Future Food Basket

Methodology for the forecasting of the future food demand

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Institute: Wageningen Food & Biobased Research

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Preface

This report presents a methodology to forecast the regional needs and demands for food intake by consumers in a certain geographic area in 2030 with a view to 2050. It contains the results of applying a mathematical algorithm for the extrapolation of historic data into a food demand forecast. The objective of this forecasting method is to provide insight in the design and requirements for regional and global food systems to meet the demand for nutritious and safe food.

The research and the output from this research is part of a strategic study by Wageningen Food & Biobased Research (WFBR) on the Redesign of Adaptive Value Chain Networks for Food and Nutrition Security (AdVaNs). The study focusses on the needs to nourish the world population properly and sufficiently (in accordance with the UN Sustainable Development Goal 2) by understanding better the food networks in demand and production. The methodology is applied for Mexico and its sub-regions (Mexico City, North-, South- and Central Mexico).

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Summary

Research by Wageningen University & Research (WUR) on global food and nutrition security focuses on the question how to achieve transitions to a food system that will be adequately equipped to nourish the growing world population. One of the challenges of this transition is to evolve to a food system that will be sustainable (resource-efficient and with minimal impact on climate change and global warming), yielding affordable, trustworthy (safe), high-quality food products. This particular report is part of a study on the redesign of food value chains from linear value chains into circular adaptive value chain networks for nutrition and food security (Redesign or **Ad**aptive **Va**lue Chain **N**etwork**s** for food and nutrition security (AdVaNs)).

In view of the global trends of world population growth, urbanization, the efficient use of natural resources, mitigation of the impact of food production on climate change and global warming, this research addresses global food and nutrition security by developing a forecast model for the content and composition of local food baskets. Enablers of changes in these future food baskets are the growing economic welfare, advancing information technologies and sustainability issues that affect regional and global value chains. Knowledge about these trends in this future demand on food is searched for by policy makers and governments that are in need of accurate and reliable quantitative information for strategic decision-making. By developing forecasting models that are dedicated to human nutritional needs and consumption patterns, historic quantitative data can be transferred into future trends and predictions regarding food demand in specific regions.

A methodology, using autonomous time based linear regression, was developed by the authors to predict a future food basket in terms of energy, composition and products for the near future in 2030 based on available historical data. The methodology was used for 4 regions in Mexico (Mexico City, North-, South- and Central Mexico). Also the amount of micro-nutrients, including vitamins and minerals, in the food was estimated. The forecasted results were also categorised by two demographic characteristics: income class (low income vs. high income) and the residential environment (urban vs. rural environment). The forecasting is based on FAO data in combination with national data for the prediction of the specific regional food baskets in Mexico. The results show that the urban region obtains more energy and vegetables, fruit and meat, having also the more wealthy class of the population. Also in Mexico most proteins and carbohydrates are consumed as part of staple foods.

In this research validation of the methodology was carried out by using data from the past to predict the situation in 2011 of the composition of the food basket. This comparison of the present data with the forecasted data shows that this linear regression method can be used to forecast the food basket in 2030 for a majority of product groups, but to a smaller extent for milk and pulses in particular.

1 Introduction

1.1 Reason for the research

Research by Wageningen University & Research (WUR) on global food and nutrition security focuses on the question how to achieve transitions to a food system that will be adequate to nourish the growing world population. One of the challenges is to evolve to a food system that will be sustainable (resource-efficient and with minimal impact on climate change and global warming), yielding affordable, trustworthy (safe), high-quality food products (Kampers & Fresco, 2017).

This particular report is part of a study on the redesign of food value chains from linear value chains into circular adaptive value chain networks for nutrition and food security (Redesign or Adaptive Value Chain Networks for food and nutrition security (AdVaNs)). The contextual basis for this redesign of value chains is based on the needs to nourish the world population properly and sufficiently, in accordance with the UN sustainable development goals. In order to better understand the interaction between food production and distribution networks and specific demand for food products, Wageningen Food & Biobased Research (WFBR) has developed a methodology to forecast the regional needs and demands on food in 2030 with a view to 2050. This method is presented in this report.

The growth of the world population in the coming decades, and the migration of people from rural areas to large urban conglomerations require new solutions for an insured food supply. It is expected that in the year 2050 around 70 percent of the population (about 6 billion people) will live in one of the expanding cities (UN, 2018). Urbanization influences consumer diet and spending patterns (Regmi, 2001). Food chains will have to adapt to the shift in demand for foodstuffs to these metropolitan regions, which will also have to be able to respond in time to the change in the composition of this demand (including the increasing demand for animal proteins, but also convenience and time saving will play a role in the choice of the type of food products). For this it is necessary to gain insight into the expected future need for food in the metropolitan regions (see also chapter 3 of this report on the context and background regarding global food and nutrition security).

In the research by WFBR, a methodology has been developed, in which a link is established to connect the expected demand for food calories (energy-intake) and macronutrients (nutritional need) with the specific food products. By doing this, a future food basket can be composed that is regional specific and contains information for the future development of food chains in that region. By forecasting future food baskets for different metropolitan regions in the world it can be made evident what the value chain networks as part of the food systems in these regions are up against in terms of consumption patterns, production needs and logistical infrastructure.

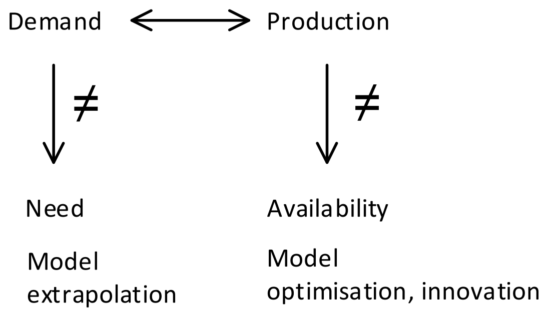
1.2 Objective & research questions

The objective of this research is to develop an extrapolation model that will enable researchers to apply historical data on food consumption to make a quantitative prediction of a population’s needs and demands for food and nutrition in 2030, with a view on 2050. Ultimately the model will give insight in a country’s specific future food basket given the dietary needs and demographic trends in food demand and consumption. In this food basket forecasting methodology the following question is taken into account:

- What changes can be expected from the increasing urbanization with regard to energy and nutritional intake from food in comparison to the rural regions?

The future food basket model shows:

- The demand in 2030 (with a view to 2050) of food in terms of energy, composition in nutrients and products.
- The needs in 2030 based on the expected growth of the world population. The needs are based on



  the physiology of the human being at different ages/gender. The demand is more based on the perceptions of the consumer.
- The effects on food quantities and composition of the variables:
  - geography, or regions in the world
  - urban and rural
  - income classes (as a support to understand the needs for the poorest and the middle class)

1.3 Chosen approach

For the forecasting of the future food basket, a model has been created based on extrapolation techniques. Models can be developed to predict the demand and the production with the processing in future. Through innovation and optimisation in production and processing an improved availability of food can be established.

Essentially, this research intends to support the understanding of how agricultural production and consumer food demand will interact in the world in the period up to 2030 and further to 2050. For this three levels have been chosen for determining food demand:

1. demand for energy given by the food,
2. the composition of the food by its nutrients,
3. the products in the food basket.

Part of the research consisted of finding useful available data, as well as to find ways to combine these data to obtain a useable outcome for the demand forecast. As a case study for illustration and validation the model has been applied for four regions of Mexico, including Mexico City.

1.4 Context

Research on increasing food and nutrition security is largely dominated by the topic of increasing production and productivity of farmers and fishermen. Also the demand for food by the consumers receives ample attention in research. The logistics (with storage, transport, processing and distribution) form the essential link between production and consumption and to make food

1. available by enabling the flow of food products from production to market,;
2. accessible by realisation of the physical distribution within the appropriate time-window, while safeguarding product quality and food safety;
3. affordable by creating cost-efficiencies in linking food supply and demand; and
4. utilised for its intended purpose (nutrition) and in accordance with its intended purpose to provide sufficient energy and nutrient intake by individuals.

The importance of the availability of food products and with that of logistics and value chain management is illustrated by the fact that approximately 1/3 of the agricultural production in Sub-Sahara Africa (SSA) is lost after harvest. These post-harvest losses can be attributed to a wide variation of causes, narrowed down to a lack of knowledge and facilities and a poor physical value chain infrastructure. It is still difficult to protect the harvest against pests or fungi and premature microbial degradation by poor storage and transport with a lack of preservative processing, such as drying.

In countries where middle class income groups are growing, a large chump of the available food is wasted at the consumer side of the value chain. Here food waste is created by households when some of the food is not used on time, especially of those products that are vulnerable to microbial degradation of perishable products. This is especially the case for fresh produce during storage with not enough preservation or cooling/freezing.

The food demand will be presented with the food energy and its nutritional composition as an indication of the quality of the food. Main variables of food demand are growth of the population and the geographical spreading of this population with an emphasize on the urban migration. Another parameter is the lifestyle or diet pattern, indicated by the income classes. Also the differences between the rural and urban population have to be taken into account. There is a difference on the need for food and the demand for food by consumers. The *need for food* is more specified according to the physiology of the human beings involved, while the *demand for food* also includes the effects of, for instance culture, and income.

Data on the geographical production and on the expected changes in the next decennia, provided by other research expertise are complementary to this research. These changes depend for instance on the climate changes, the change of soil properties due to human activities, the planted crops and husbandry animals (including the waste), and the agricultural population available. Adaptive chains are necessary to fortify the resilience of the value chains and to use the resources as efficient and effective as possible.

The matching of production and demand has to be created by the chain in between demand and sources worldwide. The question is what gaps are there between the input or production and the output or needs/demands of food supply chains and how these gaps can be solved? Therefore the world food logistic supply network has to be optimized using for instance operational research tools, but also new directions for creating food will be needed. These needs for food, especially ingredients such as proteins or micronutrients, can be met by providing alternative productions with related processing and logistics.

1.5 Possible stakeholders for this research

Sub-Saharan Africa (SSA) is often mentioned in the context of food insecurity, because in this part of world most of the global population growth takes place while agriculture is stagnant (World Bank, 2011; Searchinger et al., 2014). However, Africa is also the region with a potentially important future role in the supplies of raw materials, including agricultural trade commodities such as coffee and cocoa. There is a political and economic importance to invest in co-operation with countries in the SSA region. This is what the Dutch government does with a number of bilateral development programs. The Dutch government is active abroad by the Ministry of Foreign Affairs with the embassies, the Ministry of Economic Affairs through the agricultural councils and the RVO, also working with Dutch industry and research. In 2016 the ministry of Economic Affairs published a vision paper about the food basket in future “Aan Tafel! Tien visies op de toekomst van ons voedsel” (Van Dam et al. 2016). In this paper a vision was presented on the national and international implications of future national and global food supply.

On both national and international level the role of non-governmental organizations in food system development is considerable. In the Netherlands Dutch government co-operates in various programmes with NGOs, such as 2Scale, BoP, AIM and SVN. A similar line of co-operation happens at the global level through The High-Level Task Force on the Global Food Security Crisis (HLTF), which was founded in 2008 by the UN Chief Executive Board (CEB). In this taskforce the entire UN System of FAO, WFP, IFAD, UNDP and the World Bank cooperate. At global level, other non-governmental organizations such as Oxfam, AIM or GAIN are active but also philanthropic organisations such as the Bill & Melinda Gates Foundation, and the Rockefeller Foundation.

An increasing number of private parties are involved in the food security debate and in financing of development projects, including businesses, business platforms and banks. Internationally operating agribusiness and food companies increasingly seek for opportunities in growth markets such as in Africa and Asia. Their involvement in strengthening local development and investment in production can be explained from their interest to develop future sales markets.

1.6 Reading guide

The second chapter in this report contains information on the background of the global food system in relation the with the research scope, stakeholders and research objective. Chapter 3 contains the description of the methodology used to obtain a suitable forecasting model and the application of it in obtaining a future food basket. In chapter 4 the results of the applied forecasting model are presented and discussed. Considering the scope and restrictions of the used model chapter 5 contains a discussion on the results, after which in chapter 6 the main conclusions are presented.

2 Global food security: background on the forecasting of food and nutrition demand

2.1 Drivers of global food demand

The world population is changing in a steady but rapid pace. For 2030 it is expected that the world population will grow to over eight billion people (Wiegel et al., 2016). 90% of this population growth will take place in these urban areas. In comparison: in 1950 17% of the people lived in a city; half a decade later more than half of the people's homes are located in the city dwellings. In the year 2050 population numbers will have increased to nine billion people and the prognosis is that a vast majority of these people (70%) will live in urban areas. Most of these large cities will located in India and China. Especially large cities with more than 3 million people in India and China are expanding quickly. Given the absolute size of the population growth in the near future, and the fact that growth is concentrated in the relatively small metropolitan areas, the care for food and nutrition security in the world will become more focused on nourishing a growing part of the population that is not (directly) involved in the production of food. The fact that more people will migrate from rural to urban areas also means that fewer people will be available for food production in these rural areas. Moreover, in developing countries urbanization is often synonymous with poverty and problems with malnutrition, especially for the poorest people in the growing slums.

Given the growth of the population and the increasing demand for food some people advocate an intensification of agricultural production on the available arable land. But precisely this intensification will create problems due to the constraining availability of resources, including water and soil. Intensification may lead to a depletion of soils and scarcity of potable water, minerals and nutrients. Irrigation water is becoming a scarce commodity in various parts of the world, particularly in Sub-Saharan Africa (SSA) and in Asia. But also in the southern part of the African continent the absence of precipitation over the past years has created locally alarming situations such as in Cape Town (Holder & Kommenda, 2018). The rationing of water by accessing through fresh water taps in the city with a population of over 3.7 million people (2016), has led to tensions among the residents.

In addition to the regional constraints in food and water availability, the required energy for preparation of daily meals is also limited. In many parts of the world the main fuel for cooking is wood and other lignocellulosic biomass materials. Cooking is important for food safety, especially in reconstituted infant food formulas. Also the diminishing global supplies of phosphate rock will lead to a lower availability of phosphate as fertilizer in agricultural production, which will affect yields and productivity in crop production. In the future phosphate will become a strategic resource (Oscar Schoumans in Wageningen World 2017).

The effects of climate change on food production will show regional variations, as well as differences per crop (with either positive or negative effects in terms of crop yields, see also figure 3.1). Global organisations such as OECD and the international research programme on climate change and food security CCAFS (research programme on Climate Change, Agriculture and Food Security) state that climate change does impose additional challenges to agriculture and food production when 'current cropping systems will no longer be viable in many locations' (OECD, 2015; CCAFS, 2018). Overall productivity levels will decrease due to changes in temperatures, crop water requirements and water availability and quality. In other words, global food systems are at risk when the growing food demand will insist larger productions from resources that are increasingly under pressure (land, water, labour, energy & nutrients). The UN 2030 Agenda for Sustainable Development that was launched in 2016, addresses this through the formulation of seventeen sustainable development goals (SDGs). As a continuance of the Millennium Development Goals (MDGs) the combined SDGs aim to end all forms of poverty and hunger in the world in an ecologically and socially sustainable way. In the following paragraph a closer look is taken on how the SDG agenda and the future food basket are intertwined.

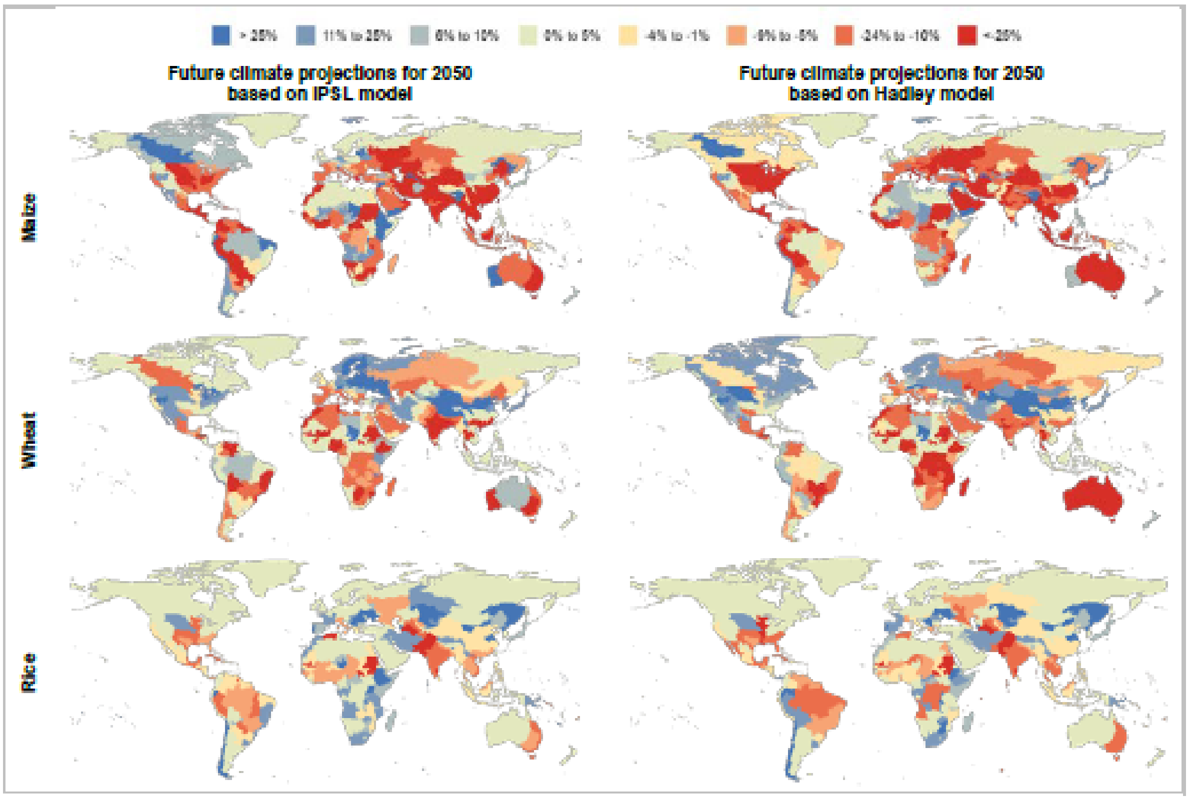


Figure 2.1 Effects of climate change on yields are negative in most producing regions (red shades), but some regions may actually benefit (blue shades) (Source: OECD, 2015).

2.2 UN Millennium Development - and Sustainable Development Goals

In 2000 the United Nations responded to these worrying developments by formulating a set of goals for global action by political and non-political stakeholders against economic, social and ecological unsustainability. These Millennium Development Goals (MDGs) became worldwide accepted as targets for creating a better world to live in in the new millennium. MDG-1, for example, was set to improve the food supply and the reduction of extreme poverty for the year 2015. Later these MDGs were adjusted for the year 2030 and are now referred to as the Sustainable Development Goals (SDGs) (United Nations, 2017). In total 17 SDGs have been formulated with 169 targets and about 300 global indicators.

Figure 2.2 The seventeen Sustainable Development Goals.

2.2.1 SDG-2: No hunger

The future food basket has a relationship with SDG-2: no hunger. The old goal in the Millennium Development programme was formulated as to halve the number of people that are dying from hunger and malnutrition before 2015. By 2013 it became clear that this target would not be met when it was established that approximately 842 million people were still chronically suffering from hunger. Most of these people (827 million or 14.3% of the world population) were living in developing countries. In 2016 it was further decreased to 790 million people (United Nations, 2017b). The two most critical areas for malnutrition are Sub-Saharan Africa (SSA) and South Asia. The projects initiated by the MDG programmes have been successful. Especially in Southeast Asia the amount of people with hunger reduced of around 31% in 1991 to 11% around 2013. In South and Southeast Asia many of the global major metropoles are situated and also in SSA some larger metropolitan areas are visible. The expansion rate of these cities is high, giving new challenges for feeding the cities and to control the environment in the cities.

Based on these results new targets were introduced, to obtain a zero-hunger end result in 2030 instead of a relative reduction. Eradicating hunger from the world completely in 2030 has become the goal, or SDG-2. The other 16 SDGs are closely intertwined with SDG-2. The importance of clean water and sanitation, availability of sustainable and clean energy for meal preparation was already addressed. Responsible consumption and production, climate action are all addressing an aspect of safe and healthy food. The SDGs are also directed to improve the social and ecological sustainability. SDG-11 is directed to sustainable cities and communities, for which a special guide was developed (UN SDSN, 2016). Targets are for instance about reducing emissions of the greenhouse gas carbon dioxide and the preservation of ecosystems, but also getting a better availability of clean drinking water and sanitation and reducing the size of slums, where one third of the urban population in developing countries lives. This is also reflected in SDG-6, which indicates that the living conditions of at least 100 million slum dwellers must be improved in 2020. The growing population in these city districts lack the infrastructure for clean drinking water, sanitation and housing.

Figure 2.3 Sustainable food initiatives by global stakeholders on the nexus of sustainable food systems.

The scientific agenda's for research and development are becoming more and more connected with these SDGs. Efforts and initiatives by various stakeholders from the profit and non-profit sector are mobilised around the societal challenges that are addressed by the SDGs. In figure 3.3 some of these global initiatives are pictured as operating on the nexus of these challenges that global food systems are facing.

2.3 Changing food composition: examples of food baskets

2.3.1 The need for healthy nutrition

The composition of the food baskets, as used by the people around the world, is in direct relation with the population growth and the food production. Other aspects for the different food compositions are for instance cultural differences and income classes.

In 2009 there was 2,831 kcal (approx. 12,000 kJ) per capita per day of food available in the world and by 2050 this number will be 2,026 kcal with unchanged policy. According to the UN's World Health Organisation (WHO) 2,300 kcal (approx. 10,000 kJ per person per day) is desired, so predictions for 2050 are well below the nutritional threshold. In other words, there will be more food scarcity in the future if appropriate policy measures will fail. Especially micronutrients will be needed more. At present, 790 million people are undernourished (figure 2016) and also 767 million people were living in extreme poor conditions with a welfare of less than $1.90 per day (UNICEF and WORLD BANK 2016). According to this briefing note, children are the most vulnerable part of the population, especially young children.

Many children under the age of 1000 days ("golden age") will die because of a lack of food and proper nutrients. Malnutrition at a young age can have a lifelong effect, leading to diseases and underdevelopment of the brain as well, which are beyond possible healing in later life. The consequences are not directly recognizable, but this lower vitality of people will influence the economy. Later in life, symptoms such as diabetes can be aware, due to former malnutrition during childhood. For this reason the WPF supplies fortified food rations for vulnerable groups of the population, such as children.

2.3.2 Food baskets

Several models for a local food basket have been made (Safefood, 2018; PROOF, 2018). Some of these modelling also include cost monitoring. The examples are often based on situations such as a family of two parents and two children, one female parent with two children, two pensioned adults or one adult. An example of such a food basket modelling is “Safefood” (2018). Safefood provides information about healthy food baskets in the Republic of Ireland, including the costs. “Safefood” gives also a methodology to measure the minimum living standards based on the Consensual Budgets Standards (CBS) approach with a food basket in rural and urban environment. The composition of the products the food basket depends on:

- availability of the products,
- affordability,
- acceptability, depending on culture and religion,
- utilisation, depending on life style and culture.

The needed nutrients are shown in the "food pyramid", representing the optimal number of servings to be eaten each day from each of the basic food groups (Safefood, 2018). The Dutch analogue of the Irish food pyramid is the Schijf van Vijf (Voedingscentrum 2017).

Based on the needed nutrients a related reference food basket can be determined. An example is the World Food Programme of the FAO with food assistance to more than 80 million people in 80 countries (WFP, 2017). The organisation has tailored a food basket to local needs. The basket is based on 2,100 kcal daily intake per person with 10–12% energy from proteins, 17% from fat and the necessary micronutrients according to WHO/FAO guidelines. The main components of the WFP food basket are:

- staple food, such as rice or wheat flour
- pulses such as beans, chickpeas or lentils
- vegetable oil
- salt
- sugars
- fortification with vitamins (also in the oil), iodine (in the salt) and minerals.

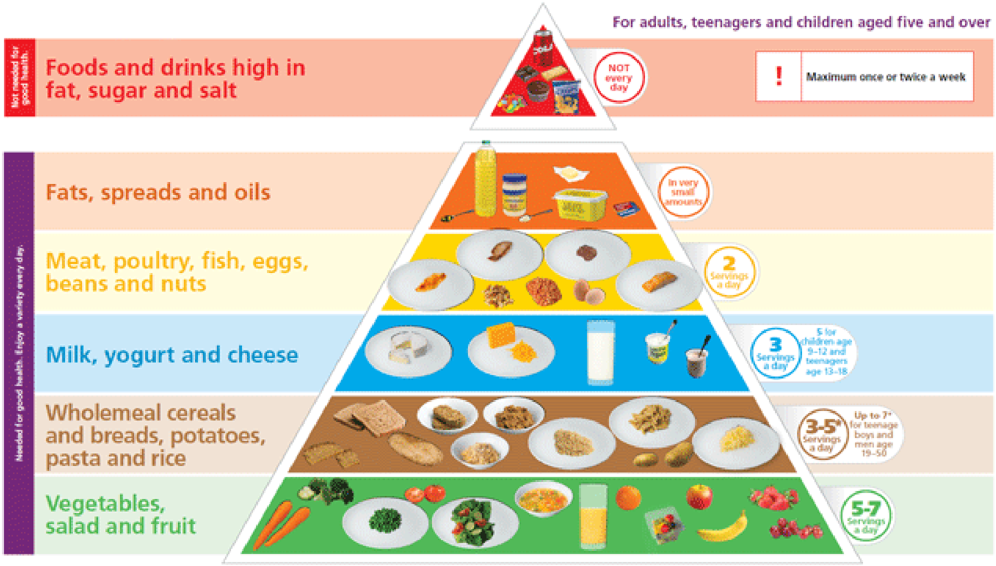


Figure 2.4 The Food Pyramid *(www.safefood.eu)*.

Also other institutions are composing food baskets, based on the nutrients needed by groups of people, such as a standard family. An example is the Victoria food basket in Australia, defined by the Monash University (Palermo and Wilson, 2007).

As given in the WFP food basket, in many parts of the world the meals consist of a basic food or "staple food", often a starchy product. It is prepared by baking or cooking in order to make it digestible. Examples are cooked rice or potatoes, porridge of maize or cassava, as well as pancakes, pizza or injerra (Ethiopia). In addition to the meal a "sauce" or "relish" is served, as it is traditional in Africa. It is based on beans and/or pulses, vegetables and spices with sometimes fish or meat.

In former days in Europe it was common to serve bread with a soup as a meal (pot-au-feu, potage) or sometimes more a thick sauce as a "stew", which resembles the African "sauce". Fermentation of the starch product can be applied, such as the Teff for injerra or for the "sauce" as in Ghana is common for fermenting fish waste.

Staple food ingredients are usually well preserved with simple post-harvest processing and are easy to transport and to store. Food security during the year is based on these products. A tasty sauce, forms an important addition to the meal to obtain the required proteins and micro-nutrients. Meat, vegetables and fruit in this sauce are much more perishable than the staple food ingredients.

2.3.3 The urban food basket

More people are living in the city around the world every year. Urban families need more convenience and faster preparation for the cooking of the food than the rural families (FAO, 2005). Rice fits better in this life style than for instance sorghum. In many parts of the world the urban food supply is still based on an informal market in the vicinity of the city and on local production. Because many citizens possess less agricultural knowledge and using also less productive grounds in the city then in the rural regions, this will have an effect on the yields of these crops such as rice or vegetables. Obtaining an healthy food basket will be more difficult for the poor in the city than for the people in the rural areas.

The food basket in the city contains more perishable products, making logistics with transportation and storage important, especially if the fresh products are coming from the peri-urban vicinity of the city. Cold chain requirements are needed in that case, but are scarce in many parts of the world. Processing vegetables and fruit makes the logistics more simple, while maintaining an healthy urban food basket.

Food supply for the city, especially for the vegetables and fruit, is also originating from urban and peri-urban agriculture (UPA). This concept is also referred to as respectively Metropolitan Agricultural Supply (MAS), and Local Agricultural Supply (LAS). In addition there is also the global supply (GAS) of food to the city.

Especially in Sub-Saharan Africa (SSA) food crops (vegetables) are grow in the vicinity of the cities (peri-urban <30 km). In Dar es Salam sometimes 50-90% of food is supplied from the surroundings of the city. "Staple food", such as corn and sweet potato is also grown in some seasons in the immediate vicinity of the city if an overall shortage of food is likely to happen. This is urban agriculture in a broader sense, than is indicated by UPA or MAS. Agriculture for staple food and vegetables in the surrounding areas or in the city itself takes place in a free public accessible space and is often an ancillary activity. The products are mostly traded through informal networks, except for the more exotic products that are grown for sale as extra income (cash crop). In many regions of the world (especially SSA) 60-80% of the expendable income is spent on food. Vegetables are often still not rewarded as important in many cultures, also for young children.

Women are often responsible for the daily food basket, although the family income is more controlled by men, especially in patriarchal societies. However, in many countries there are the women, who take care for actual local agriculture and trade, influencing the content of the food basket.

The vegetables from urban agriculture in the city and surroundings are also important for the living quality in the city due to the "green" environment, the social experience and the education of children, which may later return to work in agriculture. Since in the city more malnutrition occurs due to a lack of micronutrients, this urban agriculture is important.

2.4 Changing food production

The following lists a number of developments and aspects that directly affect the production and consumption of food in developing countries (FAO, 2017).

2.4.1 Production

- *Phosphorus peak* - In many countries around the world agricultural production is growing. Intensification of agriculture has proven successful in the past in the Netherlands, but is not happening everywhere in the world. In particular in Africa the agricultural production fails to grow. Modern agricultural systems have become dependent on the availability and continuity of inputs of phosphate fertilizers from phosphate rock. Several researches and forecasting models have indicated that the world phosphorus production will increase to a peak at some point in time between 2025 and 2075 (Cordell et al., 2009). After that global supplies will run out and production will decrease rapidly to zero in the next century. The phosphorus application is decreasing in the western countries with an increasing uptake by the soil. Also in Asia the uptake increases, giving a better yield, although the application is growing too fast. In Africa the application and uptake are far too low (Sattari, et al., 2012).
- *Soil depletion* - At present in Africa small scale agriculture often takes place on depleted land. A lack of financial funds makes fertilization not affordable for farmers. However, about 70% of the world's food comes from small-scale agriculture, which makes that sufficient funding for seeds and fertilizers is important. Funding of the cultivation gives risks because of the tight margins for small-scale farmers. The earnings of many farming families is below 2 USD per day. The traditional principle of mixed farming has the advantage of cheap fertilization from animal manure, improving soil fertility (FAO, 2017).
- *Climate change* - In SSA the development of horticulture becomes stagnant due to climate change, water shortages and erosion of soils. The uncertainties due to changing climate influence the choices of crops, which are either resistant to drought (sorghum) or are able to cope with abundant rainfall. In general, water becomes more scarce. In agriculture, water should be used more carefully and water shall be used for irrigation with more efficiency. Covering the soil against erosion and evaporation is easy to do, but is rarely done. Furthermore, the social infrastructure is changing under the influence of urbanization and of changing relationships in forces outside the family and tribal order.

- *Property rights* - Also in many countries there is uncertainty about land ownership due to the traditional rights of for instance nomad people. The political turbulence that results from disputes on land ownership, for instance, notable in Ethiopia directly affect agricultural production and food security in the area.
- *Knowledge and skills* - Knowledge about farming and especially experience with farming is in many areas still a problem, taking into account that the median age of farmers in areas such as tropical Africa is about 18 years and in India 27 years. In comparison the median age of farmers in West-Europe is about 45 years. Agricultural training is an important contributing factor to increase agricultural production and performance.
- Especially around the metropoles the resulting effect for the growth of non-staple food is important. The choice of food produce is often different in Asia and Africa than in the Western countries. It is not about producing lettuce and tomatoes, but growing local indigenous vegetables, which are unknown in the Western world, making the food basket less simple to determine.
- The food basket depends in urban agriculture on unused free or public grounds in Dar es Salam 7% of the agricultural production, but over 15% in Nairobi. Especially for the poor, this cultivation gives work and the possibility of some agricultural education for the children.

2.4.2 Consumption market

- *Price volatility* - In recent decades world market prices for food crops are fluctuating more, with a tripling of prices for food only a few years, for instance in the year 1975 to 2003 going from high to low. (FAO, 2011 and 2015). This is particularly noticeable for those who are dependent on the formal food chains, especially in the case of import products.
- *Market infrastructure* - Urban consumers traditionally rely for their daily supply of food products on the daily fresh ('wet') markets where producers deliver their produce in the cities. For urban consumers these markets are uncertain in terms of availability and affordability (price uncertainty). By applying methods for preserving fresh produce it would be possible to obtain distribution over the year with an increased stabilization of prices and availability. Nowadays, fresh products are often the only affordable way for the poorest, with huge product losses as a result of the lack of a proper infrastructure (including adequate storages).
- The food basket of the poorest citizens is more guaranteed by dry products, such as rice or pulses, instead of perishable products, that have to be cooled. However, fresh produce can become a luxury for the middle class consumer. This will require an improved infrastructure for the distribution and storage to minimize product losses and consumer awareness to keep food waste at home to a minimum.
- The *informal food chains* in the metropolitan areas consist of direct contact between consumers in the city and the small-scale farming around the city by relatives in village communities. This farming is informal and focused on self-sufficiency.

2.5 Growth of the metropoles

In Africa, especially "Sub Saharan Africa" (SSA), and in Asia but also in Eastern Europe there is a strong connection between the city and urban and peri-urban agriculture through informal channels. Logistics mainly takes place by connections between family and friends (FAO, 2017).

Peri-urban refers to a transition zone around cities where urban and rural activities occur together in a landscape that's often subject to transitions in the human society. Land in peri-urban corridors with an adequate supply of water as well as good transport connections that allow produce to reach cities within 2-3 hours has potential for the production of fresh vegetables. Producing vegetables for cities is often a lucrative endeavour for farmers because of the quick return on investment and the high prices fresh produce can fetch (AVRDC, 2017).

There is no strict separation between urban and rural areas: people in the city stay connected to a village, for historical or family reasons. The logistics are based on social and economic networks, including the informal networks where food will be exchanged for goods or services. Without these networks access to cheap and fresh food in the city forms a problem (AVRDC, 2017).

The poorest in the city obtain their meals also from food kiosks or street vendors, because they do not have a refrigerator or freezer or any other possibility for storing food. The cold or frozen chain is still not available for most people. Also for cooking, the poor have no facilities or access to fuel.

Actually, there are two essential food flows for the poor: "staple food" or starchy foods and micronutrient food (vegetables, etc.). The poor people eat especially "staple food". If they keep connected to the periphery of the city by family or birth village, there is more chance of obtaining vegetables and other food products, often fresh. The middle class can make use of the third, more western style chains of supermarkets, but need the cold/frozen chain. Also in Africa more snacks and vegetables are sold by the supermarket with less use of the informal markets.

Much of the food for the poor is still sold on the market. Due to the poor infrastructure, especially in Africa, and the times for the market, the supply is difficult. Markets sometimes take place once a week for religious or practical reasons, creating a supply problem for perishable products. These logistic problems need better infrastructure, perhaps based on unconventional solutions, and more use of technologies, such as cooling or processing.

For example, at least one billion people in SubSahara Africa (SSA) and South Asia live in city slums. In SSA this means, that 72% of the urban population lives in shanty jerry-build neighbourhoods. These illegal slums for the poor are more or less autonomous clusters of neighbourhoods in the metropolis, not officially equipped with infrastructure of the city (e.g. energy, sewage). The metropoles have thus an infrastructure sprawl in precisely those places with poor nutrition. The expanding metropoles give rise to logistical changes but it can be expected that in future more decentralised solutions will be chosen for these metropole's infrastructure. The development of food supply solutions will then be based on a new non-European approach, enabled by new technologies (such as IT).

3 Modelling

3.1 Introduction

Within this project, a model for predicting a "Future Food Basket" has been developed to forecast the consumer demand on food by 2030 (towards 2050) under unchanging conditions, such as political or environmental changes. The forecasting is time based, using historical food consumption pattern.

The data are based on the three levels in the food basket:

1. energy of the food (needed or demanded)
2. the food nutrient composition (needed or demanded)
3. the food products in the basket

The needed food nutrient consumption uses certain assumptions about the physiology of the human and the composition of the population. The demanded nutrient consumption in the presented data is also dependent on, for instance, culture and income. This effect will be visible in the graphics in chapters 3 and 4 for regions and income differences.

The extrapolation used for the forecasting or prediction is based on an autonomous time based linear regression method as often used in many applications, such as Microsoft Excel.

The extrapolation has to show:

- The demand in 2030 on food in energy, composition and products. The used demand is based on the historical perceptions of the consumer.
- The needs of food in 2030 based on the expected growth of the world population.
- The effects of the following variables on quantities and composition:
    - geographic
    - urban and rural
    - income classes (as a support to understand the needs for the poorest and the middle class)

The forecasting method has been verified by comparing predicted data with present known data.

3.2 The case of Mexico

We explain the modeling process on the basis of a case, Mexico, for which we predict the nutrition per product group, according to region, income class and living environment. The exercise starts with extrapolating the total food intake. This is done using the Food Balance Sheet of FAO, that gives production, import, export, source for feed, source for seed, waste, processing and consumption – per land per year – for each product group from 1961 till 2011. The Food Balance Sheet is part of FAOSTAT, a platform of FAO that contains food and agriculture data, covering almost all countries in the world (FAO 2017). “Data on per caput food supplies are expressed in terms of quantity and – by applying appropriate food composition factors for all primary and processed products – also in terms of caloric value and protein and fat content.”

Subsequently we calculate the total food intake per region in Mexico (North, Central, Mexico City, South), income class (I and V) and living environment (urban, rural) on the basis of data from the National Institute of Public Health in Mexico. Also, these data show trends, which we shall extrapolate.

Finally, we compute the nutrient intake from these results, based on The Nederlands Voedingsstoffenbestand (NEVO), a source of data about the composition of foods (source: Nevo-online version 2016/5.0, RIVM). The file gives the concentrations of nutrients for each product. We choose this source above the USDA Composition Databases, because the Dutch database is more product oriented on a general level where the USDA counterpart lists specific products a consumer can buy.

In our exercise, we distinguish the following product groups:

- cereals
- starchy roots
- pulses
- vegetables
- fruit
- meat
- milk/dairy

Cereals, starchy roots and pulses represent staple food; sauce is a mix of vegetables, fruit and meat.

Starchy roots are not listed as a class in the data of Barquera (Barquera et al. 2006), used in the next paragraph for determining the statistics about regions, urban/rural differentiation and effect of income classes. The consumption is low according to FAOSTAT with 40 vs. 403 g/cap/d in 2011 (FAOSTAT).

Debatable in the food basket is whether the pulses, such as beans, chickpeas or lentils, are a staple food with the main component carbohydrates instead of proteins. The World Food Programme of the FAO takes pulses as a main component in the food basket in Mexico. According to FAOSTAT the consumption is relative low with 30g/cap/d in 2011 in Mexico.

3.3 Food supply in three American nations

Before extrapolating the total food intake in a country or region, in this case Mexico, it may be recommended to check whether there is room for growth at all. For this reason, we do not only look at Mexico but also to the food intake of the most important economic neighbor, the United States, and of a perhaps more comparable country, Brazil (figure 3.2). The food intake in Mexico has already shown an increasing trend for decades, just like in many other countries. However, some western countries, amongst which the United States and the Netherlands, have recently shown a decrease in food energy consumption.

The food intake in the U.S. reaches its maximum in the mid-2000's, with 3800 kcal/capita/day, almost twice as much as the recommended daily allowance. However, since then it has decreased slowly. The food intake in Brazil runs behind with the food intake of the U.S., with in the beginning of the 2010's a level of 3300 kcal/capita/day. Mexico is somewhere in between the U.S. and Brazil, except in the last decade, where Brazil has passed Mexico. The level in Mexico has approximately been constant since the 1980's, but that is no guarantee that this will remain this way. Also in Mexico living conditions are improving and wages increasing and with that, the desire to use more energy-rich food. However, it seems from these data that Mexico has not yet reached its “welfare maximum”. For that reason we do not yet have to take an asymptote into account in our predictions, after which the food intake may decrease.

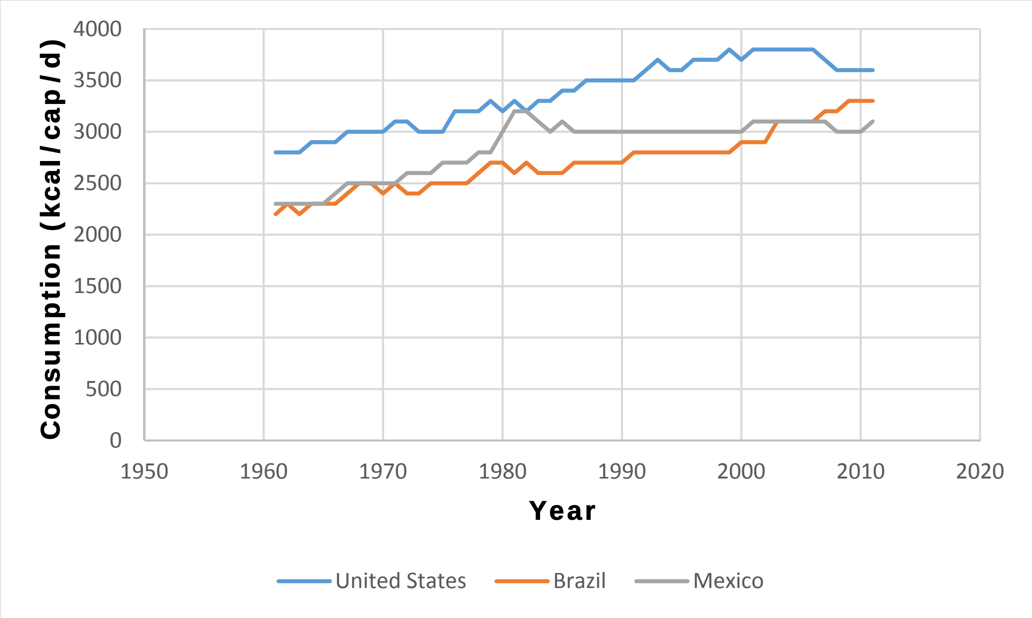


Figure 3.1 Total consumption in the U.S., Brazil and Mexico, in kcal/cap/d, in the period 1961-2011 (source: FAOSTAT Food Balance Sheet).

The data are close to 2,831 kcal (approx. 12,000 kJ) per capita per day around the world available in 2009. A daily advisable intake of 2,300 kcal (approx. 10,000 kJ per person per day) is desired according to the WHO. The World Food Programme has tailored local food baskets based on 2,100 kcal/capita/day (WFP 2017) for the need on food.

3.4 Extrapolation of the FAOSTAT-data (Food Balances)

The food intake in Mexico per product group from 1980, so since the above-ascribed more or less stationary period, is shown in figure 3.3. The cereals show roughly a trend downwards; milk/dairy has increased more or less the last decades; fruit seems to get out of a recent dip; vegetables go up and down within a broad bandwidth; meat is increasing; starchy roots are increasing; and pulses go down. The rise that we see in the 2000's in vegetables and fruits and earlier on also in meat could be explained by an increasing prosperity in Mexico. The consumption of pulses is decreasing in Mexico. Although this food product is strongly associated with this country, it is perhaps not so much desired by the inhabitants.

The used extrapolation technique of simple linear regression can be refined by introducing methods such as exponential triple smoothing and linear regression DMA (Double Moving Average).

The extrapolations are validated by a visual comparison of the predicted food intake in 2010 (i.e., extrapolating) based on data from the period 1980-2000 with the measured data up to 2010. Figure 3.3 also shows the results for the forecast function in Excel. This first validation of the forecasted data with the historical data shows to be in a reasonable agreement. However, the consumption of vegetables and fruits, associated with higher incomes and wealth, appears to be hard to predict from this historical data. This can be due to the economic boom in Mexico in the 2000's. The increase of meat seems to increase also for this reason, but more gradually.

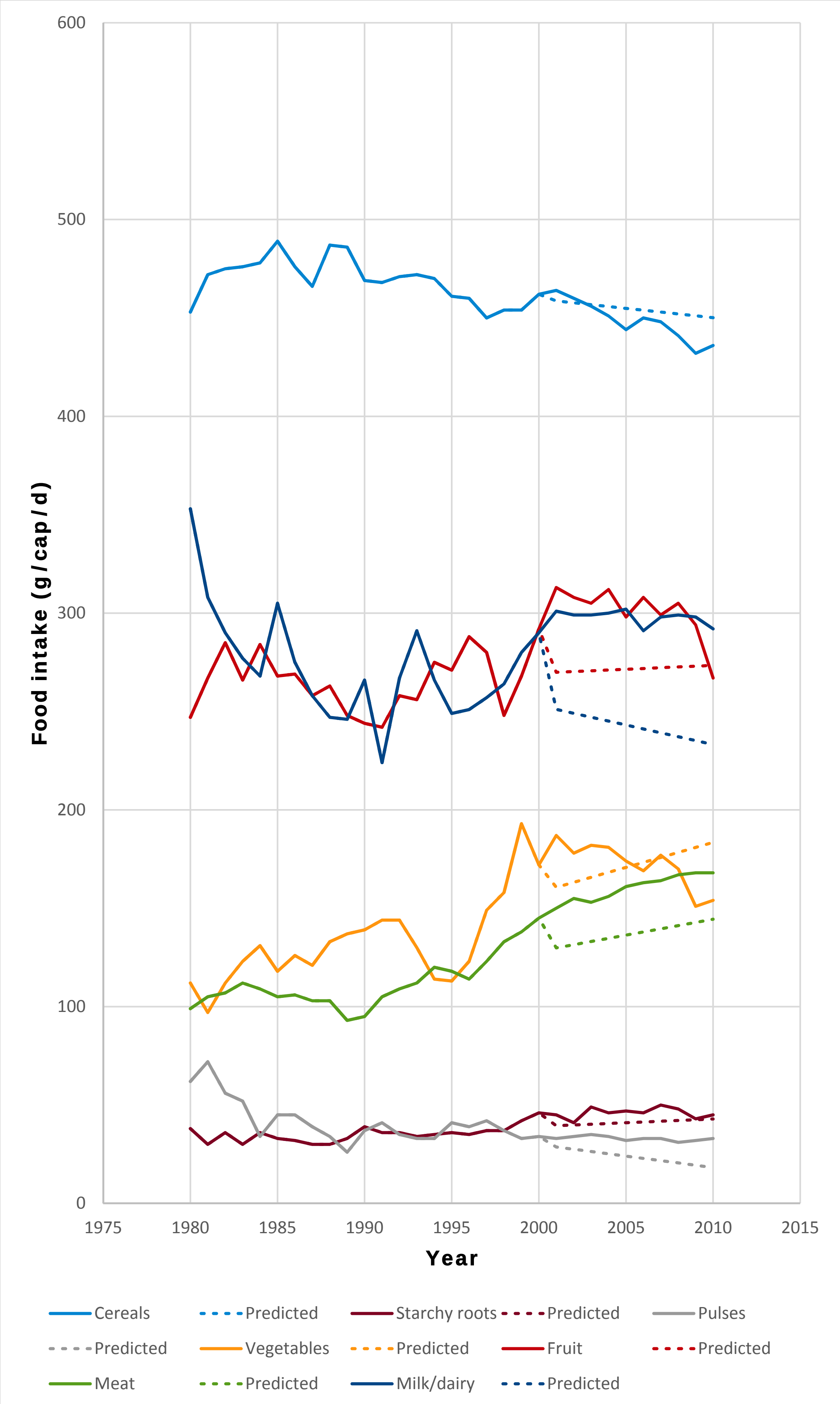


Figure 3.2 Food intake per product group in Mexico, in g/cap/d, in the period 1980-2010 (source: FAOSTAT Food Balance Sheet). The dashed lines indicate predicted values based on the foregoing, measured data points, using the Forecast function in Excel.

3.5 Extrapolation of the data for Mexico

Data of the National Institute of Public Health in Mexico, as given in the paper of Barquera et al. (2006) (figures 3.4a-o), show the ratios of consumption of the different regions (North, Central, Mexico City and South – see below), income classes (the lowest scale, I, and the highest, V) and living conditions (urban and rural), for a number of groups of food products, amongst which the cereals, vegetables, fruit, meat and milk/dairy, from 1989 till 2002.
The regions correspond to the regions as distinguished in a publication of ENSANUT (*Barquera et al***.,** 2006), a representative of the four regions in Mexico: northern, central, Mexico City and southern. These four regions, having common geographic and socioeconomic characteristics, encompass all of Mexico's 32 states, with region (1) north: Baja California, Southern Baja California, Coahuila, Durango, Nuevo Leon, Sonora, Sinaloa, Tamaulipas and Zacatecas; region (2) central: Aguascalientes, Colima, Guanajuato, Hidalgo, Jalisco, Mexico, Michoacan, Nayarit, Querétaro, San Luis Potosí and Tlaxcala; region (3) Mexico City and; region (4) south: Campeche, Chiapas, Guerrero, Morelos, Oaxaca, Puebla, Quintana Roo, Tabasco, Veracruz and Yucatan. This regionalization scheme has been used in previous epidemiologic analyses to make within-country comparisons.' Figure 3.3 shows a map of Mexico in which the four regions are located.
Starchy roots and pulses do not appear in the data of the National Institute of Public Health; we assume the same ratios for these product groups as cereals.

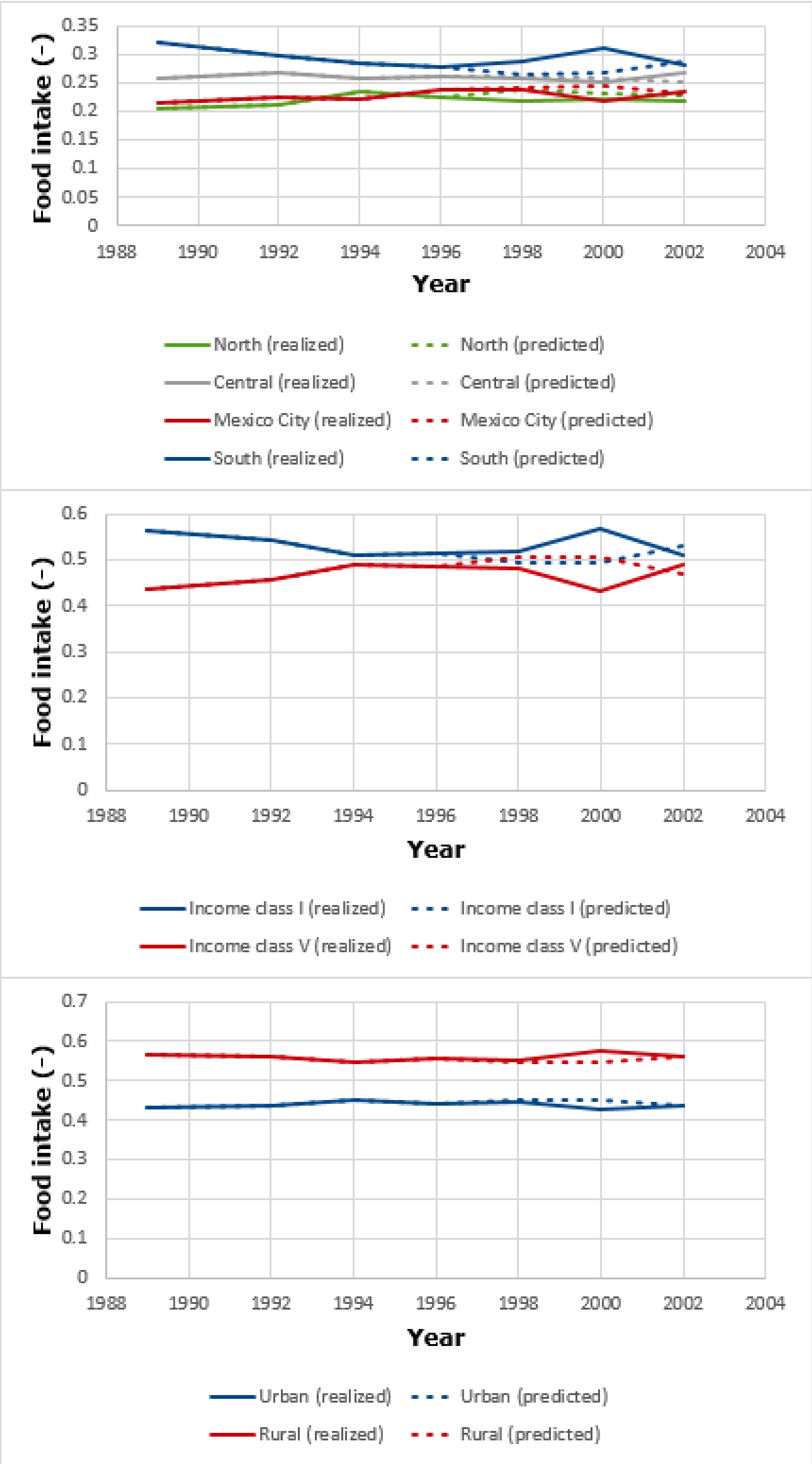
Figure 3.3 The four distinguished regions, N, C, MC and S, as situated in Mexico (ENSANUT Barquera et al., 2006).

In the figures 3.4 the relative food intake is given during the years 1989 – 2002, with the intake defined as relative daily food weight for an inhabitant for a specific region, environment or economical class in comparison to the daily total weight over the inhabitants (g/cap/d/(tot. g/cap/d).

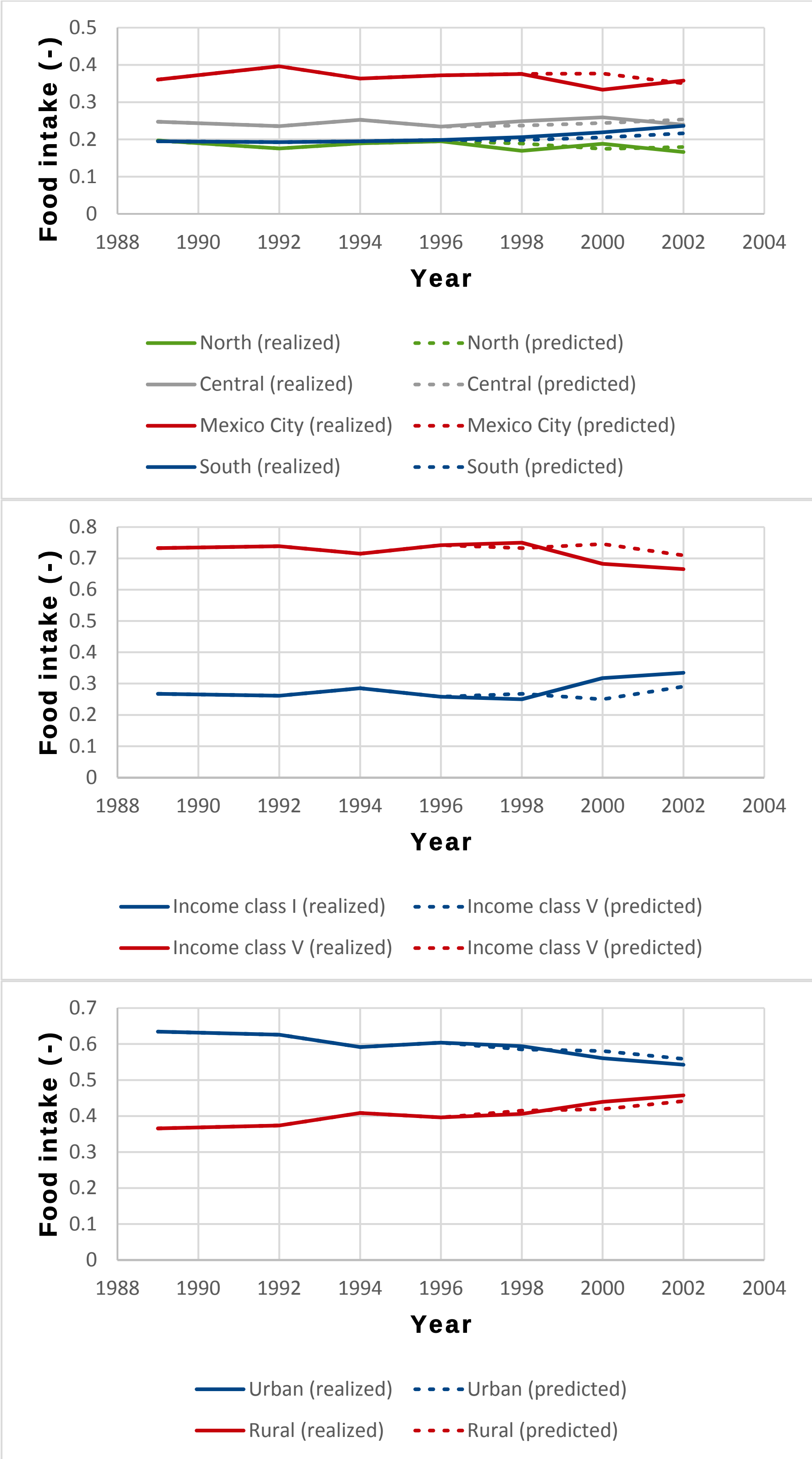
The data in the figures 3.4 show trends that can be extrapolated. The linear regression tool in Microsoft Excel has been used to forecast or predict the values in future. The interpretation of the results shows, that the poor start eating more and more like the rich have as an intake. Food will be better accessible for everybody. This means that more food must be available and other factors will change that affect accessibility (income, price, infrastructure, etc.). FAO indicates that the food security has indeed improved globally, that malnutrition has decreased, fewer people starve to death, although nutrition security has not improved (FAO et al., 2017). However, if we assume that the poor

eat more and more like the rich, the consumption percentages of the different groups will grow towards each other, assuming that the rich are satisfied by the food they eat. At a sufficiently long extrapolation period the consumption of the rich and poor is coming more together. According to this principle everybody will eventually consume approximately the same, regarding food and amount. However, when an expected equilibrium has been established, such as for example, poor and rich both consume 50% of a product group, the prediction can't be logical anymore, as it would not be acceptable that the poor would *surpass* the rich regarding the consumption of a specific group of products as an example. The obtained percentages are applied to the extrapolated values from FAOSTAT in the previous section.
These percentages are multiplied with the food intakes per product group for the particular years, obtained before, in order to obtain a prediction of the food intakes of the different regions, income classes and living environments. For validation, we extrapolate the period 1989-1996 to 1998 to 2002. Figure 3.4a-o shows the results in kcal per inhabitant or capita per day during the years using the variables. The predictions for regions are presumably less reliable than for the income classes and living environments, since these, presumably, alter composition because of the migration to the city.

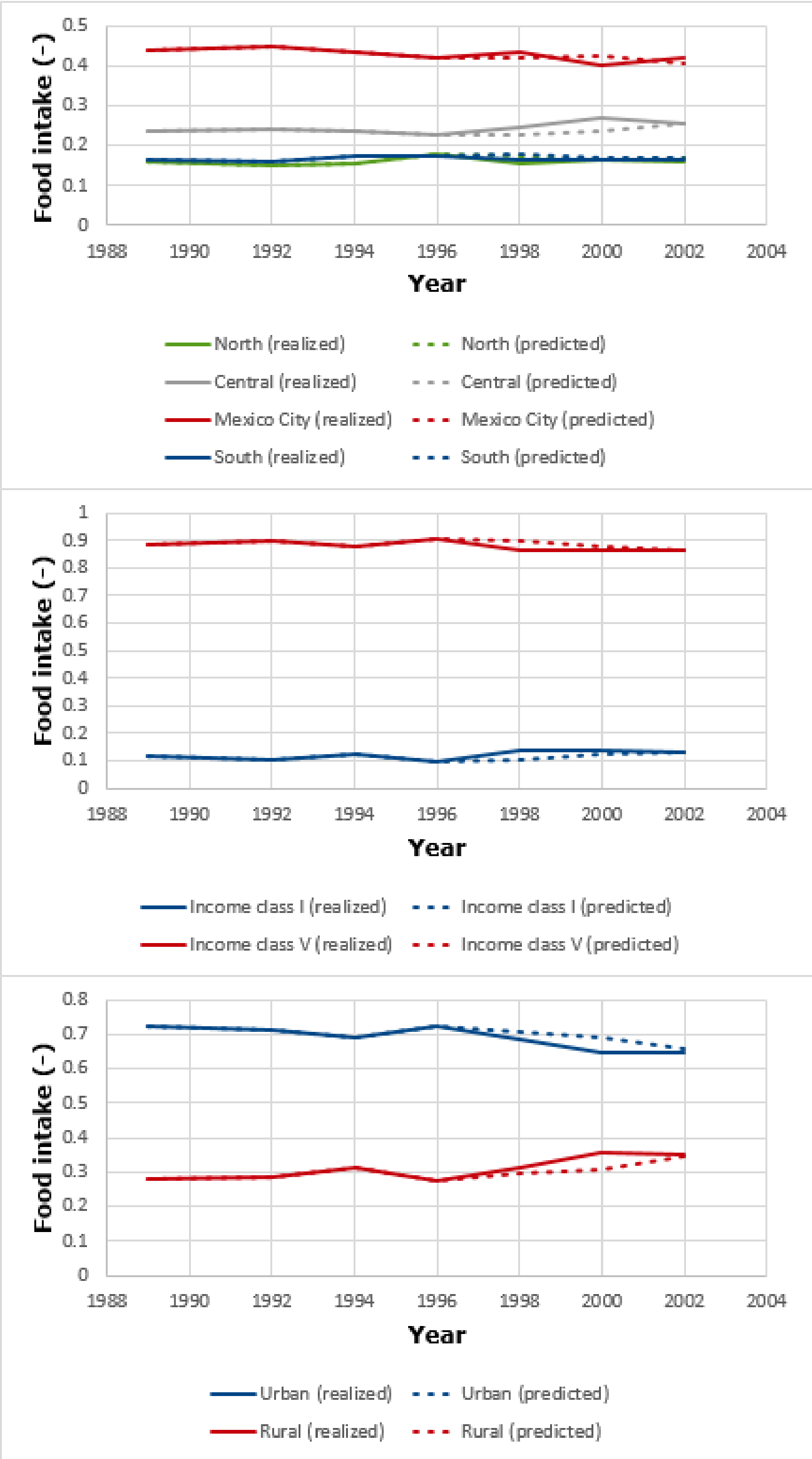
Further interpretation of the results in figure 3.4 shows that the main difference are between the food intake in the urban region of Mexico City and the other parts of Mexico. More food is eaten in the city and especially more vegetables, fruit and meat. Most of the vegetables, fruit and meat are going to the highest income class (Class V), while the energy intake as a total is about the same for all groups.



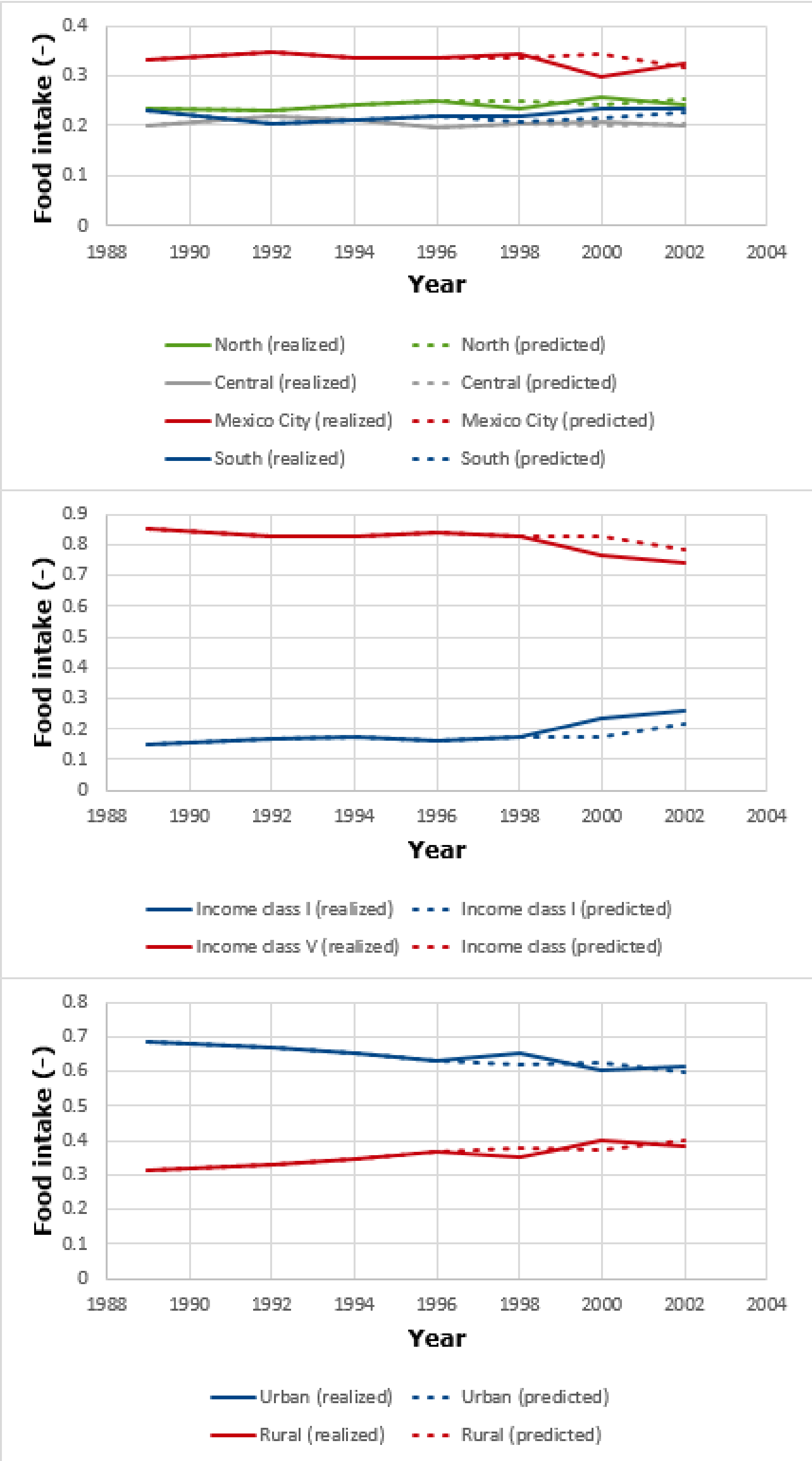
Figures 3.4a-c. Relative food intake (g/cap/d/(tot. g/cap/d)) of cereals per region (a), income class (b) and living environment (c) in Mexico (fraction), in the period 1989-2002 (source: Barquera et al., 2006). The dashed lines indicate predicted values based on the foregoing, measured data points, using the forecast function in Excel.



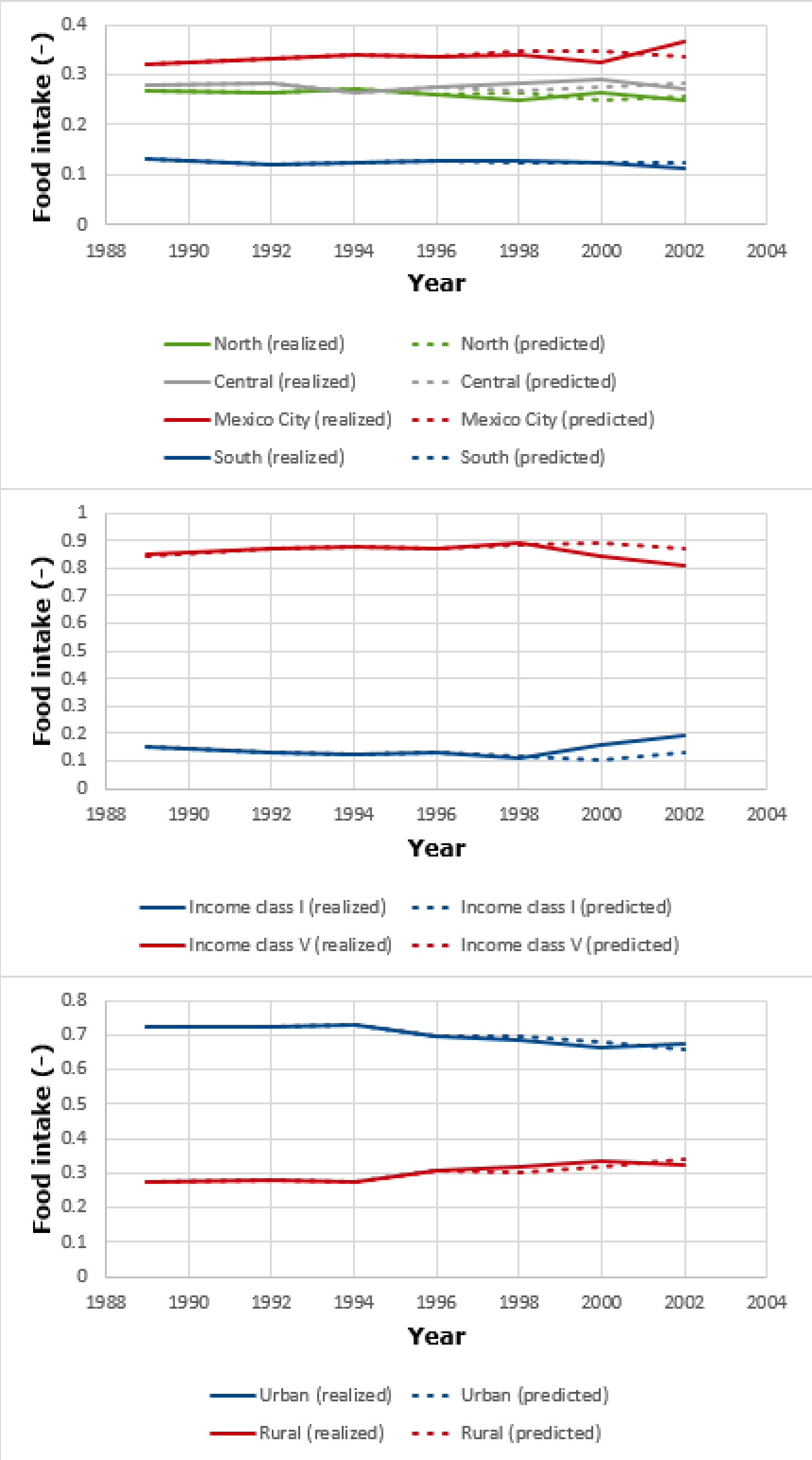
Figures 3.4d-f. Relative food intake (g/cap/d/(tot. g/cap/d)) of vegetables per region (d), income class (e) and living environment (f) in Mexico (fraction), in the period 1989-2002 (source: Barquera et al., 2006). The dashed lines indicate predicted values based on the foregoing, measured data points, using the forecast function in Excel.



Figures 3.4g-i. Relative Food intake (g/cap/d/(tot. g/cap/d)) of fruit per region (g), income class (h) and living environment (i) in Mexico (fraction), in the period 1989-2002 (source: Barquera et al., 2006). The dashed lines indicate predicted values based on the foregoing, measured data points, using the forecast function in Excel.



Figures 3.4j-l. Relative food intake (g/cap/d/(tot. g/cap/d)) of meat per region (j), income class (k) and living environment (l) in Mexico (fraction), in the period 1989-2002 (source: Barquera et al., 2006). The dashed lines indicate predicted values based on the foregoing, measured data points, using the forecast function in Excel.



Figures 3.4m-o. Relative food intake (g/cap/d/(tot. g/cap/d)) of milk/dairy per region (m), income class (n) and living environment (o) in Mexico (fraction), in the period 1989-2002 (source: Barquera et al., 2006). The dashed lines indicate predicted values based on the foregoing, measured data points, using the linear regression function in Excel.

3.6 Conversion of product groups to nutrients

On the basis of the NEVO table – a data source containing nutritional values for food products (see section 3.2)- we calculate the nutrient intake per region, income class and living environment from the predictions obtained in the previous section. In this way it can be investigated whether certain populations have a shortage or a surplus of particular nutrients such as vitamins, minerals, proteins, etc.
We focus on the following nutrients:

- Proteins
- Carbohydrates
- Fats
- Vitamin C
- Retinol
- Retinol activity equivalents
- Retinol equivalents
- Beta carotene
- Alpha caroteen
- Vitamin B12
- Iron
- Iodine
- Zinc

These are among the most important nutrients.

Since the NEVO table is not organized per product group, but per product (such as white bread), we had to take the averages of some products from the product group of interest. Thereto we have selected a small number of representative products per product group (see Table 3.1).

Table 3.1 Selection of products in the NEVO table to represent the required product groups in the prediction of the nutritional intake.

Cereals	Starchy roots	Pulses	Vegetables	Fruit	Meat	Milk/dairy
Bread brown wheat	Potatoes wo skins boiled average	Beans brown tinned	Vegetables average boiled	Fruit fresh citrus average	Meat average raw >5% fat excl liver	Milk whole
Bread white milk based	Casava boiled	Beans white/brown boiled	Vegetables average raw	Fruit fresh average excluding citrus		Milk semi-skimmed

The calculated averages are given in Table 3.2.

Table 3.2 Average mass fractions of nutrients in product groups based on the NEVO table (source: Nevo-online version 2016/5.0, RIVM, Bilthoven).

		Proteins (g/g)	Carbohydrates (g/g)	Fats (g/g)	Vitamin C (mg/g)	Retinol (µg/g)	Retinol activity equivalents (µg/g)	Retinol equivalents (µg/g)	Beta carotene (µg/g)	Alpha caroteen (µg/g)	Vitamin B12 (	Iron (mg/g)	Iodine (µg/g)	Zinc (mg/g)
Staple food	Cereals	0,07	0,38	0,01	0,00	0,00	0,00	0,01	0,02	0,01	0,00	0,01	0,37	0,01
	Starchy roots	0,01	0,25	0,00	0,13	0,00	0,00	0,01	0,03	0,00	0,00	0,01	0,02	0,00
	Pulses	0,07	0,15	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,01
Sauce	Vegetable	0,01	0,03	0,01	0,12	0,01	1,00	2,10	11,00	2,10	0,00	0,01	0,02	0,00
	Fruit	0,01	0,11	0,00	0,30	0,00	0,09	0,17	0,31	0,08	0,00	0,00	0,02	0,00
	Meat	0,21	0,01	0,09	0,08	0,15	0,16	0,17	0,08	0,00	0,01	0,01	0,02	0,02
	Milk/dairy	0,03	0,05	0,03	0,01	0,25	0,26	0,27	0,13	0,00	0,00	0,00	0,15	0,00

We multiply the obtained mass fractions of nutrient with the predicted food intake in order to obtain the predicted nutrient intake. The results are shown in Figure 3.5.

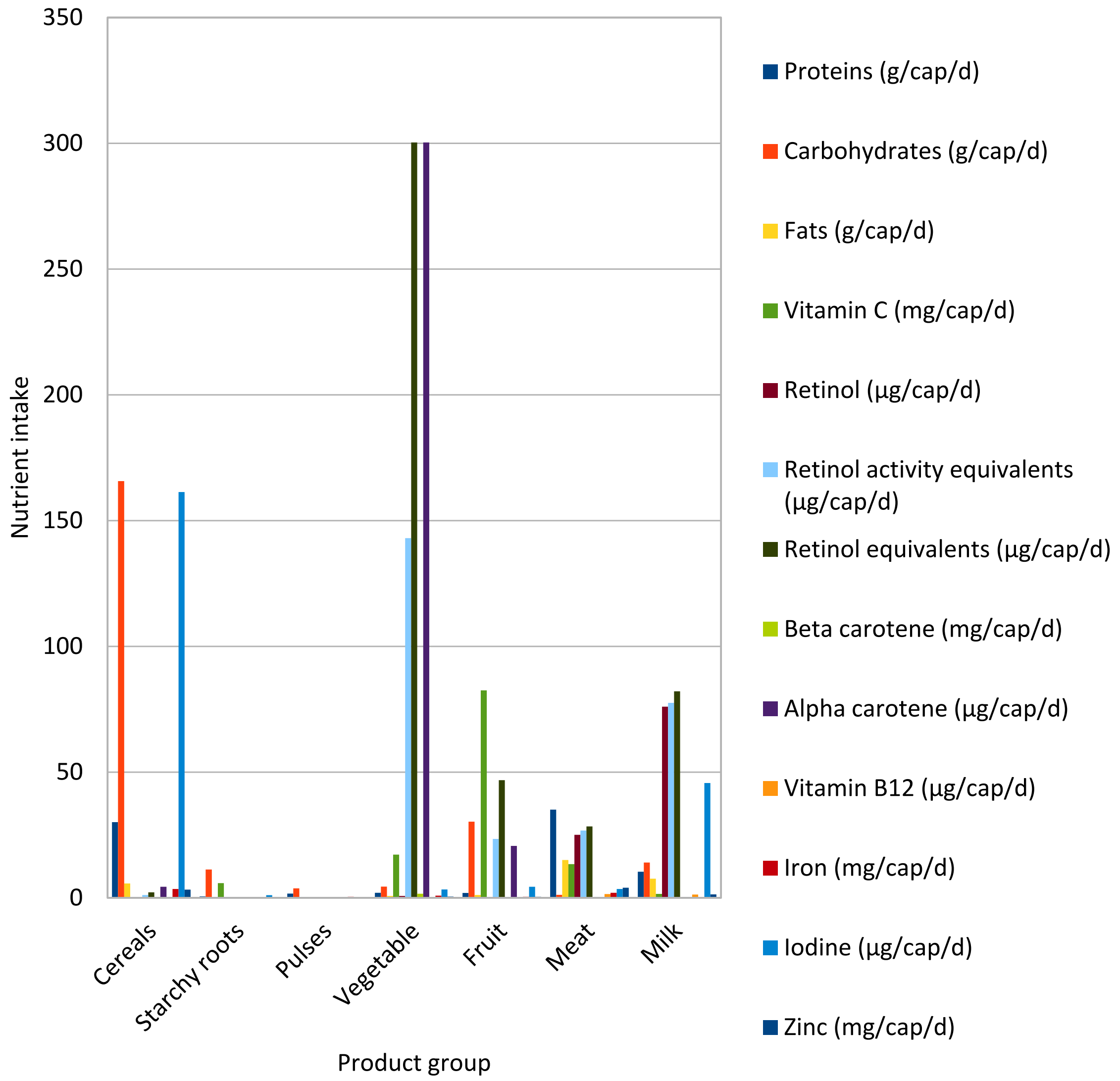


Figure 3.5 Predicted nutrient intake for Mexico in 2010.

4 Results Future Food Basket forecasting: prediction of the situation in 2030

We use the method that has been validated for the past of Mexico in the section before, to predict the situation for the country in the future, in 2030. For this purpose, we extrapolate the complete data until 2010. The results are shown in figures 4.1a-g.

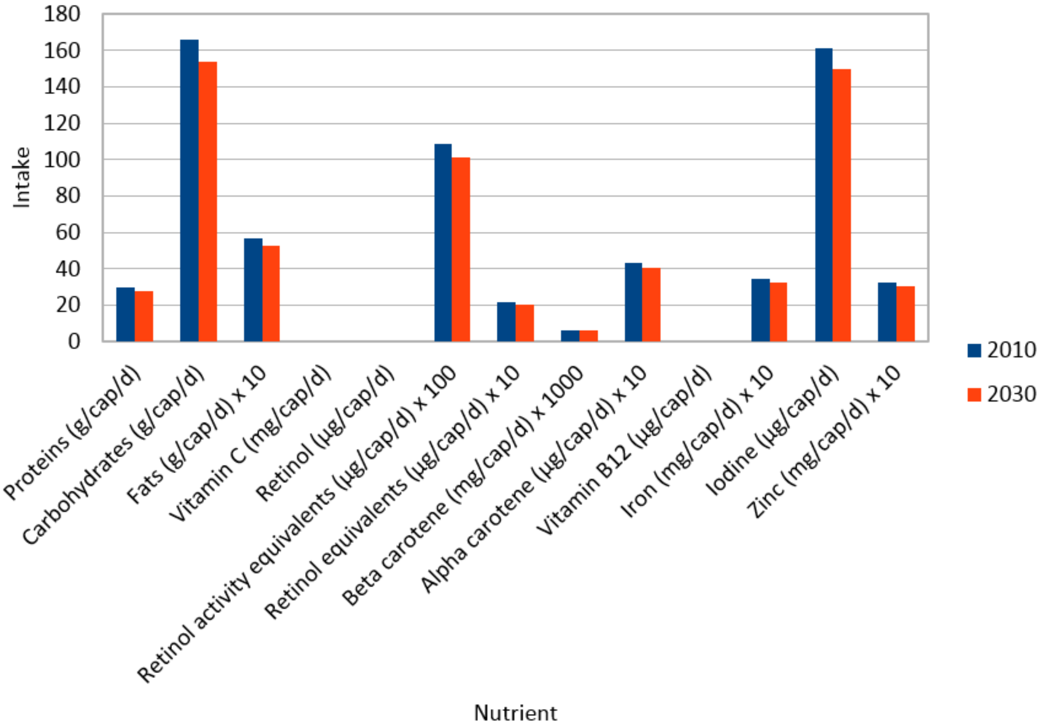


Figure 4.1a. Predicted nutrient intake Mexico for cereals in 2030. Some values have been multiplied, for presentation purposes (the factors are mentioned with the particulars nutrients).

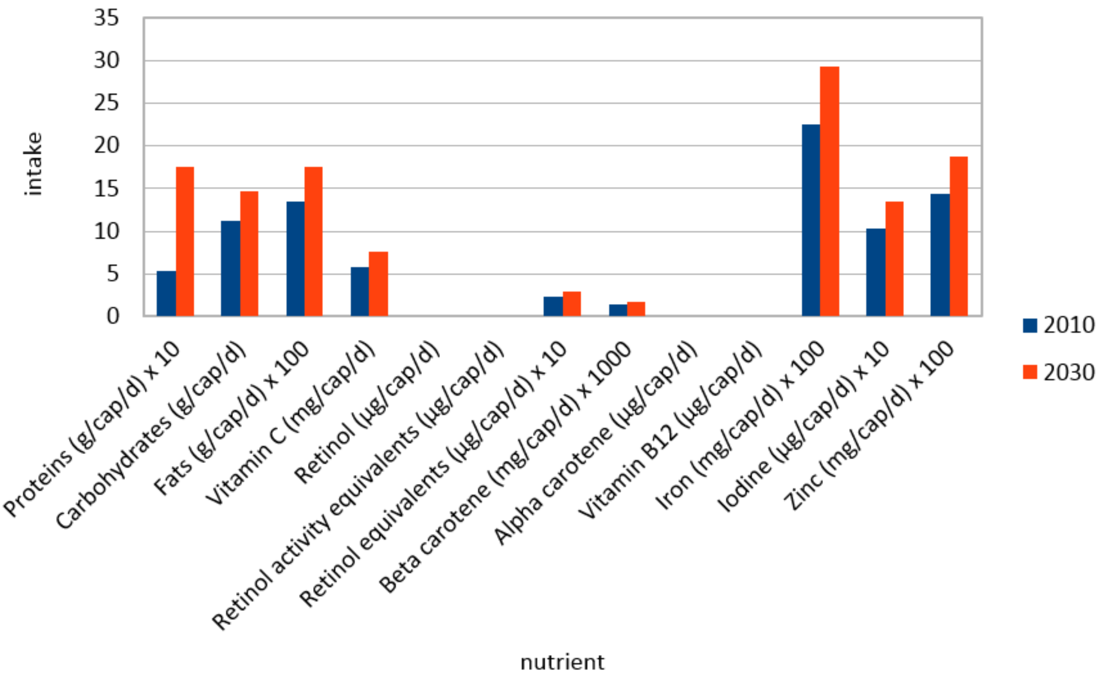


Figure 4.1b. Predicted nutrient intake in Mexico for starchy roots in 2030. Some values have been multiplied, for presentation purposes (the factors are mentioned with the particulars nutrients).

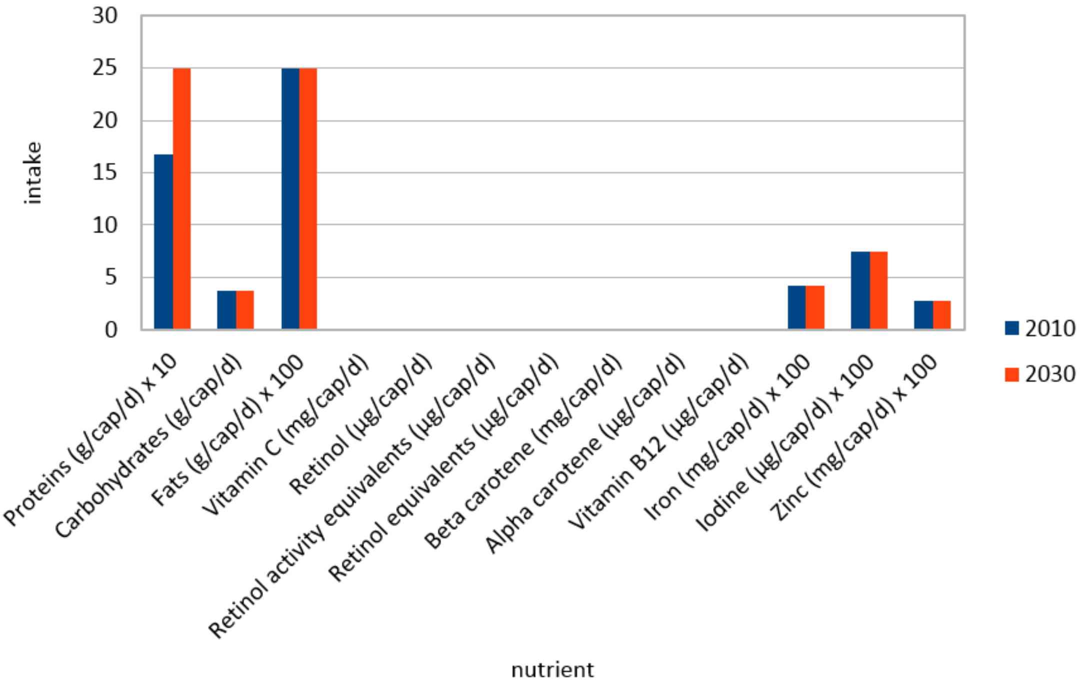


Figure 4.1c. Predicted nutrient intake in Mexico for pulses in 2030. Some values have been multiplied, for presentation purposes (the factors are mentioned with the particulars nutrients).

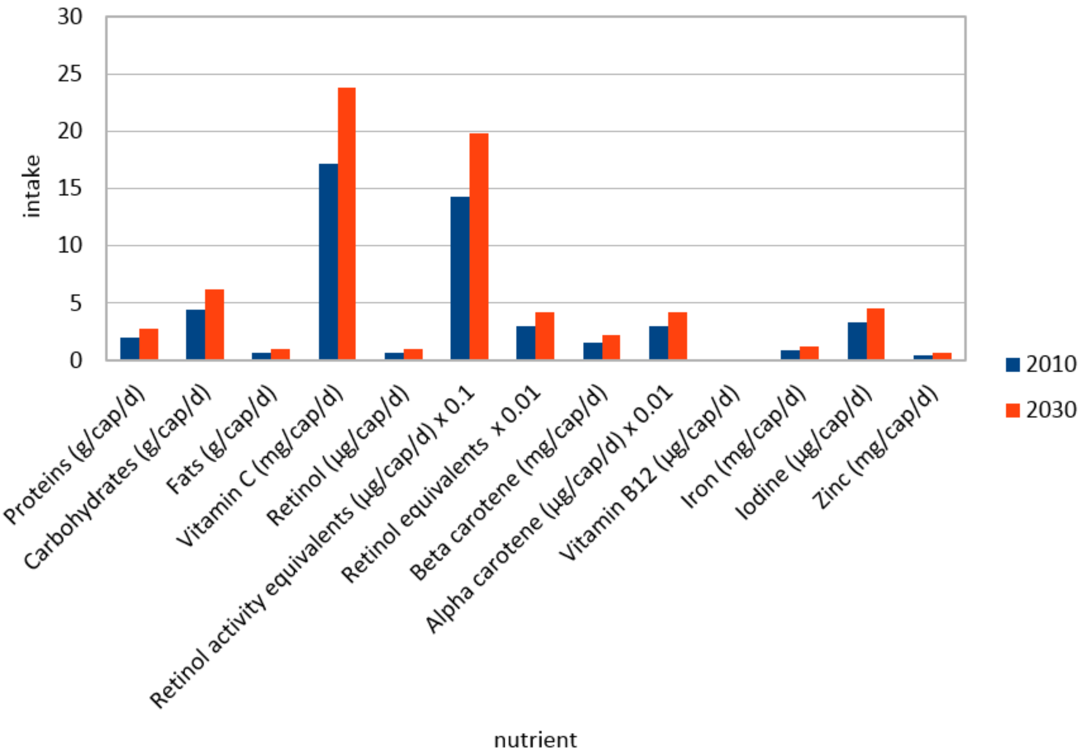


Figure 4.1d. Predicted nutrient intake Mexico, for vegetables, in 2030. Some values have been multiplied, for presentation purposes (the factors are mentioned with the particulars nutrients).

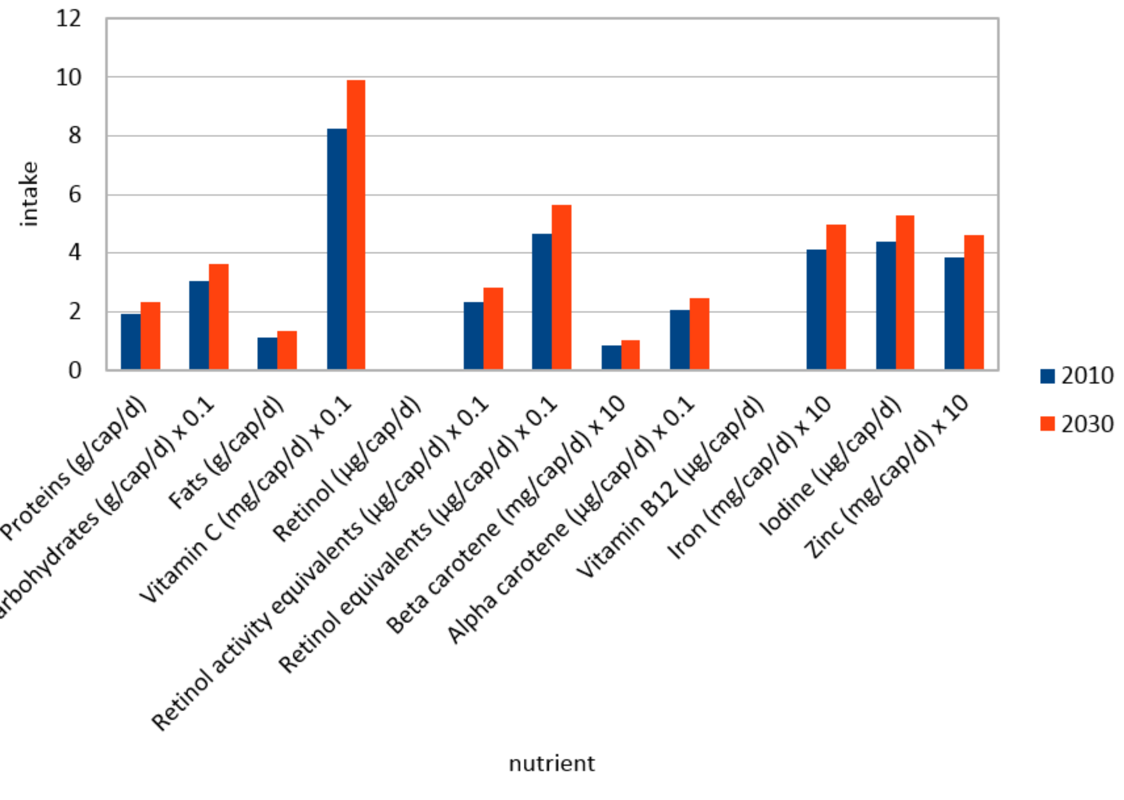


Figure 4.1e. Predicted nutrient intake Mexico, for fruit, in 2030. Some values have been multiplied, for presentation purposes (the factors are mentioned with the particulars nutrients).

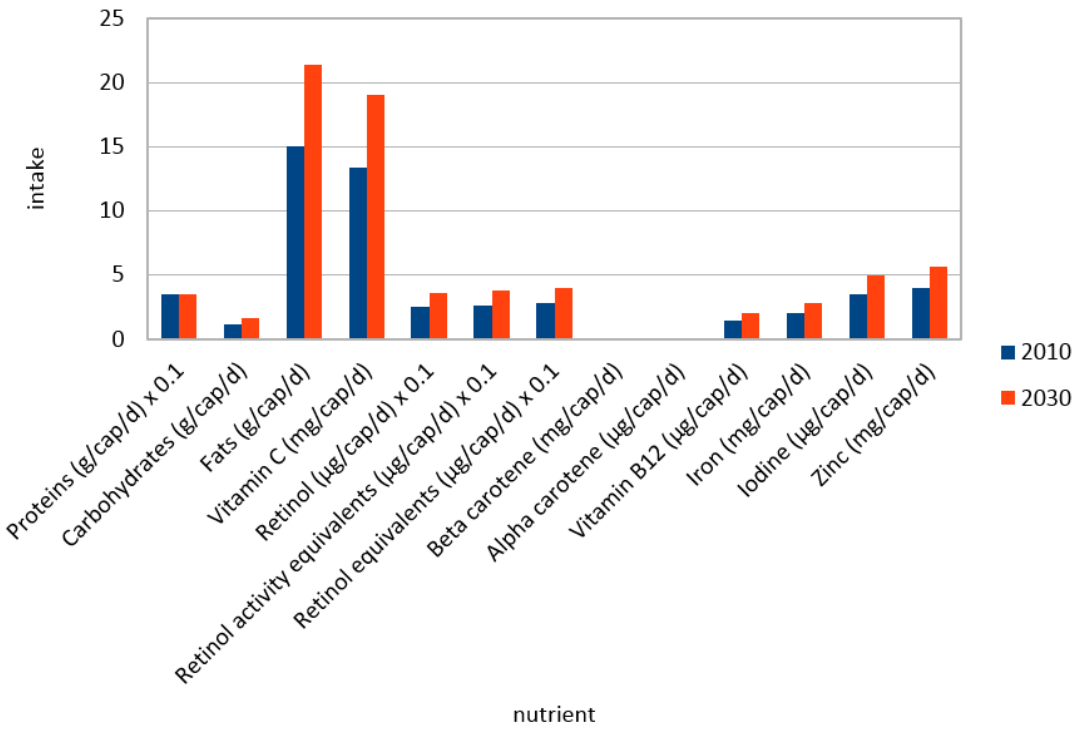


Figure 4.1f. Predicted nutrient intake in Mexico, for meat, in 2030. Some values have been multiplied, for presentation purposes (the factors are mentioned with the particulars nutrients).

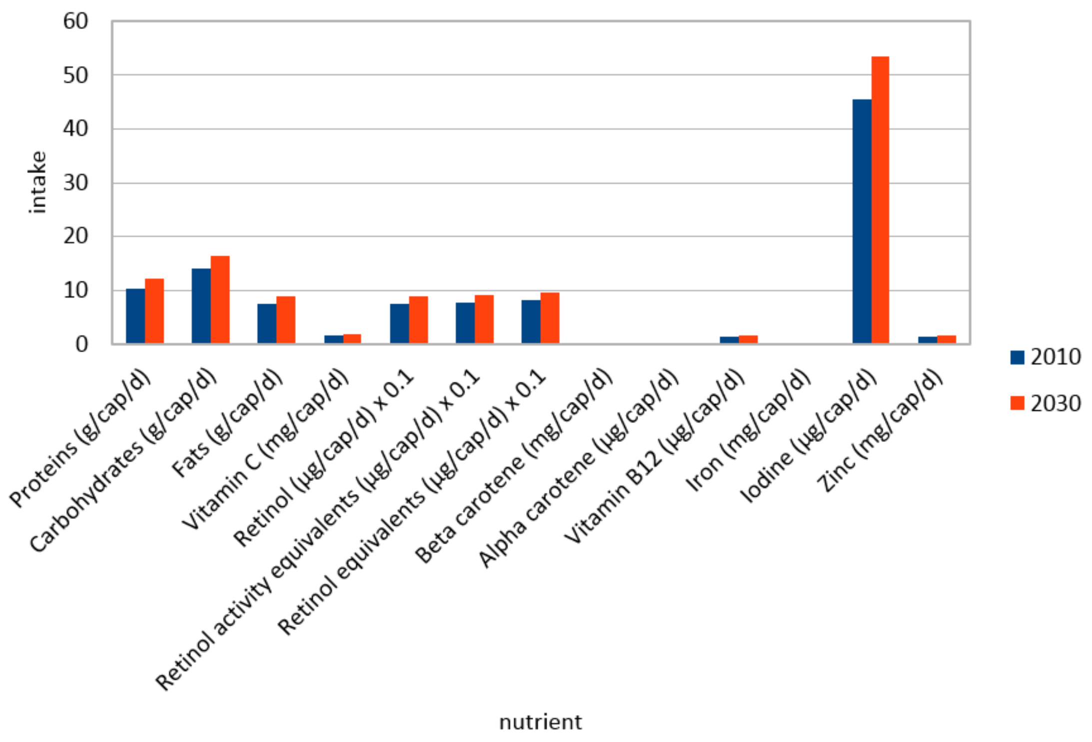


Figure 4.1g. Predicted nutrient intake in Mexico, for milk/dairy, in 2030. Some values have been multiplied, for presentation purposes (the factors are mentioned with the particulars nutrients).

5 Discussion

The composition of the daily food, giving the food basket, is based on a global interpretation of the cultures with regard to food. It often contains a staple food with carbohydrates and additional components, such as a sauce with for instance meat and vegetables. The model, that has been developed for the food basket, is based on the composition as given in literature for several cultures in the world, using data for the needed nutrients as given by the World Food Programme (WPF). The model as presented in this report enables the forecasting of future food demand in 2030 through extrapolation of historical data. The model focuses on the following main food product groups: cereals, starchy roots, pulses, vegetables, fruit, meat and milk/dairy.

The model uses an extrapolation method based on historical data from the FAO and regional organisations. The forecasting model formulates a food basket for a region that can be considered as a minimal scenario for the food demand in the near future (2030) in a stable environment. Other influences on future food demand such as unexpected changes in political climate (e.g. political turmoil and instability), economical welfare, climate change and other environmental factors affecting food production and consumption have not been included in the forecasting model.

Forecasting the regional needs for food will help to develop better policies for the global food security, including the logistics to bring the desired food products from the production locations around the world to the specified regions. A more homogeneous global food availability can be the result. This will especially be important for Sub Sahara Africa, as given in chapter 2.

The forecasting uses a linear regression method and is autonomous time based. The model was tried and validated for the case of Mexico by using historic data between 1980 and 2000 to predict the situation between 2000 and 2011. Data for this extrapolation have been obtained from the FAO database (FAO Food Balance Sheet), and was combined with data from the Mexican national statistical service, giving a comparison of the measured data with the extrapolated data for 4 regions in Mexico, 2 income classes and the living environment, specified to urban or rural. The latter database enabled the forecasting of the food baskets for specific regions in Mexico including the nutrients. By focusing on the earlier mentioned food product groups the forecasting model will create insight in the future need for a healthy diet, based on energy-intake and required nutrients.

Further interpretation of the results about the food intake in Mexico shows that the main differences are between the food intake in the urban region of Mexico City and the other parts of Mexico. More food is eaten in the city and especially more vegetables, fruit and meat. Most of the vegetables, fruit and meat are going to the highest income class, while the daily energy intake as a total is about the same for all groups.
The food basket in the city contains more fresh products. The logistics for these fresh products, often cooled, is more demanding from the infrastructure. In the growing metropoles this is a challenge.
The poor class will use the informal market to obtain cheap vegetables. When the cities become large fields around the city become less connected for these inhabitants. The alternative supply by the formal market is often only affordable for the middle class on.

The poor classes are more depending on the informal markets using the connections with the grounds in and around the city. With the growth of the metropoles this more complex infrastructure becomes challenging with the formal market in “Western style” more leading. For the growing middle class the demand for a good food basket will not be a problem, but for the poor the food prices become more volatile and beyond their wallet.

Also visible for nutrient intake in Mexico is, that meat and cereals are equally important for the protein intake, while the cereals are the main source for the carbohydrates. In many parts of the world the cereals are the main staple food and by that also the main source for most nutrients. However, vegetables and fruit, but also milk and meat give the additional essential micronutrients. Retinol, beta carotene or iron are coming from ingredients, available in the sauce, which makes the food tasty.

This type of predictions has a narrow statistical base and is unknown in literature. The verification of the forecasted data is therefore difficult. The model enables only time-based extrapolation of historic data; the outcomes of the validation of the forecasting model show that the calculated or forecasted data on food consumption show a good resemblance with the actually recorded data for the majority of product groups, but to a smaller extent for milk and pulses.

The validation of the regression method with upcoming data will help to improve the results of the future food basket forecasting model. Different product groups show different spikes and trends, which can have a strong influence on the forecasted data. Therefore, in the process of validation also the selection of a suitable regression methodology (e.g. linear regression, exponential triple smoothing and linear regression DMA (double moving average)) is to be further investigated and tested.

How the food basket will be composed in the future around the world, depends on how the infrastructure and welfare will develop for the food supply. Considerations for a changing food basket in future include:

- **Urbanisation** - Migration of the population from the rural areas to the metropoles with a consequently change in the food supply network in the city and surrounding areas, giving a changing food basket.
- **Feed vs. food** - Local starch supply does not seem to be the major nutritional problem, but there is competition with the feed industry for the carbohydrate and protein supplies. In future the feed industry may have a larger influence on these supplies.
- **Distribution of nutrients** - In some regions proteins in the food basket are locally more limiting in the nutrition (for instance in Sub Sahara Africa), while in other regions there are sufficient proteins, for instance in Europe. The development in global logistics will have an effect on the distribution of proteins.
- **Food sustainability (1)** - Value chain efficiency will affect the overall sustainability of the food system. Awareness of the need to decrease food wastage in the chain, specifically with growing production volumes and consumer welfare will have an influence on food demand and the decrease of potential nutritional spoilage. Logistics will need to be developed, in relation with transport, storage, post-harvest and processing techniques, methods and communication.
- **Food sustainability (2)** - The effectiveness of resources used in the production and distribution of food will have to be coupled with awareness about impact of food diets and choices made for acquiring sufficient nutritional needs. Regionally the food basket may contain less meat because of the growing awareness regarding the environmental impact from meat production. On the other hand more meat will be demanded when a growing number of people with a middle class income will shift their consumption pattern to more meat.

The changes in demand and needs in Sub-Saharan Africa (SSA) will need special attention because in 2050 half of the births in the world will occur in this part of the African continent (Dupont 2009). Here global production with the food logistics and local production have to be brought together to satisfy at least the *needs* for nutritious food in SSA in the future.

Questions for further research, in which the FFB forecasting model can provide supporting data and background information:

- Is there sufficient protein in the food basket of a region?
- Does the forecasted micronutrient composition give the food balance for a healthy life or does the forecasted food basket require a need for action to change this?
- What products need to be added to the predicted basket in 2030 based on the changing conditions, such as economy, but also because of new insights in an healthy diet?

- If there is a mismatch between the needs or demands and the availability, we can change variables and look to the effects. How to solve this mismatch? For example:
  - adaptation of the production (farming)
  - adaptation of the demand by changing the culture around food, for instance using more a flexitarian menu
  - innovation and alternative production (of proteins) from the sea, other resources and food residues
  - optimizing the logistic chain, including routes for product processing
  - alternatives for effective new routes in processing (balance between food and non-food)

6 Conclusions

The reasons for a strategic study on redesigning the flexible or adaptive value networks for nutrition and food security can be found in the needs to feed the world properly and sufficiently as indicated in the UN millennium and sustainable development goals.

While the world population migrates to the metropoles and the infrastructure for the food security with the food basket must adapt to this quickly changing world in regard for instance to communication and environment, a modelling is required for policy to have insight into future problems on the needs on food by the population worldwide, demand by consumers for food products and the supply in a quantitative manner.

A methodology to forecast a future food basket in energy intake, composition and products was made for the near future of 2030. Also the amount of micro-nutrients in the food, including vitamins and minerals, has been estimated.

This forecasting has been based on FAO data in combination with national data for the forecasting of the regional food baskets around Mexico City. In this report verification of the methodology has been carried out by using historical data to predict the present situation in 2011 of the food basket. The calculated data show a good resemblance with the actually recorded data for a majority of product groups, but to a smaller extent for milk and pulses in particular.

The forecasting of the food basket, showing the nutritional needs and demands, has been given for Mexico. The results show that the urban region obtain more energy and vegetables, fruit and meat, having also the more wealthy class of the population. Also in Mexico most proteins and carbohydrates are eaten with the staple foods.

The poor classes are more depending on the informal markets using the connections with the grounds in and around the city. With the growth of the metropoles this more complex infrastructure becomes challenging with the formal market in “Western style” more leading. For the growing middle class the demand for a good food basket will not be a problem, but for the poor the food prices become more volatile and beyond their wallet.

Also the agri-production will be forecasted for many regions in the world by groups in Wageningen UR. Together the forecasting of production and demand will give a base for strategies to overcome the mismatch between food supply and demand regionally in the years to come. It will be an opportunity to come to better controlled logistics worldwide.

Models can be developed to predict the demand and the production with the processing in future. Through innovation and optimisation in production and processing an improved availability of food can be established.

In the second part of the research (report volume 2) other countries and metropolitan regions will be investigated to assess their future food baskets.

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