapter can be read independently.

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Contributors

Thom Achterbosch *thom.achterbosch@wur.nl*
Karen Batjes
Jan Verhagen