RELATIVE YIELD GAP ROOTS AND TUBERS 2031

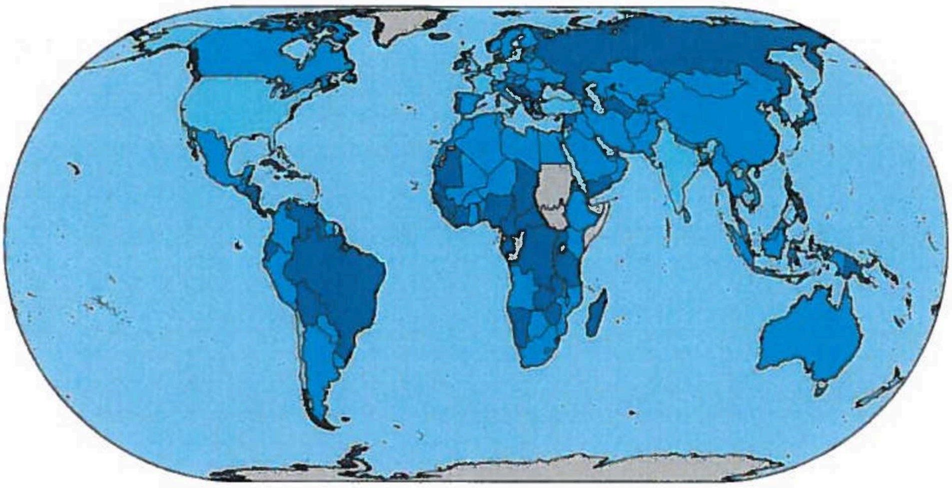

FIGURE 21. COUNTRIES RELATIVE YIELD GAP FOR ROOTS AND TUBER IN 2031. DARKER COLORS CORRESPOND WITH A HIGHER RELATIVE YIELD GAP

RELATIVE EFFECTIVE YIELD GAP ROOTS AND TUBERS 2031

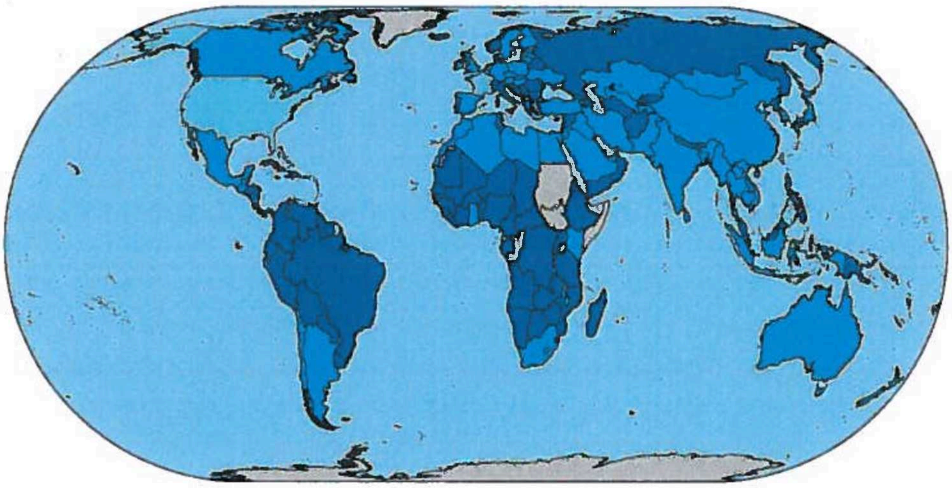

FIGURE 22. COUNTRIES AVERAGE VALUES FOR RELATIVE YIELD GAP AND EFFECTIVE YIELD GAP FOR ROOT AND TUBERS IN 2031. DARKER COLORS CORRESPOND WITH A HIGHER RELATIVE YIELD GAP

4.3 Causes high food import dependency

It is interesting to see the causes of an increased import dependency for cereals, meat, and roots and tubers. On the basis of this scenario discovery approach it was analyzed what the effects were with specific regard to the main drivers that were envisioned and used in the modeling, and were considered to be the most important in exploring future effects on the food system. The three drivers are the middle class effect – the combined effects of both economic developments and population growth – climate change and yield gap – the difference between the actual agricultural production and the potential of agricultural lands (i.e., maximum yield).

Middle class effect

One of the key drivers of the relative demand for meat imports in 2031 is the middle-class effect.

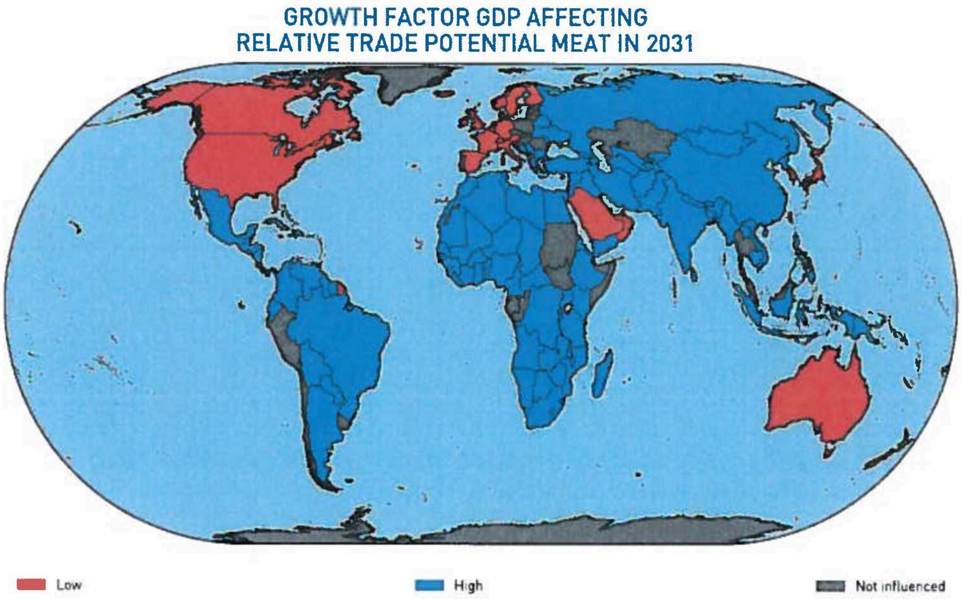

FIGURE 23. GDP GROWTH CAUSING A LOW RELATIVE TRADE POTENTIAL FOR MEAT IN 2031

This effect is caused by low population growth with relatively high economic growth. Many countries are affected. Mostly, at present, this concerns the higher echelons of lower income countries, or the lower echelons of middle-income countries. The uncertainties impacting these developments most are economic and population uncertainties (Table 14). The table makes clear that economic and middle-class effects are most pronounced for the demand for meat imports.

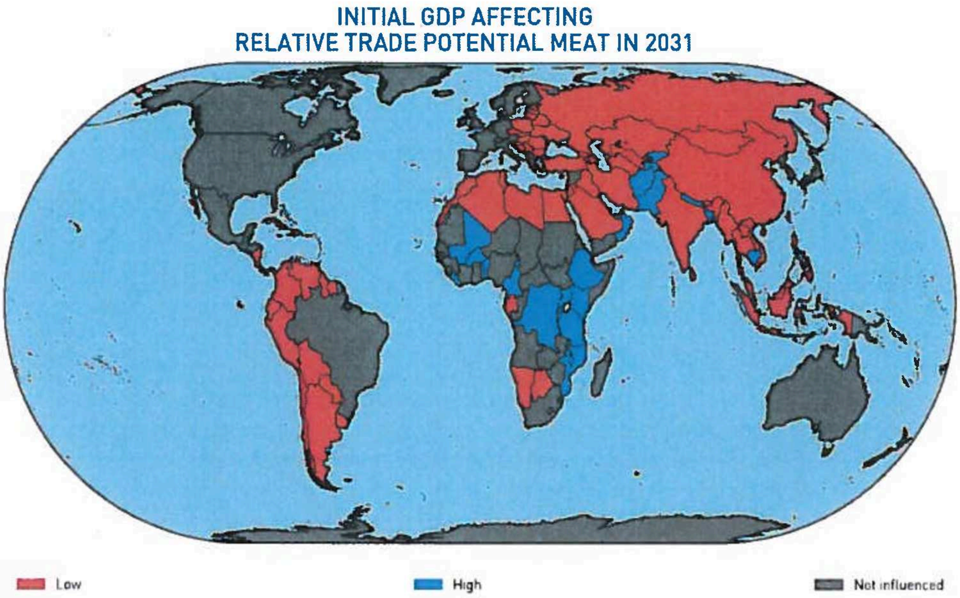

FIGURE 24. INITIAL GDP UNCERTAINTY CAUSING A LOW RELATIVE TRADE POTENTIAL FOR MEAT IN 2031

In Figure 24 we see that the initial GDP uncertainty affects the relative trade potential for meat in many countries. The issue here is that the actual value of a country's GDP is deeply uncertain, and that multiple methods exist for calculating the size of the GDP. This is both the case for different GDP estimates published by single institutions (c.f., nominal GDP values and purchasing power parity, PPP, GDP values), as for estimates published by different institutions (c.f., GDP values published by the World Bank, the UN, and the CIA World Factbook). As population estimates can be considered to be less uncertain – as the population can be counted, while the GDP has to be modeled – the actual status of a country's GDP per capita is arguably most dependent on the estimate for the GDP. The GDP per capita is the prime proxy for the development level used in this study, and therefore, for the middle-class effect.

When we observe Figure 24 once more, we see that those countries that are already observing a middle-class effect get higher relative trade deficits for meat when the GDP estimate used was on the lower portion of the total bandwidth. This can be understood as when they have relatively much to improve in the local purchasing power for food; the meat demand will increase more than when this middle-class effect was already underway for a longer period of time. On the other hand, we see that countries with a potential, however small it may be, for reaching the middle-class effect will have the highest deficits when the GDP estimate used is on the high side of the spectrum.

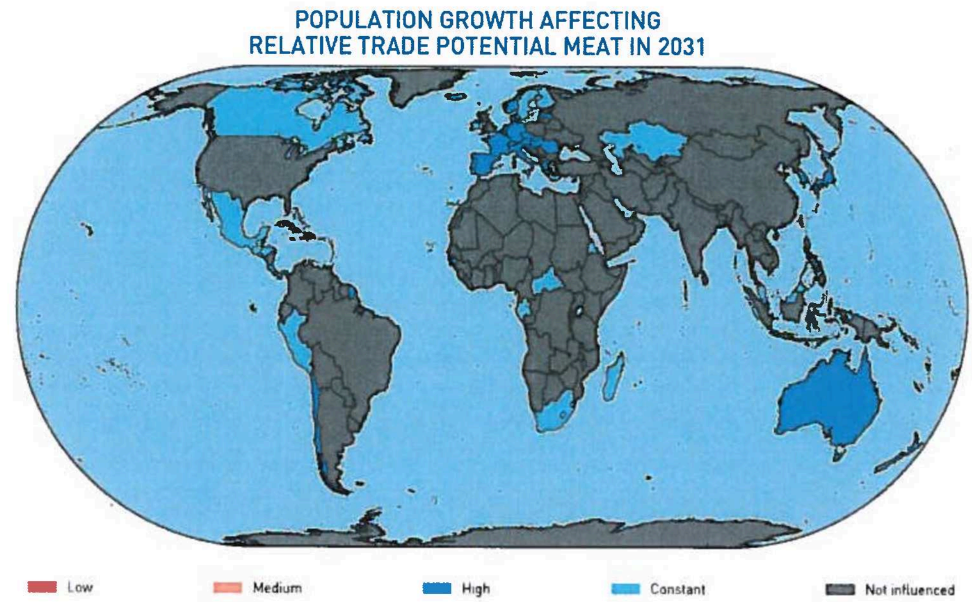

FIGURE 25. POPULATION GROWTH SCENARIOS CAUSING A LOW RELATIVE TRADE POTENTIAL FOR MEAT IN 2031

High and constant population growth affect mostly countries where the GDP level is already relatively high, as it has a detrimental effect on the average GDP per capita, making middle-income countries' meat demand level out with low or medium scenarios. For countries in Western Europe and Australia, however, it is clear that when the population growth is relatively high until 2031, the meat demand will increase most.

Table 14 shows which types of impact we have observed for how many countries per food type. We clearly see in this table that climatic change, expressed here by the change in annual precipitation, mostly increases the import dependency for cereals and roots and tubers, while the meat production is not affected. For vegetal food types it can thus be stated that increased import dependency is purely an issue of supply, than of demand. For meat, however, increased import dependency is purely an issue of increased demand.

UNCERTAINTY	TYPE OF IMPACT	CEREALS (# COUNTRIES)	MEAT (# COUNTRIES)	ROOTS AND TUBERS (# COUNTRIES)
Low annual precipitation	Climate	62	0	61
Medium annual precipitation	Climate	30	0	33
High annual precipitation	Climate	57	0	58
Constant annual precipitation	Climate	1	0	1
50% increase in precipitation	Climate (shock)	0	0	1
Low initial gdp	Economic/middle class	0	75	0
High initial gdp	Economic/middle class	0	27	0
Low growth factor gdp	Economic/middle class	16	29	18
High growth factor gdp	Economic/middle class	0	110	0
High population growth	Economic/middle class	0	29	0
Constant population growth	Economic/middle class	0	27	0
High normalization factor gdp per capita	Economic/middle class	0	10	0
Low delay on changes in annual plant production	Yield	0	0	4
Low reallocation delay on agricultural land	Yield	2	0	3
Low technological progress	Yield	0	0	1
Low maximum increase in agricultural land per year	Yield	25	0	24
High natural land degradation restoration time	Yield	120	0	117
Nothing found		7	1	2

TABLE 14. UNCERTAINTIES LEADING TO IMPORT DEPENDENCY IN NUMBER OF COUNTRIES

Climate change

When we observe which countries are most affected by the different scenarios for changing precipitation patterns, we see in Figure 26 that it is not easy to classify which regions are more affected by increasing or decreasing precipitation.

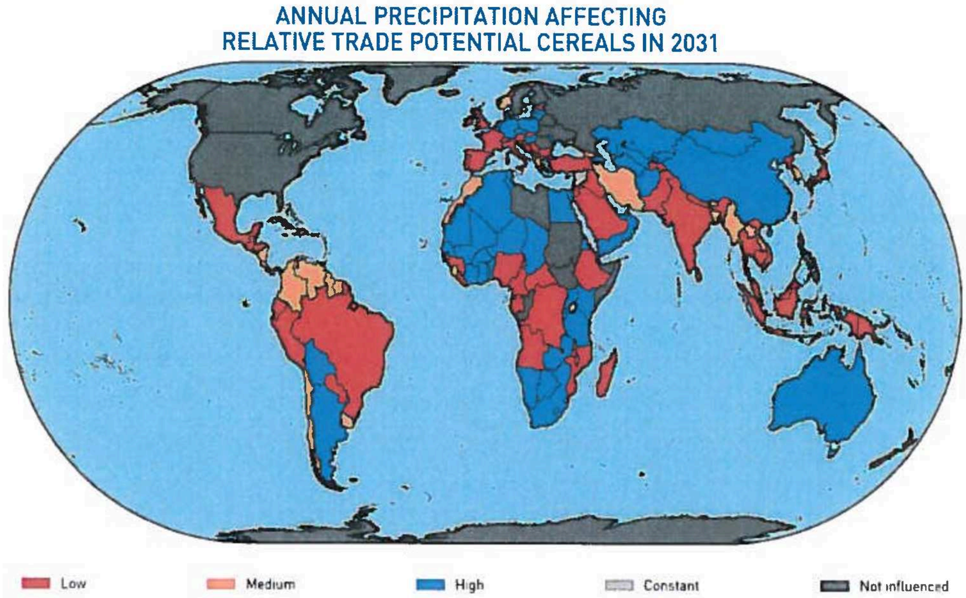

FIGURE 26. ANNUAL PRECIPITATION SCENARIOS CAUSING A LOW RELATIVE TRADE POTENTIAL OF CEREALS IN 2031. THE MAP OF ROOTS AND TUBERS IS SIMILAR

This is as country A or B being more sensitive for increasing precipitation does not mean that the decreasing precipitation has no effect on agricultural production. It solely means that that particular scenario's changes are most detrimental. It should be noted that the uncertainty in these precipitation scenarios is so large, that for many countries in the world it is not known whether climatic change will leave them with decreasing or increasing rainfall. It can, therefore, be such that the high precipitation scenario is simply more extreme than the low precipitation scenario, compared to the present precipitation levels. Further, a country's agricultural system can be expected to be optimized for current precipitation levels. Countries like Australia and Namibia, which are used to arid conditions, are therefore more affected by wetter conditions, as they may cause soil erosion. On the other hand, countries which on average experience high rainfall, like Brazil, the DRC, and Great Britain, will have greater issues with dealing with decreasing precipitation. In any case, for climate adaptation policies aimed at agricultural production, measures need to be taken both for increasing and decreasing precipitation level if this precipitation uncertainty exists.

Related to this issue is the effect of the natural land degradation restoration time visible in Figure 27. In practically all countries vulnerable to changing precipitation patterns, the effects will be smaller if soil degradation restores as fast as possible, in effect increasing the countries' resilience as the maximum effect of soil degradation and time to recover will then be smaller.

Yield gap

Yield gap reflects a large difference between agricultural production (i.e., yield) and potential of agricultural lands (i.e., maximum yield). It is caused by local traditions, lower availability of modern technology, and local climatic circumstances.

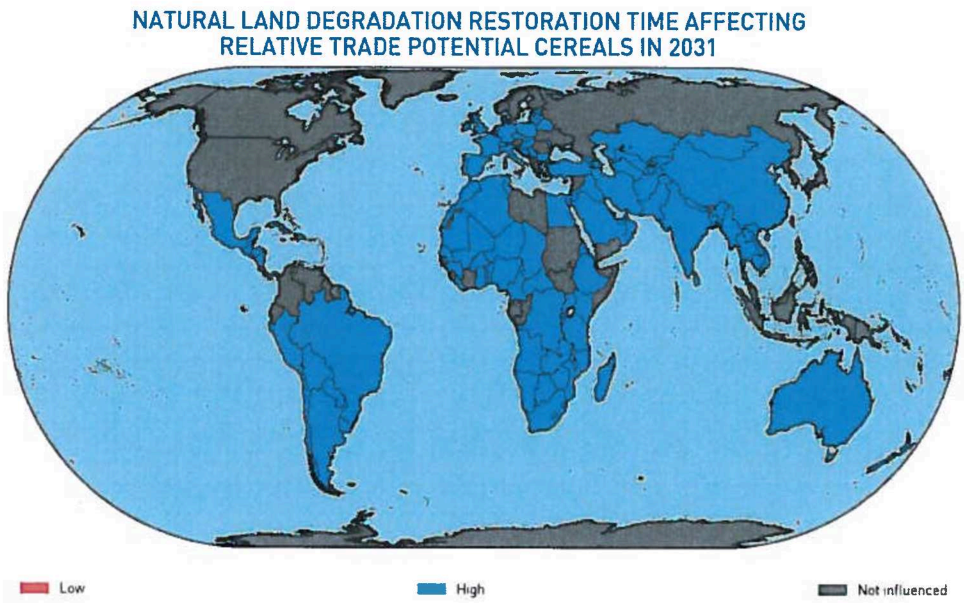

FIGURE 27. NATURAL LAND RESTORATION TIME UNCERTAINTY CAUSING A LOW TRADE POTENTIAL FOR CEREALS

Many countries are affected, at present mostly both lower and middle income countries. This is due to delays in improving yield relative to GDP per capita development: a country becomes richer first, then increases yield of agriculture.

The yield gap issue may be especially problematic for China if on a global scale it will not be possible to let the maximum possible yield for roots and tubers increase sufficiently, making the potential yield increase in China itself also lower.

5 SYNTHESIS

5 SYNTHESIS

After the analyses of the preceding chapter, it is interesting to see how robust current Dutch agricultural policies are with regard to trends witnessed already by different countries both within and outside Europe, and the food trade system in the Netherlands. We will obtain these results by comparing the insights from Chapter 2 on trends affecting the global food system and Chapter 3 regarding current food trade in the Netherlands with our simulation results from Chapter 4.

5.1 Trends and shocks affecting supply and demand

As we compare the contextual analysis of Chapter 2 and the research carried out in Chapter 4, we find that climate change is the most important issue (particularly with regard to changing precipitation patterns), for the future supply of vegetal food sources when it comes to demand. We also found that the middle-class effect (that is change in lifestyle and consumption patterns) is key for both current low-income countries and current middle-income countries, while demographic trends are only significant in current high-income countries.

The overall climate change phenomenon seem to have more effects than temporary, even multi-year, shocks in precipitation levels. However, it should be noted that changing precipitation patterns may not imply a change in average precipitations overall (i.e., is it going to be more wet or more dry), which is how it was interpreted in our research, but may rather mean a change in the bandwidth of yearly precipitation for every country.

5.2 Trade relations

A number of key findings can be harvested based on combining inputs of Chapter 3 and Chapter 4.

Inside Europe

Relevant export partners to the Netherlands and within Europe currently include Germany, Belgium, and the UK. In the future, this group of countries is not expected to change. This is understandable, as their geographic proximity cannot be changed, while the already high-income level of these countries does not make significant changes in both food demand and supply patterns. Only population growth can have an impact, but, as we know, even the high population estimates for these countries forecast a very modest growth in population size.

The most important import partners in Europe currently include Germany, Belgium, and France. The strength of their relations with the Netherlands is likely to remain similar in the future. Poland and other Eastern European nations can be expected to gradually gain in importance in the future.

Outside Europe

Export partners of importance to the Netherlands currently include China, the US, and Russia. In the future, export countries for meat would include Russia, China, and India, although Russia can be expected to become a net food exporter, and will therefore have a decreasing importance as key export partner to the Netherlands. The group picture may become more regional in the future, and is set to include Central Asia, several ASEAN countries such as Indonesia, Malaysia, and Brunei, the Middle East and Africa, Central and South America. In other words, the Netherlands should be prepared to deal with partners from the whole of Asia, the whole of Africa, the whole Central and Southern part of the American continent excluding Brazil.

Regarding import partners, Brazil, the US, and Indonesia are currently key to the Netherlands. We anticipate that Indonesia will be of lesser importance in the future as an import partner, while Brazil, Canada, the US, and New Zealand will gain in importance, particularly in terms of their meat trade status. For cereals, partners will include Russia, Canada, and Australia – and perhaps Tanzania, Mozambique, and Ethiopia.

5.3 Dutch knowledge export

Present Dutch knowledge export is primarily directed to China, Indonesia, and India, and mostly concerns the growth of total factor productivity (TFP, i.e., the total output growth relative to input of labor and capital). Further, knowledge is shared about water and energy shortages.

Efforts on TFP may need to focus more on yield gap countries such as CIS countries, Central and South American countries, the Middle East and Africa. China, Indonesia, and India may not be where most productivity gains can be found.

While most efforts regarding water and climatological issues currently focus on droughts, our findings suggest that in many countries, especially those experiencing semi-arid conditions, may also benefit from knowledge focusing on how to deal with flooding and other water-related soil degradation.

6 CONCLUSIONS AND RECOMMENDATIONS

6 CONCLUSIONS AND RECOMMENDATIONS

With the use of input coming from the qualitative analyses of the HCSS foresight studies in combination with the modelling results from both the descriptive analytics as well as the scenario discovery, it was possible to better understand the future consequences of the most important drivers for the food system worldwide, as well as the possible effects over time for the various countries. On this basis, some policy consequences as well as consequences for Dutch trade were identified.

6.1 Consequences for Dutch policy

As a consequence of the possible changing effects of the drivers on the food system, policies might need to change and adjust. In this paragraph, possible future focus shifts and adaptations are listed. With the modeling results it was generally possible to identify no-regret options for policy, having a robust approach towards anticipating future uncertain developments at the same time. It is acknowledged that these policy options will have to be scaled and probably be region- and/or country-specific. When developing the new policies, detailed analyses and country-specific analyses will be required.

For policy makers, it is important to have clear aims based on which they can pinpoint their policies. The analysis shows that relevant policy goals include targeting other or additional countries, placing more emphasis on those affected by trends and drivers identified and various trade partners that will gain in importance, and the evolution of Dutch knowledge export.

Consequences for Dutch knowledge export

- In terms of Dutch knowledge exports, efforts made for total factor productivity (TFP) may need to focus more on yield gap countries such as CIS countries, Central and South American countries, the Middle East and Africa. China, India, and Indonesia may not be where most productivity gains can be found. Countries experiencing semi-arid conditions may also benefit from knowledge focusing on how to deal with flooding and other water-related soil degradation.

- To increase yields, it is important to have food prices that incentivize higher food production. This can be made possible by increasing technology availability in those areas with the highest yield gaps. This is an effect that may especially have effects for larger scale farmers.

The need for an increase of the value of food

Without a well-functioning market where food commodity prices allow supply and demand to adjust to each other (i.e., taking the monetary value of food into account), it will be hard to produce enough food, on a global scale, to satisfy changing food demand patterns. The availability of meat and oil crops is particularly critical in this sense.

The causes of this food scarcity are caused by developments on both the demand side and the supply side. On the demand side, the middle-class effect causes increased food demand per capita. Therefore, the food scarcity is often not a matter of life or death, but of lifestyle. In itself this is, of course, not a negative effect, as larger parts of the world population will have increased income.

On the supply side, food producers and farmers will have to deal with the consequences of water scarcity caused by temporary droughts and climate change, and a yield gap caused by limited technology availability.

- Hence a well-functioning global food market can potentially mitigate these effects. Such a market should be **transparent and be optimized with technology capabilities** for increasing yields.
- **Additional measures could include decreasing meat demand and increasing meat supply.**

The need to increase transparency

Enhanced transparency helps all actors in the food value chain to give access to information about present and historic food prices per food commodity. Making technology available is important because it may increase the availability of market information and technology information to allow farmers to bigger yield growth, especially when a large proportion of small-scale farmers can have access to the Internet to increase information availability for them.

In particular, important and key countries to do so are, for example, countries in Sub-Sahara Africa, the Indian peninsula, and South-East Asia. In these countries, limited access to information, combined with limited financial resilience of local farmers, and often the position of middle men with incentives to keep prices low for local farmers reduce the income of food production, and reduce options for increasing it. For example, when a local farmer in rural Sub-Sahara Africa is growing maize in the wet season, he or she will generally have very limited financial reserves left from selling the previous harvest – the wet season is in many of these countries known to be the 'hunger period'. He will thus be more easily convinced to accept low prices offered by local middle men.

Increasing farmers' information position on global food prices will empower them in taking action to reduce these harmful effects.

The need to increase the capability to deal with water scarcity

In many regions of the world, water is already a limited resource. The analysis shows that climate change induced reduced water availability will especially have detrimental effects on food production in countries around the equator, India, most countries in the Middle-East, and also Southern-European countries.

There are multiple ways of dealing with these negative effects, mostly aimed at reducing the water intensity levels of farming.

One way is to change the crop types grown in specific regions. The water demand for for maize, for example, is very high. In regions characterized by either permanent low water availability or temporal multi-week droughts in the growing season, millet and sorghum may significantly increase local food production and, consequentially, local farmer income.

Another way is to reduce the evaporation of water in inefficient irrigation systems. This can be done, for example, by covering irrigation channels or make less use of flooding the fields with water as means of irrigation.[163]

Finally, yet another way is to stop promoting the production of cash crops by small-scale farmers and instead encourage them to focus on more sustainable and less intensive forms of subsistence agriculture, or permanent crops. While this may decrease their income from agriculture, at the same time it may significantly increase the reliability of their food production throughout the year of, for example, permaculture-like types of agriculture.The reduced agricultural income may further be compensated by increased options for other economic activities if the type of farming is not only less resource input dependent, but also less time input dependent. The used modelling technique in itself though could not substantially support this analysis further because the necessary analysis for this kind of question was not carried out.

The need to increase the capability to deal with an excess of water caused by climate change

Our results showed that many countries that are sometimes already quite stressed in terms of water availability may have issues if precipitations increase over time. The same may happen when, regardless of present water scarcity, precipitations may increase considerably. Examples of these countries are China, countries in the Sahel region, but also Germany and Poland. In these countries, it is of great importance to be able to deal with increased annual precipitation. This means in practice:

- Being able to buffer a temporal excess of water
- Being able to let high water levels decrease relatively fast
- Making sure that soil erosion is halted as much as possible.

Current policy approaches focus on circumstances involving dry climatic conditions. It is our assessment that they should also and more significantly **focus on higher precipitations.**

6.2 Consequences for Dutch trade potential

The ways in which the Dutch trade relations will involve and with which countries were investigated, giving an estimate of the future Dutch trade potential and which countries trade policies should target.

As the middle-class effect can be felt in low GDP per capital levels already, the following countries were identified as areas of concern to take into account: China, India, Vietnam, Mexico, the Philippines, Myanmar, Pakistan, Indonesia, Colombia, and Egypt. On a global scale, if no policy changes occur, none of the model runs showed that meat supply would match meat demand in 2031. The same applies also to other animal foods such as milk.

Regarding approaches aiming at increasing the effect of Dutch trade relations in Europe, Poland and other Eastern European nations can be expected to gradually gain in importance in the future next to Germany, Belgium, and France as current export partners to the Netherlands. Outside Europe, the Netherlands should be prepared to deal with partners from the whole of Asia, the whole of Africa, and the whole Central and Southern part of the American continent excluding Brazil. With regard to import partners, Indonesia will be of lesser importance in the future, while Brazil, Canada, the US, and New Zealand should be included in the radar, particularly in terms of their increased significance in meat trade. For cereals, partners will include Russia, Canada, and Australia.

APPENDIX A – MODEL DESCRIPTION

APPENDIX A – MODEL DESCRIPTION

In this Appendix, we discuss the models used for analyzing the impact of food on the trade potential of the Netherlands and its relations to others. The specifics of the modeling method and Exploratory Modeling & Analysis (EMA) are discussed, while the general modeling assumptions, as well as a discussion on general model validity are also given.

A.1 System Dynamics and Scenario Discovery in general

System Dynamics

In this study, two different simulation models are used. These simulation models were made using the System Dynamics (SD) method.[164] SD is a quantitative modeling method which allows us to make causal relations between different factors explicit as mathematical equations and, as such, replicate feedback structures similar to the feedback mechanisms seen in real complex issues.

SD models allow us to simulate the simultaneous interactions of different feedback mechanisms, generating non-linear dynamic scenarios for the system elements represented in the model. One run with an SD model is thus an internally consistent set of dynamic scenarios for each system element modeled.

Scenario Discovery

Many complex systems are characterized by deep uncertainty about their functioning. Deep uncertainty can be defined as: "where analysts do not know, or the parties to a decision cannot agree on, (1) the appropriate conceptual models that describe the relationships among the key driving forces that will shape the long-term future, (2) the probability distributions used to represent uncertainty about key variables and parameters in the mathematical representations of these conceptual models, and/or (3) how to value the desirability of alternative outcomes."[165]

A method which allows for the development of scenarios for these systems is Scenario Discovery.[166] Scenario Discovery builds on the intuitive logic scenario techniques and allows for the exploration of the consequences of deep uncertainty with quantitative (simulation) models. As such, Scenario Discovery fits within the broader Exploratory Modeling & Analysis (EMA) methodology.[167] The application of Scenario Discovery with SD models, which methodologically can be referred to as Exploratory System Dynamics Modeling & Analysis (ESDMA),[168] allows the exploration of dynamic scenarios of systems that are both complex and uncertain.[169] As each scenario generated in the set corresponds to an individual SD model run, each scenario is internally consistent.

A.2 General modeling assumptions

In essence, all assumptions made in the modeling process are uncertain. The extent to which the assumption is uncertain depends on the amount of consensus (e.g., in the literature) about the assumption. However, for many of these assumptions no direct literature is available and where literature is available, this does not always indicate an absence of uncertainty. In this case, and also when no alternative assumptions are available, we assume that all assumptions are uncertain.

Method assumption

The first level of uncertainty, and consequentially, in the assumptions lies in choosing the simulation modeling method. As each method has both limitations and strengths, choosing a specific method influences the outcomes the model can generate. As such, it is important to choose a method that fits the characteristics of the problem.

The SD modeling method used in this study has several implicit and explicit method assumptions. SD can be used for forecasting scenarios based on input. The transformation of input to output in SD happens by focusing on the internal causal relations within a system. Another, contrasting method in this respect is econometrics. In extremis, econometrics focuses on estimating the correlation between input and output variables. SD is thus more a white box method, while econometrics is a black box method. As was indicated above, SD is a modeling method specifically suitable for complex problems. It functions by top-down unraveling the causal structure of the system of the research problem. It can thus be contrasted with Agent Based Modeling (ABM)[170], which is characterized by a strict bottom-up approach: the agents in the system are modeled and the top-down behavior is considered emergent. A final characteristic of SD modeling is the assumption of gradual or continuous change in the model variables. Discrete events or shocks can thus be modeled exogenously, but this is, in SD literature, generally considered to be undesirable.

The limitations of a particular modeling method can, from an uncertainty perspective, be overcome most elegantly by using multiple types of modeling, which complement each other in this perspective. However, it should be noted that choosing multiple methods makes the modeling phase in a research program longer, and generally requires multiple analysts from different modeling backgrounds to overcome biases attached to having a dominant field of work per analyst.

Model assumptions and uncertainties

After the choice has been made to use a specific modeling method, the first issue is the perspective from which the model is built. This can be seen as perspective uncertainty. A simple example may be the difference between a top-down and a bottom-up approach to calculating demand. Top-down, demand is calculated by looking at the economic development level of the population (GDP per capita) and the size of the population. Via a correlation between resource use and GDP per capita, the demand for a specific resource can be calculated. Bottom-up, one could look at the demand for specific uses of a resource and how far this demand has been met. Depending on an autonomous demand growth for each use, the aggregated demand can be calculated. When specific resource uses are considered, this may have a profound impact on other elements in the model as well. The perspective choice may thus influence the complete structure of a model, in essence leading to two different models.

On a slightly lower aggregation level, assumptions have been made about structural (formula) and parametric value uncertainties. Structural uncertainties are in essence modeling choices about formulas. Every model formula is thus an assumption. The majority of formulas can be derived using common sense, but specific formulas and model structures are not trivial.

The parametric uncertainty (with, as special variant, trend uncertainty) is the most concrete version of uncertainty encountered in the modeling process. All parameters in the model, except the definitions of specific parameter boundaries, are assumed to be uncertain. For a complete overview of all relevant assumptions, see the model

Model validity and limitations

A model is generally considered valid when it is suitable for the purpose intended.[171] Often this state of the model is referred to as model validity. Validating models used for scenario discovery, as in this study, is somewhat different compared to models that can rely on one reference run, as is done in traditional modeling. The absence of a reference run and the focus on different plausible dynamics in the system renders historic comparison largely obsolete. However, the issue of validation can, although only partly, be overcome by specific techniques, aiming at *ex ante* correct construction of the model, and *ex post*, face validation of the behavior shown by the model. All techniques described below were performed for both models in this research.

The *ex ante* validation contains basically three different checks and best practices. First, all variables in an SD model have units as well as values or formulas. A unit check can be performed in order to check whether the model is constructed consistently with regard to the units. A second check is to see whether literature exists with regard to specific relations between variables. Given the fact that correlations are only seldom useful in an SD model and statistic causal relations are not always translatable into a simulation model, this is however seldom possible. The third check is a sanity check, to see whether model relations make sense. We performed this in model construction workshops with energy experts.

Ex post, after model construction, it is possible to check whether the behavior of the model satisfies plausibility or extreme condition checks, for example, negative values for stockpiled resources should not be possible. Even if only one run in the whole set of scenarios generated with the model shows impossible behavior, this indicates model errors that need to be corrected. Further, the uncertainty analysis helps to detect these errors. A final check is whether the behavior shown by the model at least contains the expected behavior in the set of generated scenarios. If this is not the case, it should become clear why this does not happen and whether this is a plausible explanation for the impossibility of the initially expected behavior. In this study we used peer review sessions with energy experts for this purpose.

A.3 Model description

The overall model is composed of 5 different sub-models for food demand, land use, food supply, agricultural productivity, and water availability (Figure 28).

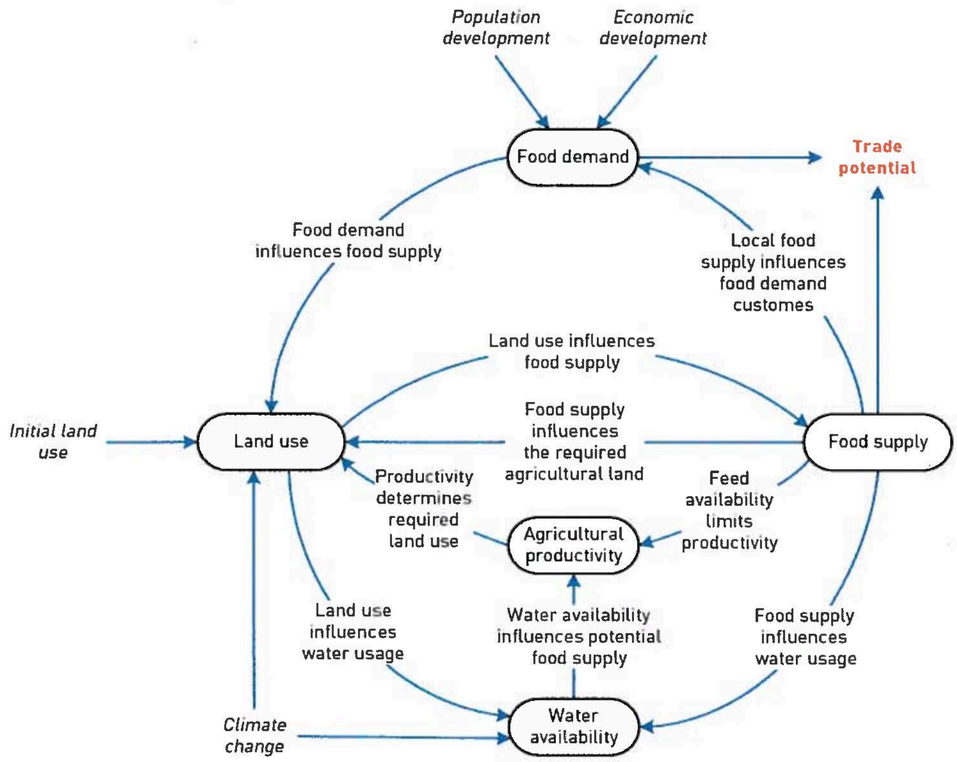

FIGURE 28. MODEL OVERVIEW

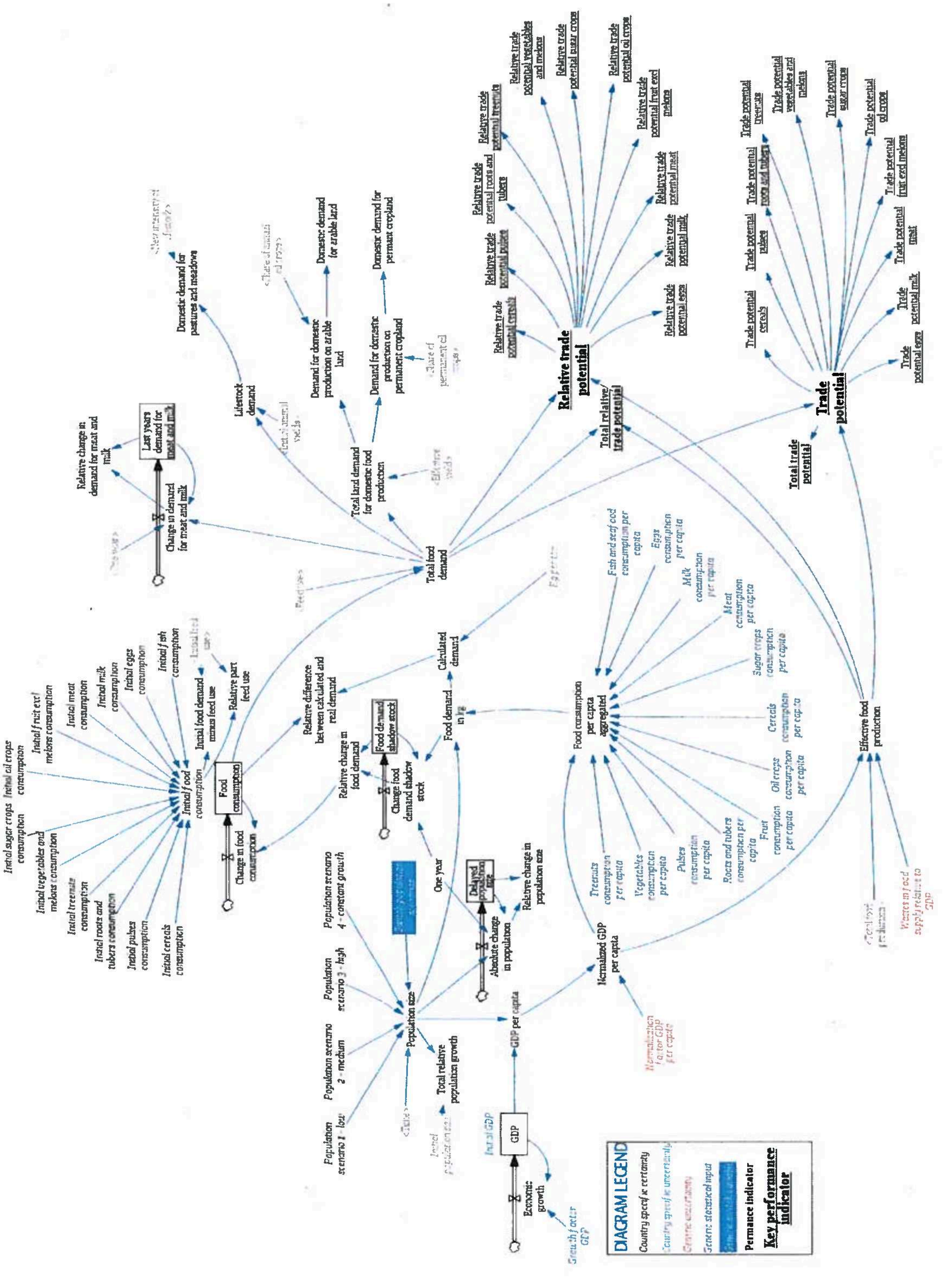

FIGURE 29. FOOD DEMAND SUB-MODEL

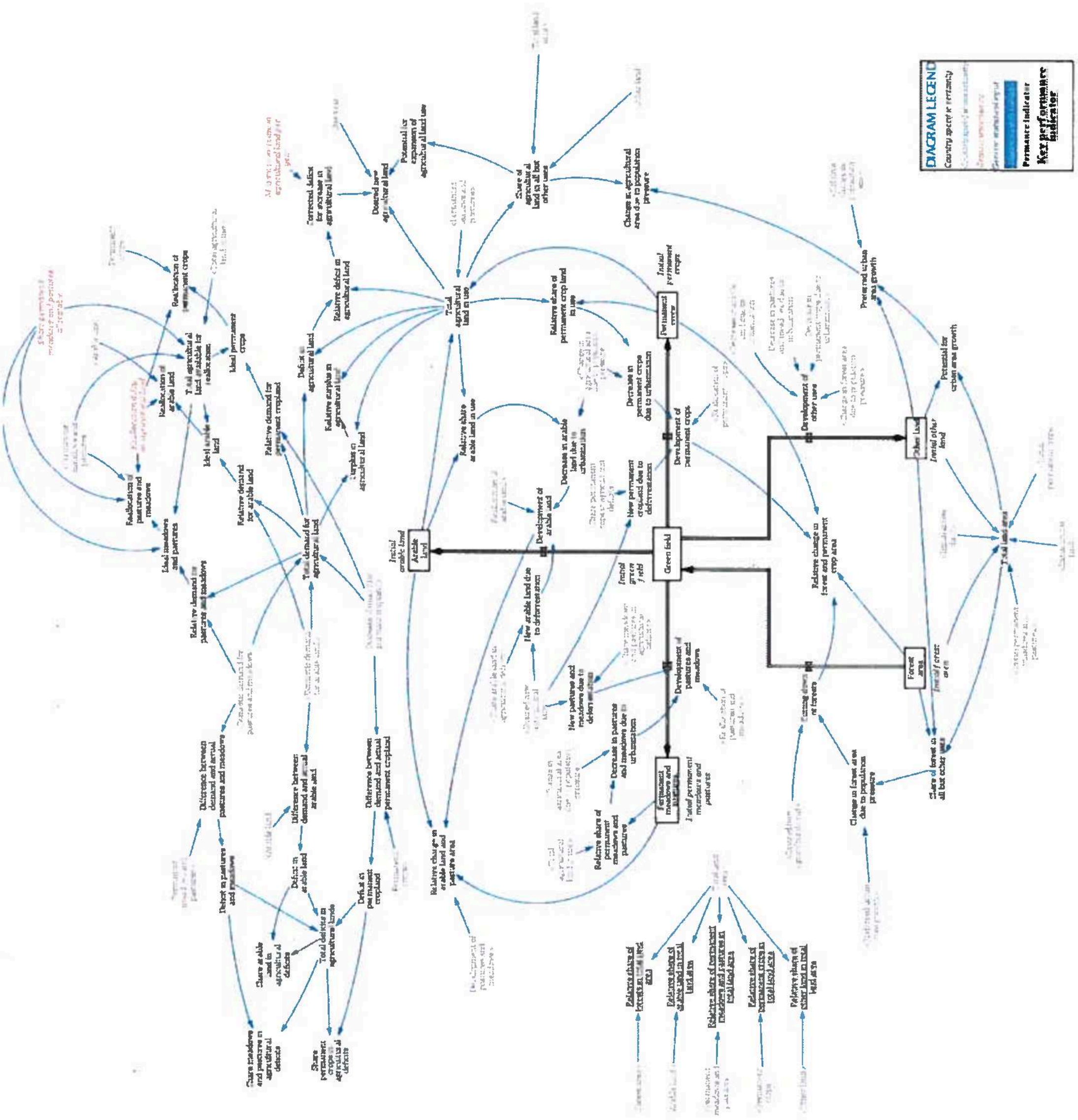

FIGURE 30. LAND USE SUB-MODEL

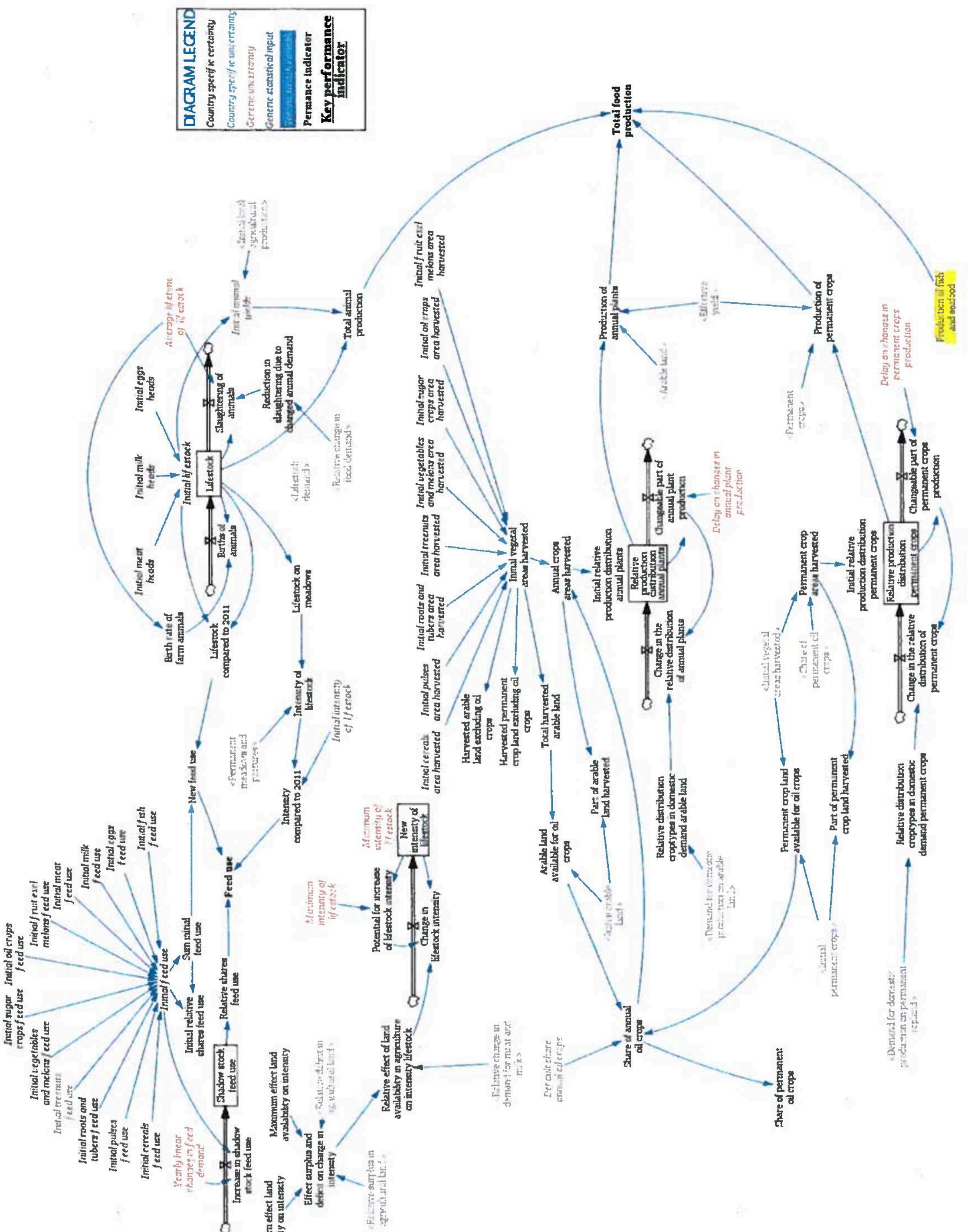

FIGURE 31. FOOD SUPPLY SUB-MODEL

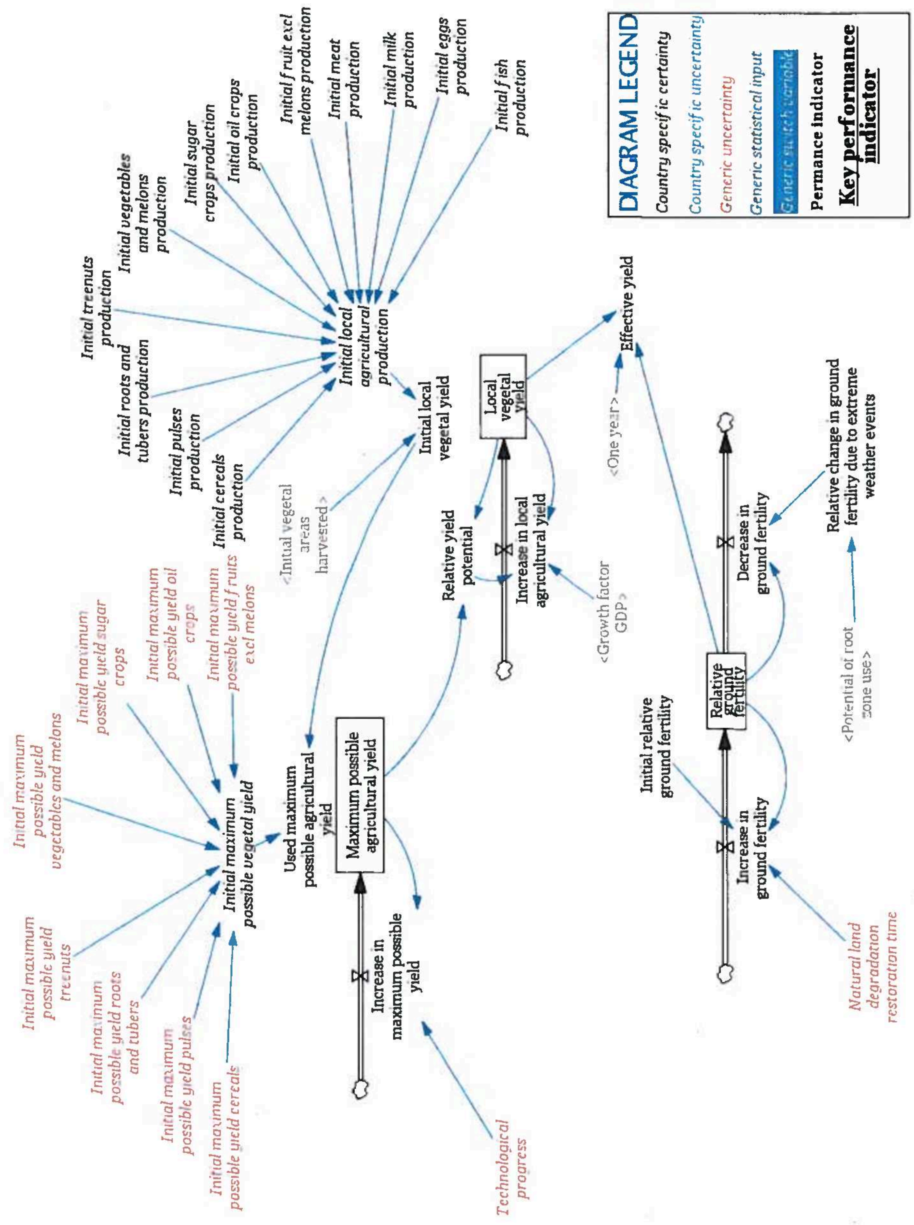

FIGURE 32. AGRICULTURAL PRODUCTIVITY SUB-MODEL

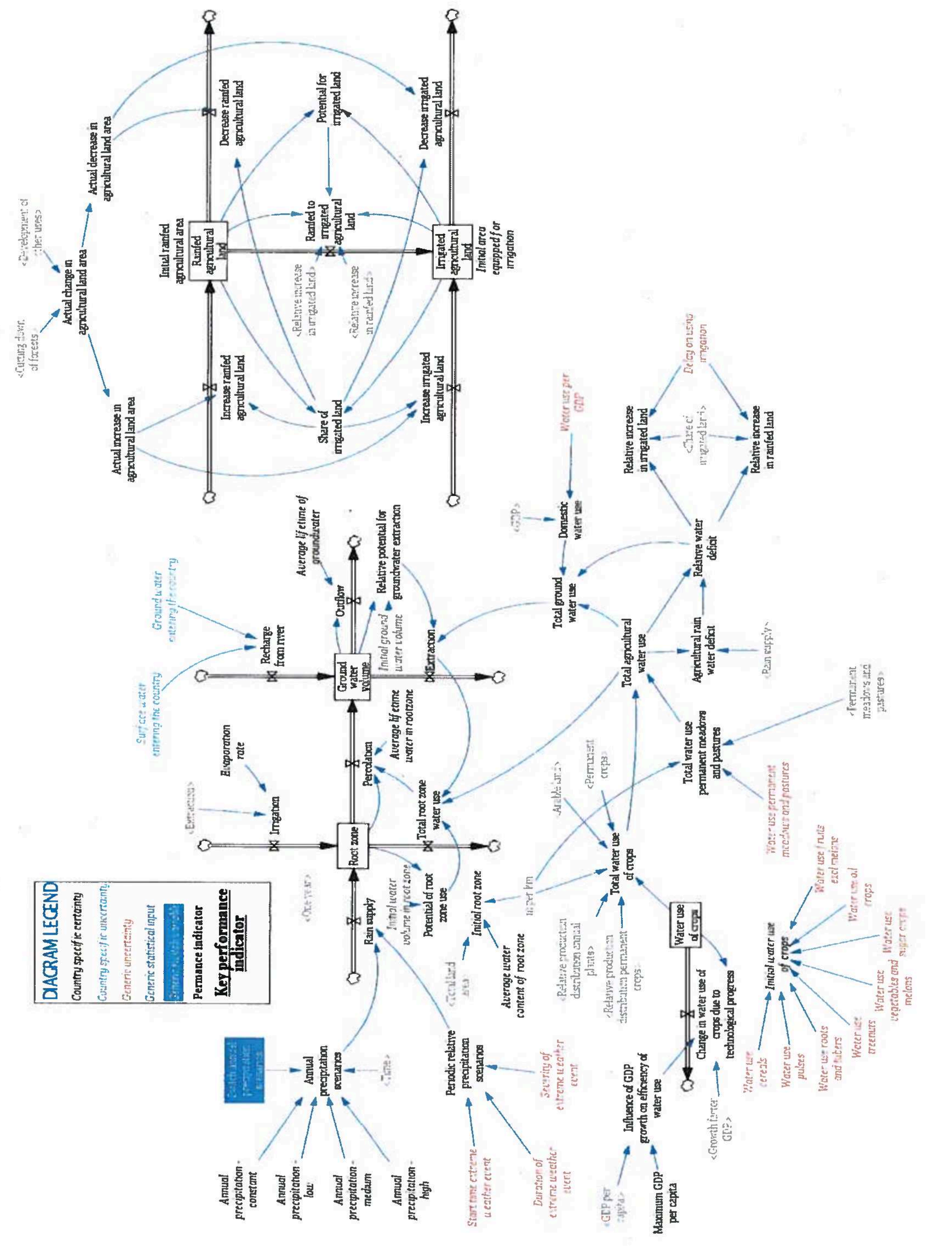

FIGURE 33. WATER AVAILABILITY SUB-MODEL

APPENDIX B –'METAFORESIGHT' METHODOLOGY

APPENDIX B –'METAFORESIGHT' METHODOLOGY

In this study, we make use of the innovative 'Metaforesight' methodology for agriculture and food. The goal of this approach is to enhance awareness of emerging issues and drivers of change from other parts of the world. It intends to reveal visions of the future from emerging economies and languages that are generally not addressed in Western foresight studies.

Metaforesight adds value to decision making and planning processes, as it is a systematic way of gaining a better understanding of the bandwidth of views about the future security environment – views that do not only include those from Western countries. The idea is to support the production of more robust, adaptive and flexible strategies for the long term.

This study first builds on the latest state of the art in research on trends, drivers of change, criticalities within the global food system to generate visions in terms of scenarios and building blocks for the future. The research particularly uses resources such as the 2014 HCSS study *Future Contours of Agriculture and Food*, which provided a broad vision on the future of food systems displayed by foresight studies from emerging agricultural economies. Using manual coding, it had yielded fresh insights to feed into the discussion by policy and research management groups. From the perspective of a global 'agricultural and food' economy, it is indeed important to be aware of visions/policy perspectives of the future from emerging economies, such as China, India, Brazil, which are likely to be decisive factors in the future of agriculture. For example, the *Future Contours* study includes Chinese visions on how to sustain Chinese food consumption through 2030. Some of these insights were used for this project, and summarized in this report. Understanding their views about drivers of change and building blocks for the future may shed light on important developments and global developments that may affect the future of the global food system.

This research strand has a more qualitative nature. It draws on the insights of the foresight community of several 'language domains' reflecting the perspectives of Brazil, China, India, Africa, and those of the West (some - US, EU, UK, The Netherlands) for the world of food and agriculture through 2050. The workload consisted in updating the manual coding results of foresight studies used in the 2014 *Future Contours* study, restructuring it along the lines of a new coding scheme relevant to this project, and executing the same task with new foresights feeding the selection (the 'Western' cluster). In total, our collection includes 151 foresight studies.

Manual coding serves to identify relevant pieces of information on the topic in every study (e.g., ...), to outline the parameters pre–defined and refined, informing our analysis on the different elements that emerge, and ultimately, to address the research questions. Once redefined, the coding scheme ensured that all relevant issues could be identified in the foresight database i.e., as described below, drivers, of supply, of demand, of mitigation, and shocks, but also policy perspectives.

- *Drivers of demand* are actions or trends or developments that have an effect on what buyers (companies, industries, consumers, people in general) want to buy as well as the volume/quality of the buy
- *Drivers of supply* are actions or trends or developments or situations or structures that have an effect on how the supply chain works, on what is produced, on how the systems delivers (quantified with efficiency, qualified in terms of situations, etc.), and on how companies, industries (buyers, but which can also be suppliers) supply
- *Drivers of mitigation* are actions or policies that intent to mitigate negative or sub-optimal externalities or developments emerging from the food system. Mitigating here is the action to solve existing problems and which is taken by the government, companies, or workers. For example, it can include making changes in existing subsidy policies to make these more efficient
- *Policy perspectives and options* for food systems are ways of approaching the food system. They include ideologies, attitudes, models or tendencies that affect the food system. They reflect the views of governments (e.g., transitioning from a State-centered food system to a more private investment system or views on competition); societal views (e.g., agricultural jobs connoted with low social status); or managerial approaches (e.g., investment in human capital or new technologies as a way forward), among others. One illustration of a policy perspective can be a subsidy policy being established, or that ceases to exist.

- *Sudden events or shocks* are unexpected or unpredictable occurrences, innovative breakthroughs or game changers (these can be difficult to grasp from a non-expert perspective) that affect the food system either positively (e.g., good weather conditions) or negatively (e.g., droughts).

This report includes a summary cross-comparing and synthesizing the main takeaways. Much deeper analyses were produced at first in order to achieve this cross-comparison and overview. These and the list of foresight studies collected for this exercise are available on request.

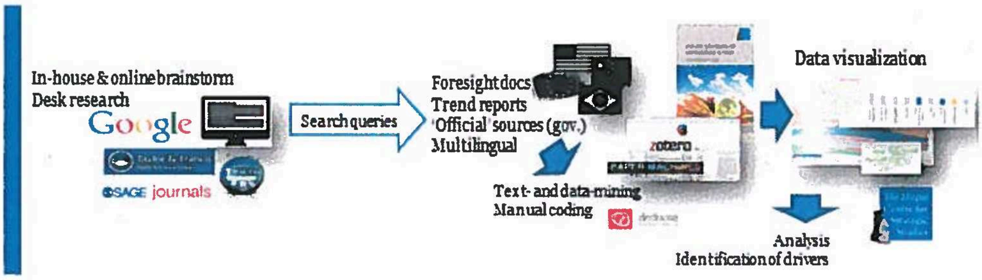

FIGURE 34. METAFORE FOR FORESIGHTS: RESEARCH PROTOCOL, FROM BRAINSTORM TO DATA COLLECTION, ANALYSIS AND VISUALIZATION

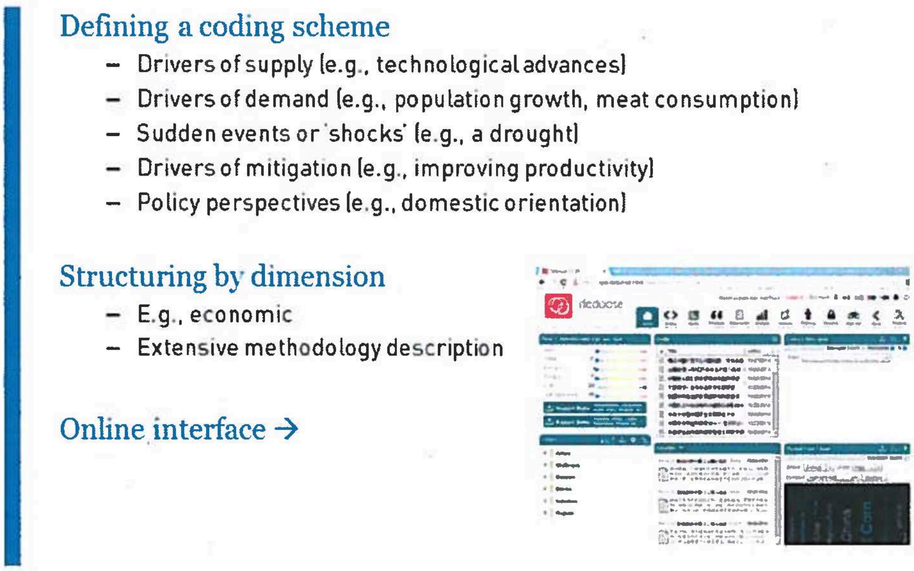

FIGURE 35. WHAT IS MANUAL CODING?

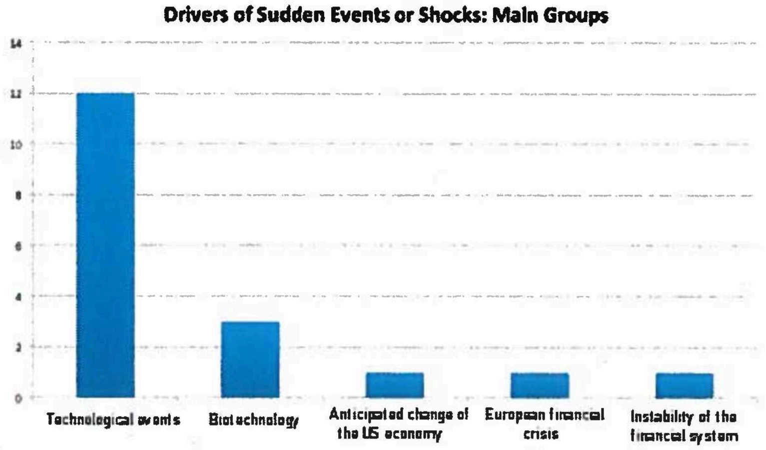

FIGURE 36. EXAMPLE OF MANUAL CODING RESULTS VISUALIZED FOR THE PARAMETER 'SHOCKS' BASED ON THE CHINESE FORESIGHTS. THE NUMBER ON THE AXIS INDICATES THE NUMBER OF TEXT FRAGMENTS CODED AS SHOCKS.

ENDNOTES

ENDNOTES

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