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THE CALM BEFORE THE STORM

The consequences of climate change for the agricultural economy and consumers with examples of selected products and their main growing countries

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The Calm before the Storm

The consequences of climate change for the agricultural economy and consumers with examples of selected products and their main growing countries

When we hear the catchword climate change we usually think of extreme weather events, hurricanes and islands threatened by rising sea levels in distant parts of the world. But few realise that climate change is already having an effect on our daily lives as well.

The major change to temperature and precipitation patterns affects the growing areas for agricultural commodities, amongst other things, where extreme weather events take their toll on people, flora, fauna and infrastructure. Climate change also causes crop failures, sometimes with devastating results for the local population. In some cases crop losses are so severe that even the importing countries feel the consequences.

In this collection of case studies WWF investigates some particularly beloved luxury foods (coffee, bananas, oranges and hazelnuts) and asks what changes these will be subjected to in the crops' main growing countries due to advancing climate change. The countries of origin are among the most important growing regions on a global scale, supplying 40–70 % of the present-day demand. The changes caused by the changing climate will therefore make themselves increasingly felt on the world market in future.

The starting point for this study is the supply risk analysis tool,¹ which WWF uses to analyse the environmental, social and economic risks and opportunities associated with agricultural commodity production and procurement. Each agricultural commodity is viewed in terms of the risks affecting production of the raw materials. These risk assessments were used to provide information for this report on the climate-related extreme weather events which have affected the specified agricultural commodities and regions in the past and how these events are expected to intensify in future.

Visible signs of climate change: droughts. Farming, cities and ecosystems compete for diminishing water supplies.



**Climate change
will affect the
availability, quality
and price of food-
stuffs much more
than in the past.**

In order to make more precise evaluations of future changes in climatic and meteorological conditions for agriculture and to illustrate these more clearly, WWF Germany combined the global production areas for agricultural commodities with the projections from the most recent assessment report by the Intergovernmental Panel on Climate Change (IPCC)² to produce climate risk maps. These maps make use of the results from the climate models for the development of temperature and precipitation conditions which have been incorporated in the Assessment Reports – using the data for the most extreme scenario. This describes the developments which we will face by the end of the century if we do not succeed in reducing global greenhouse gas emissions within the next few decades. In this case, the global temperature would rise by around 3–5 °C in comparison with the pre-industrial level. Examples of these climate risk maps are given in this collection of case studies for the selected agricultural commodities and their main growing countries.

These changes could bring about huge economic problems in producer countries such as Brazil, Colombia and Turkey. But consumers of these popular foodstuffs will also be affected by these developments. In future climate change will have an increasing impact on the availability, quality and price of food – and as a result on our daily lives.

The key results of the analysis can be summarised as follows:

Changes in weather conditions and extreme weather events such as heatwaves, droughts and floods are already causing losses in yield of many agricultural commodities. The negative effects of climate change will increase further in future, depending on the degree of global warming and the capacity to adapt to this. Some regions and species of plants will actually be able to benefit from climate change, but for other agricultural commodities such as wheat and maize it appears that climate change has already had a negative effect on crops in some growing regions and from a global perspective. This report investigates the luxury foods coffee, bananas, oranges and hazelnuts with the following results:

- » Half of the global cultivation of coffee takes place in Brazil and Vietnam where it is a mainstay of the economy. These regions have already experienced major crop losses in recent decades. It is calculated that 50 % of the areas in the world suitable for growing coffee will be lost by 2050.
- » In Ecuador, the world's largest exporter of bananas, their cultivation is at risk from droughts. Agriculture already uses over 80 % of the freshwater abstracted. In Colombia, the third largest banana exporting country, around 60 % of the area suitable for growing bananas could be unusable by 2060 due to climate change.
- » Around half of the orange juice consumed in the world comes from Brazil. The oranges used for this are grown primarily in the state of São Paulo. In recent years, farming there has moved further south due to changes in temperature and rainfall conditions.
- » Around 70 % of hazelnuts are grown in Turkey. After a particularly mild winter in Turkey, it took only one night of frost and hail to reduce the crop by half and to more than double the price on the world market.

There are major differences in the effects of climate change in the exporting and importing countries. In importing countries the availability, quality and price of foodstuffs will suffer increasingly from changes in the climate. But it is unlikely that this will endanger food security. For the population in many growing regions, however, the loss in earnings when crops fail often means that their livelihoods are at stake.

WWF supports the following key demands:

- » The international community must dramatically reduce global greenhouse gas emissions to keep temperature increases and the associated effects on the climate system as small as possible.
- » The affected growing countries need rapid and ongoing support in developing and implementing adaptation strategies in order to be able to deal with the results of climate change.
- » Companies should be obliged to check where they source their raw materials and whether they have been produced in a climate-friendly and socially and ecologically sustainable manner. Local adaptation and mitigation strategies have to be developed and implemented jointly.



COFFEE

Coffee is one of the most important global commodities. In 2013 coffee exporters had a global turnover of around 20 billion US Dollars. Over half the world's production of green coffee beans comes from Brazil and Vietnam. Coffee is extremely important for Brazil and Vietnam from an economic point of view. Exports of this luxury foodstuff amount to around a quarter of the total export volume for both countries³.

The Finns come top of the list of coffee drinkers: the annual per capita consumption there is around 12 kg of unroasted coffee beans. The EU average is around 5 kg. If we consider net imports, that is, total imports minus resales abroad, the USA is the largest importer of coffee in the world with 24 million sacks of coffee beans.⁴ EU countries together import 42 million sacks of unroasted coffee beans.⁵

Coffee bushes need a stable climate. Ideal temperatures lie between an average of 18 and 25 °C. The plants do not tolerate extreme temperatures above 30 °C, longer periods below 13 °C or frost. The plants are damaged by too much direct solar radiation and likewise by constant strong winds. Coffee plants are particularly sensitive to water shortage. They require watering if the amount of precipitation falls below 1,000 mm per year, and coffee growing is not worthwhile below 800 mm per year.

The Brazilian Agricultural Research Corporation is forecasting the largest crop losses of the last 50 years.

Droughts in recent decades in **Brazil** have reduced the coffee crop every 3–6 years. In 1999 a severe drought from August to November destroyed an estimated 40 % of the entire Brazilian coffee crop⁶. Between 2000 and 2007 floods and droughts as well as a hurricane for the first time led to the most serious damage ever reported from Brazil⁷. The World Meteorological Organisation (WMO) described the 2013 drought in Northeast Brazil as the worst in the last 50 years. An unusually prolonged drought in 2014 led to enormous price increases on the world market due to crop failures⁸. At the beginning of 2015, many of the country's reservoirs were so low that cities such as São Paulo and Rio de Janeiro had to introduce water rationing and at times even shut the water off. The Brazilian Agricultural Research Corporation is now forecasting the largest crop losses of the last 50 years, including for coffee⁹.



As the climate risk map in Figure 1 shows, the number of consecutive days without precipitation could increase by more than 10 days per year by the end of the century in almost all the coffee growing areas of Brazil if global greenhouse gas emissions are not drastically reduced. Rising temperatures and heatwaves will aid evaporation processes and result in more regional droughts during the increasing periods without precipitation¹⁰. Although less water in total will be available in many growing regions, extreme rainfall events could also lead to flooding. Pests such as the coffee leafminer (*Perileucoptera coffeella*) and the nematode (*Meloidogyne incognita*) are also likely to spread due to the changed temperature and humidity conditions¹¹.

In its 2009 country notification, the World Bank forecasts that suitable areas for coffee growing in Brazil could shrink overall by around 7 % by 2020 and by as much as 27 % by 2070. IPCC authors forecast that, in the states of Minas Gerais and São Paulo, where most of the coffee is grown, suitable areas could decline from 70–75 % to 20–25 %. It is probable that Brazilian coffee growing will shift even further southwards, where more moderate temperatures and the amount of available water provide better conditions.

Brazil's coffee farming, with its forest clearance to create growing areas and intensive use of fertilizers, also contributes to climate change and then suffers from the consequences.

It can be expected that Brazil will lose suitable areas for coffee growing due to climate change and will suffer increased crop losses due to weather extremes.

Brazil is one of the world's biggest emitters of greenhouse gases, with most of the country's CO_{2e} emissions being caused by changes in land use, agriculture and forestry¹². Coffee growing itself, involving forest clearance to create space for cultivation and intensive use of fertilisers, also contributes to climate change and then suffers from the consequences of this.

Vietnam, the second most important coffee growing region in the world, was one of the seven countries most seriously affected by extreme weather events between 1994 and 2013. In this period the Global Climate Risk Index recorded over 200 extreme weather events with almost 400 deaths and economic losses of 1% of the gross domestic product. According to the World Bank it is also one of the 5 countries which will be worst affected by climate change. Besides extreme weather events, Vietnam is threatened by rising sea levels. Around 5,500 ha of agricultural land could be lost by the end of the century due to flooding¹³.

Deforestation, land degradation, high-input monocultures and the overexploitation of ground water have led to high yields up to now, but also make the coffee plantations particularly susceptible to extreme weather events. An unusually severe period of drought in 2009/2010 also affected coffee production in the central highlands of Vietnam. In the western highlands in particular, changing rainfall patterns and dry periods are already reducing crop volumes and coffee quality.

The bulk of coffee grown in Vietnam is Robusta which withstands high temperatures better than Arabica. However, in this country the high yields from coffee to date have been dependent on the availability of groundwater for irrigation on account of the irregular distribution of rainfall through the year. The groundwater table could drop by up to 11 m below current levels by the end of the century. The climate risk maps for this region also show that the number of consecutive days without precipitation could rise by up to 10 days in the south and by up to 6 days in the north by the end of the century, thus exacerbating the water shortage. A study by the IPCC forecasts that, by 2080, Vietnam could forfeit 1.4 % of gross domestic product due to the reduction in agricultural productivity.

A 2014 study by the Humboldt University of Berlin predicts that half of the agricultural acreage suitable for coffee growing worldwide could be lost due to climate change by 2050¹⁴. Relocating to more suitable higher altitudes would only be possible through forest clearance which would release more CO₂.



BANANAS

Bananas can also be used as an example of how climate change will indirectly affect importing countries in future. In 2013 around 107 million tonnes of bananas were harvested worldwide¹⁵. No other fruit is grown in such large quantities. The principal producer countries in 2011 were India and China, however the top exporters of bananas are Ecuador (31 %), the Philippines (11 %), Colombia (10 %), Costa Rica (10 %) and Guatemala (8 %)¹⁶.

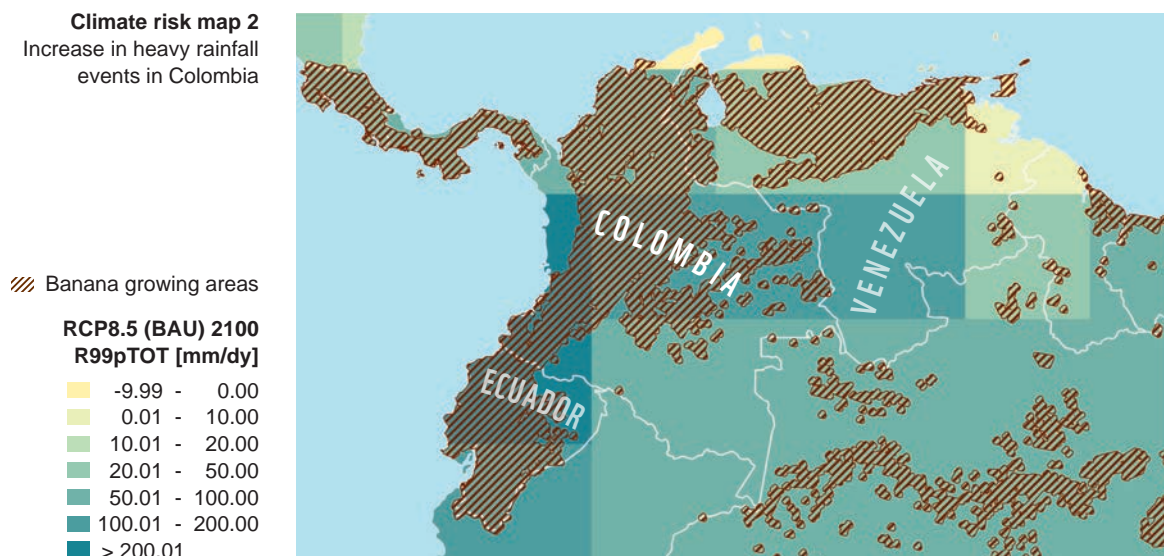
Bananas need a regular water supply and a freely drained soil which does not become waterlogged. Bananas flourish in temperatures between 15–38 °C. New leaves are produced at temperatures around 30 °C while the fruit itself ripens best around 20 °C. Banana plants are killed by frost, and temperatures above 38 °C stop growth and burn the leaves. They are very sensitive to wind. At 20–50 km/h the leaves tear and reduce productivity and at higher wind speeds the leaves and stems can break off completely¹⁹. Bananas are particularly prone to disease due to their very limited genetic diversity²⁰.

In 2011 in **Columbia**, floods resulting from the La Niña weather phenomenon led to the loss of 4,000 ha of banana plantations, causing the price of bananas to rise²¹. The following year a winter storm along with the spread of Moko bacteria caused a loss of 15 % of the crop²². As it was possible to destroy over 730 ha of the affected banana and plantain farms in time, the Moko attack was prevented from spreading to plantations producing for the export sector²³. However, there is no guarantee that the bacteria will not succeed in spreading to the export sector if flooding becomes more frequent. It would then cost around 300,000 US Dollars per hectare to wipe out the disease.²⁴

More frequent heavy rainfall events encourage the spread of plant diseases.



Warmer temperatures as well as storms and floods also favour the large-scale spread of Black Sigatoka²⁵. Of all the banana diseases in the world, this fungus causes the greatest economic damage and has already been estimated to have led to crop losses of up to 50 %²⁶. The large amounts of pesticide needed to control Sigatoka in Central America account for an average of around 30 % of production costs. This is unusually high compared to the cost of controlling other pests and diseases²⁷.



The climate risk map in Figure 2 – for the scenario in which there is no significant reduction in emissions – shows a clear increase in heavy rainfall by the end of the century i.e. in the risk of flooding and therefore the spread of pests and diseases for the banana growing regions in Colombia and Ecuador²⁸. A current study predicts that Colombia will lose around 60 % of land suitable for growing bananas due to climate change by 2060²⁹. In a few countries such as Mexico, some areas already used for agriculture will be more suitable for banana growing in future, so that the suitable acreage there will increase. However, overall it is expected that the areas in Central America and north-western South America which can be used for conventional banana growing will decline by around 20 % in the next few decades.

In **Ecuador**, in the period from 1997 to 2006, over 400,000 people were affected by floods which caused economic damage of 63 million US Dollars. In 2008 floods destroyed around 115,000 ha of agricultural land especially in coastal areas, including banana plantations. The agricultural sector suffered total losses of 161 million US Dollars as a result³⁰.

In 2008 floods destroyed around 115,000 ha of agricultural land, including banana plantations.

In the wet winter of 2012 there was an attack of the black Sigatoka fungus which reduced the crop of bananas for export by 13 % in comparison with the previous year³¹.

However, one of the most serious threats to banana growing is droughts. Around a quarter of the land area of Ecuador is already affected by droughts and in places even desert formation. Agriculture in Ecuador consumes over 80 % of the fresh water abstracted. Around a third of the agricultural land is irrigated, about

three times higher than the norm in South America³². Banana plantations come in second place after rice fields in terms of irrigation³³. Although rainfall will increase in future, precipitation will become more erratic and occur increasingly in extreme events (see Figure 2)³⁴. Therefore the high water demand in summer will remain. The melting of the glaciers in the central regions will only exacerbate the water shortage in future.

Around a third of the production costs in banana growing arise from controlling the Black Sigatoka fungus.





ORANGES

The global orange crop production in 2013 was around 71 million tonnes³⁵. Of this, around 25 % was produced in Brazil, 11 % in the USA and 10 % in China. The other important producer countries were India (9 %), Mexico (6 %) and Spain (5 %). Over half the orange juice consumed in the world comes from Brazil³⁶, with the largest quantity exported to the European Union. Oranges as whole fruit are mainly exported from Spain, followed by South Africa, the USA and Egypt.

Orange trees grow well in warm areas, but require irrigation in dry regions. The trees are damaged by longer periods of frost or drought.

Around 80 % of all Brazil's oranges are grown in the state of São Paulo³⁸. In the northern parts of the state, the average temperature in the period 1995–2005 was around 2 °C higher than the historical average according to measurements by the Brazilian National Institute of Meteorology (Inmet). This is an above average regional warming in comparison to the global average of 0.8 °C. A lack of precipitation there has already had a detrimental effect on orange growing and makes intensive irrigation necessary, something that was not required in the 1960s and 1970s³⁹. A relocation of the orange growing areas to the south of the state can already be observed. The reasons for this are the rising land prices from competing sugar cane growing, the spread of diseases to citrus trees and also the changing weather conditions. This means that new areas have to be opened up for agriculture, which can cause conflicts with the local population and with conserving biodiversity.

Orange growing in Brazil has moved further south in recent years – also as a result of changing climate patterns.

Climate risk map 3
Further temperature increase in Brazil's orange growing areas

/// Orange growing areas

RCP8.5 (BAU)
2100 Tmax [°C]

2.01 – 3.00
3.01 – 4.00
4.01 – 5.00
5.01 – 7.00



**Climate change
predictions for Brazil
forecast negative
effects for all
agricultural yields.**

*Farm owners and
workers lose their
income when crops fail.*

In 2010 the water level in the Amazon fell to its lowest since 1963 due to a long period without rainfall. This drought caused major crop losses and price increases, including in the orange juice market⁴⁰.

Droughts like this could become much more frequent in future due to rising temperatures and decreasing rainfall⁴¹. As can be seen in the climate risk map in Figure 3, in the Brazilian orange growing regions annual maximum temperatures could increase by a further 3–5 °C by the end of the century, in some regions by as much as 7 °C, giving rise to increased evaporation processes. As was shown in climate risk map 1, the number of consecutive days without precipitation are expected to increase across the whole country, except in the south, where a slightly smaller increase is predicted and more heavy rainfall events may occur.

Overall it can be anticipated that Brazil will suffer more frequent droughts and that the rising temperatures will be detrimental to all agricultural yields there, including orange production⁴².

In the world's second largest orange producing country, the **United States of America**, the average temperature has risen by about 0.8 °C since 1900. 2012 was the hottest year in the hottest decade there since records began. Over the last few decades there has been an increase in extreme weather events, such as heavy rainfall, heatwaves and more severe droughts in some regions⁴³. Around 1,500 tornadoes cross the country every year and 17 hurricanes affect coastal areas per decade, including the orange growing region in Florida.



In 2014 California experienced a disastrous drought, with some oranges being much smaller than normal.

In the US midwest, extended growing periods and the CO₂ level in the atmosphere have led to increased yields of some agricultural commodities. However, these increases were often more than negated by crop losses from heatwaves, droughts and floods. In the southwest US droughts and high temperatures have led to forest fires and increased competition for the diminishing water supplies between agriculture, towns, the energy sector and ecosystems. Surface and ground water supplies are already under pressure. Around 20 % of the land area is affected by droughts at any one time.

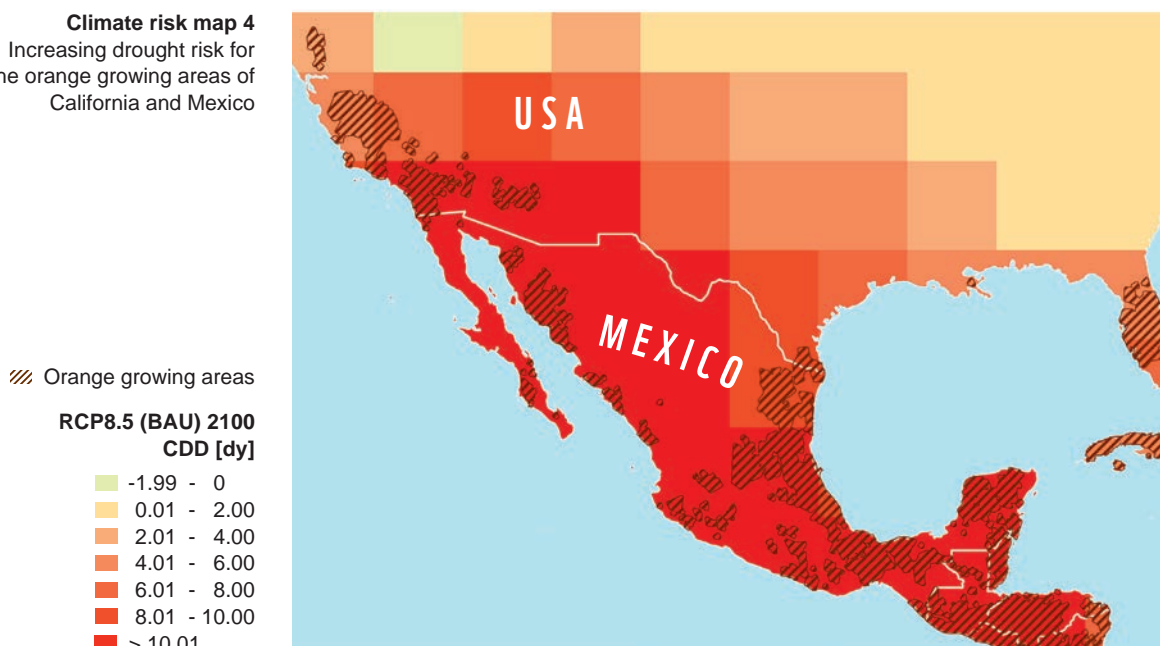
Since 2011, California has been experiencing an unusually severe drought. Rivers and lakes are scarcely recognisable due to the low water levels. As a result, in 2014 some of the oranges were very much smaller⁴⁴. More oranges and more man hours were needed to fill a standard box, a clear loss-making business for the farmers and plantation workers.

In future a large part of the USA will be subject to more frequent droughts. The climate risk map in Figure 4 shows that, for the scenario without significant reductions in emissions, by the end of the century the number of consecutive days without precipitation will increase in the orange growing areas of North America. California and Mexico will be particularly badly affected.

The orange growing areas of the USA are also at risk of flooding. The coastal growing areas of Florida are threatened by rising sea levels in the long term. In addition, in 2005 tornadoes spread diseases such as growths on citrus trees in the northern regions of Florida. The production areas for oranges in the USA have been declining for some years⁴⁵.

Agriculture in the USA has already suffered from extreme weather events. The US government forecasts that the negative effects will increase by the end of the century. A study by Lobell et al. predicts that Californian growing regions with high yield potential and orange crops will be further reduced in future due to climate change.

Climate risk map 4
Increasing drought risk for the orange growing areas of California and Mexico





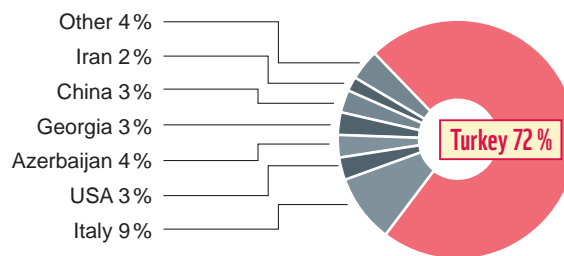
HAZELNUTS

Turkey is the leading producer of hazelnuts, providing about 72 % of the world supply in 2012. Additional major growers are Italy, the USA, Azerbaijan, Georgia, China and Iran⁴⁶. Germany, Italy and France are the largest buyers of Turkish hazelnuts⁴⁷.

In winter 2014, Germans became aware of the effects of a concrete example of a shortage on the world market. Many shops lacked an ingredient without which baking the traditional German Christmas biscuits is out of the question: hazelnuts.

Hazelnut bushes grow particularly well on aerated soils in a mild damp climate between 250 and 1,000 metres altitude. The Turkish region by the Black Sea is particularly suited to this, with its normally mild winters and ample amounts of precipitation. While other producer countries manage to achieve larger yields per hectare using higher yielding varieties, modern production methods, intensive irrigation and large applications of fertilisers and pesticides, government support for Turkish hazelnut growing via a minimum price has led to continuous expansion of the growing areas over the last 40 years⁴⁸.

Global Hazelnut
Production by growing
country in 2012



As the global hazelnut supply is dominated by Turkey, any major crop failure there has an immediate effect on the world market. Farm owners and workers have to be prepared for economic losses. Hazelnuts and hazelnut products could become more expensive or even unavailable at times for companies and consumers.

The year 2014 started out unusually mild by the Black Sea so that hazelnut bushes there began producing the first ripening fruit. Then a single frosty night in March combined with a hailstorm was enough to destroy half the crop and drive the price on the world market up by 60 % to a historical record level⁴⁹.

On account of the high concentration of the global hazelnut growing areas in Turkey, a single night of frost was enough to more than double the price on the world market.

Yields are particularly dependent on weather conditions in the growing period at the beginning of the year. Hail poses a large economic risk as it is common in Turkey between March and July, coinciding with the period when the bushes flower and bear fruit. The number of days with hail has risen in Turkey since 2004. It is also anticipated that hail damage will occur more frequently in future.

Over the last 65 years there has been a clear trend towards less precipitation in winter and higher temperatures in spring in most parts of the country, particularly in the Mediterranean region. The Turkish Ministry of Environment⁵⁰ predicts that the Black Sea region will also be more affected by this tendency in future.

Rising temperatures, higher amounts of evaporation and heatwaves plus an irregular rainfall pattern and decreasing amounts of precipitation have already led to droughts and water shortages in some parts of Turkey and, in a few cases, even to population migration. By 2030 water stress in central and western Turkey will

A quarter of employees in Turkey work in agriculture and depend on good harvests.



increase markedly and will also increase in the south-east and east of the country. The groundwater table will fall in almost all regions. In the semi-arid areas which depend on irrigation, agriculture will have to cope with falling yields in future.

The number of disasters in Europe caused by weather and climate conditions have doubled since 1990 in comparison with the previous decade, while the frequency of natural disasters not related to weather such as earthquakes and volcanic eruptions has remained constant.

Turkey is one of three European and Central Asian countries which will be most affected by extreme weather events in the future. Turkey has already been affected by almost all types of natural disasters (apart from tropical storms and volcanic eruptions). Besides non-climate related earthquakes, the most frequent are storms, floods and hail. Between 1975 and 2011 Turkey suffered 820 floods involving 660 deaths, with around 800,000 ha of agricultural land affected and an economic loss of approx. 45 million euros. The number of storms and floods has increased since 1995, and the frequency, length and intensity of extreme rainfall events with resulting floods and landslides will increase further in future. The climate risk maps indicate a distinct increase in severe rain events, especially in the north of the country.

Agriculture is one of the sectors most affected by climate change. A quarter of employees work in this sector. The Turkish Ministry of Environment anticipates a reduction in the period favourable to plant growth, a relocation of growing areas and decreases in yield for the whole country, caused in part by extreme weather such as droughts and floods, with a resulting decline in prosperity.

We can still limit the scale of the effects of climate change

The examples described here are representative of a problem which will certainly affect us more frequently in future. We are already experiencing the effects of climate change on agriculture. Many producers of agricultural commodities suffer crop losses due to changing weather conditions, extreme weather events and pests and plant diseases. Farmers (both large and small scale) and farm workers are mostly affected by these losses in terms of lost revenue. In some cases shortages in supply are even felt in importing countries – through reduction in quality, higher prices or simply because certain products are not available at times. Consumers may only experience a minor increase in the price of a product in which the agricultural commodity is only used as one of several ingredients, such as hazelnuts in Christmas biscuits. Up until now customers, companies and politicians have largely been unaware that it is climate change that might lie at the root of a price increase.

It is likely that climate-related crop losses and shortages will occur more frequently and in more severe forms in future. Like luxury food items, basic food items are also affected by climate change. While some regions and agricultural commodities might actually benefit from climate change, for example due to longer growing seasons from warmer temperature or more CO₂ in the atmosphere, this study shows that the negative effects on yields for some of our luxury foodstuffs predominate in their current major growing regions. The Intergovernmental Panel on Climate Change IPCC has reached the same conclusion for basic foodstuffs such as wheat and maize. Changes in the pattern of temperature and precipitation and the increased frequency of extreme weather events have had a detrimental effect on wheat and maize yields in many growing regions and also from a global perspective. Wheat yields in some European countries have stood still in recent years despite more intensive growing techniques. In Asia, losses in yield were actually higher than gains from increased efficiency⁵¹.

Climate change is already causing crop losses in many wheat and maize growing areas.



There is still a need for a comprehensive study of the overall picture of global food security taking account of the relocation of growing regions and the ensuing competition for limited agriculturally suitable areas and for the available freshwater. The consumption of luxury foodstuffs could become much more expensive in future and at times be interrupted completely. However, it is unlikely that food security in the main importing countries will be endangered. The inhabitants of the affected growing regions, on the other hand, could lose their income completely, putting the basis of their livelihood at risk. It is now up to us to limit the scale of the effects of climate change.

- 1. The international community must dramatically reduce global greenhouse gas emissions to keep temperature increases and the associated effects on the climate system as small as possible.**
- 2. The affected growing countries need rapid and ongoing support in developing and implementing adaptation strategies in order to be able to deal with the results of climate change.**
- 3. Companies should be obliged to check where they source their raw materials and whether they have been produced in a climate-friendly and socially and ecologically sustainable manner. Local adaptation and mitigation strategies have to be developed and implemented jointly.**

**Carbon dioxide
emissions stagnated
for the first time.
We need to
make this into a
premanent trend.**

There is hope: in 2014 the carbon dioxide emissions from the global energy sector which had been increasing up to that point remained constant for the first time. The main reason for this is the reduction in power generation from coal. This trend must now be consolidated and massively speeded up.

Footnotes

- 1) Further information available at: www.supplyrisk.org.
- 2) The IPCC report combines thousands of studies from over 800 international scientists. This assessment report represents a globally established and recognised state of knowledge on climate change and forms the basis for the decisions made by the international community during the climate negotiations.
- 3) Kaffee in Zahlen 2014, p. 13, 72.
- 4) Standard trading unit: 1 sack = 60 kg. 9 million sacks are equivalent to 540,000 t of green coffee beans.
- 5) Kaffeemarkt 2013. pp. 3, 5, 6, 13, 14.
- 6) International Coffee Organization.
- 7) World Bank 2009. p.1.
- 8) Caulyt, Deutsche Welle 2014.
- 9) Fischermann, Zeit online 2015.
- 10) World Bank 2009, p. 2.
- 11) IPCC AR 4 WGII.
- 12) WRI CIAT Climate Data Explorer. And 2nd National Communication to UNFCCC, p. 12.
- 13) Hagggar 2011, p. 6, 10, 36.
- 14) Locker 2014.
- 15) Statista 2015.
- 16) Risk analysis for bananas, Columbia, p. 6. FAOSTAT.
- 17) Deutscher Fruchthandelsverband 2011.
- 18) BMEL 2015.
- 19) Robinson 2010. p. 187ff.
- 20) Pearce 2008.
- 21) Fresh Fruit Portal 2011. The Packer 2011.
- 22) Fresh Fruit Portal 2012.
- 23) Fresh Fruit Portal 2013.
- 24) Fresh Plaza 2013.
- 25) Bennett, Arneson 2003.
- 26) CGIAR
- 27) Bennett, Arneson 2003.
- 28) See also Lau, Jarvis, Ramirez. 2012.
- 29) Machovina, Kenneth 2013. p. 83-95.
- 30) World Bank 2010.
- 31) CropLife LA
- 32) World Bank 2010.
- 33) FAO Aquastat Ecuador 2000.
- 34) World Bank 2015. Climate risk maps.
- 35) Schiebel, Sutor, Simon 2013. p. 93.
- 36) Brazilian Association of Citrus Exporters 2010.
- 37) FAOSTAT 2015.
- 38) USDA. Average value 2005-2009.
- 39) Neves 2011, pp. 59,67 ff and 77.
- 40) Kassai 2010.
- 41) Marengo et al. 2011.
- 42) Risk analysis for oranges, Brazil. p. 12.
- 43) United States Climate Action Report 2014. p. 162ff.
- 44) Henckel 2014.
- 45) Risk analysis, oranges, USA, pp. 7, 15, 17.
- 46) FAOSTAT 2015.
- 47) Pabst 2014.
- 48) Hütz-Adams 2012, p. 6.
- 49) Nordhausen 2014.
- 50) The Turkish Ministry of Environment and Urbanisation.
- 51) IPCC AR 5 WG II SPM. pp. 5, 17, 30f.

Sources

Data sets used for climate risk maps: IPCC GCM: CMIP5 – Intergovernmental Panel on Climate Change, Global Climate Models, Coupled Model Intercomparison Project, Phase 5, from the KNMI Climate Change Atlas. This information sheet has used the RCP 8.5 scenario for long-term changes in the period 2081–2100 in comparison with 1986–2005. For the growing regions of agricultural commodities use was made of: Monfreda et al. (2008), "Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000", Global Biogeochemical Cycles, Vol. 22, GB1022, doi:10.1029/2007GB002947.

WWF supply risk analyses for agricultural production:

- Coffee growing in Brazil and Vietnam
- Banana growing in Colombia and Ecuador
- Orange growing in Brazil and the USA
- Hazelnut growing in Turkey

As the supply risk analyses are not publicly available, the relevant sources are indicated with (SRA) at the end.

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