The ‘Water, food, energy and ecosystem Nexus’ and Migration

An explorative study of key drivers of migration flows and their impacts

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Het rapport *'Water, food, energy and ecosystem Nexus and Migration'* brengt de eerste resultaten van het KennisBasis-onderzoek rondom dit thema samen. Doel is om beter inzicht te verkrijgen in de complexe en veelzijdige relatie tussen de Nexus en migratie. Het rapport gaat in op het conceptuele raamwerk, een analyse van mogelijke relevante modellen en tools om uiteindelijk tot potentiele strategieën, handelingsperspectieven en een gezamenlijke kennisagenda te komen voor toekomstig onderzoek rondom migratie en de Nexus.

The report 'Water, food, energy and ecosystem Nexus and Migration' brings together the first results of the Knowledge Base research on this topic. The aim is to gain better insights in the complex and multifaceted relationship between the Nexus and migration. The report dives into the conceptual framework, an analysis of possible relevant models and tools to come to potential strategies, actions perspectives and a joint knowledge agenda to come to future research about migration and the Nexus.

Keywords: Nexus, water, food, energy, ecosystem, migration, livelihood, models, tools, approach

The pdf file is free of charge and can be downloaded at https://doi.org/10.18174/507857 or via the website www.wur.nl/environmental-research (scroll down to Publications – Wageningen Environmental Research reports). Wageningen Environmental Research does not deliver printed versions of the Wageningen Environmental Research reports.

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Summary

The Knowledge Base program ‘Water, food, energy and ecosystem Nexus’ (KB Nexus) of Wageningen Research aims to better understand, describe and model the complex nexus relationships and to develop action perspectives for policy makers, companies and NGOs in the Netherlands and abroad. Part of the program and the subject of this report is to gain more insights in the complex and multifaceted relationship between the Nexus and migration. Migration is not only triggered due to conflicts, but also (slow on-set) natural disasters and by changing livelihood conditions. Nonetheless, often there seems to be a direct or indirect relationship with the Nexus. However, many questions about this relationship still remain unanswered. The focus of this report is on identifying major strands of existing work on the links between migration and the Nexus, within and outside of Wageningen University & Research, and to put forward suggestions for future research on migration by Wageningen University & Research.

The objectives of this report are: 1) Provide a common, shared conceptual framework that will ensure a consistent lens to look at the multifaceted interactions between the Nexus, conflicts and different types of migration. 2) Provide a first assessment on data, models and (participatory) tools for the use to better understand drivers and the relation Nexus and migration and prepare future forecasting/ projecting of migration at different scale levels and in different regions and 3) Putting forward a solid basis for promising strategies, interventions and future (action) research.

Chapter 2 discusses current migration trends and causes. Striking in the migration patterns are the continuous rapid growth of the number of international migrants worldwide in recent years, reaching 258 million in 2017, up from 173 million in 2000. The global emigration level rate (based on total population size) however, remained close to 3% since 1960. Most displaced persons find shelter or a new place in the region itself, while age distribution of international migrants is dominated by ages from 20 to 64 years in 2017, which represents the working age productive population. Except of Africa, all continents expect a decline in population size for the period to 2050. Specifically for Africa, a rapid increase in population is expected which, compared to other parts of the world, contains a relatively large proportion of very young people. Regarding the causes of migration, it appears that the share of extreme event migration associated with armed conflicts is small compared to regular economic and non-economic migration (9,5%, IOM 2015). Displacement due to sudden-onset disasters is not included in these numbers. In 2015 an additional 19.2 million people were displaced by natural disasters across 113 countries. Between 2008-2018 in total 227,6 million were displaced internally due to extreme natural disasters.

Chapter 3 introduces the conceptual framework for analysing migration through a nexus lens. The framework provides insight into causal relationships and feedback loops between the Nexus and migration and also takes social and spatial differences into account. Both the Nexus and migration depend highly on the scale which is at stake. It is clear that local, regional and global mechanisms between the Nexus and migration are highly interlinked. This perception of scale and processes is also relevant to link models and tools, almost every model or tool is tailored at a specific scale.

With regard to different types of migration distinguished in literature, it is important to cover all types of migration and to analyse the effects of the overall change in the number of people (departing or arriving) on food systems and the nexus in a coherent way. Still there is a huge data challenge in migration analyses. Partly because the ‘regular’ data is limited, deficient and incomplete, especially within-country population changes. To disentangle relevant drivers in different contexts, for different groups of people and different types of migration, data must be selected directly and innovative methods will be needed to empirically ground the analyses.

Traditional thinking around drivers for migration revolves around the “push-pull” model. People’s processes towards moving to another place however, are not mechanically determined by a given set

of bio-physical and economic constraints, but are based on specific social, cultural and political factors. Livelihood choices moderate a range of factors culminating in a decision to move (or not) and provides a wide range of system implications culminating from these individual or societal choices. In terms of research this means that diversity of individual and societal circumstances and choices must be taken into account, similar to the need to capture spatial or temporal variability in food systems.

Developing our own thinking while exploring existing frameworks, the conceptual framework developed by Black et al. (2011) has been adopted in this study. The framework builds on available evidence on migration to put environmental factors of migration in context with other factors of migration decisions. The framework already has earned its standing, being used in various studies of migration, and thus provides a linking pin to existing research and policy debates. It explicitly includes environmental drivers alongside other motives for migration. The five groups of drivers include: environmental, economic, social, demographic, and political. The drivers operate at different levels of people's realities: at their macro, meso, and micro environments. The existence of migration drivers however does not necessarily imply that migration will occur. International migration for example is costly and often based on good knowledge of and strong networks in the countries of destination. Not all of those who want to migrate possess such capital. Many are forced to stay, implying that increase in welfare can also lead to increased migration, illustrating the need to understand complexity of migration to ensure investments are effective.

The conceptual framework also stresses that environmental change often affects a number of drivers at the same time, for example water availability or agricultural productivity, which might lead to a loss of income. Research has proven that environmental change affects all drivers of migration in higher or lower degree. A complete analysis of migration in the nexus context must be based upon a thorough understanding of the impact of environmental change on all migration drivers and the relationships between them in different contexts.

While models assist by focusing on analyses of specific relationships, they cannot capture the real complexities that migration contexts provide. Moreover, individuals are not separated from a society, and sometimes the migration decision is based on societal reasoning more than individual ones. Political instability is a factor influencing and being influenced by environmental and nexus related factors, and it is unclear what exactly is causing the urgency to migrate. Understanding nexus and migration complexity can contribute to making targeted and effective strategies work that can release the urgent problems instead of matters that do not really count. It can assist in identifying and targeting the most urgent problems associated with migration, and if the aim is to reduce future migration, it becomes clear which investments can have the largest effects.

Chapter 4 deals with the assessment of Nexus related data and tools to understand drivers and effects of migration. It explores the usefulness of existing Nexus models used within Wageningen University & Research for studies on migration. A total of 11 models - covering aspects of climate, water and food, have been assessed for possible links with migration.

At the local level, a number of models are of interest to explain field level decision making regarding resource use. Household level income from farming, now and in the future can sometimes be brought into the picture (LINTUL, WOFOST). At the more intermediate / regional level, an optimising model like Waterwise may be interesting to make a distinction between food security at the national level and at the regional (sub-national) level, as its optimising functions can assist for this. At the global scale, LPJmL and Magnet are already in the process of being linked, and a linkage to migration seems very well possible. Resource analyses (water&food) can be made at this scale with these models. Magnet has a climate forcing module. LPJml uses various sources for this. Consistency will be required (role for RAMS/WRF). Nutrient cycles are also covered by Magnet (use of principles from BioSpacs may be considered). This can assist in identifying the link between migration flows and drivers of such migration flows when such drivers relate to the shortage of resources. The question is whether general equilibrium models can be upheld under the more extreme conditions.

In addition, Chapter 4 also discusses instruments aimed at decision-making factors within the migration mechanism and understanding the factors that promote migration. In this perspective the

VARI-App tool is discussed, the tool has been designed for interviewing migrants to ask directly what factors influence their decisions to migrate. The tool is promising for a more in-depth and highly participatory analysis of migratory decisions in the nexus context. It may be noted that the contribution of Wageningen University & Research on Nexus-Migration is currently mainly focusing on the issues of food security and water availability.

Chapter 5 discusses promising strategies, interventions and future (action) research. For the coming years a research agenda has to be further developed focusing on the relation between migration and the Nexus. First an overarching narrative on the relation between migration/extreme events and nexus is needed to be developed. Further, strategic interventions and practical solutions need to be developed and tested in hotspot areas where adapted technology approaches on food security can be experimented with. Third, different models will be linked to migration and global level analyses about changing patterns of food and water demand and supply. Fourth, individual priorities of migrants will be assessed. The Food System Approach, a unifying concept for a lot of the work of Wageningen University & Research, will be connected to migration, extreme events, climate change, localized technology needs and globalization, thus allowing to study complex phenomena and provide solutions.

Understanding food systems implies that dynamics of moving people must be understood, because different needs and demands move and operate in across localities, countries and regions. WUR has a responsibility to contribute to the Sustainable Development Goals of 2030, including among others the one on aiming for zero hunger. Promising strategies for the coming years are further elaboration of Nexus models for migration showing linkages between water use, food security and migration (meta)SWAP, WOFOST, LINTUL) and models that can assist in future scenarios (RAMS, LPJmL, Waterwise, MAGNET). Also promising is further development of the VARI-tool App for interviews in hot spot areas like Jordan. With the VARI-Tool, within country, internal migration issues can be captured, and lack of available data is not an issue because information will be selected directly. The conceptual framework developed within project shows how the complexity investigations and modelling approaches complement each other. Making use of different interdisciplinary research approaches suitable at different levels, we will focus on building the empirical base (both qualitatively and quantitatively) for elaborating the role of migration in food systems and the water-food nexus.

The overall aim of future research should be to obtain knowledge about the complex links between food security, water shortage and migration issues, in the scope of climate change. We propose to further elaborate the following objectives: a) Decide on identified hotspot areas that will be used for further investigations; b) Extend the framework with multiple fields of expertise within WUR, around food security and the water-food nexus, technologies and models, AKIS, transition pathways and the living lab approach; c) Develop, extend and combine biophysical and economic models suitable for different hotspots, and for analysing global trends; d) Develop technology concepts for sustainable food systems and water supply 'fit for food'; e) Design products in the forms of interactive sessions (i.e. designs of workshops/focus groups, online impact assessments, or online tool inviting anyone to participate), consulting with migration stakeholders to identify semi-quantitatively by means of the APP what different reasoning and priorities are among people, groups and contexts.

Gaining knowledge in the field of migration is relevant for Wageningen to position our self in the global network of migration challenges and will be demanded by international, national and local governments, entrepreneurs and business, NGO's and science partners. The Wageningen University & Research network in this field continues to expand. The Roadmap to value creation will give focus on utilization by making research findings applicable to specific users and stakeholders combined with elements of utilization by making knowledge available to the public (debate) and utilization of research results through socio-economic innovation and transition pathways. Within this direction the aim is to extend the WUR team from the different Wageningen Research institutions, as well as Wageningen University. For example, WCDI and WPR on respectively, knowledge on capacity building as well as knowledge on plant production technologies/agronomy models are essential. As such, we could maximise the societal impact and build further on a better integrative understanding and tailored solutions.

1 Introduction

1.1 The 'Water, food, energy and ecosystem Nexus' and migration

Global challenges such as growth of the world population, migration, urbanization, climate change, changes in eating patterns and economic growth are increasingly putting pressure on the demand for and supply of water, food, (sustainable) energy and resilient ecosystems. Agriculture, ecosystems, and (bio-) energy are inextricably linked via the soil-water system, also referred to as the 'Water, food, energy and ecosystem Nexus' or hereinafter: 'the Nexus'.

The Knowledge Base program 'Water, food, energy and ecosystem Nexus' (KB Nexus) of Wageningen Research aims to better understand, describe and model the complex nexus relationships and to develop an action perspective, consisting of innovative technologies and scalable (policy) concepts for policy makers, companies and NGOs in the Netherlands and abroad.

The ambition of Wageningen Research with the KB Nexus is to have:
- A substantiated <u>insight into the relationships</u> (positive and negative feedback relations) between domains in the Nexus,
- To <u>generate a set of models and tool</u> and(iii) to <u>develop technologies</u> that are a win-win for water, food, energy and ecosystems,
- To <u>gain knowledge and practical experience</u> with our customers and knowledge partners.

The KB Nexus aims to contribute to Zero Hunger by combining interdisciplinary knowledge in the agri-food and water domains to shape the transitions towards sustainable food systems. In the context of this program Food Security is defined as sufficient, safe and nutritious food for local populations. In this way relevant input will be provided for policy making in government, business, international organizations and NGOs in the fields of global food security, water management and monitoring of aquatic ecosystems, spatial planning, soil management, energy transition and climate adaptation. The KB Nexus program can thus contribute to the deployment of the Netherlands in international policy dossiers in the field of water, food security, nature and energy transition, energy and ecosystems, for investment decisions, and for research and business management in both the public and private sectors.

Large influxes or out-fluxes of people affect the size and characteristics of local populations, and thus change the challenge of achieving food security to all. Migration affects both the production part of the food system (labour force, knowledge and possible other types of capital move with people) as well as the consumption part (the number of mouths to be fed in a specific location and their purchasing power). At the same time migration decisions are (in part) determined by the performance of local food systems. Migration thus needs to be considered when studying the transition of the food system.

Migration can be a direct response to extreme events with fast onset – and is then categorised as environmental emergency migration. Other categories of migration are referred to as internal (i.e. national) or cross-border (i.e. international) environmentally forced or motivated migration. The environmentally forced migration can be caused by the same drivers as for the extreme events although with slow onsets, and motivated migration are caused by slow onsets and mixed motives. For example, people may move to low lying coastal cities due to structural pressure on the local food system (slow onsets) in rural areas and may as well search for improved working opportunities and livelihood (mixed motives).

Migration is a complex societal issue, currently and most likely in the future as well. The relationship between the Nexus and migration is complex and multifaceted. Migration is not only triggered due to conflicts, but also (slow on-set) natural disasters and, last but not least, by changing livelihood conditions. Nonetheless, often there seems to be a direct or indirect relationship with the Nexus. However, many questions about this relationship still remain unanswered.

At the same time, due to the humanitarian and other effects of migration streams, the national and international attention and demand for effective (and timely) interventions is growing.

1.2 Towards common understanding and future actions

The focus of our research on the relation between migration and the Nexus has been on identifying major strands of existing work on: 1) the links between migration and the Nexus (within and outside of WUR) and 2) the scope for future research on migration by WUR.

The main research question in this report is:

- What is the relationship between the Nexus and migration and how do they influence each other?

Questions that are linked to this main question are:

- How can we use existing modelling of the Nexus to assist timely in interventions?
- Where can we expect migration flows, how will this affect this people and where and how should we intervene?

In this report, we present the main results. We have developed more clear insights in the relationship between migration and the Nexus and the relevant aspects. An important task is to explore the link between existing Nexus models and migration and vice versa. Based on the relevant aspects we have assessed models, tools and data which could form a basis for predicting the chance of conflicts or disturbances (in the Nexus) that could lead to migration. Finally, we put forward clear suggestions for future action research.

1.3 Objectives

In the perspective of the problem statement and challenges mentioned above, this report aims to:

- Provide a common, shared ***conceptual framework*** that will ensure a consistent lens to look at the multifaceted interactions between the Nexus, conflicts and migration. The different types of migration: ranging from internally displacement, to regional or international refugees; voluntary and non-voluntary – will be taken into account to assist different relationships and strategies. Within this framework more insights are given about the ***key drivers*** of (the different forms of) migration, and the relation with the nexus; from the perspective of different actors
- Provide a first assessment on **data, models and (participatory) tools** for the use to better understand drivers and the relation Nexus and migration and prepare future forecasting/projecting, at different levels, from global to local and in different regions
- Putting forward a solid ***basis for promising strategies, interventions and future (action) research***

As such, it will:

- Contribute to the (inter)national strategy for managing migration and reducing conflicts
- Strengthen the unique selling point of the Nexus for Wageningen Research
- Valorise and extend existing knowledge based on clear assessment and gap analysis
- Guide more evidence-based decision making and better targeted and more effective interventions for the Netherlands in international perspective and add societal benefits in the areas of origin and the areas of destination.

2 Current migration trends and causes

2.1 Introduction

To start with, it is important to have a good look at all the figures that are available on current migration trends and patterns. Therefore, we present an overview of global migration patterns based on different sources from the literature.

2.2 Global migration patterns

The number of international migrants worldwide has continued to grow rapidly in recent years, reaching 258 million in 2017, up from 173 million in 2000 (Figure 1). Over 60% of all international migrants live in Asia (about 80 million) or Europe (78 million). Migration relative to the population of destination countries, are about 4% in Latin America and the Caribbean (world minimum), 11% in Europe, and 21% in Oceania (world maximum). North America hosted the third largest number of international migrants (58 million), followed by Africa (25 million), Latin America and the Caribbean (10 million) and Oceania (8 million) (Figure 2).

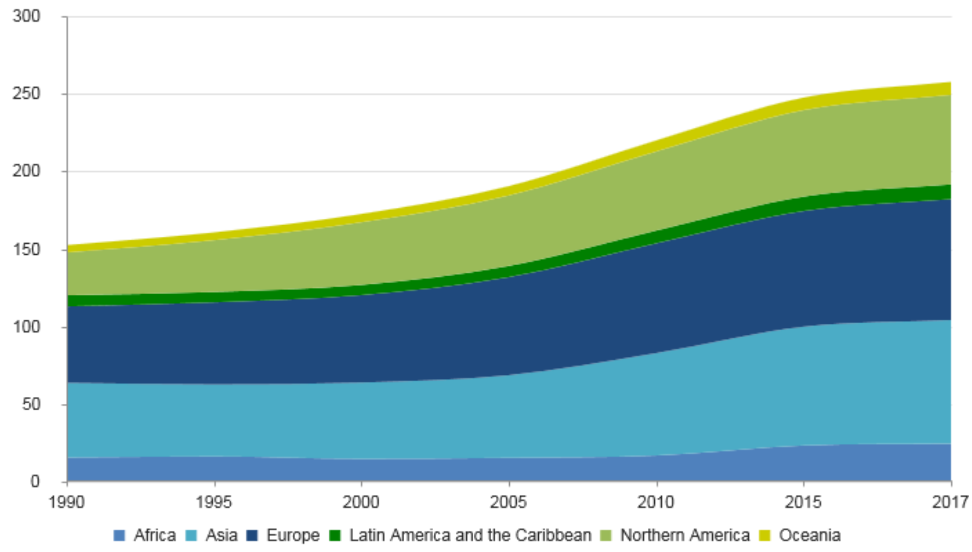

Figure 1 *Number of international migrants by major area of destination.*
Source: UN DESA, 2017 Migration Report.

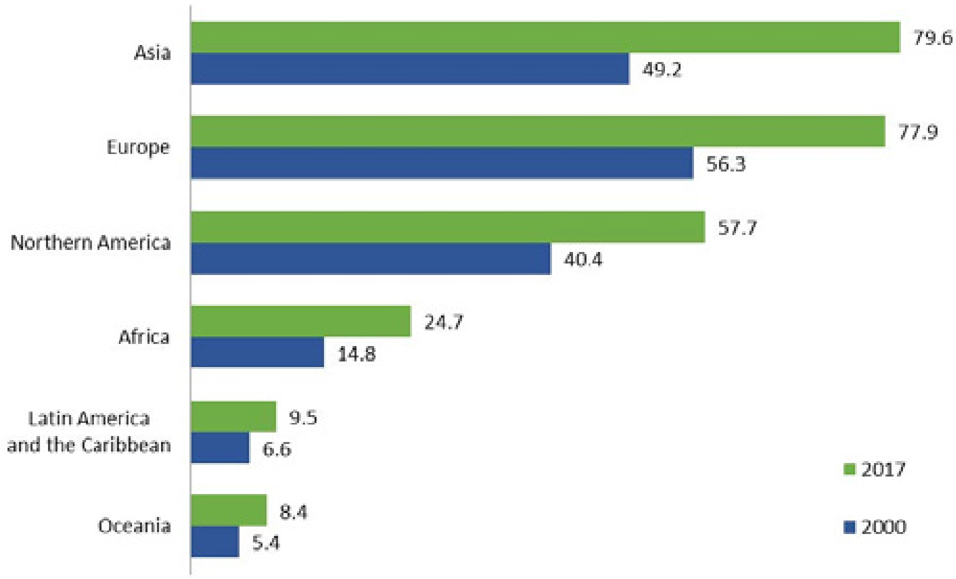

Figure 2 *Number of international migrants (millions) by region of destination, 2000 and 2017. Source: UN DESA, 2017 Migration Report.*

The increase in the migrant populations in countries of destination was mirrored by the increase observed in absolute number of emigrants in countries of origin (Figure 4 and 5). Note, however, that in relative terms (as percentage of the population of origin), the level of global emigration remained close to 3% ever since 1960 (Figure 3).

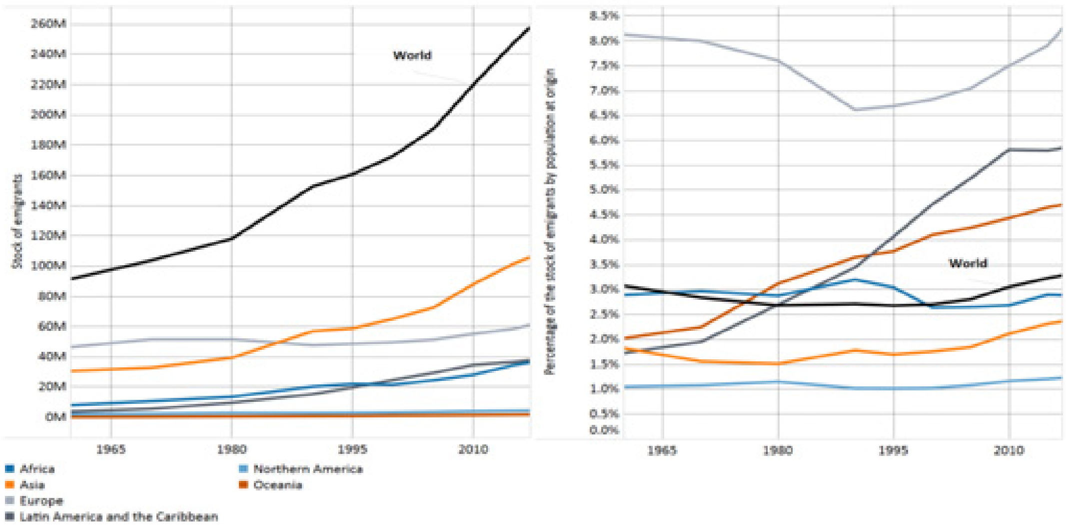

Figure 3 *Evolution of the stock of emigrants by continent of origin. In absolute numbers (left) and as percentage of the population of origin (right).*
Source: Migali et al. (2018). Based on migration stocks, UNDESA and World Bank.

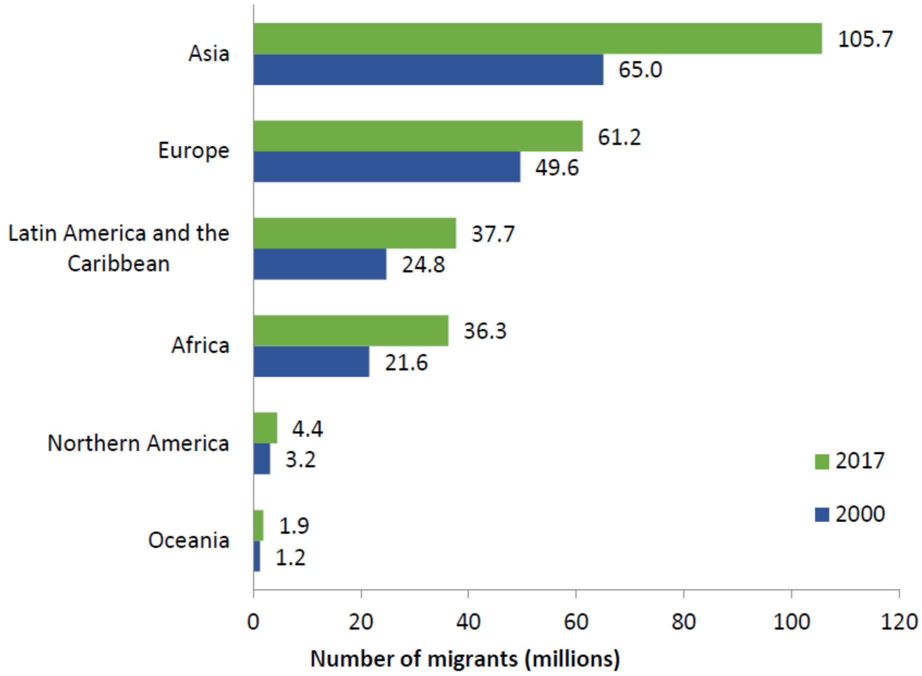

Figure 4 *Number of international migrants (millions) by region of origin, 2000 and 2017. Source: UN DESA, 2017 Migration Report.*

The stable 3% global emigration level rate is explained by the world population growth that reached 7.6 billion in 2017, up from 6.1 billion in 2000 (UNDESA, World Population Prospects 2017), capturing the increase in absolute numbers of migrants.

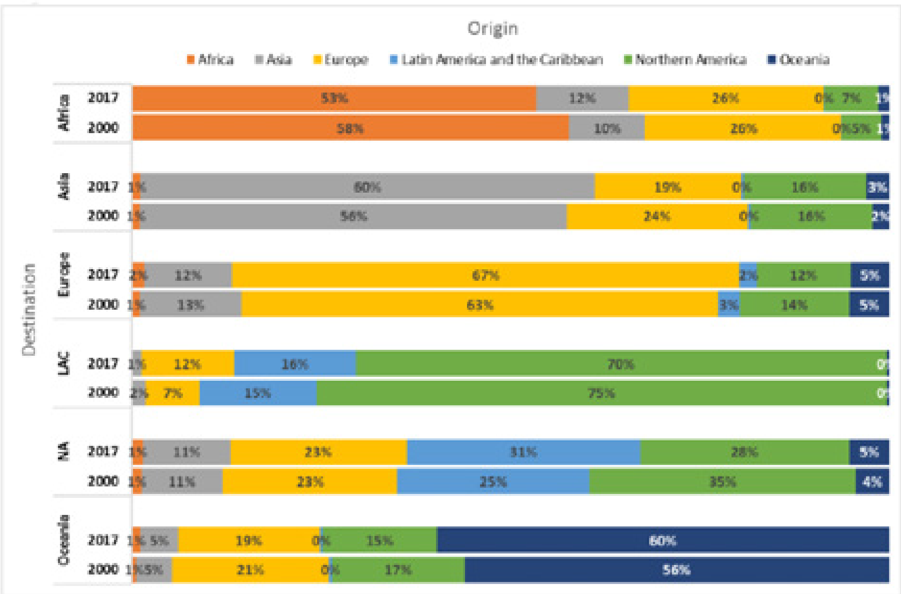

Figure 5 *Distribution of international migrants (millions) by region of destination and origin. Source: UN DESA, 2017 Migration Report.*

The detailed distribution of origin of international migration in destination countries (Figure 6) further adds that European migrants were the largest group (67%) of migrants with destination in Europe, and Asian migrants made up a majority (60%) of migrants with destination in Asia in 2017. The origin of international migrants in North America was dominated by three groups: Europe (23%), Latin America and the Caribbean (31%), and Oceania (28%).

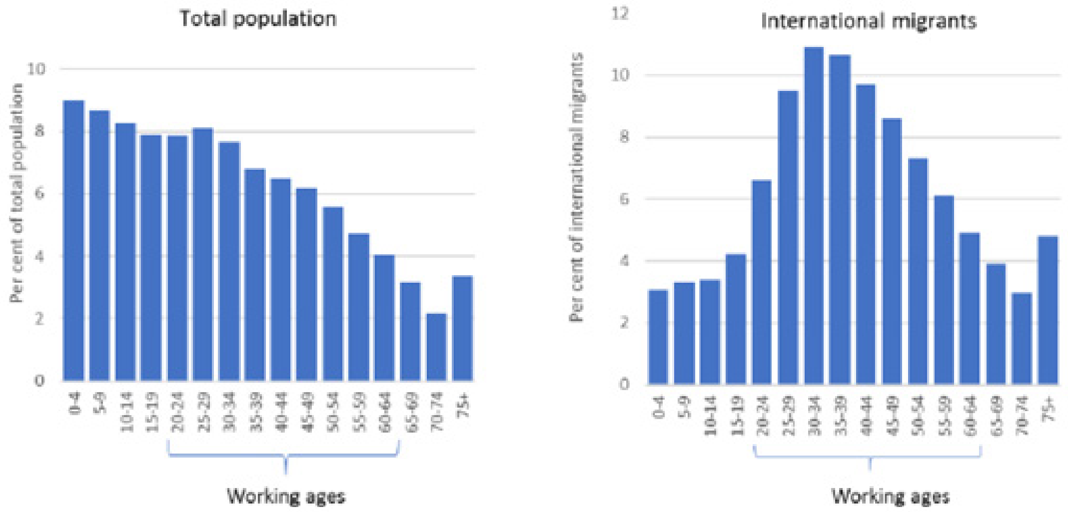

Figure 6 *Age distribution of the total population and of international migrants worldwide, 2017. Source: UN DESA, 2017 Migration Report.*

Age distribution of international migrants was dominated by ages from 20 to 64 years in 2017, which represents the working age productive population (Figure 6). This relatively young age of international migrants compared with settled populations, at least in Europe, can play an important role to support aging populations. The proportion of older persons has been increasing worldwide over time due to higher life expectancy and declining fertility rates. Europe's population is predicted to start shrinking in the near future at current trends in fertility, mortality and migration (Figure 7). Except of Africa, all continents expect a decline in population size. In contrast, Africa expects rapid increase in population size that contains a relatively large share of very young people compared with other parts of the world (Figure 7).

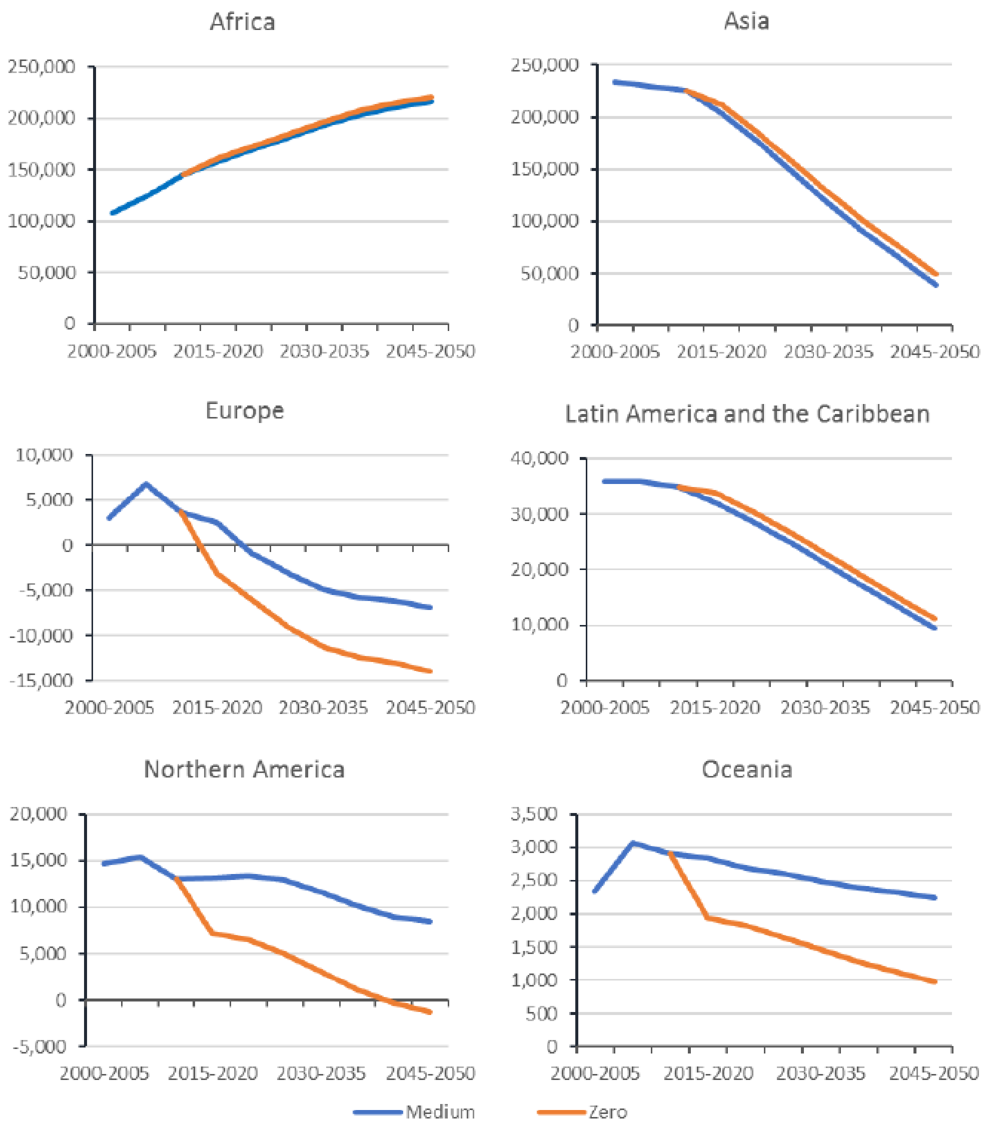

Figure 7 *Estimated and projected change in total population over five-year time periods by region from 2000 to 2050, with and without international migration starting in 2015 (in thousands). Source: UN DESA, 2017 Migration Report.*

Globally, the number of persons aged 60 or above is expected to more than double by 2050 and more than triple by 2100. The world's population aged 60 years amounted 962 million in 2017 and is projected to increase to 2.1 billion in 2050 (UNDESA, World Population Aging Report 2017). The global median age, the age at which half the population is older and half is younger, is projected to increase from 30 to 36 years between 2015 and 2050, especially in the more developed regions, where it is projected to increase from 41 years in 2015 to 45 years in 2050. In the less developed regions, it is projected to rise from 28 years in 2015 to 35 years in 2050.

2.3 Causes of migration

The share of (international) extreme event migration associated with armed conflicts (refugees and asylum seekers) is small compared with the regular economic and non-economic migration (roughly 9.5%; IOM, 2015). In 2015, 65.3 million individuals were forcibly displaced worldwide due to persecution, conflict, generalized violence, or human rights violations. This includes 21.3 million refugees, 40.8 million internally displaced people (IDPs) and 3.2 million asylum-seekers. An additional 19.2 million displaced by natural disasters across 113 countries during 2015 (a number based on flow data and therefore not comparable with the stock figures) is not included in the number (ibid).

In 2017, 18.8 million people were newly displaced in the context of sudden-onset disasters within their own country. A total of 135 countries were affected. In 2017, displacement has been caused primarily by extreme weather events, especially flooding (8.6 million) and storms (7.5 million). Particularly devastating were hurricanes Harvey, Irma and Maria in the Atlantic and the Caribbean, and a series of typhoons in South and East Asia and the Pacific. In particular, China, the Philippines and Cuba recorded the highest numbers of disaster displacements in 2017. (IDMC, 2018).

The Internal Displacement Monitoring Centre (IDMC) records that worldwide, over a period of nine years (2008-2016), about 227.6 million people were displaced internally in response to disasters (Figure 9). South and East Asia, the Caribbean and the Pacific were the most affected regions. (IDMC, 2017).

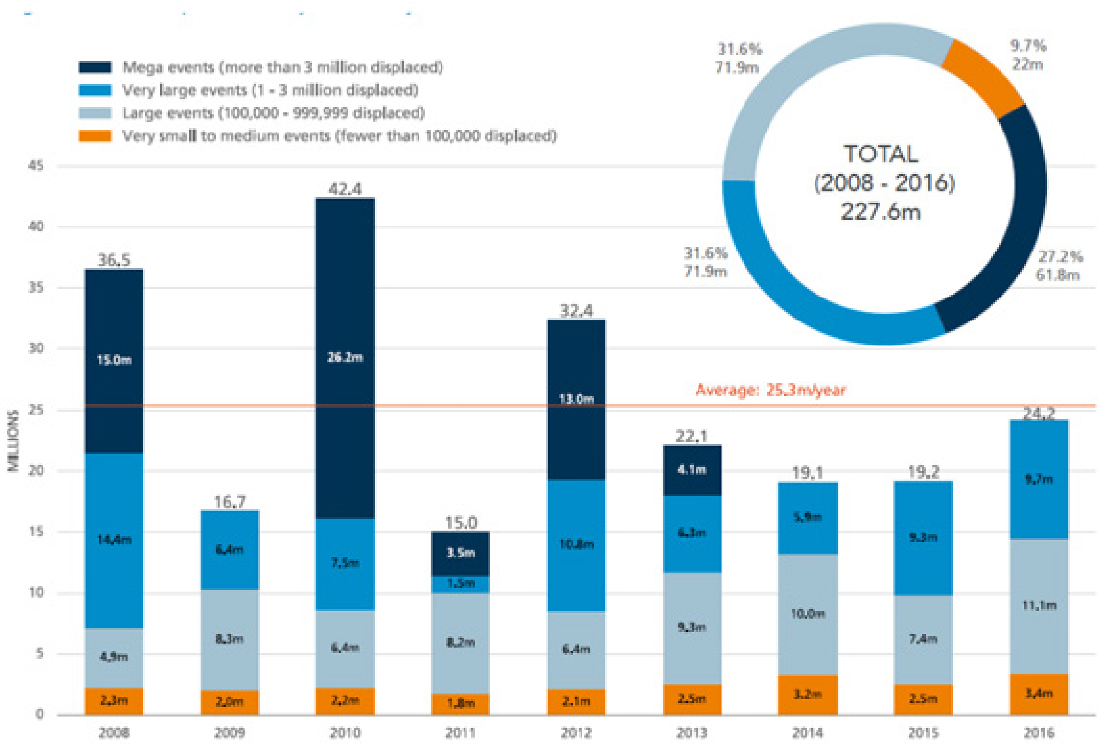

Figure 8 *New annual displacements by disasters by scale of events.*
Source: IDMC (2017).

2.4 Conclusion

To conclude, the most important insights in relevant trends and patterns in migration are:

- The actual number of displaced people is increasing rapidly up to 258 million in 2017 from 173 million in 2000
- The global emigration level rate (based on total population size) however, remained close to 3% since 1960
- Most displaced persons find shelter or a new place in the region itself
- Age distribution of international migrants was dominated by ages from 20 to 64 years in 2017, which represents the working age productive population
- Except of Africa, all continents expect a decline in population size for the period 2015-2050. Africa expects rapid increase in population size that, compared with other parts of the world, contains a relatively large share of very young people
- The share of extreme event migration associated with armed conflicts is small compared to regular economic and non-economic migration (9,5%, IOM 2015)
- Displacement due to sudden-onset disasters is not included in these numbers. In 2015 an additional 19.2 million people were displaced by natural disasters across 113 countries. Between 2008-2018 in total 227,6 million were displaced internally due to extreme natural disasters

3 Conceptual framework for analysing migration through a nexus lens

3.1 Introduction

The starting point to strengthen the knowledge base on the complex relationship of the Nexus and migration is the development of a common shared conceptual framework. A framework that provides insight into causal relationships and feedback loops between the Nexus and migration, and that takes social and spatial differences into account. This chapter is devoted to the formulation of this conceptual framework for the analysis of drivers and effects of migration and their relations with nexus.

3.2 Contribution of migration to food security and the water-food nexus

Both the Nexus and migration depend highly on the scale which is at stake. Often migration decisions are made at the very local scale but come forward from bigger changes and drivers at a larger scale (meso-level/regional). The effects of migration, both in areas of origin as in areas of destination, are also evident at the meso level, but will also influence the local scale directly. These effects will also drive migration or non-migration decisions at their turn. All together this leads to global migration patterns, which could be connected to global (environmental) changes. Hence, every global shift will also cause impact at the regional scale, and in the end the local scale. To conclude, local, regional and global mechanisms between the Nexus and migration are highly interlinked.

The feedback loops between the different scales are visualised in Figure 10. This perception of scale and processes is also relevant to link the models and tools. Hence, almost every model or tool is tailored at a specific scale.

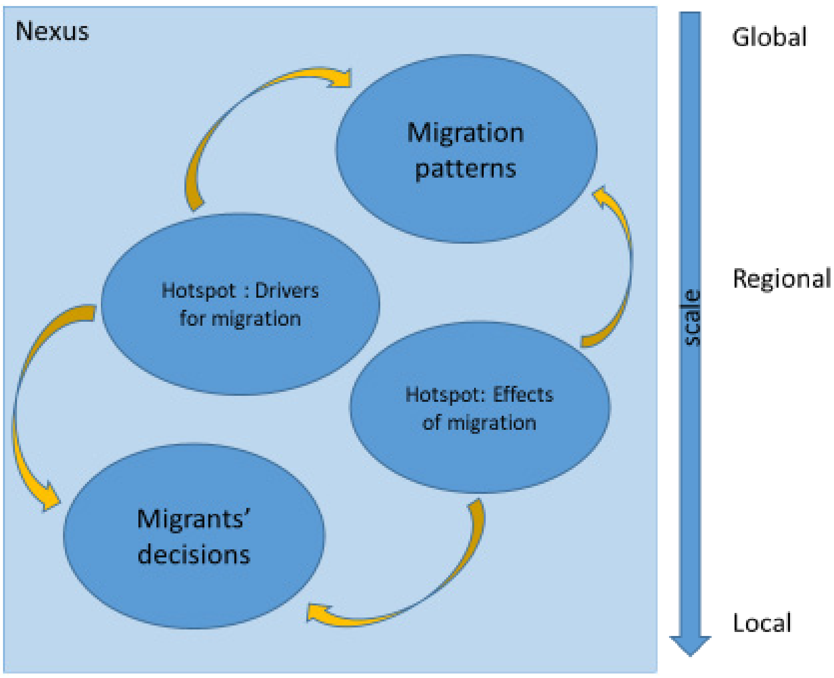

Figure 10 *Feedback loops Nexus and migration.*

3.3 Migration types relevant for the scope and focus

With migration being a hot political topic, a strong legally inspired set of definitions have evolved which do not always match commonly used language. For example, terms like refugees and internally displaced people are reserved for people fleeing violent conflict or persecution across borders (**refugees**) or within a country (**internally displace people**). To connect with and frame this research in the scope of ongoing debates, an internationally recognized definition of migration is needed. This research takes a two-fold approach.

First, when studying the impact of the water-food nexus on migration decision, a focus on **environmental migrants** is taken as defined by the International Organisation for Migration (IOM) covering three types of nexus-based motivations:
- Environmental **emergency** migrants,
- Environmentally **forced** migrants and
- Environmentally **motivated** migrants.

This distinction illustrates varying scope of agency - fleeing a life-threatening environmental disaster as an emergency migrant leaves little room for other motivations. There is also a temporal factor associated with these three types of migration. Whereas emergency- and forced migrants are associated with sudden extreme events, environmentally motivated migration is a less visible process of change, in which perceived opportunities for a future livelihood play a key role, more than any environmental factors.

Second, when analysing the impacts of migration at a larger scale, however, the definition of environmental migrants does not account for all migrants including refugees and internally displaced people. This research intends to also address this wide spectre of migration to analyse the impacts of **overall change in number of people (leaving or arriving) on food systems and the nexus.** When studying the impacts of migration on the Nexus in sending or receiving destinations we thus account for all types of migration. Trends and patterns discussed in section 2.1 remain highly relevant to such impacts.

People move for different reasons and to different places. There is a huge data challenge in migration analyses, partly because the 'regular' data is limited, deficient and incomplete, especially within-country population changes. Notably, statistical data is available on cross-border movements, while migration in less developed countries, such as many countries in Africa, are not captured at all. African migration includes short distance, local movements within countries, as well as within regions. The movements often comprise temporary migration, such as for example circular and seasonal migration, or chain migration[1]. Only in-depth analyses of carefully designed case studies can provide insights in these migration patterns.

Regarding recent trends in environmental migration some data exists, even though this data is far from being complete and comparable with stock data discussed in the previous section. Environmental migration is reported based on migration flow records, i.e. the actual migration streams occurring at a given time and with a given space. In such cases, time and geographic units are not defined according to any standardized definitions but are related to the events that caused the flows. The flow data relate only to newly displaced persons, who in a majority are temporary migrants and most of them return to home after the disaster is over. Most commonly, the flows comprise internal migrants, and only exceptionally report on cross-border movements. The flow data cannot be compared with the stock data.

[1] Originally chain migration refers to a process in which initial movements of migrants lead to further movements from the same area to the same area. In a chain migration system, individual members of a community migrate and then encourage or assist further movements of migration. Chain migration may also be based on ethnic or family ties with members of the same family migrating at different times, usually with primary wage earners migrating first, followed by secondary or non-wage earners. In countries with more or less liberal regulations on the rights of migrants to family reunification usually in accordance with international conventions, family reunification as an incidence of chain migration explains much of the growth in the total migrant population.

The exact motives (and their relation to other motivations) of migrants are not systematically registered. To disentangle relevant drivers in different contexts, for different groups of people and at different time scales for the environmental migration, as well as for the refugees and the internally displaced people, data must therefore be selected directly. Innovative methods will thus be needed to empirically ground the analyses.

3.4 Drivers of migration in areas of origin and destination

Traditional thinking around migration revolves around the "push-pull" model where factors either push people out (e.g. environmental degradation lowering food production, poverty) or pull people towards other places (e.g. better production circumstances, better jobs). While this thinking fits nicely to the modelling traditions in both the bio-physical and economic domains it ignores the agency of people. People's processes towards moving to another place, are not mechanically determined by a given set of bio-physical and economic constraints, but based on specific social, cultural and political factors. Migration decisions thus need to be analysed by understanding processes with influencing factors to reasoning of, and decisions to, move to other locations. This could be part of a household or livelihood context.

Figure 11 summarizes how agency or livelihood choices moderate a range of factors culminating in a decision to move (or not) and shortly provides a wide range of system implications culminating from these individual or societal choices. In terms of research this means accounting for the **diversity of individual and societal circumstances and choices**, similar to the need to capture spatial or temporal variability in food systems.

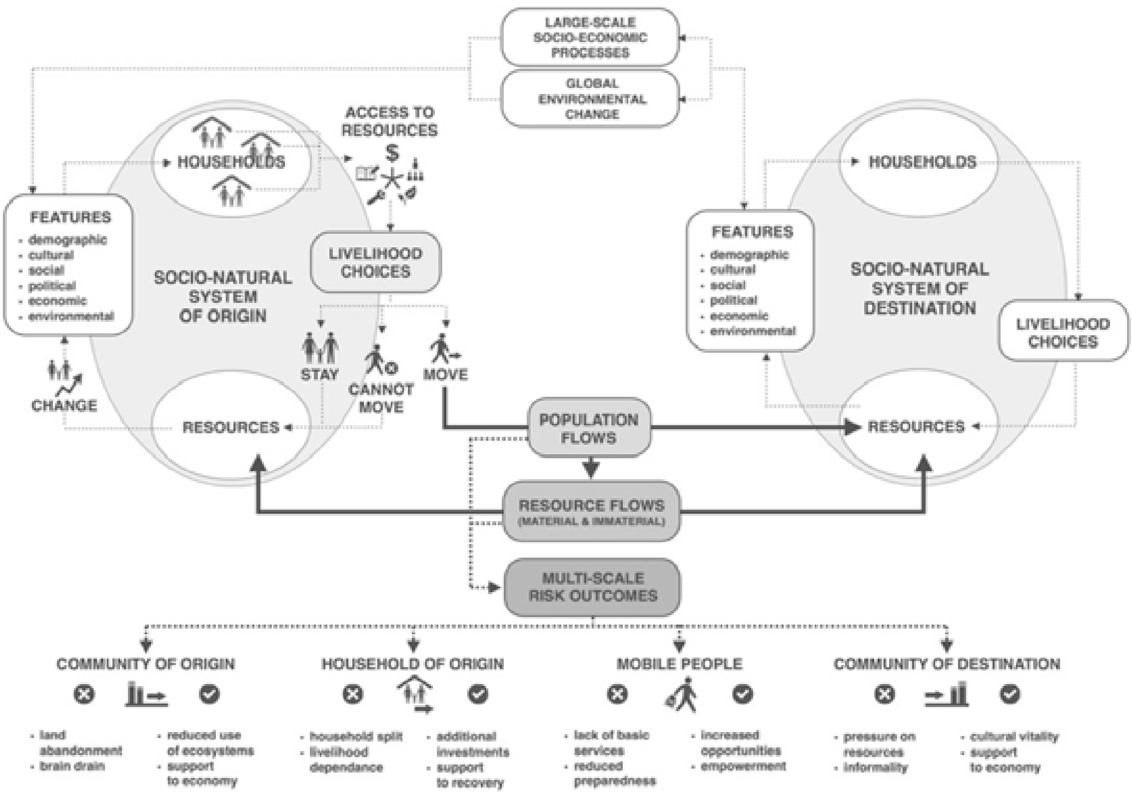

Figure 11 *Livelihood choices moderating the decision to move.*
Source: Figure 2.1 (p17) in Guadagno (2017).

The environmental nexus is often paralleled by a plethora of other factors, such as poor socio-economic development, political instability, race, religious or ethnic discrimination, bad governance, corruption of power structures, limited or lacking financial institutions etc. All these political instability factors are not only recognized drivers of migration, but also highly relevant for the functioning of (local)) food systems and the scope for interventions. Accounting for this complexity as part of a migration analyses, will contribute to a broader understanding of food systems functioning and development.

3.5 Conceptual framework for analyzing migration through a nexus lens

A conceptual framework serves to delineate the boundaries of the analysis and the interdependencies between different parts. Developing our own thinking while exploring already available frameworks, the conceptual framework developed by Black et al. (2011) is adopted in this research. This framework builds on available evidence on migration to place environmental drivers of migration in context with other drivers of migration decisions (Figure 12).

The framework already has earned its standing, being used in various studies of migration, and thus provides a linking pin to existing research and policy debates. It explicitly includes **environmental drivers alongside other motives for migration**. The five groups of drivers include: environmental, economic, social, demographic, and political. The drivers operate at different levels of people's realities: at their macro, meso, and micro environments. People are exposed to the actual facts, but being part of societal operations of drivers, individual perceptions are formed based these forces. The facts and perceptions, together with individual characteristics of persons and their households, and a number of intervening factors in the closest environments of the potential migrants jointly create mechanisms leading to a migration decision or the lack thereof. Thus, the existence of migration drivers does not necessarily imply that migration will occur. As a matter of fact, substantial resources; social, economic, human and other, may be required to enable people to migrate, especially internationally. International migration is costly and often based on good knowledge of and strong networks in the countries of destination. Not all of those who want to migrate possess such capital. Many are forced to stay, implying that increase in welfare can also lead to increased migration, illustrating the need to understand complexity of migration to ensure investments are effective.

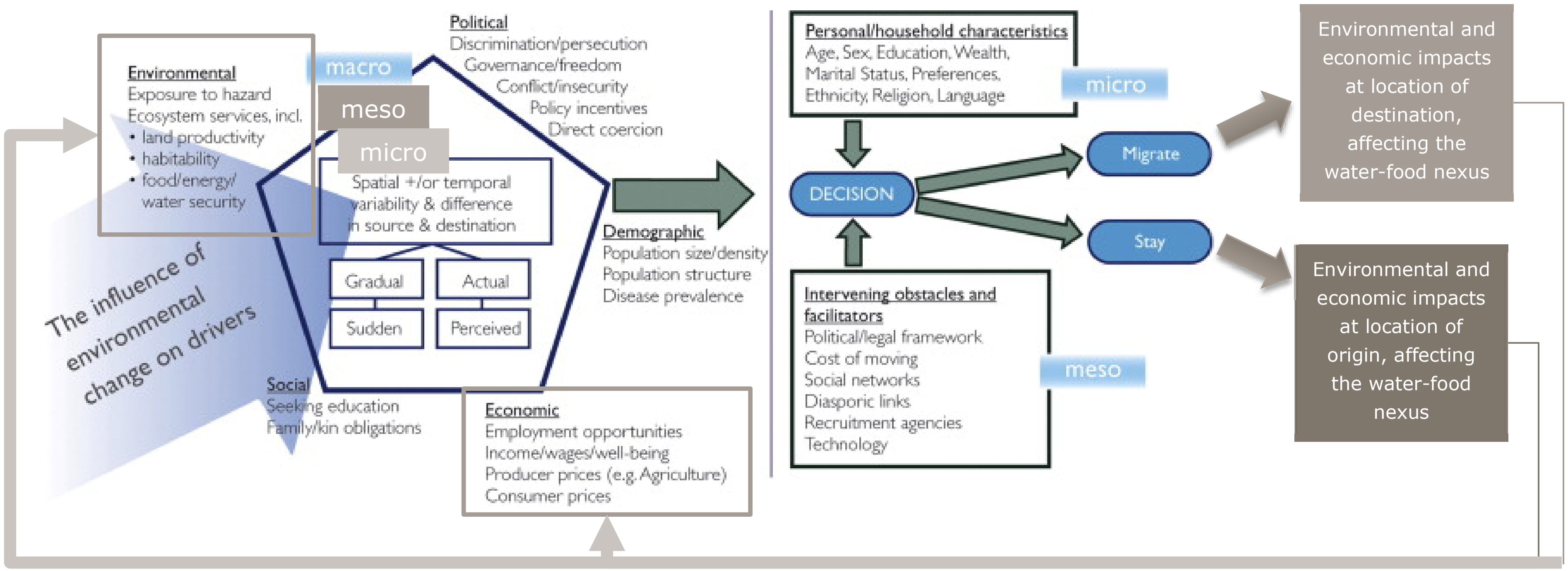

Figure 12 *Conceptual framework of the drivers of migration (macro-, meso- and micro-factors) with added feedback from environmental changes in sending and receiving destinations.*

Source: adapted from figure 2 in Black et al. (2011).

The conceptual framework in Figure 12 also stresses that environmental change often affects a driver or a number of drivers at the same time, for example water availability or agricultural productivity, which might lead to a loss of income. Research has proven that environmental change affects all drivers of migration in higher or lower degree. Figure 13 summarizes the relative influence of the environmental change on migration drivers, which is based on opinions collected from 350 world experts from 30 countries invited by the British government to a project called 2011 Foresight. A series of workshops, reviews, discussions, and contracted papers served to establish the schematic diagram. The experts represented diverse disciplines including geography, migration studies, climate science, anthropology, economics and international politics. The knowledge they brought into the project provided a broad, global perspective to both the project and its report.

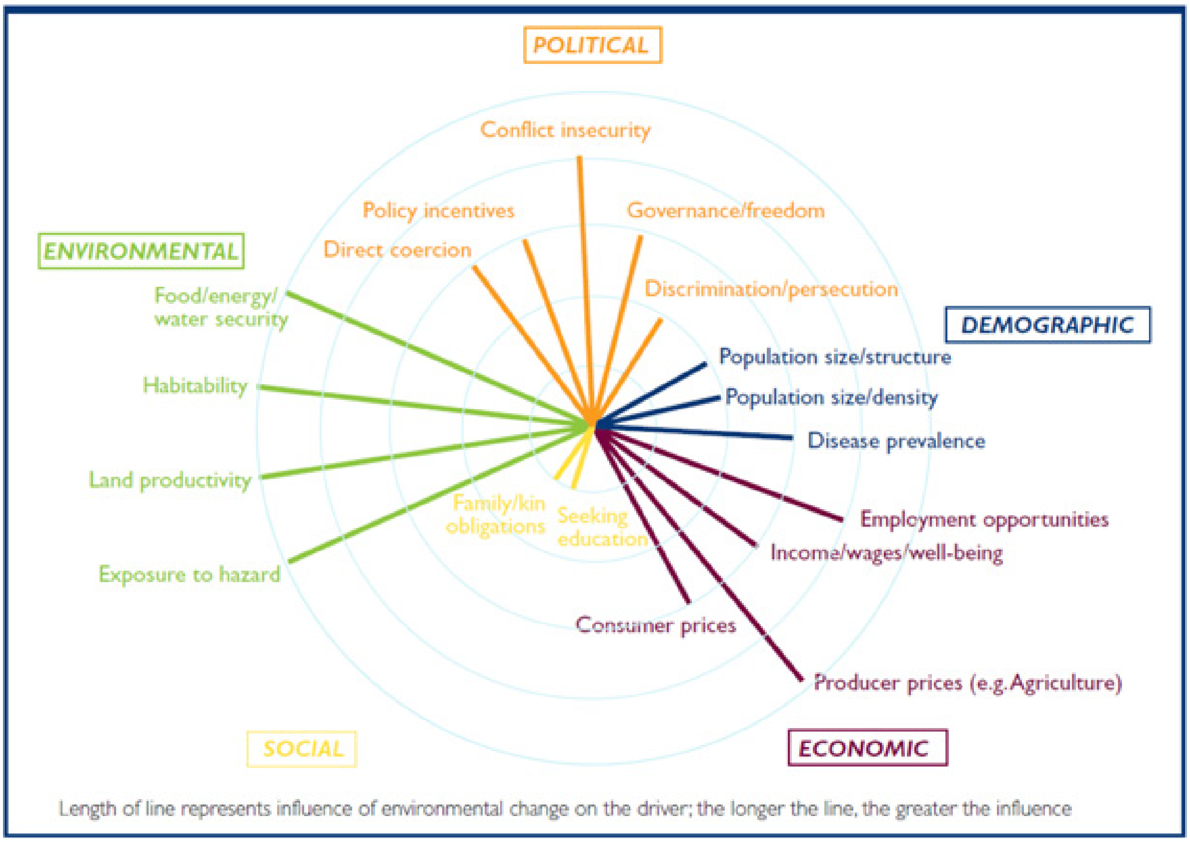

Figure 13 *The relative influences of environmental change on the drivers of migration.*
Source: Foresight (2011).

Given the reasoning of Foresight (2011), the schematic diagram suggests that it is most likely that environmental and economic drivers of migration will be influenced by environmental change; notably, producers prices and employment opportunities in agriculture are the second most affected. Moreover, it is suggested that social and demographic drivers are the least likely to be influenced, and political drivers are somewhere between these poles.

Obviously, this suggested pattern will not be true for every local context, as drivers will differ among contexts and groups of people. Moreover, there is a complex important interaction between social and demographic drivers and environmental drivers in the nexus analyses of migration. A complete analysis of migration in the nexus context must be based upon a thorough understanding of the impact of environmental change on all migration drivers and the relationships between them in different contexts.

3.6 Migratory decisions in the nexus context

As mentioned above, complex interlinkages among different nexus related drivers that influence migration cannot be captured by existing nexus related models and available datasets, although particular issues can. In other words, while models assist by focusing on analyses of specific relationships, they cannot capture the real complexities that migration contexts provide. Understanding complexity can be about understanding differences in perceptions within and across locations and groups. Decision making leading to migration (or not) is complex when occurring as a matter of processes with multiple factors influencing each other and over time. Moreover, individuals are not separated from a society, and sometimes the migration decision is based on societal reasoning more than individual ones. Political instability is a factor influencing and being influenced by environmental and nexus related factors, and it is unclear what exactly is causing the urgency to migrate. Understanding nexus and migration complexity can contribute to making targeted and effective strategies work that can release the urgent problems instead of matters that do not really count. Such understanding can thus assist in identifying and targeting the most urgent problems associated with migration, and if aim is to reduce future migration, it becomes clear which investments can have the largest effects.

3.7 Integration of the analysis at global, regional, and individual levels

Migration is as topical as it is politicized. Adding a scientifically grounded perspective on migration firmly rooted in the core expertise around food security and the water food nexus is a valuable aim in itself, aligned with the ambition to make a positive contribution to society. Expertise that can contribute to analysing migration at the global, hotspot regional, and local levels from a nexus angle is needed. This implies investigation of:

- Global trends of demands and supply and needs for food given migration,
- Impacts on nexus drivers and effects at hotspot levels, as well as
- Complexity to understand reasoning for migrating in different contexts and among different groups of people.

4 Assessment of nexus related data and tools to understand drivers and effects of migration

4.1 Introduction: relevant expertise for nexus food and water security related migration

An important task of this Nexus Migration project is to explore the link between existing nexus models and migration and vice versa. The complex problem of migration seems to be linked to resource use (e.g. water, energy and food related) and drivers on those resource use (e.g. climate change). Therefore, it seems relevant to use nexus models to see whether these can be linked. The nexus models focus on different scale levels from local to regional and global. To address specific migration issues, nexus model results at the appropriate scale are necessary: local level decision making regarding migration is different from global flows of migrants. The figure below (Figure 14) illustrates this.

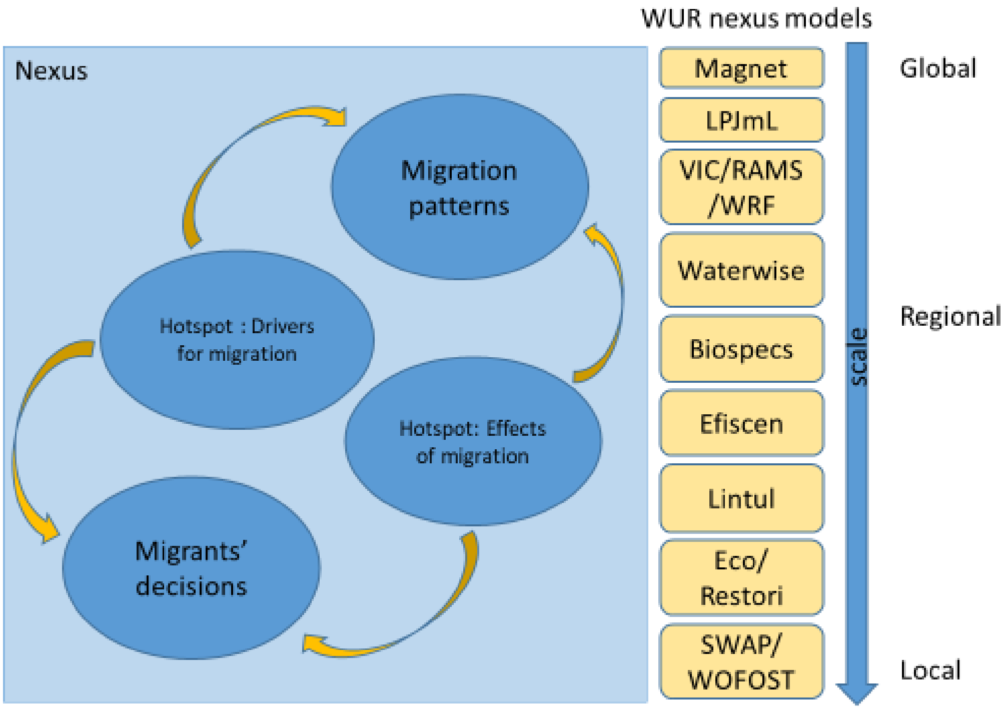

Figure 14 *Levels to address migration and the Nexus, linked to Nexus related models.*

Both for nexus models as well as for migration, this element of scale is an important aspect. For nexus related modelling, global, regional and local or field level scales are used. For hydrological modelling usually catchments (or sub catchments) or river basins are used. Both can be transboundary, i.e. including more than 1 country. For migration, the general pattern is from poor countries to rich countries, further compounded by lack of resources and drivers affecting resources. Patterns can be assessed at global level, identifying in specific places (hotspots) the drivers of migration, while in other specific places (hotspots) the effects of migration can be assessed. Further, while migration can take place as part of a 'group process', decision making about migration also takes place at the individual level. In some cases, a decision is made for migration by sudden interferences, sometimes by slow onset events.

The figure represents a visual combination, and served to facilitate the interaction with model experts, to explore the potential linkage between the nexus models and migration.

Below, we will first explore a number of nexus modelling tools related to migration (4.2). We will also take in account other specific tools, especially focussing on the decision-making factors within the mechanism of migration and understanding drivers of migration. When contexts are complex, it is necessary to ask people concerned directly to identify what factors influence decisions to migrate. In addition to the other project activities, the tool VARI-App has been designed for hotspot interviews (4.4). The way migration, nexus models and this app relate is elaborated in Chapter 5 Promising strategies, interventions and future actions.

4.2 Investigating nexus models regarding the link to migration

A possible link between the nexus and migration using nexus models needs investigation. When starting with the nexus related models, all relevant links to migration were explored.

So far, the nexus models have been used to study different physical and socio-economic aspects that are part of the nexus. There is a lot of experience in modelling. Think of demand and supply for instance of water, nutrients and food. Currently, these models are designed primarily for one of the nexus domains and for a specific spatial scale.

Though not originally designed to be linked to migration, if we could establish a relationship between migration and the nexus through the models we use. This may provide important insights in current and future migration patterns as well as the influence of migration on the nexus.

We depart from the figure in Chapter 3.1 to understand the pro's and con's of the models and data from the nexus. A number of nexus related models and tools were identified, like LPJml, (meta)SWAP, WOFOST, LINTUL, MAGNET etc. An overview of the models is found below in Table 1.

Methodology
For each of the 11 models, information was gathered in semi structured interviews and literature research using 5 key questions:

1. The scale that the model is addressing
2. The type of data the model is using
3. Inputs and outputs of the model with examples/case studies etcetera
4. Advantages and limitations of the model in **addressing nexus and migration** on the four different scales
   a. Nexus Factors and global migration patterns?
   b. Nexus Factors and drivers of migration?
   c. Nexus Factors and effects of migration?
   d. Nexus Factors and personal decision makers of migrants?
5. How adaptable is the model to make it useful for our (4a to 4d) challenges?

The information was gathered by researchers of various backgrounds, interviewing model experts. They all used the same basic questions as above. The information was brought together and discussed with model experts invited (3 December 2018) and additional information was provided.

__Table 1__ Overview of models, Nexus aspects covered and application scale covered.

	Model	Nexus aspects	Scale	Remarks
1	LPJml	Crop/Vegetation, water use, climate impacts	Global and regional	
2	SWAP	Transport of water and solutes in soils; Effects on crops	Local and regional (meta SWAP)	
3	EKO/RISTORI	Aqua ecological systems; effects of interventions	Local and regional	
4	WATERWISE	Optimization of nexus resources	Regional	
5	WOFOST	Crop production, food security	Local and regional	
6	LINTUL	Crop production, food security	Local and regional	
7	BIOSPACS	Optimizing (macro) nutrient flows	Regional	
8	MAGNET	Agricultural land use, water use (under construction), fossil and renewable energy sources (including biofuels and bio-based chemical products), GHG emissions with feedback to agricultural land productivity via global temperature, food production (including processed foods) prices and private household income (availability & access dimensions of food security), macro and micro nutrients in food (nutrition security), international migration	Global and economy-wide (covers all economic activities) with national level resolution	Focus on macro-economic implications, connects to bio-physical models for enhanced spatial (sub-national) and production technology representation
11	EFISCEN	Effects of management and climate change on (European) forests	Regional	

Note that not all used models could be included in the analysis, e.g. VIC, Soil Data, WRF, RAMS. In the next paragraph the findings are summarized.

4.3 Summary of the findings regarding nexus models and migration

The 11 models used in Wageningen in the nexus area covering aspects of climate, water and food - listed in paragraph 3.3 - and their possible link to migration, are presented below.

4.3.1 LPJmL – global vegetation model

LPJmL (LPJ stands for Lund–Potsdam–Jena model (Sitch et al., 2003)) and is used to study the effects of climate change and climate variability on the productivity of crops and the resilience of carbon stored in natural vegetation. With these models, the predictability of seasonal crop forecasts and long-term vegetation projections can be assessed and improved.

LPJml with Managed Land model is a dynamic global vegetation model (DGVM) with managed land use and river routing (Schaphoff et al., 2018). LPJml implements the ‘Carbon, vegetation, agriculture and water’ part of the IMAGE framework (Figure 15, source: PBL, 2014) but is also a standalone biophysical model WR does not own the model, but can use it.

LPJmL is used to study the effects of climate change and climate variability on the productivity of crops and the resilience of carbon stored in natural vegetation. With these models, the predictability of seasonal crop forecasts and long-term vegetation projections can be assessed and improved.

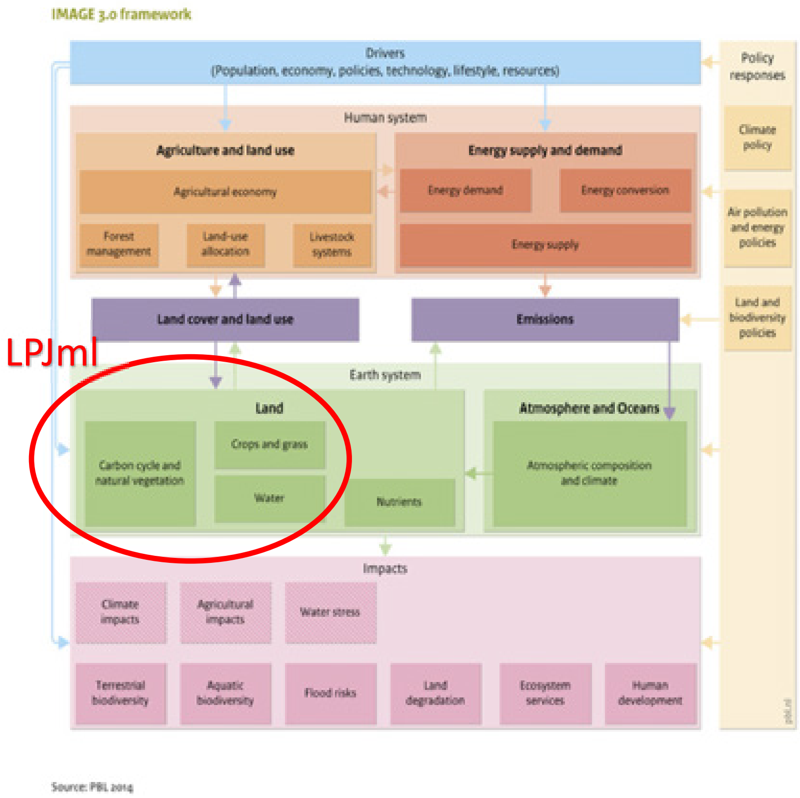

Figure 15 *LPJml in Image 3.0 framework.*

Mutually interacting modules in the LPJml model are:
- Carbon cycle and natural vegetation
- Crops and grass
- Water
- Nutrients (not yet developed)

Coupled land-atmosphere models like RAMS/WRF (presented below, in 3.4.10) are used to study the effects of large scale irrigation and urbanization on rainfall recycling mechanisms.

The LPJml model can be used in combination with climate models for study on migration and provides then information on the vulnerability of the nexus, especially on water availability and crop production. These are possible drivers of migration. When combining specific indicators of LPJmL with other models/info, derived outcomes can be generated.

Examples of derived indicators on potential drivers:
- Indicator showing to what extent locations are dependent on upstream countries for water supply (e.g. what if upstream water use increases)
- Rainfed and irrigated yield gaps (difference between actual yield and non-water limited yield)
- Interannual variation in ***crop yields*** in relation to storage capacity of a region
- Dependence of ***food security*** on LOCAL crop production (vs food imports)

Examples of derived indicators on potential impacts:
- Land claim of a city, how much ***land*** is ***needed to produce food*** for an expanding city

Currently, the model is being used by the WorldBank for its work on climate migration (Figure 16).

More information: http://models.pbl.nl/image/index.php/LPJmL_model

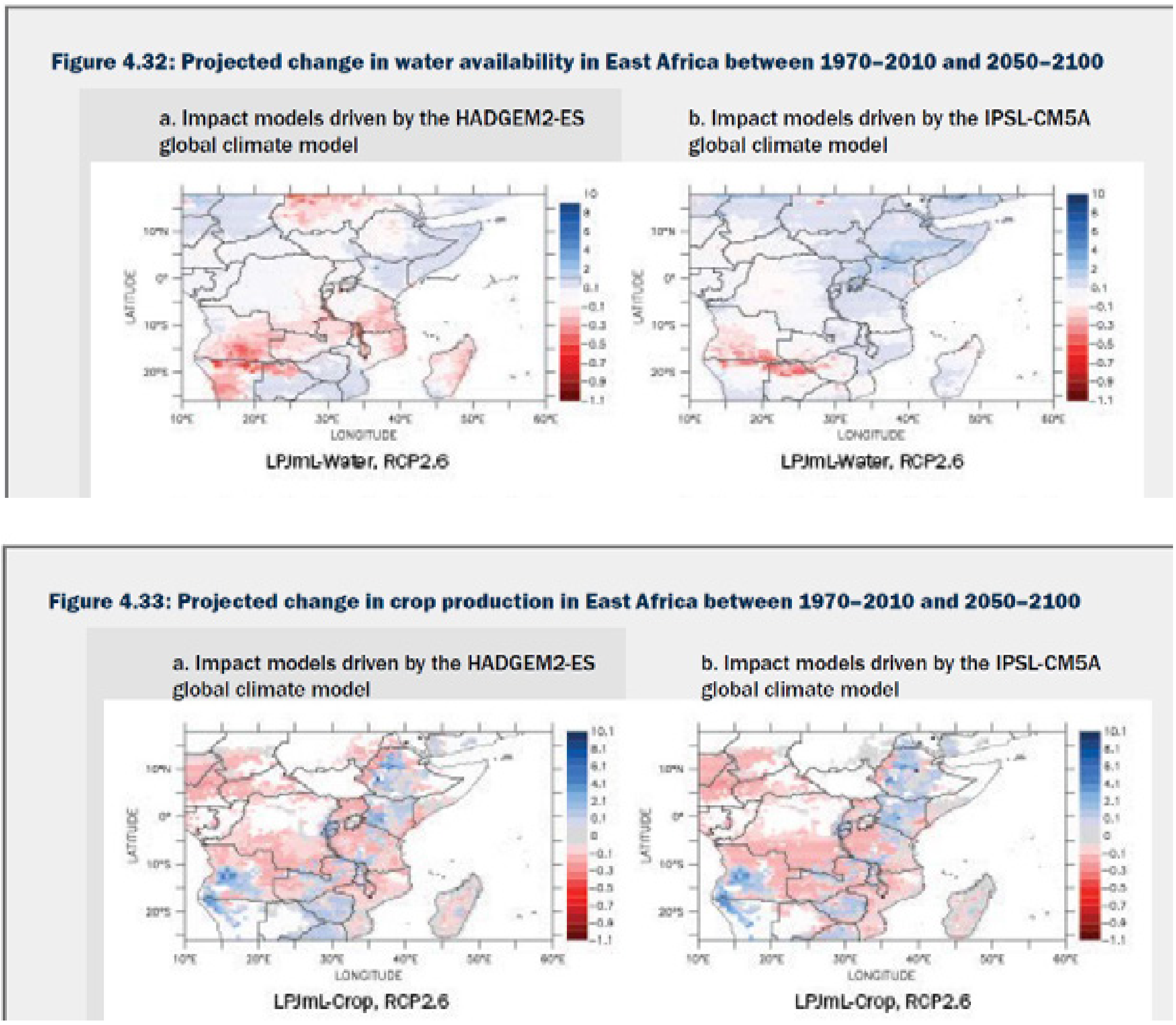

Figure 16 *Projected change in water availability and crop production in East Africa. (Groundswell, 2018).*

In conclusion, this model has very interesting potential to link the nexus and migration, especially on the global and national scales level.

4.3.2 SWAP – local flow & transport in soils

SWAP (Soil, Water, Atmosphere and Plant) simulates transport of water, solutes and heat in unsaturated/saturated soils. The mechanistic model is designed to simulate flow and transport processes (of water, solutes and heat) at field scale level (saturated and unsaturated soils), during growing seasons and for long term time series. It offers a wide range of possibilities to address both research and practical questions in the field of agriculture, water management and environmental protection.

SWAP offers a wide range of possibilities to address both research and practical questions in the field of agriculture, water management and environmental protection. It is a physically based model, and it is 'calculation time intensive'. Meta SWAP has been developed, which is a.o. used in WaterWise (see 3.2.x below). Catchment or river basin scales are covered by meta-SWAP. SWAP and Meta-SWAP are often used in combination with WOFOST (plant production model, see 3.3.5 below). Linked with WOFOST SWAP is an accurate model to predict farm yields and well as the effects of interventions at this scale and the effect of CC. Coupled to market data it could provide insights in the profitability/sustainability of e.g. subsistence farming, which may also drive migration. It lacks farm/plot/crop management (see LINTUL).

As the model was initially developed to simulate field level soil-water-plant processes, the usefulness of the model in relation to migration is not immediately clear. With increasing computation capacities of computers, larger areas may be included in the calculations, which might make the model interesting related to drivers and effects of migration.

Potentially, it could address inter-seasonal droughts – which we think have a link with migration. Groundwater depletion is an issue which plays at the larger scale, and hence is covered by meta-SWAP.

More information: http://www.swap.alterra.nl/

In conclusion, this model has very interesting potential to link the nexus and migration, especially on the regional scale level.

4.3.3 EKO/RISTORI – regional aqua ecological stress

EKO/RISTORI is a tool for classification of ecological water systems. The Eko/Ristori Toolbox consist of 2 models: Cesa and Restori. Cesa combines land use with stressors on ecology (e.g. specific pollution), stress levels 1-5. Restori links the Cesa model to the aqua ecological impact. It is a statistical model, e.g. to assess impact of pollution on the fish population. At the moment the model is just conceptual and only applied in NL. Currently research is on-going to enlarge the scope of the model, and make the model available for other areas as well.

For migration, therefore, the model does not have an immediate functionality, though water quality certainly is an issue in migration hotspots. Also there is a weak link to food security issues. However, although ecological water quality is just part of the bigger water and water quality constraints it certainly could be considered, both from driver as well as impact side in relation to nexus/migration issues.

More information: https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Programmes/Sustainable-Water-Management/Water-quality/Freshwater-Ecosystems/Ecological-water-management-applications.htm

In conclusion, this model has some interesting potential to link the nexus and migration, especially on the local scale level.

4.3.4 WATERWISE - regional water optimization

Waterwise is a tool to prioritise land and water management options in large river basins. The prioritisation is based on an integrated model for hydrology, crop production and hydropower, coupled to a mathematical optimisation algorithm.

Advantage of the model is that it is not a model with data input, and data output. It optimizes water use for the agricultural-, hydropower and other water consuming sectors. This is all about farm/field/crop management which can affect crop yields very significantly. LINTUL could be able to deal with that (3.3.6). It is important to notice that market information has not been included so far, so optimal water use from water perspective does not automatically lead to optimal income.

Adaptability
In WATERWISE, food security can be optimised by optimising water use at river basin. This can also be done at country level for instance. Thinking about migration, this could be very relevant, and this can be further explored.

More information: https://www.wur.nl/en/show/Waterwise.htm

In conclusion, this model has very interesting potential to link the nexus and migration, especially on the regional to national scale level.

4.3.5 WOFOST

WOFOST (WOrld FOod STudies) is a simulation model for the quantitative analysis of the growth and production of annual field crops. It is a biophysical model that measures on a square meter level how plants grow. It links to nexus factors climate change, water, and food. The model uses only biophysical data –socio-economic factors are not included. The inputs of the model are water, nutrition and temperature. The output is optimal growth of plants.

Advantage of the model is that it can analyse the impact of climate change on plant growth. Thus, as migration partly may link to income, food security and climate change (drivers), scenarios for future crop growth could be one of the indicators for future migration. The model does not take farm/field/crop management into account, which can affect crop yields very significantly.

LINTUL (3.3.6) could be able to deal with that. One of the physical conditions is the water availability for the crop (primary production factor). This is one of the factors which can be provided by SWAP (3.3.2) rather accurately.

Adaptability
Because the behaviour of people – the socio-economic factors are very important to explain land use change, it could be possible to combine the biophysical model with socio-economic analyses.

More information: https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Facilities-Products/Software-and-models/WOFOST.htm

In conclusion, this model has very interesting potential to link the nexus and migration, especially on the field to regional scale level.

4.3.6 LINTUL

LINTUL is a crop growth model and, addresses the Nexus factors: soil, land use, climate change, water, and food. The scale at which the model can be used (global, national, regional or household,) depends on the data. The model uses biophysical data (weather, soil, crop) as well as farm management data (use of irrigation, choice of plants, against sickness (pesticides), etc.) – and can find optimal conditions for crops and estimate what effects on crops are with changing conditions (climate, soil, weather, water, nutrition, slopes, etc.). Inputs are then weather, soil, crop, farm management, and outputs crops in kg.

Advantage of the model is, that it focuses on crops and use mostly biophysical data to find impacts on crops. It is possible to combine with all kinds of other studies on changing demands and supply, economic models, climate change, and also migration as when influencing these factors. LINTUL can also be linked to other models (MAGNET, etc). The LINTUL model is currently used by researchers (Agricultural System Analysts) who also carry other different related research, including risk analyses and livelihood analyses. The use of the model and related research could indicate conditions getting under a certain threshold, which could lead to migration. The use of LINTUL is limited in water scarce situations.

Adaptability
The model can be used at different scales as well as in Asia/Africa, among others. It is always the fact that quality of data as inputs will provide/restrict opportunities for output.

More information: http://models.pps.wur.nl/lintul-1-simple-crop-growth-model-simulate-growth-under-potential-growing-conditions

In conclusion, this model has very interesting potential to link the nexus and migration, especially on the local scale level.

4.3.7 BIOSPACS

BIOSPACS (Balancing Inputs and Outputs for the Sustainable Production of Agricultural CommoditieS) quantifies N and P flows, between five interacting components in the food system The five components are: (1) human population consuming food items, (2) the food balance supplying (non-) food items, (3) livestock producing animal-based products, (4) organic fertilizer consisting mainly of excreted manure from livestock and (5) agricultural land comprising arable land and permanent grassland for the production of food crops and feed for livestock. N and P stock changes are determined for agricultural land, the food balance and the population (Conijn and van Dijk, 2018) Related agricultural land requirements and GHG emissions from agricultural production are also calculated.

Nexus factors addressed in the model are nutrition, food security, crop production. The model is used at national level (Asia, Africa). The type of data the model is using are FAO statistical data, dependent on what the diets are (grain, roots, vegetables, meat, etc.), and needs are identified. Inputs are the needs for food, and outputs are how to fulfil nutrition gaps with new conditions.

The model identifies the nutrition need and how to provide supply, which is relevant to food security. It uses FAO data, which means that the data is not local but dependent on national level databases. Running it with local data could be explored.

Adaptability
Not across geographical levels but may be interesting to apply for conflict areas and hotspots.

More information: https://doi.org/10.18174/441272

In conclusion, this model has some potential to link the nexus and migration, especially on the national scale level.

4.3.8 MAGNET

MAGNET (Modular Applied GeNeral Equilibrium Modelling Tool) is an economy-wide, general equilibrium model to examine the costs and benefits of policy scenarios via changes in input and output prices and allocation of competing (agricultural and non-agricultural) uses of primary factors and intermediate inputs (Woltjer and Kuiper, 2014). MAGNET is an advanced recursive dynamic variant of the well-known Global Trade Analysis Project (GTAP) model (Corong et al., 2017) and database (Aguiar et al., 2016). MAGNET currently uses version 9.2 of the GTAP database with a coverage of 140 regions (mostly individual countries), 57 sectors and 8 production factors (land, five labour types, capital and natural resources). The database includes detailed information on production, gross bilateral trade flows, transport costs and trade protection data for a 2011 benchmark year.

MAGNET encompasses numerous sector splits from the GTAP parent sectors to enhance the representation of food items key for food and nutrition security versus climate concerns (like various types of meat with different health and emission profiles, wild fish and aquaculture sectors) or studies on a transition to a more bio-based economy (crop residue and other biomass use for biofuels, bio-plastics and bio-electricity, split of fossil and renewable energy sources). Recently a migration module has been added (not yet calibrated), allowing either endogenous wage-drive international migration or a study of the impact of exogenous migration flows on sending and receiving countries. A broader demographic module looking beyond national level population projections is not yet in the model at the moment. Capturing changes in demographic structure would considerably enlarge possibilities for scenario analysis in the context of migration.

Adaptability
MAGNET 's modular structure allows to make use of various modules, related to the study at hand (Figure 17 presents the current modules). It also allows fast take-up of developments in related areas of research, allowing for trade-offs across multiple domains like environmental versus food security concerns. This is for example the core of the Social Development Goals (SDG) insights module, capturing changes in indicators across a range of SDGs. Given this modular structure and breadth of

scope, MAGNET impact assessments have appeared in a number of policy arenas including: land-use change (Schmitz et al., 2014) conventional biofuel policy (Banse et al., 2008 and 2011); second generation biofuel policies (Van Meijl et al., 2018), food security (Rutten et al., 2013, Hasegawa, 2018) and climate change (Frank, 2018; Nelson et al., 2014).

In conclusion, this model has very interesting potential to link the nexus and migration, especially on the global scale level.

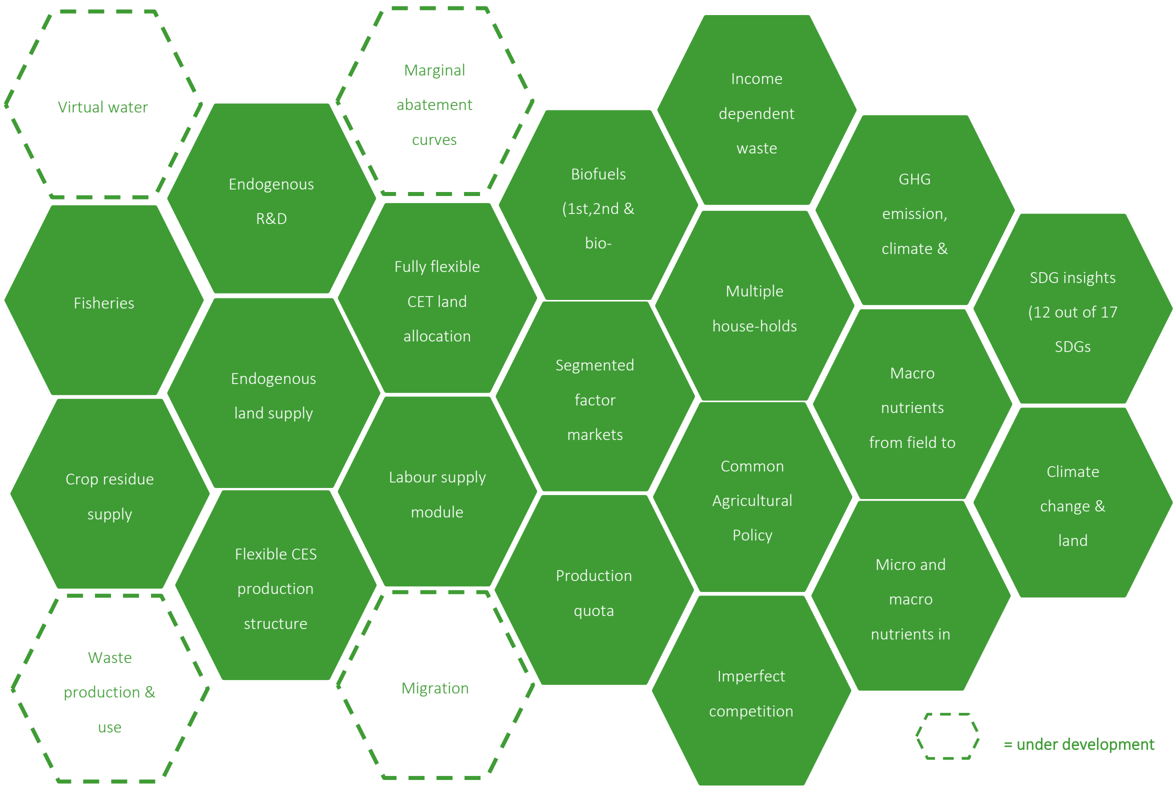

Figure 17 *Overview of modules in Magnet.*

4.3.9 VIC

VIC (The Variable Infiltration Capacity) model (Liang et al., 1994) is a grid-based, large-(macro)scale, semi-distributed hydrologic model. (van Vliet et al., 2012) (Van Vliet et al., 2013)

The VIC model is a descriptive bio-physical model. It represents sub-grid variability in vegetation and elevation, partitioning each grid cell into multiple land cover (vegetation) and elevation classes. The soil column is commonly divided into three soil layers.

VIC simulates hydronic and surface energy balance, from river basins to continents, and global scale; it is used for scenario analysis. The water-food-energy Nexus remains central to the model. The major research question investigated by VIC is how global change will affect the water-food-energy Nexus (change impact and scenario studies).

Water is the Nexus factor covered in VIC. Scenarios on water scarcity represent research on demand supply mismatches.

Migration is not directly included, but assumptions regarding migration could be made via the implicitly present population.

More information: https://www.wur.nl/en/Research-Results/Chair-groups/Environmental-Sciences/Water-Systems-and-Global-Change-Group/research/Water-pollution-assessments-1/VIC.htm

In conclusion, this model has some interesting potential to link the nexus and migration, especially on the national to global scale level.

4.3.10 RAMS/WRF

The Weather Research and Forecasting Model (WRF) and the Regional Atmospheric Mesoscale Model System (RAMS) are frequently used for (regional) weather, climate and air quality studies.

The Weather Research and Forecasting (WRF) model is a next-generation mesoscale meteorological model developed in cooperation of atmospheric researchers and operational-user communities. WRF offers a wide range of options with regard to physical parameterizations. The Advanced Research WRF core model (ARW-WRF version 3.9) is particularly suited to answer various research questions. Information on vegetation, land-use type, terrain elevation, and other variables are part of the model. The physics in the ARW core are categorized in different modules, each with different options for the parameterization schemes (Skamarock et al., 2008).

WRF is basically a weather forecasting model, which can also be used for regional climate studies. It forecasts temperature, humidity, wind, evapotranspiration, soil moisture etc. The model can be used to perform scenario studies, i.e. for a warmer climate or for land use changes (deforestation, urbanisation etc) and their impact on the weather and climate. The model is flexible and can be applied to any location in the world.

With regard to the nexus, the model can provide essential forcing inputs for agro-hydrological-, crop production- and energy production models, as well as feedbacks from a changed land-use. Related to all minor feedbacks, if migration results in land use change, we can change the land use in the simulation, but this is not directly interactive with the migration. Effects of urbanisation can be studied by applying a larger anthropogenic heat production in cities in the model. Set against climate change, which has an important linkage with migration, this is an important model option, and can provide inputs to other models.

More information: https://www.wur.nl/nl/Publicatie-details.htm?publicationId=publication-way-343039393739

In conclusion, this model has very interesting potential to link the nexus and migration, especially on the national to global scale level.

4.3.11 EFICEN

EFICEN (European Forest Information SCENario) is a large-scale forest model that projects forest biomass and forestry development on a regional to European scale. This model has been developed together with the European Forest Institute (EFI). Wageningen Environmental Research and EFI own the model. Currently, it is an open source model. The model is suitable for the projection of sustainable forest management for a period of 50 to 60 years. The model uses national forest inventory data as a main source of input to describe the current structure and composition of European forest resources. Based on this information, the model can project forest resources based on scenarios like climate change. These scenarios are mainly determined by management actions, but the model can also take into account changes in forest area, as well as changes in growth e.g. due to climate change

The nexus factors addressed by this model are climate and land use change. The data the model is using is about types of forest, exploration, how fast the forest grows, use of forest. Inputs are the growth of forests, different types of trees, climate change, while outputs are the changing use and availability.

In the KB NEXUS project, already an active search is undertaken, how to combine this model with MAGNET (see earlier, in 3.2.8), as there is a use and harvest component that can be translated into demand and supply. The advantage of the model is that it can say something about change in forest use and link with climate change. The disadvantage of the model is that sofar the model is only applicable to Europe, at European level. Needs very sophisticated levels of data at local level which is not available e.g. in conflict areas. If land use in conflict areas are to be modelled, a more generic level model is needed that will not require such details.

How adaptable: Currently, the model is not suitable for use outside Europe because the model needs very detailed information. If the link with MAGNET is made than it may be possible to find a link with migration. For analyses of land use change in conflict areas, a completely different model is needed.

More information: https://www.wur.nl/nl/project/European-Forest-Resource-analysis-tools.htm

In conclusion, this model has some interesting potential to link the nexus and migration, especially on the local scale level.

4.4 Summary of findings VARI-App for in-depth analysis of migration decisions

The VARI App is based on the approach 'Value Analyses of Relative Importance Tool: i.e. **VARI-Tool'** and is designed based on the Analytic Hierarchy Process (AHP) method (Pöyhönen, Vrolijk, & Hämäläinen, 2001; Renn, 2006; Saaty, 2004; K. Soma, 2010; Katrine Soma et al., 2013). This NEW VARI Tool for value-based assessments have been designed to prepare for hotspot interviews of people to identify core factors influencing decisions to migrate (or not).

Different frames exist for analysing migration decision-making. Different disciplines use different argumentation, based on different framings. For instance, neo-classical economic theory could argue that a decision is made on the rationale of maximizing utility (Diogo, Koomen, & Kuhlman, 2015; Mullan, Sills, Pattanayak, & Caviglia-Harris, 2017). A utility function would indicate how to maximize utility given income, price levels and amount of goods. Over the years behavioural economics has developed alternative ways of maximizing utility – provided that utility functions would be a lot more complicated and could include different aspects, including trust, ethics, and other emotional factors (Onwezen, Antonides, & Bartels, 2013). Challenges of quantifying such aspects and assuming they are comparable on a monetary scale, have supported arguments of humans being irrational. However, this so-called irrational behaviour could also be explained by failures in the modelling approach in catching the real and exact dimensions of the utility functions. Another example, referring to decision making from a social perspective, embraces issues of power and inclusiveness to be a lot more important as explanatory factors to explain personal decision making (Castells, 2007; Kent, Sommerfeldt, & Saffer, 2016). Analyses of power relations and inclusiveness are mostly addressed qualitatively, by observing, discussing and explaining how these factors influence decision making processes. Also, this framing may fail to capture the real factors, if power is not the main issues.

When contexts are complex, the assumed factors, such as of power, inclusiveness, utility function, having influence on decision-making within different disciplines, may be biased and fail to include the actual complexities of different contexts. Ideally, no specific research framing should be imposed when analysing complexities. Instead of assuming what influence a decision the most, an interdisciplinary manner is to keep it open and let the people concerned identify what the factors actually are themselves. This is the strategy of the VARI-App interviews.

In order to allow opening up and limiting framing impacts of different disciplines, a so-called value-tree can be created to reflect on and map out relevant drivers to a specific context, and for different groups and individuals. A value-tree can visually structure factors and assist discussions identifying which drivers play a role and how different drivers interlink (Pöyhönen, Vrolijk, & Hämäläinen, 2001; Renn, 2006; Saaty, 2004; K. Soma, 2010; Katrine Soma et al., 2013).

A value-tree is basically a mapping out of different aspects that are of relevance to a specific decision. The mapping out and structuring of arguments ensure transparency when contexts are complex.

Possibly, multiple value-trees can be developed, which may be summarised into one overall value tree. In a value-tree approach, the more general objectives are put at the top and more specific criteria are listed below. See example of a value-tree in Figure 18.

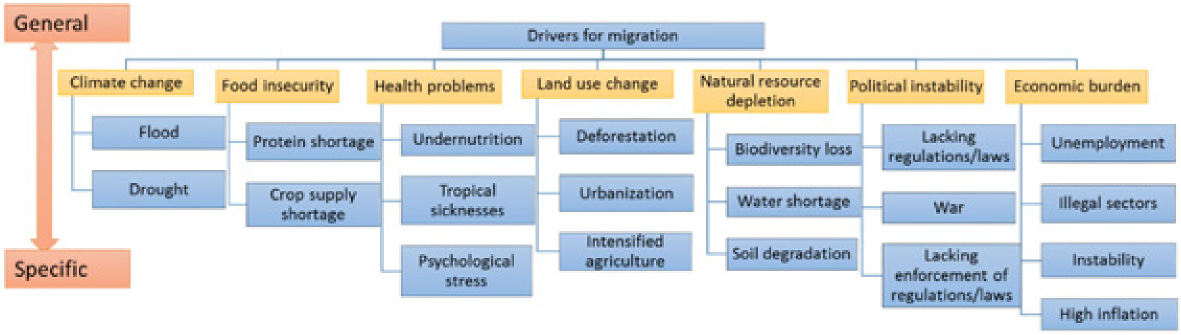

Figure 18 *Example of a value tree with drivers for migration.*

Notably, a value-tree just gives an overview of WHAT is important, not about what is relatively more important to whom. Assigning weights is the same as to inform about what is relatively more important (Banani, Vahdati, Shahrestani, & Clements-croome, 2016; Munda, 2004). If different people assign different sets of weights, levels of importance of different drivers are identified for different people or groups. Strategies to assign weights to find what is relatively more important belong to methods falling in the category of multi criteria analyses (MCA). MCAs consist of a large variety of methods, sharing that they can handle complex issues by evaluating multiple alternatives. They include more qualitative versions such as REGIME and EVAMIX (Vogd, 1982), and more quantitative version building on the assumption of utility theory (MAUT) (Guitouni & Martel, 1998). Yet another version is referred to as the Analytic Hierarchy Process (AHP) (Huizingh & Vrolijk, 1997b, 1997a).

Different weighting techniques exist that can estimate weights. For instance, REGIME is designed for 'direct assessment', while other more quantitative approaches assign weights by, for instance, 'expected value method', 'random weights' and 'extreme weights' (Janssen & van Herwijnen, 2011). These weighting techniques lack accuracy and do not fit to complex issues (*ibid.*). Another option to assign weights is 'pairwise comparison' (AHP). In this method, the interviewee only needs to compare two factors at the time, and outcomes show more details as to which the importance difference between factors is relatively low or high. This method can also handle different levels of specificity. While no limit is set to total number of factors, there is a limit to factors belonging in a same category, as otherwise the number of questions will escalate. The pairwise comparison is thus dependent on categorization of multiple factors (value-tree) before weighting can take place (Ramos et al., 2014; Saaty, 2004; K. Soma, 2010). Overall, the pairwise comparison is judged the most suitable for complex issues.

Based on the value-tree developed for migration as benchmark, a questionnaire can be designed for pairwise comparison using a semi-quantitative scale (e.g. 5 4 3 2 1 2 3 4 5) to identify relative importance (Ramos et al., 2014; Saaty, 2004). As a result, relative importance of the different drivers will be assigned for different individuals, groups and contexts. In summary, following the logics of AHP, the VARI Tool consists of three main steps: First, design a value tree (could be values, criteria, indicators, alternatives, measures, options, etc.) based on semi-structured interviews, experts and literature review (Figure 18). Second, apply the structure of value tree(s) to design questionnaire survey in an App (can differ across levels and contexts) (Figure 19).

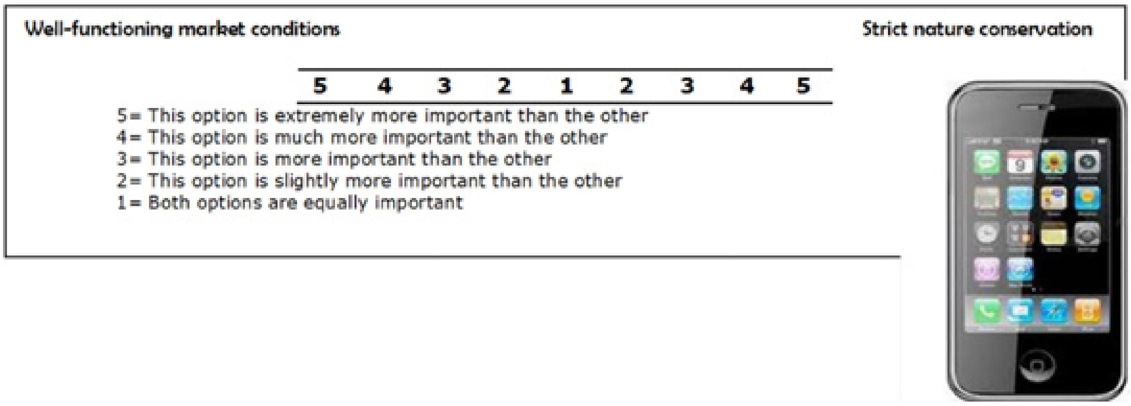

Figure 19 *Example of pairwise comparison.*

Third, estimate (matrixes) relative importance (adding up to 100% priority per interviewee/group) and present outcomes in figures designed to visualize relative importance (=weights). Figures are then designed to illustrate how preferences differ.

The VARI-Tool approach is circular as illustrated in Figure 20, thus consisting of sequences of mapping out value-trees, assigning weights by pairwise comparisons, evaluating and presenting information, upgrading information and re-designing value-trees, and so on.

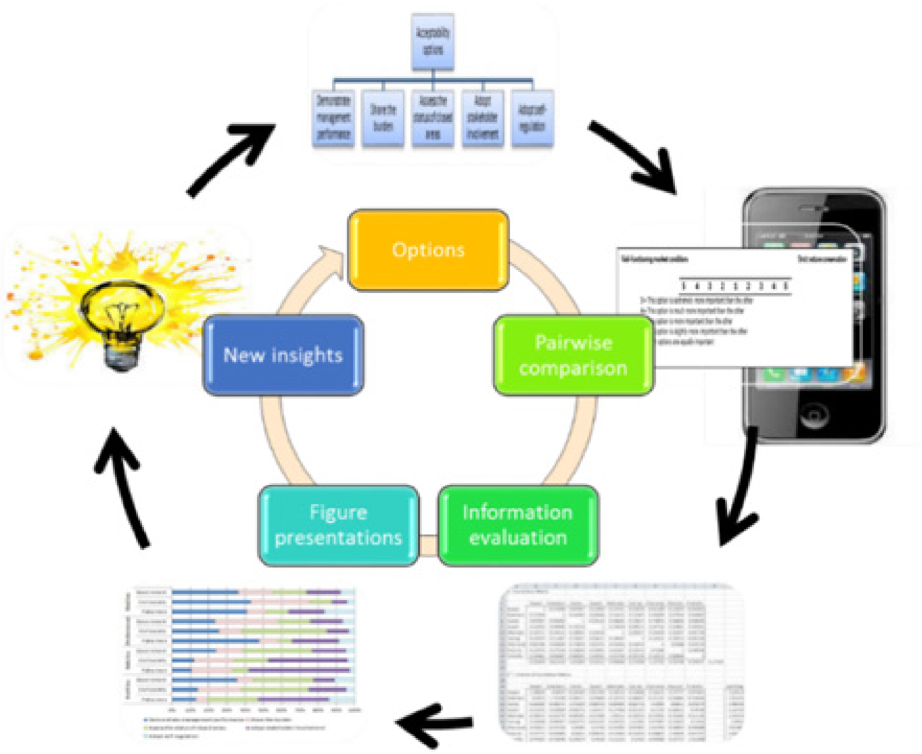

Figure 20 *Example of pairwise comparison.*

Acknowledging that incentives differ across persons, groups and context, the VARI-Tool has been designed for ensuring in-depth analyses of actual nexus factors influencing as drivers for people to migrate (or not).

4.5 Conclusion

To study the link of migration with the nexus, the potential use of 11 models and 1 app's for nexus analysis were discussed.

Surmise all reviewed models depend on data, but our primary concern is functionality in relation to migration issues. Data comes in as secondary. The functionality in relation to migration issues is promising though at different levels of scale (local, regional, national, global).

At the local level, a number of models are of interest to explain field level decision making regarding resource use. Household level income from farming, now and in the future can be brought into the picture (LINTUL, WOFOST). The link to migration needs further study.

At the more intermediate / regional level, an optimising model like Waterwise may be interesting to make a distinction between food security at the national level and at the regional (sub-national) level, as its optimising functions can assist for this.

At the global scale, LPJmL and Magnet are already in the process of being linked, and a linkage to migration seems very well possible. Resource analyses (water&food) can be made at this scale with these models. Magnet has a climate forcing module. LPJml uses various sources for this. Consistency will be required (role for RAMS/WRF). Nutrient cycles are also covered by Magnet (use of principles from BioSpacs may be considered). This can assist in identifying the link between migration flows and drivers of such migration flows when such drivers relate to the shortage of resources. Question is whether general equilibrium models can be upheld under the more extreme conditions.

Besides the overview and analysis of relevant models, attention is paid for a promising methodology and tool for a more in-depth and highly participatory analysis of migratory decisions in the nexus context. It may be noted that the contribution of Wageningen University & Research on Nexus-Migration is currently mainly focusing on the issues of food security and water availability.

Based on this overview, concrete possible future steps are identified and explored (Chapter 4).

5 Promising strategies, interventions and future (action) research

5.1 Introduction

For a societal challenge as migration, a research agenda should be further developed focusing on the relation between migration and the Nexus. In order to this, first an overarching narrative on the relation between migration/extreme events and nexus is needed to be developed. This report addresses that point. Further, strategic interventions and practical solutions need to be developed and tested in hotspot areas where adapted technology approaches on food security can be experimented with. Third, different models will be linked to migration and global level analyses about changing patterns of food and water demand and supply. Fourth, individual priorities of migrants will be assessed. The Food System Approach, a unifying concept for a lot of the work of Wageningen University & Research, will be connected to migration, extreme events, climate change, localized technology needs and globalization, thus allowing to study complex phenomena and provide solutions.

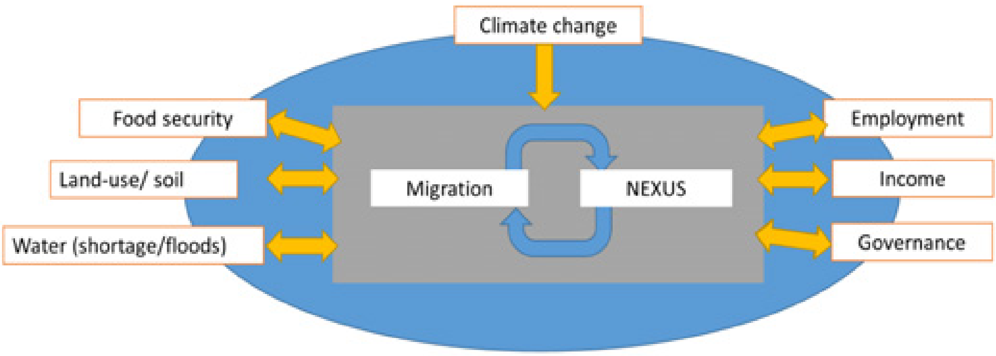

Figure 21 *The Water-Food-Ecosystem-Energy Nexus and migration.*

5.2 Scientific relevance

With climate change and globalization comes migration, and more so in the future. Understanding food systems implies that dynamics of moving people must be understood, because different needs and demands move and operate in across localities, countries and regions. WUR has a responsibility to contribute to the Sustainable Development Goals of 2030, including among others the one on aiming for zero hunger. In approaching movements of people within food systems and zero hunger, new food system approaches will developed based on existing WUR expertise, including water modelling and technology approaches, soil and crops modelling approaches, global demands and supply modelling approaches, as well as tools designed for local decision making and reasoning to obtain how this differ among people and contexts. Besides challenges of climate change and migration, opportunities with new upgraded technologies that can support future food systems will play an important role in this future research approach. The food system approach (making use of models, literature and case studies for development and tests) will address both emigration and immigration – in areas of origin as well destination.

5.3 Promising strategies

Further analysis using (meta)SWAP, WOFOST, LINTUL can assist in showing linkages between water use and food security and migration. Also, forcings with RAMS can assist in providing future scenarios. Analysis using LPJmL and Waterwise can be interesting at a larger scale level.

At local level, to prepare for complexity investigations, the first year of this project has invested in developing a so-called VARI tool made available in an App. The plan is to apply this new design of a VARI-tool App for interviews, to be conducted in hotspot areas (e.g. Jordan (see also *Reference project Forced migration and settlement*) and Kenya). Based on these interviews, it is possible to effectively get a good insight and understanding about reasoning among people moving from rural to urban areas, and from urban to rural areas, within and across countries and regions. With the VARI-Tool, within country, internal migration issues can be captured, and lack of available data is not an issue because information will be selected directly.

Besides, a series of models and research approaches that currently are being used and upgraded have been investigated the first year. There is strong base in modelling water-food interactions in bio-physical terms (#list models) and in modelling the nexus in macro-economic terms (MAGNET). To our knowledge MAGNET has the capability to model international migration through a dedicated country-level module, although calibration of the module has not yet taken place. Multiple models are available that do not model migration directly, but can find how migration affect or is affected by flooding and drought, natural resources, food and water availability, soil degradation, etc.

In the conceptual framework developed within project, it shows how the complexity investigations and modelling approaches complement each other, making use of different interdisciplinary research approaches suitable at different levels. The framework concisely summarizes the literature reviews and discussions of the project team on the types of drivers and migration to focus on, without losing track of, the broader context. Given the expertise at Wageningen Research the focus and contribution of the next phase of research would include, on the one hand, qualitative approaches to investigate complexities at local levels. On the other hand, it would include quantification of the contribution of environmental and economic drivers on the migration decisions, the impact of migrating (or staying) on sending and receiving locations in environmental and economic terms and how these impacts may alter the drivers of migration. It seems obvious to apply existing models for analyses of environmental and economic drivers and outcomes due to migration. Combining different models is already pursued elsewhere in the KB programs, and this is also a possibility when analysing migration issues. We thus focus on building the empirical base (both qualitatively and quantitatively) for elaborating the role of migration in food systems and the water-food nexus.

Suggested steps towards realizing this ambition are:

1. Deepen the conceptual framework via literature study: **explore essential drivers** of migration in and from Africa, including Nexus related and others, such as: Aridity zones, Levels of soil degradation, Extreme weather events (fast onset), Poverty levels/Income levels, Population density, Working age population in agriculture, Urban population size.
2. **Collect the latest data** (say 2000+) on these drivers for all African countries. Explore which of the Nexus drivers studied are covered by the WUR bio-physical models. Cooperate with these models' teams regarding WUR data on relevant Nexus drivers. In a series of maps, **visualize the currently observed levels** of these drivers.
3. Integrate the time series of driver levels into an index that would express the **vulnerability of countries** from the viewpoint of the Nexus-related migration driver levels and change.
4. Create a typology of countries based on the vulnerability index. **Use the typology to define Nexus hotspot areas**. Nexus hotspots will be countries/groups of countries that will remain the central focal point in our further analyses. For these locations, migration data will be collected and analysed, and a modelling scenario analyses will be performed for studying economic impacts of migration.
5. For the Nexus hotspots, make a literature **review and collect migration data** (including both country and regional within a country, if available) on the internal and international migration, by

type and origin-destination split. Include multiple migration types: economic, environmental, violent conflict and other; circular and chain; temporary vs long-term etc.

6. Based on historical trends and data collected (or estimated if needed) make **a foresight analysis for overall migration**, and environmental migration in particular, in the hotspots areas.
7. Acknowledging that **contexts differ**, and people's preferences differ with similar contexts, value-based impact assessments will be conducted across hotspot areas to take account of the differences and understand complexities.
8. The issue of **strategic intervention** which affect migration and possible prevent it, will be very central to future research. Based on knowledge about actual context specific challenges, targeted strategic interventions will be evaluated to fit the real context, to make sure that targeted migration issues eventually are affected.
9. Use the Nexus hotspots and related migration observed from and within the hotspot areas to formulate alternative **hypotheses on future migration flows** by their origin, destination and type; provide both the qualitative formulation of the hypotheses and the quantitative expression of migration flows for further processing in a modelling analysis.
10. **Run a modelling scenario analysis with the WUR nexus modelling tools** to process the alternative hypotheses on migration as related to Nexus factors, highlighting the socio-economic impacts of these migrations on both countries of origin and of destination of these migrations. The modelling can be done by zooming in to the hotspots countries/regions of Africa and Europe.

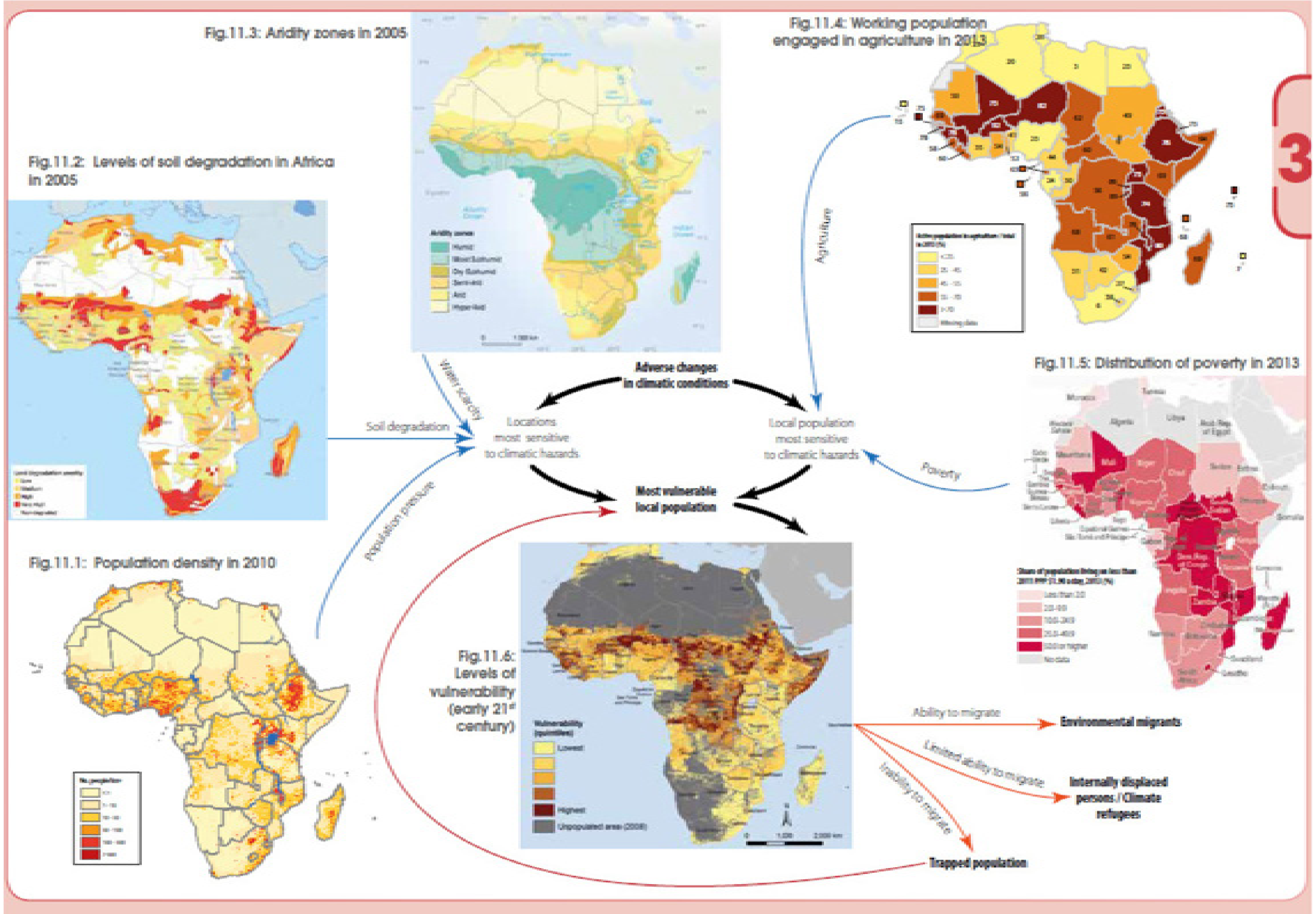

Figure 22 *Example of a multi-faceted analyses of migration and the water-food nexus. Source: p45 in Mercandalli et al. (2017).*

5.4 Future goals

Migration is a complex issue that in different ways relate with food security and the water- food nexus. While literature exists on links between agriculture-climate change and migration, the issue of food security in relation with migration is scarce. The overall aim of future research should be to obtain knowledge about the complex links between food security, water shortage and migration issues, in the scope of climate change.

The following objectives need to be investigated:

- Decide on identified hotspot areas that will be used for further investigations
  - a hydrological and food systems perspective (e.g. arid/semi-arid areas, e.g. Jordan, Nile Delta)
  - clusters of people that want to migrate (e.g. below northern Africa, Mali, Niger, Mauritania)
  - conflicts about food and water security, regional stability and environmental resilience (e.g. great lakes area: Congo)
  - make a translation slum area where similar challenges occur and where results can be implemented
- Extend the framework with multiple fields of expertise within WUR, around food security and the water-food nexus, technologies and models, AKIS, transition pathways and the living lab approach
- To develop, extend and combine biophysical and economic models suitable for different hotspots, and for analysing global trends
- To develop technology concepts for sustainable food systems and water supply 'fit for food'
- Design products in the forms of interactive sessions (i.e. designs of workshops/focus groups, online impact assessments, or online tool inviting anyone to participate), consulting with migration stakeholders to identify semi-quantitatively by means of the APP what different reasoning and priorities are among people, groups and contexts

This is to prepare for the following objectives:

- Use WUR knowledge to upgrade food system research approaches, appropriate tools and approaches to make an impact in hotspot areas and derive new results about existing and potential water and food resiliency.
- Adapt and design tools, techniques and models that forecast and aid these strategies and help to increase interventions in food systems to be implemented by stakeholders. Quantify identified drivers (emergency, forced, motivated) for migration as to predict future migration patterns and design interventions to prevent migration.
- Demonstrate technology concepts in selected hotspot areas on pilot scale.
- Conduct interactive sessions with migration stakeholders in hotspot areas to obtain knowledge about context differences and different reasoning among people and groups to understand how and where to invest to ensure secure livelihood and avoid unwilling migration.
- Identify options to improve capacity building and resilient farming and water and ecosystem management techniques (addressing food security and water-food nexus in migration) focussed at (a) people that are migrating, as well as (b) population in areas of origin as well as (c) destination (to improve social and environmental carrying capacity).
- Develop lessons learnt into scientifically sound and evidence-based transition pathways within the Food System Approach.

5.5 Target groups and partners in the future

Knowledge in this field is extremely relevant for Wageningen to position itself in the global network of migration challenges and will be demanded by:

- International, national and local governments
- Entrepreneurs and business
- NGOs
- Science partners

The WUR network in this field continues to expand and includes, among others

- Deltares, Universiteit Twente, ReliefBase, Clingendael, Planetary Security Initiative
- Ministry of Defence, Humanitarian Aid Innovation (DCHI), Humanity Hub/KUNO
- Gemeente Amsterdam, VNG,
- Ministry of Foreign Affairs, Directie Stabiliteit Humanitaire Hulp and Green Growth
- Embassies and agricultural attaches
- FAO, UN/UNHCR, World Bank and Regional Development Banks, UN OCHA Data centrum, UN UNITAR
- EU funds, Brussels
- Red Cross Climate Centre
- Technology suppliers in food energy water systems, SAMSAM water, JustDiggit, Greenfieldcities

5.6 Roadmap to value creation

Present and future global trends show that this knowledge is extremely relevant and will be demanded by international, national and local governments, scientific partners, businesses and entrepreneurs as well as NGOs. Therefore the focus will be on direction 1 with elements of direction 2 and 3. Because the field is so new to Wageningen Research, knowledge also has to be made available to the public, to show that we have a legitimate role to play in migration and food security challenges.

Direction 1
Utilization by making research findings applicable to specific users and stakeholders

a. There is a huge potential to build projects through contract research, collaborative research, development projects, licensing, consulting services) e.g. with international partners
b. We can provide education and capacity building handbooks, instructions, manuals for migrants, refugees, trainers in selected hotspots and beyond
c. There is a diverse group of authorities that will buy our policy advice, models on global migration, intervention strategies, action perspectives, policy frameworks)

Direction 2
Utilization by making knowledge available to the public

a. We position ourselves in the debate through scientific articles, books, reports and conference papers in different journals on migration, globalisation
b. Wageningen University & Research has more “figure heads” that are visible in debate, journal articles, participate in public dialogue, websites, social media, scientific TV/radio presentations on the topic

Direction 3
Utilization of research results through socio-economic innovation

a. We build upon social innovations, transition pathways and living labs in selected hotspots specifically for migration challenges that can be translated internationally
b. There is potential for the creation of spin-offs in technological innovations in nexus issues, that can be made available to migrants and businesses internationally

Within this direction the aim is to extend the WUR team from the different Wageningen Research institutions, as well as Wageningen University. For example, WCDI and WPR on respectively, knowledge on capacity building as well as knowledge on plant production technologies/agronomy models are essential. As such, we could maximise the societal impact and build further on a better integrative understanding and tailored solutions.

Suggested team	
Wageningen Environmental Research	Bertram de Rooij (Marian Stuiver) Catharien Terwisscha van Scheltinga, Robbert Smit, Herman Agricola
Wageningen Economic Research	Marijke Kuiper, Katrine Soma, Monika Verma, Ewa Tabeau -Kowalska
Wageningen Food & Biobased Research	Raymond Creusen
Wageningen Centre for Development Innovation	Esther Koopmanschap, Marion Herens
Wageningen Plant Research	Caroline van der Salm
Wageningen University	Han van Dijk, Bram Janssen, Ingrid Boas

References

Aguiar, A., Narayanan B. and McDougall, R. An Overview of the GTAP 9 Data Base. Journal of Global Economic Analysis 2016, 1, pp. 181-208.

Banani, R., Vahdati, M.M., Shahrestani, M., & Clements-croome, D. (2016). The development of building assessment criteria framework for sustainable non-residential buildings in Saudi Arabia. Sustainable Cities and Society, 26, 289–305. http://doi.org/10.1016/j.scs.2016.07.007

Banse, M., van Meijl, H., Tabeau, A. and Woltjer, G. (2008) Will EU biofuel policies affect global agricultural markets? European Review of Agricultural Economics 35, 117-141.

Banse, M., Van Meijl, H., Tabeau, A.,; Woltjer, G., Hellmann, F., Verburg, P.H. Impact of EU biofuel policies on world agricultural production and land use, Biomass and Bioenergy 2011, 35, 2385-2390.

Black, R., Adger, W.N., Arnell, N.W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. Global Environmental Change, 21, S3–S11. http://doi.org/10.1016/j.gloenvcha.2011.10.001

Castells, M. (2007). Communication, power and counter-power in the Network Society. International Journal of Communication, 1, 238–266.

CGIAR (2017). Farm Small, Think Big: How Agriculture Can Help in Today’s Global Refugee Crisis. Water, Land and Ecosystems. October 16, 2017. https://wle.cgiar.org/thrive/2017/10/16/farm-small-think-big-how-agriculture-can-help-today%E2%80%99s-global-refugee-crisis

Conijn, J.G. and W. van Dijk, 2018, https://doi.org/10.18174/441272 Food related land requirement and phosphorus balance of The Netherlands: Appendix of report Closing the life cycle of phosphorus in an urban food system: the case Almere (NL) report WPR – 725, Lelystad

Corong, E.L.,; Hertel, T.W., McDougall, R.A., Tsigas, M., van der Mensbrugghe, D. The Standard GTAP Model, version 7. Journal of Global Economic Analysis 2017, 2, 1-119.

Diogo, V., Koomen, E., & Kuhlman, T. (2015). An economic theory-based explanatory model of agricultural land-use patterns: The Netherlands as a case study. Agricultural Systems, 139, 1–16. http://doi.org/10.1016/j.agsy.2015.06.002

EKN, Jordan, …. Multi-Annual Strategic Plan Jordan

Foresight: Migration and Global Environmental Change. 2011. Final Project Report. The Government Office for Science, London.

Frank, Stefan, Petr Havlík, Elke Stehfest, Hans van Meilj, Peter Witzke, Ignacio Pérez-Domínguez, Michiel van Dijk, Jonathan Doelman, Thomas Fellmann, Jason Levin-Koopman, Andrzej Tabeau, and Hugo Valin (2018) A multi-model assessment of agricultural non-CO2 emission reductions to achieve the 1.5 °C climate target. Nature Climate Change. (IF 19.2)

Groot, N. de, Haddadin, W., Schurink, E. (2018). Horticulture in Jordan: A Sector in Danger?

Guadagno, L. (2017). Human Mobility in a Socio-Environmental Context: Complex Effects on Environmental Risk. In K. Sudmeier-Rieux, M. Fernández, I. M. Penna, M. Jaboyedoff, & J. C. Gaillard (Eds.), Identifying Emerging Issues in Disaster Risk Reduction, Migration, Climate Change and Sustainable Development: Shaping Debates and Policies (pp. 13–31). Cham: Springer International Publishing.

Guitouni, A., & Martel, J.M. (1998). Tentative guidelines to help choosing an appropriate MCDA method. European Journal of Operational Research, 109(2), 501–521. http://doi.org/10.1016/S0377-2217(98)00073-3

Huizingh, E.K.R.E., & Vrolijk, H.C.J. (1997a). A comparison of verbal and numerical judgments in the analytic hierarchy process. Organizational Behavior and Human Decision Processes, 70(3), 237–247. http://doi.org/10.1006/obhd.1997.2708

Huizingh, E.K.R.E., & Vrolijk, H.C.J. (1997b). Extending the applicability of the analytic hierarchy process. Socio-Economic Planning Sciences, 31(1), 29–39. http://doi.org/10.1016/S0038-0121(96)00025-0

Hasegawa, Tomoko, Shinichiro Fujimori, Petr Havlik, Hugo Valin, Benjamin Bodirsky, Jonathan Doelman, Thomas Fellmann, Page Kyle, Jason Levin-Koopman, Hermann Lotze-Campen, Daniel Mason-D’Croz, Yuki Ochi, Ignacio Perez-Dominguez, Elke Stehfest, Timothy B. Sulser, Andrzej Tabeau, Kiyoshi Takahashi, Jun'ya Takakura, Hans van Meijl, Willem-Jan van Zeist, Keith D. Wiebe, Peter Witzke. (2018) Risk of increased food insecurity under stringent global climate change mitigation policy. Nature Climate Change (IF 19.2).

Internal Displacement Monitoring Centre (IDMC). 2018. 2018 Global Report on Internal Displacement. Norwegian Refugee Council, Geneva.

Internal Displacement Monitoring Centre (IDMC). 2017. GRID 2017: Global Report on Internal Displacement. Norwegian Refugee Council. Geneva.

International Organization for Migration. 2015. Global Migration Trends: Factsheets 2015. IOM's Global Migration Data Analysis Centre. Geneva.Janssen, R., & van Herwijnen, M. (2011). Definite 3.1.

Kent, M.L., Sommerfeldt, E.J., & Saffer, A.J. (2016). Social networks, power, and public relations: Tertius Iungens as a cocreational approach to studying relationship networks. Public Relations Review, 42(1), 91–100. http://doi.org/10.1016/j.pubrev.2015.08.002

Liang, X., D.P. Lettenmaier, E.F. Wood, S.J. Burges, 1994, A Simple hydrologically Based Model of Land Surface Water and Energy Fluxes for GSMs, Journal of Geophysical Research Atmospheres 99(14), DOI: 10.1029/94JD00483 https://www.researchgate.net/publication/23922163_A_Simple_hydrologically_Based_Model_of_Land_Surface_Water_and_Energy_Fluxes_for_GSMs

Mercandalli, S., Losch, B., Jolivot, A., Lorente, J.-C., & Ba, C.O. (2017). Rural Africa in motion: dynamics and drivers of migration South of the Sahara.

Migali, S., Natale, F., Tintori, G., Kalantaryan, S., Grubanov-Boskovic, S., Scipioni, M., Farinosi, F., Cattaneo, C., Benandi, B., Follador, M., Bidoglio, G., McMahon, S. and Barbas, T. 2018. International Migration Drivers: A quantitative assessment of the structural factors shaping migration. Joint Research Centre of the European Commission. Publications Office of the European Union, Luxembourg.

Ministerie van Justitie en Veiligheid (2018). Integrale Migratieagenda. Brief aan de Voorzitter van de Tweede Kamer der Staten Generaal. Den Haag, 29 maart 2018.

Mullan, K., Sills, E., Pattanayak, S.K., & Caviglia-Harris, J. (2017). Converting Forests to Farms: The Economic Benefits of Clearing Forests in Agricultural Settlements in the Amazon. Environmental and Resource Economics, 1–29. http://doi.org/10.1007/s10640-017-0164-1

Munda, G. (2004). Social multi-criteria evaluation: Methodological foundations and operational consequences. European Journal of Operational Research, 158(3), 662–677. http://doi.org/10.1016/S0377-2217(03)00369-2

Nelson, G.C.; van der Mensbrugghe, D.; Ahammad, H.; Blanc, E.; Calvin, K.; Hasegawa, T.; Havlik, P.; Heyhoe, E.; Kyle, P.; Lotze-Campen, H.; von Lampe, M.; Mason d'Croz, D.; van Meijl, H.; Müller, C.; Reilly, J.; Robertson, R.; Sands, R.D.; Schmitz, C.; Tabeau, A.; Takahashi, K.; Valin, H.; Willenbockel, D. Agriculture and climate change in global scenarios: why don't the models agree? Agricultural Economics 2014, 45 (1), pp85-101.

Onwezen, M.C., Antonides, G., & Bartels, J. (2013). The norm activation model: An exploration of the functions of anticipated pride and guilt in pro-environmental behaviour. Journal of Economic Psychology, 39, 141–153. http://doi.org/10.1016/j.joep.2013.07.005

Pöyhönen, M., Vrolijk, H., & Hämäläinen, R.P. (2001). Behavioral and procedural consequences of structural variation in value trees. European Journal of Operational Research, 134(1), 216–227. http://doi.org/10.1016/S0377-2217(00)00255-1

Ramos, J., Soma, K., Bergh, Ø., Schulze, T., Gimpel, A., Fabi, G., … Ma, T. (2014). Multiple interests across European coastal waters: The important of a common language. ICES Journal of Marine Science, 1–12. http://doi.org/10.1093/icesjms/fsu095

Renn, O. (2006). Participatory processes for designing environmental policies. Land Use Policy, 25, 34–45. Retrieved from http://www.sciencedirect.com/science/article/pii/S0264837704000882

Rutten, M.; Shutes, L.; Meijerink, G. Sit down at the ball game: how trade barriers make the world less food secure, Food Policy 2013, 38, 1-10.

Saaty, T.L. (2004). Decision making – the Analytic Hierarchy and Network Processes (AHP/ANP). Journal of Systems of Science and Systems of Engineering, 13(1), 1–35.

Schaphoff, Sibyll; Bloh, Werner Von; Rammig, Anja; Thonicke, Kirsten; Biemans, Hester; Forkel, Matthias; Gerten, Dieter; Heinke, Jens; Jägermeyr, Jonas; Knauer, Jürgen; Langerwisch, Fanny; Lucht, Wolfgang; Müller, Christoph; Rolinski, Susanne; Waha, Katharina (2018). LPJmL4 - A dynamic global vegetation model with managed land - Part 1: Model description, Geoscientific Model Development 11 (4). - p. 1343 – 1375

Schmitz, C.; van Meijl, H.; Kyle, P.; Nelson, G.C.; Fujimori, S.; Gurgel, A.; Havlik, P.; Heyhoe, E.; Mason d'Croz, D.; Popp, A.; Sands, R.; Tabeau, A.; van der Mensbrugghe, D.; von Lampe, M.; Wise, M.; Blanc, E.; Hasegawa, T.; Kavallari, A.; Valin, H. Land-use change trajectories up to 2050: insights from a global agro-economic model comparison. Agricultural Economics 2014, 45, 69-84.

Sixt, G. and K. Poppe (2018). *The Agricultural Knowledge and Innovation System of Jordan's Horticultural Sector; Current state and suggestions for improvement.* Wageningen, Wageningen Economic Research, Report 2018-114.

Soma, K. (2010). Framing participation with multicriterion evaluations to support the management of complex environmental issues. Environmental Policy and Governance, 20(2). http://doi.org/10.1002/eet.534

Soma, K., Ramos, J., Bergh, Ø., Schulze, T., Oostenbrugge, H. Van, Duijn, A.P. Van, … Buisman, E. (2013). The "mapping out" approach: Effectiveness of marine spatial management options in European coastal waters. ICES Journal of Marine Science, 29, 1–13.

Tabeau, A., H. van Meijl, K.P. Overmars, E. Stehfest, "REDD policy impacts on the agri-food sector and food security". Food Policy 66 (2017) 73–87, section 2.1

United Nations, Department of Economic and Social Affairs, Population Division. 2017. International Migration Report 2017: Highlights (ST/ESA/SER.A/404).

United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Ageing 2017 - Highlights (ST/ESA/SER.A/397).

United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. ESA/P/WP/248.

UNHCR (2016). "Livelihoods Strategy: UNHCR Uganda Operation 2017 - 2020."

Van Meijl, H.; Tsiropoulos, I.; Bartelings, H.; Hoefnagels, R.; Smeets, E.; Tabeau, A.; Faaij, A. On the macro-economic impact of bioenergy and biochemicals – Introducing advanced bioeconomy sectors into an economic modelling framework with a case study for the Netherlands. Biomass and Bioenergy 2018, 108, 381-397.

Van Vliet, M.T.H., J.R. Yearsley, W.H.P. Franssen, F. Ludwig, I. Haddeland, D.P. Lettenmaier, and P. Kabat, 2012: Coupled daily streamflow and water temperature modelling in large river basins. Hydrol. Earth Syst. Sci., 16 (2012), 4303–4321.

Van Vliet, M.T.H., W.H.P. Franssen, J.R. Yearsley, F. Ludwig, I. Haddeland, D.P. Lettenmaier, and P. Kabat, 2013: Global river discharge and water temperature under climate change. Global Environmental Change 23 (2013) 450–464.

Vogd, J.H. (1982). Multicriteria evaluation for urban and regional planning. London: London: Pion

Woltjer, G.; Kuiper M. Eds. The MAGNET model - Module description. LEI Wageningen University & Research Report 14-057. The Hague. 2014.

Annex 1 Reference case Jordan: forced migration and settlement

Jordan is proposed as an interesting country to focus on. Since the beginning of the conflict in 2011, Jordan has received over 1.4 million people who seek refuge in Jordan, most of them being of Syrian origin and most of them (i.e. more than 80%) living in urban, peri-urban and rural areas in Jordan. Recent statistics show distribution of Syrians across different governorates and municipalities of Jordan. In addition to Syrian refugees living in host communities, there are three camps in Jordan, namely: Zatari Camp, Mukhayyam AL-Emira and Azraq Camp. The biggest population density of Syrian refugees outside Amman are occurring in Greater Irbid Municipality (ca. 200,000), Ramtha Municipality (more than 50,000), Sahal Houran Municipality (around 18,000), Mafraq Municipality (around 40,000), and Greater Zarqa Municipality (around 78,000). Greater Amman hosts more than 400,000 Syrians.

Jordan has been profoundly affected by the conflict in Syria and the fight against extremism, not only through a large number of refugees and displaced persons residing in the country, but also by the difficult economic situation in which Jordan finds itself. In order to prevent the instability in the region from spreading beyond its borders, and motivated by a sense of shared responsibility, the Dutch government is strengthening and expanding the Netherlands' cooperation with Jordan.

Jordan is a Middle Eastern kingdom located on the East Bank of the River Jordan, with a population of about 9,7 million people. Jordan is considered as a lower middle-income country with well-developed infrastructure and a relatively high standard of living along with an emerging free economy. The annual population growth rate is about 2,5% (2017). The country is administratively divided into 12 provinces or governorates, which are in turn sub-divided into 54 districts. More than half of Jordan's land is part of the Arabian Desert. Its eastern part has oases and seasonal water streams for irrigation, while the western part has both arable land and Mediterranean forests. Its agricultural sector is constrained by limited arable land, and scarce water, mineral and energy resources. Jordan's only sea coast area, located in the south-west, is shared with Egypt and Israel. Jordan is still a "beacon of relative peace" in the Middle East, but the regional political environment is affecting the country's political stability and economic outlook (de Groot et al., 2018).

Located in the middle of a complex and dynamic political, social and economic sub-system between Iraq, Saudi Arabia, Syria, Palestine and Israel, regional tensions have continuously impinged upon the country's decision-making processes. A number of crises nearby, most notably in Syria, have taken their toll on Jordan. According to UNHCR, Jordan is one of the countries most affected by the Syria crisis, with the second highest share of refugees compared to its population in the world: 89 refugees per 1.000 inhabitants. Estimates amount up to 1 million refugees currently residing in Jordan, (although UNHCR figures are a bit lower), with the majority of them coming from Syria, a significant number from Iraq and smaller numbers from Yemen, Sudan, Somalia and other countries. The large number of refugees are a heavy burden for the country.

The challenges

The Kingdom of Jordan, and especially its horticultural sector, faces challenging times. The political instability in neighbouring countries has not only resulted in a large flow of refugees, especially from Syria, but also a loss of markets. The war in Syria has blocked the export of fruit and vegetables to the east of Europe, including Russia, as road traffic has become impossible. This has led to a collapse of prices in the home market and a need for innovation in the sector (ibid).

In conjunction with the Jordanian authorities, the Netherlands contributes to economic growth and employment generation in Jordan. The horticulture sector has been identified as the sector with high potential to generate jobs for both Jordanians and Syrians. Furthermore, this sector has the potential to contribute to economic growth by enhancing production while reducing costs through more efficient use of energy and water. The renowned Dutch expertise in horticulture is another reason for prioritizing Jordan's horticulture sector in the cooperation between both countries.

Methodologies

There is growing recognition that a movement is needed away from a sector-by-sector approach to policy, science and practice, towards an approach that considers the interactions between water, food and energy, while taking into account the synergies and trade-offs that arise from the management of these three resources. The schemes below are examples of models that can be applied as guidance for 'zooming in and out' during project implementation.

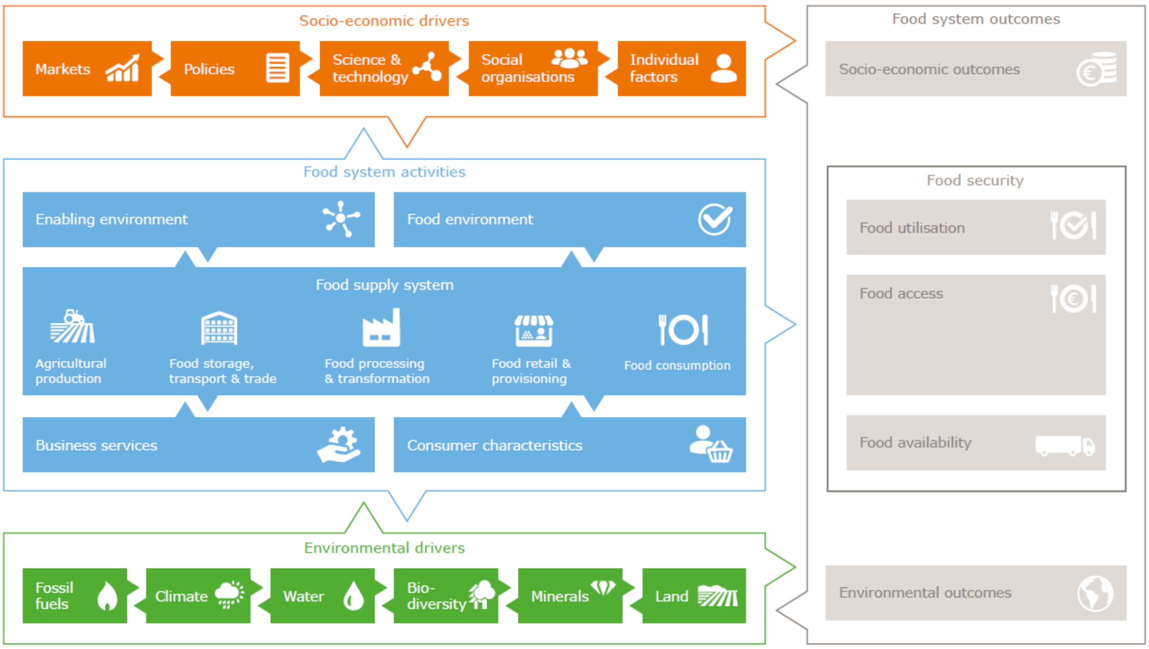

Figure A *The Food Systems Approach (Dengerink, Van Berkum, Ruben (2018)).*

WUR approaches to operationalise the Food Systems models are e.g. the 'Managing for Sustainable Development Impact', the 'Facilitating Multi-stakeholder Partnerships' approaches or WUR's and CTA's 'Youth push and pull framework'.

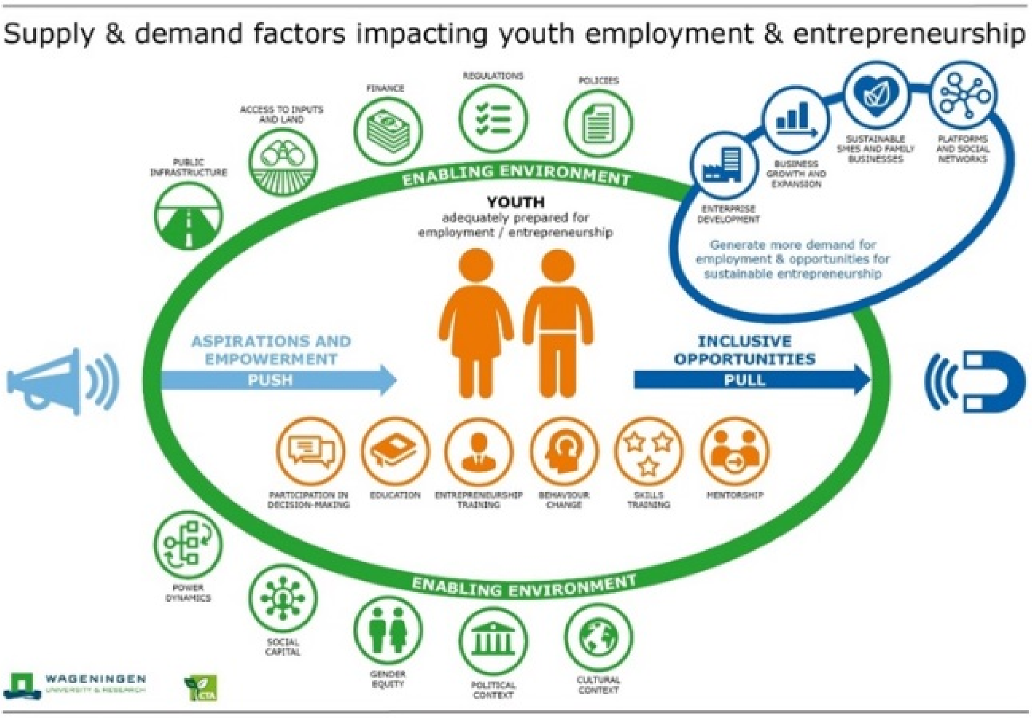

Figure B *Supply and demand factors –push/pull.*

An AKIS describes the network of actors and how they interact to impact agricultural innovations (EIP-AGRI, 2018). A well-functioning AKIS is one in which new know-how and technologies (hardware, software and orgware) are developed, tested and actively disseminated and job profiles and competence-based curricula are in line with the needs and opportunities of the sector. Building an AKIS involves developing an inclusive multi-actor network and co-creation strategy for agricultural knowledge and innovation, including the whole range of actors along the entire value chain, meaning farmers and farm workers, agricultural input suppliers, food processors, consumers, retailers, exporters, research stations, extension service, technical training and education institutes, governmental and non-governmental actors, international organisations and supporting services such as credit providers (EU-SCAR, 2013, 2012).

AKIS is about making innovation in the sector systemic, based on improved capacities of all actors involved. The basic idea is to take up the challenges of the current crisis in horticulture with an innovation strategy by making innovation a core aspect of the way it operates through innovation projects that target urgent innovation needs and capacity building projects. This will enable the Jordanian agricultural sector (business, government and knowledge institutes) to take innovation to a higher level than in the past and enabling the sector to monitor and involve stakeholders in the process of self-governance (Weber and Rohracher, 2012).

Central to overcoming the challenges facing the AKIS in Jordan is the role of Technical and Vocational Education and Training (TVET). There are three main providers of public TVET in Jordan: The Ministry of Education (MOE), the Vocational Training Corporation (VTC) and the Al-Balqa Applied University (BAU) community college system. Of the providers of TVET in Jordan, VTC is the only institution providing vocational training in agriculture. While agriculture TVET in Jordan is currently limited, it receives specific attention in this proposal because of the potential for it to have a positive impact on capacity building, linked to AKIS. The analysis by WUR (based on the two missions and the fact-finding report) concludes that focus on improving *education, technical training, research and data collection* is most important in the Jordanian AKIS. It is also an area that shows some of the greatest promise for improvement, as it has TVET providers who are actively interested in collaboration and make up the public education system of the agriculture sector.

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