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Geopolitics of Food

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Summary
The paper analyzes the food security with the four dimensions physical availability, economic and physical access, food use/utilization and stability, the economy and ecology of food production (plants, meat, fish), the risk factors for food security and the geopolitical activities. The food production increased almost 2.2 times in the past 50 years and was able to compensate the population growth, but the UN Food and Agriculture Organization (FAO) estimates that the food production must increase from 2015 to 2050 by 60%. The growth was achieved by a combination of increased irrigation, fertilizers, pesticides, genetically modified organisms (GMOs) to protect plants from harmful insects and pesticides and a general trend to larger farms and monocultures. Issues are nitrate overload, pesticide contamination, reduction of insects, pollination and birds, loss of biodiversity and land loss and degradation. Smart or precision farming based on the Internet of Things, 5 G networks, drones and Artificial Intelligence may lead to a more effective and ecologic resource use. Over the past 50 years, meat production has more than tripled. Meat production requires land for pastures and animal feed production. Meat replacements and alternatives like mock food, meat from cell cultures and insects have a small, but growing market. Another issue are livestock emissions like carbon dioxide and methane. In the past 50 years, fish production has increased by almost 4 times. Approximately one-third of the fish resources are overfished and some species are in a critical condition. The USA were the largest exporter of food in 2020 while Asia was the largest net importer. Europe was a net importer of food for many decades, but became a net exporter since 2013. While Africa's imports and exports were balanced until the mid 1970ies, the gap between imports and exports is widening. The global food market is increasingly dominated by a few multinational companies from seeds to supermarkets. The most critical risk factors for food security are climate change with soil loss and water scarcity due to higher temperatures, extreme weather with storms, droughts (and floods with continued soil loss due to wind and water erosion. Water waste and low water prices are drivers of water scarcity, e.g., by overuse of groundwater resources like aquifers. A new threat to freshwater is the global contamination with microplastic. After the food price crisis from 2007/2008, food was recognized as strategic resource leading to land lease and buying, also known as Foreign Direct Investments (FDIs) or more critically as 'land grabbing' to prevent bottlenecks in the long term. The Black Sea Grain Initiative demonstrates the vulnerability of global food supply chains and the possibility to weaponize food. Two international water conflicts are ongoing with the Grand Ethiopian Renaissance Dam GERD in East Africa and the India-China Transboundary Water Dispute. In summary, the food, meat, and fish production could be successfully increased to compensate the population growth and the increasing meat consumption, but hunger and undernourishment still exist. Main risk factors for future food security are climate change, land loss and water scarcity. In response, food is seen as strategic resource resulting in geopolitical activities and food and water conflicts.

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1 Introduction

The geopolitics of food is focused on food security. According to the official definition of the *World Food Summit* from Rome 1996, "*Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*".[1]

The four dimensions of food security are

- Physical availability which includes production, supply, stocks, and trade
- Economic and physical access to food which includes incomes, expenditure, markets, and prices
- Food use/utilization, i.e., how food is used and its biological utilization which determines the nutritional status of individuals
- Food Stability, as there can be temporary, seasonal, or chronic food insecurity caused by adverse weather conditions, political instability, or economic factors[2]

The *Integrated Food Security Phase Classification (IPC)* defines five stages of food security: generally food secure, chronically food insecure, acute food and livelihood crisis, humanitarian emergency, and as worst-case famine and/or humanitarian catastrophe[3].

Food security and shortage has ever been a problem in human history, but stepwise this emerged and was recognized as a global problem. Since the 1850ies, food production, trade and consumption were increasingly globalized by international trade for several commodities with the utilization of colonies.

At the end of World War 2, the *United Nations* with the *Food and Agriculture Organization (FAO)* and its objective to fight against hunger were founded[4]. Originally, a *World Food Board* was planned which should coordinate global food markets, but the food producing countries wanted to keep control on their own.

In the 1970ies, the FAO was accompanied by other institutions, *the Consultative Group on International Agricultural Research (CGIAR)* at the World Bank for scientific purposes, the *International Fund for Agricultural Development (IFAD)* for financial purposes and the *World Food Program* for food emergencies[5]. The plan of a *World Food Council* like the *World Food Board* failed in 1974.

While after World War 2 the food regime was originally dominated by national institutions, the global food system was taken over by private companies, from seeds to supermarkets with the rise of processed and packaged foods[6].

In 2015, the United Nations set up the *2030 Agenda for Sustainable Development* as successor of the Millenium Development Goals with the Goal 2 *Zero Hunger*[7].

The food price crisis of 2007/2008 increased the awareness for food as strategic resource: some countries like India announced export restrictions to maintain their own food security and in

[1] EC-FAO 2008
[2] EC-FAO 2008
[3] EC-FAO 2008
[4] McKeon 2011
[5] McKeon 2011
[6] McKeon 2011, Woertz 2022
[7] UN 2015

particular food-importing countries in Asia and the Middle East started to buy foreign farmland as *foreign direct investments (FDIs)* [8].

Geopolitical challenges are population growth and consumption habits (e.g., food waste, increasing meat consumption, overfishing), climate change (e.g., droughts, weather extremes, rising ocean levels), land loss and degradation, waste and overuse of water reserves and international conflicts[9].

Since 2022, the conflict between Ukraine and Russia is an urgent problem. About half of the Arab world's wheat imports come from Ukraine and Russia, e.g., Saudi Arabia is the world's second largest importer of barley, to use it to feed sheep and other animals[10]. After several extensions, the grain deal brokered by Türkiye was interrupted on 17 July 2023[11]. Water conflicts are currently going on around the Nile and Brahmaputra rivers.

The paper analyses the food security, the economy and ecology of food production (plants, meat, fish), the risk factors for food security and the geopolitical activities.

2 Food Security

The prevalence of undernourishment increased from 8.0 to 9.8% from 2019 to 2021 and between 702 and 828 million people were affected by hunger. Around 2.3 billion people were moderately or severely food insecure in 2021, and 11.7% were severely food insecure[12].

In theory, there is enough food and energy for every human being. In 2008, 4,600 kilocalories (kcal) were produced per capita (i.e., per individual) and day globally, but after harvest 600 kcal are lost), 800 kcal during trade and in households, 1,200 kcal as animal feed, resulting in only 2,000 kcal net food per capita and day[13]. The crop use is allocated to food in 43%, waste and loss in 33%, animal feed in 14%, industrial needs in 8%, and seed in 2%[14].

Hunger was reported for 20.2% of the people of Africa, 9.1% in Asia, 8.6% in Latin America and the Caribbean, 5.8% in Oceania, and less than 2.5% in Northern America and Europe[15]. The meat consumption in 2020 was 149 kg in the United States, but only 8.3 kg in Ethiopia[16]. The total protein intake was 117 g per capita in the United States and only 58 g in Nigeria[17]. Undernourishment can appear as *Kwashiorkor* (protein deficiency) or *Marasmus* (complete lack of food)[18].

In 2021, 14.6% of children had a low birthweight in 2021. In 2020, among children under five years of age, approximately 22% were stunted (low height for age), 6.7% were wasted (low weight for height), but 5.7% had overweight. Stunting and wasting can result from food deprivation, malnutrition and/or infectious diseases such as diarrhea. In 2019, nearly 33% of women between 15 to 49 years were affected by anemia (low red blood cells, typically caused by iron deficiency), which is more frequent in poor rural areas[19]. Micronutrient

[8] McKeon 2011
[9] ICA 2015, FAO et al., 2022, Geopolitical Futures 2022
[10] Woertz 2022
[11] Mihm 2023
[12] FAO et al. 2022. This report *The State of Food Security and Nutrition in the World* is also known as *SOFI report (The State of Food Insecurity in the World)* until 2015
[13] Konzernatlas 2017
[14] ICA 2015
[15] FAO et al. 2022
[16] Ritchie/Rosado/Roser 2019
[17] Ritchie/Roser 2021
[18] Eccharen 2011
[19] FAO et al. 2022

undernourishment refers to the lack of vitamins and minerals; Vitamin A deficiency leads to blindness (xerophthalmia) in estimated 250,000 to 500,000 children each year[20].

3 Food Production

3.1 Agriculture

Overall, 38% of the Earth's surface is land; of this, 29.1% were used for agriculture in 2015. This land is distributed to pastures (68%), arable land (28%) and permanent crops (e.g., trees) in 4%[21]. Pastures cover 3.5 billion hectares, arable land 1.5 billion hectares. In addition, there are 4 billion hectares forest[22].

The global production of cereals increased from 0.94 billion tons in the 1960ies to 1.89 billion tons in 1989 and 2.35 billion tons in 2007[23]. The FAO estimates that the food production must increase from 2015 to 2050 by 60%, as the growth of consumption of animal products will increase the need of animal food, such as soy beans and corn[24].

The growth of production was achieved by a combination of increased irrigation, fertilizers, pesticides, genetically modified organisms (GMOs) and a general trend to larger farms and monocultures, i.e., rationalization and modernization[25].

The average production from 1961 to 2007 increased for wheat from 1089 kg/ha to 2792 kg/ha, for barley from 1328 kg/ha to 2406 kg/ha and for rice from 1869 kg/ha to 4152 kg/ha[26].

More than half of the arable land was used in 2014 for grains (wheat, corn, rice, millet, barley, and others), more than 20% for oilseeds (soybeans, canola, cotton, peanuts, sunflower and others), approximately 6% for legumes (peas, beans), over 4% each for fruits, vegetables, and roots (like potatoes and yams), the remaining land was used for sugar, stimulants (like tea and hops), nuts, gums, spices, and fibers[27]. Some agricultural commodities are not used for food, the leading products are cotton lint, natural rubber, raw silk, and tobacco[28].

The food production increased almost 2.2 times in the past 50 years, but with a five-fold increase in the global use of fertilizers[29]. The leading fertilizer is nitrogen-based, followed by phosphate, potash, nitrogen phosphate and sulfur-containing fertilizers. Four of the five leading companies are US-based (*Agrium, Potash, Mosaic, CF Industries*), one is in Norway (*Yara*). The fertilizer use intensity is 615 in Egypt, 557 in China and 204 in Germany kilogram per hectare field[30].

The over-fertilization with nitrate leads to algae growth and a lack of oxygen in water and is dangerous for the groundwater quality[31]. More precisely, algae are consumed by zooplankton, bacteria consume excrements from zoo plankton and the dead algae, a process that needs oxygen[32]. In Europe, North-West Germany and the Netherlands are 'nitrate hotspots'. The Dutch government ordered the farmers to reduce fertilizers, but as this significantly reduces

[20] Eccharen 2011
[21] ICA 2015
[22] Fleischatlas 2018
[23] Nash 2010
[24] ICA 2015
[25] Agraratlas 2019
[26] Alcázar 2011
[27] Fleischatlas 2018
[28] FAO 2022a
[29] UNCTAD 2017
[30] Konzernatlas 2017
[31] Agrar-Atlas 2019
[32] Meeresatlas 2017

harvests and incomes of farmers, this ecologic-economic dilemma led to massive political tensions in the Netherlands since 2022.

The conventional agriculture used in 2020 1.39 million tons of pesticides in China, 407,000 tons in the US and 216,000 tons in Brazil[33]. Four companies have around 70% global market share, these are *Bayer (Germany)* with 18.8 billion Euro, *Syngenta (Switzerland)* 9.9 billion Euro, *Corteva (former DowDuPont; US)* with 5.7 billion Euro and *BASF (Germany)* with 5.5 billion Euro revenue in 2020[34].

While the substances are increasingly effective, they also can affect the environment as they can also kill useful insects as well. As a result, but also caused by monocultures and decline in natural vegetation, the volume is insects is globally declining and subsequently, the number of birds as well, in some areas of the US already by more than 50%. This also leads to the reduction of pollination which is essential for plant growth. Inappropriate handling can lead to acute and chronic intoxications (like neuropathy). The number of intoxications is estimated with 385 million cases per year, thereof around 180 million cases in South Asia where farmers often do not wear protective clothing due to poverty or because it is too hot[35]. Furthermore, residuals of pesticides can contaminate food products.

The European Union tries to reduce the use of pesticides. New non-conventional agricultural concepts like ecological and sustainable farming without pesticides are rising, but this is only possible if reductions of harvests with higher food prices are accepted by farmers and consumers. While this concept is promising for wealthy countries, the need for increased global food production will globally still be covered by conventional agriculture, i.e., fertilizers and pesticides will also be used in future.

Another concept to protect plants from harmful insects and pesticides are *Genetically modified organisms (GMOs)* which were grown across 28 countries in 2014 and the proportion of GMOs increased from 3.6% to 12.8% of global crop lands from 1996 to 2018[36]. Of the 192 million hectares with GMOs, 90% are in only 5 countries, the USA, Brazil, Argentina, Canada, and India. Leading products are soy beans with 50%, corn with 30% and cotton with 13%[37].

While these methods increased productivity, farmers and consumer remained sceptic, in the European Union and an intense debate on the pros and cons of GMOs is going on since decades. Another issue is the plant protection of GMO seeds which makes farmers dependent from the companies. The seed market is meanwhile quite concentrated. Four companies have around 60% global market share for seeds, these are *Bayer* (which bought the previous market heavyweight *Monsanto*), *Syngenta, Corteva* and BASF, i.e., the same companies that dominate the pesticide production[38]. With respect to the climate change, GMOs may also be developed to increase heat and drought resistance.

A critical point for food production is the loss of biodiversity and genetic diversity. To increase productivity, many traditional varieties were replaced[39].

For example, around 96% of the 7,098 apple varieties in the US were lost since start of the 20th century; the same is true for cabbage (95%), maize/corn (91%), peas (94%) and tomatoes (81%)[40]. Of 350 melon varieties in Spain in the early 1970ies, only 10 are still on the market. This phenomenon can be observed globally, e.g., for rice. This leads to loss of knowledge and

[33] Insektenatlas 2020
[34] Pestizidatlas 2022
[35] Pestizidatlas 2022
[36] Denning/Fanzo 2022
[37] Insektenatlas 2020
[38] Pestizidatlas 2022
[39] Alcázar 2011
[40] Alcázar 2011

makes the production more vulnerable for diseases. For example, *Helminthosporium maydes* destroyed more than 50% of the corn fields in the south of the United States as these were based only on one variety, but fortunately resistant local varieties from Africa could be utilized to stop this[41].

A special topic are biofuels such as ethanol and biodiesel. Politicians expect a significant contribution of biofuels to renewable energies. Oil crops and sugar require processing for use as food and fuel. In 2019, 207.5 million tons of vegetable were produced, such as palm oil, soybean oil, rapeseed oil and sunflower oil. The production of the main vegetable oils is quite concentrated, e.g., palm oil is mainly produced by Indonesia (57%) and Malaysia (27%).[42] However, biofuels may not be an alternative to largely replace fossil fuels, because if the EU would replace 10% of petrol and diesel from fossil sources with biofuel from their own resources, this would need 75% of its arable land[43]. Biofuels contributes to food price increases and the real production costs are underestimated as the water usage is not considered[44].

A man-made problem is land loss: forests are transformed to pastures, pastures to arable land, arable land will be used for expansion of cities. In addition, land can be used as long-term investment, i.e., investors buy farmland as they expect rising prices and indeed, farmland prices are rising in many regions globally. Land degradation by climate change, deforestation and soil destruction is expected to affect about 3.2 billion people by 2050[45].

3.2 Meat and Fish

3.2.1 Meat Production

Meat is an important food and protein source and over the past 50 years, meat production has more than tripled to 337.2 million tons per year[46], thereof poultry with 133.4 million tons, pigs with 109.8 million tons, bovine meat with 67.9 million tons, and 26.1 million tons for other products[47]. It is expected that the meat consumption will increase from 2006 to 2050 per capita and year from 77 to 95.7 kg for the industrial states and from 31 to 44 kg for the developing countries[48]. The meat consumption in 2020 was 149 kg in the United States, but only 8.3 kg in Ethiopia[49]. The production of 1 kg of beef requires 10 kg of grass or soya-based feed[50].

Animal farming was done with 2020 was 33 billion chickens, 1.5 billion cattle, 1.3 billion sheep, 1.2 billion ducks, 1.1 billion goats and 1.0 billion pigs. These numbers are only a snapshot as e.g., in 2018, 69 billion chicken and 1.5 billion pigs were slaughtered[51].

Soy beans are the most important protein source for animal production with 123 million hectares land, more than 80% of this land is in Brazil, US, and Argentina. The production is 123 million tons in Brazil, 104.6 million tons in US, 53 million tons in Argentina and 17 million tons in China[52]. The increased use of arable land for feeding has also to do with the intensified livestock farming where animals are increasingly concentrated in farms instead on free pastures.

An intense livestock farming facilitates the spread of infections. For this reason, antibiotics must be used to treat or to prevent such diseases. In 2013, the global antibiotics consumption

[41] Alcázar 2011
[42] FAO 2022b
[43] Rey 2011
[44] ICA 2015
[45] Roland Berger Focus 2019
[46] Ritchie/Rosado/Roser 2019
[47] Ritchie/Rosado/Roser 2019
[48] Fleischatlas 2018
[49] Ritchie/Rosado/Roser 2019
[50] Nash 2010
[51] Ritchie/Rosado/Roser 2019
[52] Fleischatlas 2018

for animals was highest in China with 78.200 tons, followed by US with 9.476 tons, Brazil with 6448 tons and India with 2.633 tons. The treated animals are pigs (50%), chicken (29%), cattle (17%) and sheep (4%)[53].

Another issue are livestock emissions from slurry, manure, and digestion like carbon dioxide (CO_2) and methane. Globally, 51 Gigatons of carbon dioxide (CO_2) equivalent were produced, 14% came from the meat and milk industry[54].

For these reasons, there are initiatives to reduce or to replace meat consumption, in particular meat from cell cultures. Here, muscle stem cells are grown in calve serum to meat. However, this is still challenging as large-scale bioreactors may be more energy intensive as expected[55]. Also, the texture (fibers) and the smelling are obstacles for consumption. The technology makes progress, the production costs for a hamburger fell from 250,000 Dollar in 2013 to 90 Dollar in 2020[56].

Vegan products are increasingly offered as so-called mock food, e.g., soya milk, pea meat, wheat sausage, soya sausage and coconut cheese. In 2018, the revenue in Germany was 140 million Euros[57].

Food replacements were already invented since 1850ies, after it was shown by the Chemist Justus Liebig that all food finally consists of carbon hydrates, lipid, and proteins (with small portions of electrolytes and vitamins) which opened the way to agro- and food chemistry and industrialization. In 1919, 800 meat replacements existed and many more food and meat replacements were created in the 20th century, but in the long run people returned to the original[58].

An environmentally friendly and protein-rich food alternative are insects. The use of insects as food is strongly influenced by culture and traditions and in regions without this tradition, there are often acceptance problems. In 2018, 2111 edible species were known, including 659 species of beetles, 362 caterpillar species, 321 ant/bee/wasp species, 278 grasshopper species and 237 bug species[59].

Milk and eggs are derived products from livestock farming. World milk production was growing to 887 million tons in 2020 with India and United States while global hen eggs production reached 87 million tons with China as the leading producer[60].

3.2.2 Fishery

In the past 50 years, fish production has increased by almost 4 times. Initially, this was almost completely done by wild fish catch, but now aquacultures are dominating. In 2015, aquacultures produced more than 100 million tons of fish which is 50 times more than in 1960ies, while wild fish catch is stagnating since the 1990ies around 90 million tons per year.[61] China has increased it seafood production from a few million tons in 1960 to over 60 million tons in 2020 and is the market leader followed by Indonesia, India, Vietnam, and United States.[62]

[53] Fleischatlas 2018
[54] Fleischatlas 2018
[55] Kabiskch 2017
[56] Emzin 2020
[57] Herden 2020
[58] Herden 2020
[59] Fleischatlas 2018
[60] FAO 2022b
[61] Ritchie/Roser 2021
[62] Ritchie/Roser 2021

Seafood is only a minor source of protein intake. In 2020, the global per capita protein intake came mostly from plants and meats. The total protein intake was 117 g per capita in the United States and 58g in Nigeria only[63].

In the last decade, approximately one-third of fish populations were overfished. While tuna, shrimps, cod, and perch populations are not yet critical, mackerel and shark populations are in a critical condition[64].

3.3 Smart Farming

The digitalization of agriculture is in progress, a concept known as *smart farming, precision farming* or *Agriculture 4.0*.

The technical basis for smart faming is the *Internet of Things (IoT)*, as it connects sensor devices processing units, analyzes data and supports decision-making in real-time. Further elements are drones and robots which are controlled or supported by *Artificial Intelligence (AI)*. Smart farming can support or conduct monitoring of temperature, air, water, soil, humidity, leaf color and animals, growth stage monitoring, harvesting, seedling, disease and weed detection, irrigation, spraying of agricultural pests and IT applications for livestock. This leads e.g., to a precise and reduced use of irrigation and pesticides and an effective use of agricultural machines[65].

Obstacles for smart farming is the need for high investments, technical uncertainty, and organizational changes of traditional farming. In developing countries, the coverage with broadband data connections and 5G networks is still low[66].

4 Food Market

4.1 Trade Data

The nominal value of global agricultural exports in 2020 was 1,492 billion Dollar which was 3.7 times higher than in 2000, with 22% for fruit and vegetables, 16% for cereals and preparations and 12% for meat and meat preparations[67].

The global export value of cereals increased between 2000 and 2020 from 34 to 119 billion Dollar, with around 90% market share for the three crops wheat (38%), maize/corn (31%) and rice (22%). The export value of meat and meat preparations exports increased from 43 billion Dollar in 2000 to 155 billion Dollar in 2020 with bovine meat (37%), pig meat (35%) and poultry (22%)[68].

The United States of America was the largest exporter of food (excluding fish) in 2020 with 124 billion Dollar, followed by the Netherlands with 79 billion Dollar and Brazil with 73 billion Dollar. Asia was the largest net importer with a 214 billion Dollar trade deficit in 2020 (intra-regional trade excluded). Europe was a net importer of food for many decades, but became a net exporter since 2013. While in 1955, Europe imported more than 45% of global foods and Asia around 15%, this changed in 2010 to around 17% for Europe and 42% for Asia, i.e., they changed roles[69].

[63] Ritchie/Roser 2021
[64] Ritchie/Roser 2021
[65] Roland Berger Focus 2019, Said Mohamed/Belal/Kotb Abd-Elmabod et al. 2021
[66] Roland Berger Focus 2019, Said Mohamed/Belal/Kotb Abd-Elmabod et al. 2021
[67] FAO 2022a. In this paper, 'Dollar' always refers to the US-Dollar
[68] FAO 2022a
[69] Daviron/Doulliet 2014

Europe's change has much to do with the *Common Agricultural Policy (CAP)* of the EU, with 408 billion Euros the largest EU budget (36% of total budget)[70] which promotes food production and trade.

While Africa's imports and exports were balanced until the mid 1970ies, the gap between imports and exports is widening. In 2007, the exports reached more than 15 billion Euro, but the imports around 40 billion Euro. Africa is mainly exporting raw food products, while Europe is mainly exporting processed food products.

An UNCTAD analysis revealed the lowest agriculture productivity per worker rates in Africa based on traditional production methods[71]. The *Comprehensive Africa Agriculture Development Program (CAADP)* from 2003 was re-enforced by the 2014 *Malabo Declaration* where states had to commit at least 10% of their annual public budget to agriculture and rural development and to achieve agricultural growth rates of at least 6% per year to meet the targets of the *African Union's Agenda 2063* and of the *Sustainable Development Goals*. In 2020, only Lesotho, Malawi, Ethiopia, and Benin spent 10% or more for agriculture and only eight countries met the 6% target. A new measure to promote trade and food security is the *African Continental Free Trade Area (AfCFTA)*[72].

Europe (the EU) supports the agricultural sectors in Africa with various strategies. The least developed countries are allowed to export everything except arms without duties or quotas while other countries have trade agreements with certain conditions. They need to show that their product is not coming from third countries (i.e., not imported from elsewhere to reduce custom fees), this is the "*country of origin*" rule[73]. Sometimes, trade can be counterproductive. The export of poultry wings and legs as cheap by-product from Europe to Africa has substantially damaged the domestic industry, e.g., in Ghana.

The United States support Africa's market with similar agreements, but currently, *non-tariff measures (NTMs)*, i.e., legal measures such as *sanitary and phytosanitary measures (SPS)*, *technical barriers to trade (TBT)* and customs procedures are an issue for both EU and US[74]. The US Market has food safety access conditions against infections with various flies and viruses etc., while main EU reasons for food import rejection from Africa were mycotoxins (34.1%), pathogenic microorganisms (10.0%) and pesticide residues (9.2%)[75].

4.2 Private Companies

The food production, processing and trade is increasingly dominated by a few multinational companies.

- Four companies have around 41% global market share for agricultural machines, these are *Jon Deere* in US with 31.3 billion Euro, *CNH Industrial* in the Netherlands with 22.9 billion Euro, *Kubota* in Japan with 15.5 billion Euro and AGCO in US with 7.9 billion Euro revenue in 2020[76]. The next largest companies are *Claas* in Germany and *Mahindra* in India[77].
- Four companies have around 60% global market share for seeds, these are *Bayer* (which bought the previous market heavyweight *Monsanto*), *Syngenta, Corteva* and BASF, i.e., the same companies that dominate the pesticide production[78].

[70] Kornher/von Braun 2020
[71] Akiwumi 2022
[72] Akiwumi 2022
[73] Kornher/von Braun 2020
[74] Kareem 2019
[75] Kareem 2019
[76] Pestizidatlas 2022
[77] Konzernatlas 2017
[78] Pestizidatlas 2022

- Four of the five leading fertilizer companies are US-based (*Agrium, Potash, Mosaic, CF Industries*), one is in Norway (*Yara*).
- Four companies have around 70% global market share for pesticides, these are *Bayer (Germany)* with 18.8 billion Euro, *Syngenta (Switzerland)* with 9.9 billion Euro, *Corteva (former DowDuPont; US)* with 5.7 billion Euro and *BASF (Germany)* with 5.5 billion Euro revenue in 2020[79].
- The so-called ABCD group (*Archer Daniels Midland, Bunge, Cargill* from US, and *Louis Dreyfus* from the Netherlands), control 70% of the agricultural trade; meanwhile *Cofco* from China is the fifth global player[80].
- The market for processed food is increasingly concentrated and 50 companies have together around 50% global market share, the largest companies are *Nestlé (Switzerland), JBS (Brazil, meat producer), Tyson Foods, Mars, Mondelez and Kraft Heinz* in US, *Unilever* as Anglo-Dutch company, and *Danone* in France[81].
- On the supermarket level, *Walmart* from US with 6.1% global market share is the largest company; in Europe 10 groups controlled already in 2011 almost 50% of the EU market. Largest global companies are *Walmart, Costco, Kroger* in US, then *Schwarz/Lidl, Tesco, Carrefour, Aldi,* and *Metro*[82].
- Food is also a good traded at Future Exchanges. The trade of corn in 2015 at the *Chicago Board of Trade* (one of several specialized future exchange trading places for food) had a trade volume of 10.5 billion tons while the real global production volume was only 986 million tons[83].

5 Climate Change and Water Scarcity

The most critical risk factors for food security are climate change with soil loss and water scarcity.

5.1 Effects of Climate Change on Food and Water Security

The key element of climate change is global warming. According to the *Intergovernmental Panel on Climate Change (IPCC)* data from 2021, each of the last four decades has been successively warmer than any decade that preceded it since global surface temperature was 1.09°C higher in 2011–2020 than in 1850–1900, with 1.59°C on land and 0.88°C on the ocean. Globally averaged precipitation over land has likely increased since 1950, there is a significant global retreat of glaciers since the 1990s, a decrease of snow cover, a retreat of permafrost, a decrease in Arctic ice and a warming of the global upper ocean (0 to 700 m) since the 1970s. The climate models indicate that without human influence there would be no global warming since the 1950ies. In 2019, atmospheric CO_2 concentrations were higher than at any time in at least 2 million years (high confidence)[84].

Agriculture accounts for some 13.5% of total anthropogenic greenhouse gas emissions, through production of fertilizers (3% of global energy), methane emitted in rice production and livestock digestion (47% of global anthropogenic emissions) and 58% of global nitrous oxide emissions[85].

For food security, this means higher temperatures, water scarcity, extreme weather with storms and events like meteorological droughts (less rainfall) and agricultural droughts (less soil

[79] Pestizidatlas 2022
[80] Konzernatlas 2017
[81] Nash 2010, Konzernatlas 2017
[82] Konzernatlas 2017
[83] Konzernatlas 2017
[84] IPCC 2021
[85] Naheed 2023, UN 2019

moisture) and floods with continued soil loss due to wind and water erosion[86]. Climate change affects freshwater by altering streamflow and water quality by increased temperature, increases in sediment, nutrient and pollutant loadings due to heavy rainfall.

Flood hazards are projected to increase in parts of South Asia, South-East Asia, North-East Asia, tropical Africa, and South America. In 2015, the *Third United Nations World Conference on Disaster Risk Reduction* in Sendai, Japan adopted the *Sendai Framework for Disaster Risk Reduction 2015–2030*[87].

The practice of *no-tillage*, i.e., leaving residue of the previous season's crops on farmland, can increase water infiltration while reducing evaporation as well as wind and water erosion[88].

5.2 Overuse of Water

Water is vital for all agricultural activities and while food production could be increased, the availability of water is expected to decline. Already in 2010, 1.4 billion people lived in areas with sinking ground water levels[89]. An estimated 3.6 billion people live in areas that are potentially water scarce at least one month per year. According to *The United Nations World Water Development Report,* water scarcity may affect 4.8–5.7 billion people by 2050[90]. Water waste and low water prices are drivers of water shortage and mismanagement. The true costs of water use and food production are therefore underestimated, the same is true for industry: Water pollution from the energy sector sometimes makes water unusable for agriculture, fishing, and human consumption, unless intensely cleaned [91].

Agriculture is the biggest user of water on the globe. From 1950 to 2000, the world water use tripled, with 71% of this used for irrigation[92]. In 2017, agriculture used 2.417 km³, industry 833 km³ and households 357 km³[93].

The expansion of irrigated agriculture into semi-arid areas with limited precipitation and surface water and the increasing number of people in mega-cities has greatly increased groundwater use and withdrawal[94]. Increasing water scarcity and salinization of soils is found in many areas of heavy irrigation[95]. Several of the top 10 food exporters are water-scarce regions. An important aspect is so-called *Virtual Water*, the water for the development or production of a commodity[96]. Food exporters export their virtual water with the food while importers can mitigate their own water shortage, in particular the MENA region[97].

Dams with reservoirs can promote the evaporation of water, can withhold nutrition rich sediments from the downstream areas[98].

In addition, non-renewable groundwater resources like aquifers are overused and depleted[99]. The groundwater levels are falling in many countries (including Northern China, the US, and India) due to widespread over-pumping with powerful diesel and electric pumps[100]. Aquifers

[86] Naheed 2023
[87] UN 2019
[88] UNCCD 2009
[89] Nash 2010
[90] UN 2019
[91] ICA 2015
[92] FAO 2008, ICA 2015, Nash 2010
[93] Konzernatlas 2017
[94] Bierkens/Wada 2019
[95] UNCTAD 2017
[96] ICA2015
[97] Woertz 2022
[98] ICA 2015
[99] Bierkens/Wada 2019
[100] Naheed 2023

contain almost 96% of the global freshwater, but 21 of the 37 major aquifers have declined at an unsustainable rate, which is a particular threat for Northern Africa and the Gulf Peninsula[101].

Desalination is now the sole long-term reliable and sustainable source of fresh water for the desert Arabian Gulf Region which is steadily expanding to cover the needs of the growing economies and other activities like tourism. The most active countries are the United Arab Emirates (UAE) and Saudi-Arabia[102]. But the energy-intensive desalinization can increase local ocean salinity and is associated with die-offs of near-shore fisheries[103].

Another obstacle for desalinization, but also for water use in general is the growing occurrence of microplastic[104]. In the Alpes in 2019, about 150,000 microplastic particles were counted in one liter of snow water and even in Antarctica, 14,000 particles per liter[105].

The FAO recommends to manage farms and irrigation systems more effectively, to use non-conventional water resources (drainage water and use of lower quality water, e.g., treated wastewater and brackish water) and systematic water harvesting by collection of rain water[106].

6 Current Geopolitical Issues

6.1 Food Conflicts

6.1.1 Foreign Direct Investments

After the food price crisis from 2007/2008, food was recognized as strategic resource leading to land lease and buying, also known as *Foreign Direct Investments (FDIs)* or more critically as '*land grabbing*'.

In order to prevent bottlenecks in the long term, in the past decade China and South Africa have already bought large areas in the Congo, China in the Gambia and South Korea in Madagascar[107]. There are many more acquisitions planned or underway, e.g., in East Africa, in Europe especially in Ukraine and Russia, in Asia-Pacific in Indonesia and Papua New Guinea. Already in 2010, China has also acquired more land in the Philippines and Laos[108] while in Sudan, South Korea has made deals for 690,000 hectares and the United Arab Emirates (UAE) for 400,000 hectares[109].

Main investors come from Malaysia with 3.7 million hectares, US with 3.3 million hectares, United Kingdom with 1.8 million hectares, Singapore with 1.6 million hectares, Saudi-Arabia and The Netherlands with 1.4 million hectares each and India with 1.3 million hectares[110].

The largest target countries are Indonesia with 3.0 million hectares, Russia and Ukraine with 2.4 million hectares each, Papua New Guinea with 2.3 million hectares and Brazil with 2.0 million hectares. Large-scale land deals in Africa were estimated 22 million hectares from 2005 to 2017[111].

A new phenomenon is '*green grabbing*' which includes the production of biofuels and biomass energy through forestry and other activities that have an impact on land use[112].

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[101] ESG 2016
[102] Paleologos 2018
[103] ICA 2015
[104] Paleologos 2018
[105] Zinkant 2019
[106] FAO 2008
[107] Grill 2010, Gross 2009
[108] Wälterlin 2010
[109] Nash 2010
[110] Konzernatlas 2017
[111] Akiwumi 2022
[112] Zhou et al. 2020

6.1.2 The Black Sea Grain Initiative 2022-2023

On 24 Feb 2022, Russia started the attack on the Ukraine. As Russia was able to get large parts of the Black Sea coast under military control, the ability of Ukraine to export food was reduced. Due to the wartime conditions and the fact that the exit of the Black Sea is controlled by Türkiye, there was the risk that neither Russia nor Ukraine would be able to export food anymore via shipping. In theory, both countries could export food via land, but at higher costs.

The United Nations urgently demanded an agreement that would allow food export even during the war without attacks from either side, for the following reasons:

The Russian Federation and Ukraine are among the most important producers of agricultural commodities in the world, e.g., for barley, wheat, and maize (corn), but also for sunflower oil. *Many Least Developed Countries (LDC)* and *Low-Income Food-Deficit Countries (LIFDCs)* would be heavily affected by an export stop, e.g., Eritrea sourced 100% of its wheat imports in 2021 from both the Russian Federation (53%) and Ukraine (47%)[113].

About half of the Arab world's wheat imports come from Ukraine and Russia, e.g., Saudi Arabia is the world's second largest importer of barley, to use it to feed sheep and other animals[114].

More than 30 net importers in North Africa and Western and Central Asia of wheat are dependent on the two countries for over 30% of their wheat import needs. Twelve countries are even more than 70% dependent: Pakistan, Eritrea, Armenia, Mongolia, Azerbaijan, Georgia, Somalia, Belarus, Türkiye, Madagascar, Lebanon, and Egypt[115].

The *Initiative on the Safe Transportation of Grain and Foodstuffs* from Ukrainian ports, also called the *Black Sea Grain Initiative*, is an agreement between Russia and Ukraine signed in Istanbul on 22 July 2022, with a joint coordination and inspection center in Türkiye and the UN as secretariat. The deal was extended in November 2022, March 2023 and in May 2023. After several extensions, the grain deal brokered by Türkiye was interrupted on 17 July 2023[116], as Russia's demand for lifting certain sanctions of the Western states was not fulfilled. This ongoing conflict demonstrates the vulnerability of global food supply chains and the possibility to weaponize food.

6.2 Water Conflicts

In dry regions, water for agriculture is typically provided by irrigation systems, and there are strict access and use rules for the rural communities. Since decades, it is discussed whether water could lead to resource wars, but until today, no 'water war' took place. However, two international conflicts are currently ongoing in East Africa and between China and India.

6.2.1 The Grand Ethiopian Renaissance Dam GERD

Egypt and East Africa rely heavily on the river Nile. In the Nile region, increasing salinization of the Nile Delta may result from by rising sea levels, in addition to rapid population growth. Egypt and Ethiopia as main users will each have more than 100 million inhabitants by 2030. Ethiopia has now built the *Grand Ethiopian Renaissance Dam GERD* which is used for energy production, but it also able to control the availability of Nile water for Egypt and Sudan, because 85% of the Nile water come from the Blue Nile arm that has its origins in Ethiopia and only 15% from the White Nile in East Africa.

Egypt refers to two treaties from 1902 and 1929 which state that dams could not be built without Egypt's approval and on a treaty between Egypt and Sudan on Nile water sharing from 1959.

[113] FAO 2022c
[114] Woertz 2022
[115] FAO 2022c
[116] Mihm 2023

These treaties were not accepted by the other Nile states and in 1999 the *World Bank* and the *United Nations Development Program* started the *Nile Basin Initiative (NBI)* in 1999 which failed[117]. In 2010, all Nile states except Egypt and Sudan agreed on a Framework Agreement, these were Ethiopia, Ruanda, Tanzania, Uganda, and Burundi. Ethiopia is now filling the dam with Nile water and Egypt has threatened to use military actions (bombing) if this brings Egypt's water supply into danger.

6.2.2 The India-China Transboundary Water Dispute

China is one of the countries with the largest number of transboundary rivers in the world which mostly originate in Tibet. Areas of concern are the Brahmaputra River, water-sharing over the Indus River and the Ganga-Brahmaputra-Meghna River Basin. In 2018, the water discharge by China in the Brahmaputra River basin was the highest over the last 50 years and caused concerns in India's regions of Arunachal Pradesh and Upper Assam[118].

In November 2020, China announced plans for a hydropower mega-dam just before the Brahmaputra enters India, which could bring Northern India's water supply into trouble and resulted in strong responses from the Indian side[119]. This overlapped with territorial disputes in the region, China calls the Indian state of Arunachal Pradesh now '*Southern Tibet*' (which means that this should be part of China as Tibet is a part of China)[120]. In December 2022, this escalated to the *Tawang Clash*, but now both sides try to solve their dispute by diplomacy[121].

7 Discussion and Conclusion

The paper analyzed the food security with its four dimensions physical availability, economic and physical access, food use/utilization and stability, the economy and ecology of food production (plants, meat, fish), the risk factors for food security and the geopolitical activities.

Various actors are concerned that the population growth could de-stabilize states (e.g., in the *Youth bulge* theory[122]), could lead to food and water shortages (e.g., the theory of *Malthus*) or damage environment (*Neo-Malthusianism*)[123]. Meanwhile, the debate has shifted from population growth to the *ecological footprint*, because not only the population, but also the individual wealth and consumption is growing rapidly[124]. However, the food production could be successfully increased to compensate population growth.

The food production increased almost 2.2 times in the past 50 years and was able to compensate the population growth, but the *UN Food and Agriculture Organization (FAO)* estimates that the food production must increase from 2015 to 2050 by 60%, as the growth of consumption of animal products will increase the need of animal food, such as soy beans and corn. The growth of production was achieved by a combination of increased irrigation, fertilizers, pesticides (herbicides/insecticides), genetically modified organisms (GMOs) to protect plants from harmful insects and pesticides and a general trend to larger farms and monocultures, i.e., rationalization and modernization. Common problems are nitrate overload, pesticide contamination, reduction of insects, pollination and birds, the loss of biodiversity and land loss and degradation. Smart or precision farming based on the Internet of Things, 5G networks, drones and Artificial Intelligence may lead to a more effective and ecologic resource use.

[117] WD 2020
[118] Basumatary et al. 2018
[119] Ho 2021
[120] Adlakha 2022, Lhamo 2023
[121] Adlakha 2022, Lhamo 2023
[122] Weisflog 2017
[123] For a full overview and details, refer to Merchant 2022
[124] Diamond 2005

Over the past 50 years, meat production has more than tripled and it is expected that the meat consumption will increase from 2006 to 2050 from 77 to 95.7 kg per capita and year for the industrial states and from 31 to 44 kg for the developing countries. Meat production requires much land for pastures and animal feed production. Meat replacements and alternatives like mock food, meat from cell cultures and insects have a small, but growing market. Another issue are livestock emissions like carbon dioxide (CO_2) and methane. In 2015, aquacultures produced more than 100 million tons of fish while wild fish catch is stagnating since the 1990ies around 90 million tons per year. Approximately one-third of the fish resources are overfished and some species are in a critical condition.

The United States of America were the largest exporter of food (excluding fish) in 2020 while Asia is the largest net importer. Europe was a net importer of food for many decades, but became a net exporter since 2013. While Africa's imports and exports were balanced until the mid 1970ies, the gap between imports and exports is widening. The global food market is increasingly dominated by a few multinational companies from seeds to supermarkets.

The most critical risk factors for food security are climate change with soil loss and water scarcity due to higher temperatures, extreme weather with storms and events like meteorological droughts (less rainfall) and agricultural droughts (less soil moisture) and floods with continued soil loss due to wind and water erosion. Water waste and low water prices are drivers of water scarcity, e.g., by overuse of groundwater resources like aquifers. A new threat to freshwater is the global contamination with microplastic.

After the food price crisis from 2007/2008, food was recognized as strategic resource leading to land lease and buying, also known as *Foreign Direct Investments (FDIs)* or more critically as '*land grabbing*' to prevent bottlenecks in the long term.

The Initiative on the *Safe Transportation of Grain and Foodstuffs* from Ukrainian ports, also called the *Black Sea Grain Initiative* demonstrates the vulnerability of global food supply chains and the possibility to weaponize food. Two larger international water conflicts are currently ongoing in East Africa around the Nile with the *Grand Ethiopian Renaissance Dam GERD* and the *India-China Transboundary Water Dispute*.

Looking forward, a new research area is emerging, agriculture in space: China landed the *Chang'e-4 Moon Rover* on the far side of the moon in 2019 and included a growth experiment on the moon with a small lunar biosphere in a box (air, water, and soil): a cotton plant managed to grow under these conditions while certain other plants failed to grow[125]. A particular problem is the lunar microgravity.

If natural agriculture does not work, the only chance for human mankind to expand would be a completely *synthetic food production* of amino acids, lipid molecules and sugars (carbon hydrates) as basic elements of food. In turn, a success in this area could mitigate many problems of food production on Earth as well. But an analysis of enzymatic and chemical peptide synthesis (peptides are short amino acid chains while proteins are long ones) has shown that this cannot be done now with acceptable economic and ecologic costs, i.e., this research is in a very early stage[126].

In summary, the food, meat, and fish production could be successfully increased to compensate the population growth and the increasing meat consumption, but hunger and undernourishment still exist. Main risk factors for future food security are climate change, land loss and water scarcity. In response, food is seen as strategic resource resulting in geopolitical activities and food and water conflicts.

[125] Devlin 2019
[126] Guzmán/Barberis/Illane 2007

8 Literature

Adlakha, H. (2022): The Tawang Clash: The view from China. The Diplomat 17 December 2022

Agrar-Atlas (2019): Daten und Fakten zur EU-Landwirtschaft 2019. Heinrich Böll Stiftung/BUND/Le Monde Diplomatique

Akiwumi, P. (2022): Revitalizing African agriculture: Time for bold action. 30 September 2022. Director for Africa and Least Developed Countries, UNCTAD https://unctad.org/news/blog-revitalizing-african-agriculture-time-bold-action

Alcázar, J. (2011): Biodiversity and Security. Chapter Four. Spanish Institute for Strategic Studies IEEE. Workgroup number 06/2011 Food Security and Global Security

Basumatary, J. et al. (2020): C3S Issue Brief: 004/2020. Geopolitics of Water and Security Implications: Understanding of India-China Transboundary Water Dispute Research Intern Chennai Centre for China Studies

Bierkens, M.F.P., Wada, Y. (2019): Non-renewable groundwater use and groundwater depletion: a review. Environ. Res. Lett. 14 (2019) 063002 https://doi.org/10.1088/1748-9326/ab1a5

Daviron, B., Doulliet, M. (2014): Major Players of the International Food Trade and the World Food Security. Colloque SFER 2014 « Agriculture et géopolitique »

Denning, G., Fanzo, J. (2022): Ten Forces Shaping the Global Food System Chapter 1.1 http://karger.com/books/book/chapter-pdf/3673467/000452372.pdf

DeStatis (2022): Global animal farming, meant production and meat consumption. 2022 Edition

Devlin, H. (2019): Battlefield Moon: how China plans to win the lunar space race. The Guardian Jan 2019

Diamond, J. (2005): Kollaps. Warum Gesellschaften überleben oder untergehen. ISBN: 9783100139047

EC-FAO (2008): Food Security Information for Action Practical Guides - An Introduction to the Basic Concepts of Food Security EC - FAO Food Security Program 2008

Echarren, P.Y. (2011): Hunger and Conflict. Chapter Six. Spanish Institute for Strategic Studies IEEE. Workgroup number 06/2011 Food Security and Global Security

Emzin, M.A. (2020): Pflanzenproteine für Fleischfreunde. Spektrum der Wissenschaft July 2020

ESG (2016): CEO Briefing: Global Depletion of Aquifers. Global companies must take an active role in groundwater governance to avoid existential risks. The Earth Security Group.

FAO (2008): Water and Food Security. EC - FAO Food Security Program 2008

FAO et al. (2022): FAO, IFAD, UNICEF, WFP and WHO. 2022. The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable. Rome, FAO. https://doi.org/10.4060/cc0639en

FAO (2022a): Trade of agricultural commodities 2000–2020. FAOSTAT Analytical Brief 44

FAO (2022b): Agricultural production statistics. 2000–2020. FAOSTAT Analytical Brief Series No. 41

FAO (2022c): The importance of Ukraine and the Russian Federation for global agricultural markets and the risks associated with the war in Ukraine. 10 June 2022 Update

Fleischatlas (2018): Daten und Fakten zu Tieren als Nahrungsmittel. 2018 Heinrich Böll Stiftung/BUND/Le Monde Diplomatique

Geopolitical Futures (2022): Global Food Insecurity- September 30, 2022

Grill, B. (2010): Überall in Afrika. Die Zeit No. 7/2010, p.22

Gross, J. (2009): Das kaufen wir euch ab. Frankfurter Allgemeine Sonntagszeitung, p.53

Guzmán, F., Barberis, S., Illane, A. (2007): Peptide synthesis: Chemical or enzymatic. April 2007Electronic Journal of Biotechnology 10(2) DOI:10.2225/vol10-issue2-fulltext-13

Hafner, M, Tagliapietra, S. (2020): The Geopolitics of the Global Energy Transition. Lecture Notes in Energy 73 Springer https://doi.org/10.1007/978-3-030-39066-2

Herden, B. (2020): Was ist das? Welt am Sonntag, 09 Feb 2020, p.52-53

Ho, S. (2021): The China–India Water Dispute. The Potential for Escalation. Indo-Pacific Perspective No. 27, 2021

ICA (2015): Intelligence Community Assessment Global Food Security ICA 2015-04 | 22 September 2015

Insektenatlas (2020): Daten und Fakten über Nütz- und Schädlinge in der Landwirtschaft 2020 Heinrich Böll Stiftung/BUND/Le Monde Diplomatique

IPCC (2021): Climate Change 2021 The Physical Science Basis Summary for Policymakers. Working Group I - Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

Kabisch, J. (2017): Fleisch aus der Retorte. Le Monde Diplomatique December 2017, p.23

Kareem, O. I. (2019): Border Measures and Africa's Agri-Food Trade: Export Markets Comparative Analysis. Trade and Development Policy Research Network WTO Agricultural Symposium June 2019

Kornher, L.; von Braun, J. (2020): EU common agricultural policy: Impacts on trade with Africa and African agricultural development, ZEF Discussion Papers on Development Policy, No. 294, University of Bonn, Center for Development Research (ZEF), Bonn

Konzernatlas (2017): Daten und Fakten über die Agrar- und Lebensmittelindustrie 2017 Heinrich Böll Stiftung/Rosa Luxemburg Stiftung/BUND/Oxfam/Germanwatch/Le Monde Diplomatique

Lhamo, A. (2023): China's Increased Attention to Tibet's Borders with India. The Diplomat 04 March 2023

McKeon, N. (2011): Global Governance for World Food Security: A Scorecard Four Years After the Eruption of the "Food Crisis" Heinrich-Böll-Stiftung Berlin, Oktober 2011

Meeresatlas (2017): Daten und Fakten über unseren Umgang mit den Ozeanen 2017 Heinrich Böll Stiftung/BUND/Kieler Exzellenzcluster Ozean der Zukunft/Le Monde Diplomatique

Merchant, E.K. (2022): Environmental Malthusianism and demography. Social Studies of Science 2022, Vol. 52(4) 536–560

Mihm, A. (2023): Putin stoppt Getreidehandel. Frankfurter Allgemeine Zeitung, 17 Jul 2023, p.17

Naheed S. (2023): An overview of the influence of climate change on food security and human health. Arch Food Nutr Sci. 2023; 7: 001-011

Nash, S. (2010): The Geopolitics of Food Geofile 628, September 2010, 3 pages

National Intelligence Estimate (2021): Climate Change and International Responses Increasing Challenges to US National Security Through 2040. Director of National Intelligence-National Intelligence Council DNI NIC-NIE-2021-10030-A

Pestizidatlas (2022): Daten und Fakten zu Giften in der Landwirtschaft. Heinrich Böll Stiftung/BUND/PAN Germany/Le Monde Diplomatique

Rey, J.M.M. (2011): Biofuels and Food Security. Chapter Seven. Spanish Institute for Strategic Studies IEEE. Workgroup number 06/2011 Food Security and Global Security

Ritchie, H., Rosado, P. and Roser, M. (2019): Meat and Dairy Production. OurWorldinData.org 2019

Ritchie, H. and Roser, M. (2021): Fish and Overfishing. OurWorldinData.org 2019

Roland Berger Focus (2019): Farming 4.0: How precision agriculture might save the world. October 2019

Said Mohamed, E., Belal, A.A., Kotb Abd-Elmabod, S. et al. (2021): Smart farming for improving agricultural management. Egypt. J. Remote Sensing Space Sci. 24 (2021) 971–981

Sommers, P., White, A. (2022): Food security and nutrition as keys to human development Hearing Requested by the DEVE committee European Parliament coordinator: Policy Department for External Relations Directorate General for External Policies of the Union PE 702.566 – July 2022

UN (2015): Transforming our world: the 2030 Agenda for Sustainable Development (A/RES/70/1). In: United Nations General Assembly. New York

UN (2019): Climate Change and Water. UN-Water Policy Brief. Version September 2019 UN-Water Expert Group on Water and Climate Change

UNCCD (2009): Water scarcity and desertification. Thematic fact sheet series No. 2 UN Convention to combat desertification 2009

UNCTAD (2017): The Role Of Science, Technology And Innovation In Ensuring Food Security By 2030 United Nations Conference on Trade and Development (UNCTAD) UNCTAD/DTL/STICT/2017/5

Weisflog, C. (2017): Die Gefahr der frustrierten Jugend. Neue Zürcher Zeitung 26 Oct 2017, p.17

Wälterlin, U. (2010): Australien: Chinesen kaufen Farmen auf. Handelsblatt 18 Aug 2010, p.17

WD (2020): Wissenschaftliche Dienste des Bundestags. Sachstand. Der Grand Ethiopian Renaissance Dam – Wasserpolitik der Anrainerstaaten des Nils 2020 Deutscher Bundestag WD 2 - 3000 - 015/20

Weijering, A., Dalhuisen, J. (2013): The Emerging Geopolitics of Food. The Hague Centre for Strategic Studies (HCSS) Rapport No 19 | 02 | 13 ISBN/EAN: 978-94-91040-76-4. A report commissioned by Dutch Ministry of Economic Affairs

Woertz, E. (2022). Virtual water, international relations and the new geopolitics of food. Water International, 47(7), 1108-1117. https://doi.org/10.1080/02508060.2022.2134516

Zapf, M. (2009): Brot für den Rest der Welt. Financial Times Deutschland 14 May 2009, p.13

Zhou, J. et al. (2020): The Geopolitics of Food Security: Barriers to the sustainable development Goal of Zero Hunger. SIPRI Insights on Peace and Security No. 2020/11 November 2020

Zinkant, K. (2019): Leise rieselt das Plastik. Süddeutsche Zeitung No. 188, 16 Aug 2019