Planetary Boundaries and the Right to Food

Dr Wiebina Heesterman

Abstract

According to international law the 'Right to Food,' is a legal entitlement owed to all human beings. Fulfilment of the right has been entrusted to States party to the 1966 International Covenant on Economic, Social and Cultural Rights (ICESCR). However, in practice, the right is often breached because of hostility or indifference from individuals or institutions refusing access to provisions, or because of vicissitudes of nature. Adverse impacts due to human interference in natural processes are increasingly noticeable in the area of food production. These processes have been classified into nine distinct categories, all of which need be kept within certain margins, 'Planetary Boundaries,' which delineate a safe operating space for humanity. This paper discusses the impact each of these human-induced processes has on the provision of food as well as the other way round and what the consequences would be if the boundaries were exceeded. Since the publication of first Planetary Boundaries paper, the concept has been discussed widely in social media as well as academic papers. Yet a major question is whether the notion of Planetary Boundary processes has by now developed into common knowledge. Groups and individuals known to be active in environmental and/or social networks were asked to complete a short survey in order to assess the degree of familiarity with the concept of a Planetary Boundaries framework and its potential relevance for the Right to Food among committed activists.

Keywords

ICESCR, human rights, Food, Climate Change, Biodiversity loss, Ocean acidification, Ozone level, soil health, chemical pollution, land use

1. Introducing the Right to Food

"If there really is such a right, while there was enough for everyone, that would be terrific! But quite a few people go hungry now and there are likely to be more people hungry in the future," you may say. "And what are Planetary Boundaries anyway and how do they relate to the production and availability of enough food for all?" The *Right to Food* is set out in the 1966 International Covenant on Economic, Social and Cultural Rights (ICESCR)

Article 11:

> States parties recognize "the right of everyone to an adequate standard of living for himself and his family, including adequate food, clothing and housing, and to the continuous improvement of living conditions," (Article 11.1)

Further clarified by:

> "They recognize that more immediate and urgent steps may be needed to ensure "the fundamental right to freedom from hunger and malnutrition."(Article 11.2)
>
> a) to improve methods of production, conservation and distribution of food by making full use of technical and scientific knowledge, by disseminating knowledge of the principles of nutrition and by developing or reforming agrarian systems in such a way as to achieve the most efficient development and utilization of natural resources;
> b) taking into account the problems of both food-importing and food-exporting countries, to ensure an equitable distribution of world food supplies in relation to need.

Yes, fine, but as they used to say in my native Friesland: "It is mei sizzen net te dwaan." (= "You can't do it by saying"). That is not enough, even though the Food and Agricultural Organization (FAO) of the UN reiterated only recently that the right is legally binding on State Parties (2015), being enshrined in international law.

Firstly there are several countries that signed, but did not ratify the Covenant, such as for instance the United States, secondly, how can a so-called binding right be enforced upon a Party which is basically unwilling? To give an example, the Democratic People's Republic of Korea (North Korea) ratified the Covenant on 14 September 1981, yet the country was ravaged by famine in the mid-1990s without any attempt by the government to request international assistance. The same happened in 2011 (Human Rights Watch, 2013). It has since been reported that North Korea enjoyed a better harvest in 2013 than in former years, which might make the situation somewhat more bearable (Aljazeera, 2014).

It isn't clear what 'adequate' meant in the context of the original treaty: it reads as referring to *quantity* rather than *quality*. However, a little over ten years ago the meaning of the Right has been clarified by the *Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security*, (Right to Food Guidelines), adopted by general consensus (FAO, 2004)..

e.g. point 2.5

> States should pursue inclusive, non-discriminatory and sound economic, agriculture, fisheries, forestry, land-use, and, as appropriate, land-reform policies, all of which will permit farmers, fishers, foresters and other food producers, particularly women, to earn a fair return from their labour, capital and management, and encourage conservation and sustainable management of natural resources, including in marginal areas:

Clearly the implementation of the right is the responsibility of nation states. Most of the guidelines begin with the words "States should . . ." And there is no way of enforcing that State Parties go any further than taking the trouble of ratifying as well as signing the Guidelines. People still go hungry - Many of the hungry are undoubtedly stateless, refugees and asylum seekers who lack the protection of the State they are fleeing. In reality even in rich countries the ability to protect children from being hungry at certain times of the year may still depend on the contents of their parents' purse or on charity rather than the universal right unless States explicitly recognise their obligation (McConnell 2015).

In 2014, an estimated 805 million people – one in nine of the entire world population – were estimated to be chronically hungry (Sundaram, 2015). 791 million of these live in developing countries. It is true that the figure has gone down by nearly half during the last twenty years, from 23.4 per cent in 1990 to 13.5 per cent in 2014. Unfortunately it is still a long way away from the target, while it doesn't say anything about the *quality* of what's on offer Even the proposition that consumers should not be exposed to anything harmful in food products allowed to be sold, may on occasion be completely disregarded. Yet there are serious efforts by the UN to make the right a reality, as evidenced in periodic reports by the Special Rapporteur on Food.

It is, moreover, one of the areas targeted by the UN Sustainable Development Goals programme:

> "As an example of how we work on the ground, we are setting into motion programme activities that relate to alleviating child hunger and under-nutrition as well as projects that promote sustainable and resilient livelihoods for vulnerable households, especially in the context of adapting to climate change." (Statement by Paloma Duran, UNDP to IPS, 5 March 2015)

It goes without saying that the availability of clean drinking water is an essential component of "the Right to Food": without a reliable, uncontaminated source of fresh water the right would be no more than a hollow promise.

In my view few people are aware that a Right to Food exists and that it applies to every person on earth as a legal entitlement.

2. Awareness of the Planetary Boundaries framework

Although the Planetary Boundaries framework has been the subject of numerous academic papers, while there are several videos, discussing the concept, are available on social media, one may wonder to what extent this is generally familiar, even to those engaged in environmental and social activism. Before going into the particulars of the nine boundaries, defined as delimiting areas of safety for our planet, I want to give you some idea of the current extent of familiarity with the Planetary Boundaries Framework –

defined as a safe operating system for humanity. I therefore, first interviewed a number of people attending a “Breaking the Frame” weekend in early July 2015 and also asked members of several groups and individuals campaigning on green and/or social areas to complete a simple online questionnaire, using the Google Forms website. Respondents were asked to indicate:

1) whether they were concerned about one or more of the following areas: environmental issues, climate change, loss of biodiversity, women and children coming last, new technologies, the arms trade, GM foods, inequality, unconventional fuels such as tar sands and fracking, ocean acidification, loss of tropical forests, degradation of soils, fresh water scarcity, and ‘other’

   Nine of these subjects correspond largely to the Planetary Boundaries. The other areas are relevant as being applicable to the human need for food.

2) whether they were i) familiar with the concept of Planetary Boundaries, ii) unfamiliar or iii) had heard about them, but didn’t know any details

3) whether they thought that i) the framework was of relevance to the Right of Food, ii) it was not relevant, iii) it might be

4) whether they were members of one or more groups engaged green or social and if so, which one(s)

The survey can be found at
https://docs.google.com/forms/d/1Fr3Onmg9RRuSst_RjidHVh1XCRv1IyH8w4ia1d569YA/viewform

The results of these exercises are described in the Concluding section.

3. Describing the Planetary Boundary Framework

So, to what extent is the Planetary Boundary framework relevant to the goal of universal availability of healthy and nutritious food - and clean water? Exceeding these boundaries brings the world into unknown territory. Somewhere beyond them society is at risk of facing ‘tipping points,” an expression that will sound familiar: humanity might meet with conditions making a mockery of any notion of regular food production. Hopefully such threats are a long way away, even when reaching the unknown danger area outside the safe boundaries of these nine specified human-induced processes. The Planetary Boundaries framework has been proposed as forming a ‘safe operating space for humanity’ in 2009 by a group of scientists and economists. As long as humankind manages to remain within its boundaries we would in all likelihood not have to face any risks of being pitched into a sudden catastrophic abyss of change.

The nine boundaries may be represented graphically. The 2009 graphic at http://www.pb-net.org/faq/what-are-planetary-boundaries is somewhat simpler to interpret than the figure of the 2015 update (Rockström et al., 2009; Steffen et al., 2015). The latter is more detailed and shows that four boundary areas have already been exceeded. The areas of risk are: ‘biodiversity loss’, ‘climate change’, ‘nitrogen loading’ and ‘land-use change’. In addition two of the proposed boundaries have not yet been quantified: aerosol loading and what the authors now call *new entities*, basically substances produced or

changed by human beings. This last group is so diverse and assumes so many different guises, that any tentative proposition that a specific quantity might be safe or alternatively could propel humanity in the danger zone may be wellnigh impossible.

3.1. Three critical, large-scale boundaries with the potential for disruption of the planet's health

Overreaching any of these three specific boundary processes risks changing the stability of the current beneficial conditions, which our world has been enjoying for some 10,000 years, to the kind of wildly swinging and uncertain seesaw physical states which the globe had to endure in the more distant past. According to data from the study of ice cores, tree rings and samples of lake soil, temperatures have not moved away by more than one degree C from the average during the Holocene, while earlier conditions and temperatures varied greatly. These most critical boundary processes are:

i) *Climate change*, which already makes an adverse impact on vulnerable people and nations in particular, is undoubtedly the currently best known hazard. While remaining below an overall two-degree warming is generally accepted as still being 'safe', the safety boundary has already been exceeded according to the Planetary Boundaries framework. According to the authors we have not yet reached any dangerous tipping points yet, but inhabit an area of uncertainty.

ii) *Ozone Depletion.* The second, which was already making itself felt in the mid 1980s, is ozone depletion, caused by the use of substances used in hundreds of millions of refrigerators, hair sprays and paint guns. We may thank our stars that the danger has successfully been averted. Even so, skin cancers have multiplied in regions nearer the poles where the protecting ozone layer began to thin because of the impact of halocarbons and/or chlorofluorocarbons, used as refrigerants and propellants. One could argue that these might have been treated under the heading 'man-made substances,' but the consequences would have been so catastrophic and wide-ranging that they are treated separately in a class of their own.

iii) *Ocean Acidification*: The third critical hazard is *ocean acidification*, which so far has not reached the danger zone, although its' pressure is already quite noticeable. It is often called the 'other carbon dioxide problem'. While the oceans' capacity to absorb CO_2 from the atmosphere has proved a boon for humanity by limiting the effects of climate change, an appreciable part of the gas has combined with water into forming the fairly weak carbonic acid. Even though it is not as corrosive as many other acids, the sheer quantity is changing the chemistry of sea water.

The remaining six defined boundaries form a support system for these three areas, which are all closely linked to human activity. Looking closely at the various areas covered by the 'boundary

processes', it becomes clear that not only making excessive inroads on the domains in question has a negative impact on food security, the production of food in many instances also impacts on the boundary process involved. There is invariably a reciprocal effect.

3.2. More detailed examination of the different domains

3.2.1. Critical Boundary 1: Climate Change

Today's food production is one of the most energy-intensive human undertakings: some fourteen per cent of carbon dioxide (CO_2) and 36 percent of nitrous oxide emissions (N_2O) can be blamed on the production of food, and agriculture in particular (Reynolds, 2013). Not only are emissions due to the tilling and ploughing of the soil, the contribution of fertilizer production, a high CO_2 process, is considerable. Then there is processed food, dependent on the creation and transport of ingredients, the nature of which we can at most make an uninformed guess (see the section on substances present in food products). We have to include the emissions generated by their transport to and from industrial food plants. Add to all this the globalized system of transport of food products to and from a fairly small number of distribution centres, each serving different concerns, dotted around various countries. It's a long cry from the system some of us grew up with: straight from the farm to the shop or to a regional distribution centre.

On the other hand, climate change also has the potential of changing the current food production for the worse: higher temperatures are already having an impact on the quantity and health of crops. Some regions have been exposed to flooding by excessive rainfall, while others have become as dry as a bone. In both cases food production becomes nigh impossible. Farmers are already beginning to feel the pinch of climate change for instance, in Europe average yields of wheat have fallen by 2.5% since 1989 and of barley by 3.8% across the whole continent (Moore and Lobell 2014). According to the latest Intergovernmental Panel on Climate Change (IPCC) Summary Report for Policy Makers, climate change is projected to undermine food security (IPCCa, SPM_AR5 2014: 2.3, 2014, Figure SPM 9).

As the *Climate Change: a Risk Assessment* Report expresses it:

> As climate change increases the frequency of extreme weather events, preliminary analysis suggests what was a '1 in 100 year' shock to global food production in the latter half of the 20th century may have become three times more likely by mid-century. If policy and market responses amplify rather than mitigate the shock, a plausible worst-case scenario in the present day could produce unprecedented price spikes on the global market, with a trebling of the prices of the worst-affected grains, compared (King et al. 2015: 10).

According to Tai et al. (2014: 817) the food supply might well drop by 10% of its former quantity under business as usual by 2050, a figure the authors claim is a conservative estimate. Yet the economist, Richard Tol maintains that vegetation benefits from a warmer climate, even up to as much as 2.25 degrees C higher, see however Heesterman (2015: 180 footnote 4). In Tol's view the Summary was unduly alarmist regarding the impact of climate change on agricultural yield to the extent that he refused to put his name to the Report (Torres, 2014). This is the more extraordinary as Tol acted as one of the coordinating lead authors of Chapter 10, 'Economic Sectors and Services' and contributed to chapters 17 and 19 on 'The economics of Adaptation

to Climate Change' and 'Emergent Risks' of the report of Working Group II on Impacts, Adaptation and Vulnerability (IPCCb 2014). Then there are those who argue that the financial and services sectors are much more important to economic growth than agriculture (Byatt et al., 2006), as documented in Heesterman (2015: 176). Perhaps the authors think the production of sufficient nutritious food is of little importance?

Undoubtedly sea level rise and extreme weather have an adverse impact on the food security of those living in low-lying regions. Even the shortest inundations by seawater from a storm surge render the soil saline and unsuitable for most crops. Then there are the adverse consequences of higher temperatures and more unpredictable weather. And it is not only the land surface that is suffering the consequences of temperature change. As mentioned in Heesterman (2015: 176), the seas have also been getting warmer. Already certain species of fish, such as sardines and anchovies, part of the staple diet in the Mediterranean, were found to be swimming north towards cooler oxygen-rich waters. The impact on nutrition is only one of the ways in which human populations is likely to be adversely affected.

3.2.2. Critical Boundary 2: Ozone depletion

Despite the publication of a paper by Molina and Rowland in 1974 on the hazard posed by the use of halocarbons, the serious character on the effect on the stratospheric ozone layer was not recognised by the science community until the 1980s. Yet it is the presence of this indispensable layer what prevents the entire biosphere, including food crops, from suffering fatal damage from ultra-violet radiation. Even sea life is affected adversely: The reproduction rate of phytoplankton (minute plant organisms in the oceans), which are at the bottom of the marine food chain, suffers, and in consequence important food sources, such as fish and other sea creatures, are reduced. Larger organisms are also harmed by ultra-violet (UV) radiation (Chivian and Bernstein 2008: 61). As it is, life could not have evolved without the protection of the ozone layer, while it is merely by a stroke of luck that chlorine rather than bromine compounds had been chosen as refrigerants and propellants (Crutzen 1995: 26). Only once the Vienna Agreement and the Montreal Protocol, had been signed and ratified by 35 nations, was the production of chlorofluorocarbons (CFCs) discontinued. Unfortunately the HCFCs replacing the earlier refrigerants and propellants turned out to be even worse greenhouse gases than the earlier used CFCs. While the effect of UV radiation is well-known, the fact that the entire biosphere would suffer irreplaceable damage has long been ignored. It is a more complicated pattern than simple cause and effect: stratospheric clouds at the poles have been found to aggravate ozone depletion. See 'the Ozone Hole', Inc. for an explanation It appears that these form more readily in extreme cold. In addition the density of the ozone layer varies, with the highest density in Autumn, then decreasing until Spring, to increase once more in Autumn. Antarctic Hemisphere daily maps, showing the extent of the affected areas, are produced by the National Aeronautics and Space Administration's (NASA) Goddard Space Flight Center (2015).

Measurements in successive years have since showed a distinct overall decline. Since the successful implementation of the Montreal Protocol the overall density of the protective shield has grown again. To date it is the only critical area which humanity has been able to restore. Yet it will take a long time before the Antarctic ozone layer has reformed completely, in particular as recently four previously unknown ozone-depleting substances (CFC-112, CFC-112a, CFC-113a, and one new ozone-depleting hydrochlorofluorocarbon, HCFC-133a) have been discovered in the atmosphere (Laube et al. 2014).

3.2.3. Critical Boundary 3: Ocean Acidification

The alarm bell hasn't sounded in Planetary Boundaries (PB) circles yet, although the effect of serious acidification has been observed both in the laboratory and at a few very specific locations close to undersea volcanic vents. So far, the risk has been largely ignored by policy makers. The fact that about 30 percent of atmospheric carbon dioxide (CO_2) has disappeared out of sight into the oceans has been a boon for humanity, which otherwise would have been exposed to serious climate change much earlier. Not many people realise that CO_2 gets taken up into the sea surface, especially when the waves are whipped up by winds. Part of the gas may be absorbed by the smallest organisms and sinks to the bottom. However, quite a large fraction does not, but combines instead with water molecules, eventually to form carbonic acid, which although quite weak is still capable of drastically changing the chemistry of sea water. See 'Virtual Chembook', Elmhurst College for an explanation of the pH scale (Ophardt 2003). At the same time this process reduces the concentration of carbonate ions calcifying organisms require to build their shells (Scales 2015: 265). In the past sea water used to stand at 8.2 on the pH scale, but has become less basic (or alkaline) due to the effect of this acid and is now measured at 8.1. So it is still much more basic than tap water which rates 7.0, i.e., it is neutral. One tenth of a point does not sound much, but the pH scale is logarithmic, which implies that sea water is now less basic by over 26 percent than in pre-industrial times. If the oceans keep absorbing CO_2 at the current rate, the change may commit us to an overall figure of 7.8 on the pH scale by 2100, i.e. approximately less basic by 150 percent. At Castello Aragonese, an island off the Italian coast near Ischia, the sea water has a pH of 7.8 due to the proximity of several volcanic vents. This allows researchers to see with their own eyes what greater acidity implies for the health of the nearby sea life (Kolbert, 2011). Limpet shells had become near-translucent, while corals were lacking completely. Coralline seaweed, which acts as the living cement of coral reefs (Scales 2015: 266), cannot survive either under conditions such as these. The greater acidity appears to be compounded in the presence of metal in the seawater, for instance oyster farms off the US Pacific Coast suffered enormous losses, when oyster larvae, exposed to a combination of acidified seawater and copper died *en masse*. According to several studies mentioned by Scales (2015: 270) shellfish may be affected by lower salinity, higher seawater temperature, copper pollution as well as a loss of alkalinity, or combinations of these factors.

As shellfish form an essential part of people's food source in certain parts of the world, this is a foretaste of things to come. A drop in alkalinity of seawater affects the shells of tiny shellfish, such as foraminifera

and sea butterflies. This clearly impacts on the entire food chain: ". . . *there's a series of short hops from plankton to sea butterfly to salmon to dinner plate*" (Scales 2015: 272). They form the staple of larger sea creatures, such as sea angels – shell-less pteropods, which prey on sea butterflies - and krill, which are again consumed by fish – which in their turn serve as food for sea mammals as well as human beings. Again, it is the poor who will suffer most (Heesterman, 2015: 173) Shell forming creatures, such as starfish, shellfish and corals require a certain saturation state of aragonite to be able to build their skeletons and shells. In this case the planetary boundary expressed as *80 percent of the state of aragonite* (a form of calcium carbonate) from what it was in pre-industrial times (Steffen et al. 2015: 4). This implies that a pH of 7.8, which could be expected by 2100 under business as usual, would in all likelihood lead to mass extinctions (Caldeira 2011).

3.3. The more regional boundary Processes

3.3.1. Boundary 4: Biodiversity loss

The update of the original Planetary Boundary framework uses the term 'biosphere integrity' rather than 'biodiversity loss' as the boundary area. As Professor Rockström told the student audience of the online Planetary Boundaries and Human Opportunities course that "*biodiversity is fundamental for the regulation of the Earth system, it's fundamental for human well-being*." Without such a huge variety of living creatures, humankind would not be able to lead a full life – possibly we would not be able to live at all. Unfortunately many species are in serious danger because of over-exploitation, change in land use, pesticide use, and attacks by introduced, invasive and stronger species, mostly due to human action (IUCN). On land, food crops, grown as a monoculture are at greater risk from weather-related extremes than more genetically diverse stands (Hillel and Rosenzweig 2008: 325). A natural rate of biodiversity loss or rather 'what might be expected', would be in the order of one species per million per year. The 'safe' boundary was set at ten per million. However, the actual rate is more than ten to a hundred times as large. The so-called 'Red list of endangered species' of the International Union for Conservation of Nature (IUCN) is currently in the order of some 80,000. According to recent research there are indications that the world is heading for a massive extinction episode (Ceballos et al. 2015). Undoubtedly this would have serious repercussions for human life as well.

For instance, the decline of pollinating insects such as honey bees endangers the pollination of food crops (Ibid: 339). A recent review of a large number of research papers confirms that neonicotinoid pesticides are largely responsible for bee colony collapse (van der Sluijs et al. 2013). It is not only land-based food sources that are affected by the loss of biodiversity: Coral reefs which support numerous fish species are also at risk. This includes many used for food for as many as over 275 million people, as stated on the IUCN website (2012). As the building blocks of reefs consist of corals and coralline seaweeds, the increased acidification of seawater constitutes a serious risk to food security. In addition freshwater fish, a most important food source, is heavily endangered because of overfishing and habitat

destruction, pollution and the construction of hydro-electric dams (Ibid). One danger to marine life which rarely gets a mention is loud noise, which puts cetaceans (whales and dolphins), who rely on sound for their communication, under intolerable stress and leads to disorientation (National Oceanographic and Atmospheric Administration; Monterey Aquarium). Recently the New Scientist made a mention of the prospect of seismic testing for oil wells, reporting that a letter signed by 75 scientists call on President Obama to call a halt to the testing programme (North Carolina Coastal Federation 2015). The health of the oceans, and with it, the food chain on which many human beings depend, is closely linked to the wellbeing of marine life.

3.3.2. Boundary 5: Land-Use Change

In this case aspirations to increase profitable sources of food and other products has led to the transformation of tropical forests, wetlands and mangroves into cultivation areas to the detriment of biodiversity, and with it, habitat loss and an impoverished diet.

Old, veteran trees suck up a large quantity of moisture from sudden downpours, which is gradually returned to the atmosphere by evapotransporation, eventually to come down once more in the form of rain. Removing them has a detrimental effect on the local climate, leading increasingly to regional drought. Understandably this affects crops dependent on reliable rainfall. In several regions tracts of old growth forest have been replaced by oil palm plantations. The resulting oil is currently one of the cheapest and is therefore to be found in many processed foods: if it says ‘vegetable oil’ on the label, it is likely to be palm oil. Another lucrative use for palm oil is biofuel, supposedly more climate friendly than fossil fuels, even though this is not the case. Unfortunately oil palm plantations do not have the same capacity to store moisture as tropical forests. In addition still more tropical forest has been cleared for soybean culture, catering for the increased taste for meat products. High protein feed, such as soy, is in high demand by cattle breeders, in particular where livestock is no longer put out to pasture, but kept indoors in large sheds (which incidentally also represents a change in land use). Other land (or rather sea) use changes concerns the increasing conversion of mangroves into prawn ponds, predominantly for the export trade to the West. The feed for juvenile prawns mostly consists of pellets containing plant protein such as soybean, fishmeal and fish oil, depriving other marine life of an important food source. However, the greatest risk posed by mangrove conversion concerns the loss of a vital barrier against sea surges. One other, often omitted cause of land use change from good productive land to a to all accounts inaccessible terrain is conflict, resulting in the presence of landmines.

3.3.3. Boundary 6: Freshwater use

The use of less than 4000 m^3/year of freshwater would leave the biosphere intact. Higher than this might well become problematic according to Steffen et al. (2015: 6). Damming rivers for hydroelectric schemes cannot be judged an unqualified success either: in arid conditions, more water evaporates from reservoirs than from the original vegetation. In consequence soils may become increasingly saline. On

other schemes old wood stands were not felled prior to flooding, resulting in the generation of methane (Heesterman and Heesterman 2014: 352, 355).

Much of the stored water is being put to use for irrigation serving food production. According to the FAO over two-thirds of human water use is for agriculture, while the effect of crop and livestock production is profound and far reaching (FAO 2015). But part of this 'blue' water has been exposed to some degree of pollution. Acidification also affects fresh water sources, and may lead to the leaching of aluminium from soils. While the level of acid deposition has generally dropped in developed nations, increasing industrial activity has led to the reverse in countries such as India and China, which depend heavily on fossil fuel use (Chivian and Bernstein 2008: 57). The fact that sea level rise and increasing hurricane activity already lead to higher storm surges, not only endangers coastal agriculture, it also renders the few sources of freshwater available in low-lying areas undrinkable. This is already happening in coastal Bangladesh, but an even more serious predicament threatens the residents of atolls in the Pacific Ocean, such as Kiribati as highlighted in an article by Mathiesen (March 2015: 12). These precarious habitats have since been subjected to severe flooding from cyclone Pam on the 13th of March 2015 (Robertson 2015). Survival there now depends on a small ration of relatively 'clean' water delivered in tankers by the government, reaching however only two thirds of inhabitants. Here the promise of "the right to food" sounds particularly hollow.

3.3.4. Boundary 7: The Nitrogen and Phosphorous cycles

The move from conventional farming to an agriculture heavily dependent on fertilizers and insecticides, has had a far-reaching impact on the state of soils. It has now been recognised that changes in the presence of other naturally occurring elements, such as silica, also have an impact on the health of the earth system. While nitrogen is essential to the success of agriculture, the use of fertilizer exceeds the safe zone, as defined for the element by Steffen et al. (2015: 4). Food crops are dependent on the presence of fixed nitrogen, as found in guano (basically this is the excrement of (sea)birds and bats), which is rich in nitrogen, phosphates and potassium, all essential to plant growth. The production of synthetic nitrogen fertilizer made the Green Revolution of the 1960s possible, but now gives rise to major environmental problems. Its overuse has a devastating effect on ponds and lakes, leading to the development of toxic blue algae blooms, killing fish and in general severely affecting any wildlife. In addition agricultural runoff gives rise to dead zones in coastal seas close to river mouths (Chivian and Bernstein 2008: 52-53). Also, the Haber-Bosch process requires a large amount of energy, generating CO_2. A short history of the invention of synthetic nitrogen fertilizer can be found at http://www.the-compost-gardener.com/haber-process.html.

3.3.5. Boundary 8: Atmospheric aerosol loading

Aerosols are miniscule particles in suspension in the atmosphere. These may consist of windblown dust, soot, sea-salt spray, fly ash, pollen and several types of allergens. Depending on the size of particles, air saturated with them may absorb sunlight and therefore have an aggravating effect on

the heat budget, or, alternatively, reflect it back into space. The impact on health can be severe, with asthma or lung disease some of the worst personal consequences (Vidal, 2015: 27*ff*). They also contribute to damage to the ozone layer. The formation of the 'yellow haze' over China and South-East Asia constitutes a serious health hazard for the populations subjected to it, while at the same time proving something of a blessing in disguise, as it may dampen the effect of climate change to some extent (Ramanathan et al. 2002, as discussed in Heesterman and Heesterman, 2013: 130, 175, 239). According to measurements over a 12-year period of the impact on rice and winter wheat, yields in the Nanjing area were down by between 5 and 30% in 70% of the crops studied (Chameides et. al. 1999). The effects of atmospheric pollution by soot and ozone in particular (which are directly toxic to plants) on historical crop yields in India has been modelled by Burney and Ramanathan (2014). In addition, there is also speculation that the extensive aerosol haze over the Indian sub-continent could well switch the monsoon into a drier state (Steffen et al. 2015: 6). This would have serious consequences for the ability to produce sufficient food for the population. So far, no figure has been suggested for a boundary for the phenomenon.

3.3.6. Boundary *9: substances created or changed by humans (New Entities in 'PB' parlance)*

These include compounds of naturally occurring substances such as minerals. To date there are at least 100,000 substances changed by human input, while items under development, such as nanomaterials or plastic polymers have not even been included (Steffen et al. 2015: 6). Here I want also to discuss the topic of genetically modified food products. In my view we have to make a distinction between the Genetically manipulated (GM) produce, developed to correct a nutritional deficiency by a research body and that developed for commercial reasons by large concerns such as Monsanto. The latter tend to lock farmers into dependence on a particular strain, with the consequence that the practice of saving seed for next year's sowing is no longer possible. In addition certain modified strains, tolerant of a specific pesticide, have resulted in the creation of resistant super-weeds (Service 2013: 1329). Several other issues need consideration, for instance 'whether cross-fertilization is possible and/or desirable, before one can welcome or reject a particular GM development. To date there are very few I myself whole-heartedly welcome. One exception to my reluctance to applaud the technology is the Golden Rice, which is still under development – not because the technology isn't trustworthy or successful. The reason is that the types of rice used as source has been found not to adapt easily to local conditions in East Asia, where the families of poor, landless labourers are most at risk from food deficiency and – with it – blindness (Novella 2015).

As reported in the New Scientist Journal of 26 November 2014 a considerable number of common household chemicals is to some extent carcinogenic or toxic, although well below the doses regarded harmful by regulators (Davies and Sanderson 2014). The question is, however, whether a cocktail of several of these substances still proves harmless. A US NGO, the Environmental Working Group,

produces an annual list of products tested positive for pesticides. The ones found with the highest amount of pesticide residues: “the dirty dozen”, invariably starts with: *apples*, followed by other fresh fruit.

Since World War II the term ‘conventional farming’ has changed its meaning from ‘traditional farming’ to an agriculture depending on the use of fertilizer and pesticides. The ability to feed more people has led to greater health overall, but also to increased population growth. The production of fertilizer began during the first half of the twentieth century; while the use of pesticides originated in the course of testing agents for chemical warfare upon insects (Carson 1962: 13). As it is, her ‘Silent Earth’ book was written at a time when there were few legal regulations concerned with food production.

See below a table of pesticide residues permitted to be present in food. It has been extracted from a database created by the US Environmental Protection Agency (EPA), which takes the issue extremely serious. Regulations are enforced by the Pesticide Residue Monitoring Program from the US Food and Drug Administration – by periodic sampling. Yet even in a well regulated state, food scandals occur, mostly in connection with cheap imports, e.g. relating to tofu from Taiwan, coloured with a carcinogenic dye.(Shuan Sim 2014). Unfortunately few countries have such stringent food regulations as the US.

See below a sample of a list of pesticides, regulated in the United States by the EPA and The National Food and Drug Administration. It needs emphasizing that infants and small children are more sensitive to the toxic effects of insecticides and weedkillers.

Table 1: Pesticide & weedkiller residues permitted, expressed in parts per million (ppm) according to the US EPA standard

Pesticide / Herbicide (Pesticide chemicals that cause related pharmacological effects)	Apple	Pear	Potato	Milk	Meat (cattle)	Cucumber	Wheat (grain)	Barley (grain)	Fodder (straw)
Cloquintocet-mexyl-herbicide							1 ppm	1 ppm	
Captan	25ppm	25ppm		0.1ppm	0.2ppm		0.25ppm	0.25ppm	
Diuron					1ppm		5 ppm	0.7ppm	
Acephate				0.1ppm	0.1			8ppm	
Malathion	8 ppm	6 ppm	8ppm	0.5ppm	4ppm	8ppm			135 ppm
Ferbam	4ppm	4 ppm							
Ziram	7ppm	7ppm							
Gentamicin	0.10ppm								
S-Ethyl dipropylthiocarbamate									0.6ppm
Methyl parathion (perm. exp.)			0.1ppm					1ppm	
Methyl bromide (fumigation)	5ppm	5ppm					50ppm	50ppm	Expir.
Piperonyl butoxide	8ppm	8ppm	0.25ppm	0.25ppm		8ppm	20ppm	20ppm	
o-Phenylphenol & sodium salt	25ppm	25ppm					2ppm	2ppm	

Followed by additional pesticides:

> *Dodine, Endosulfan, Linuron, Maleic hydrazide, Folpet, Chliforphon, Dicloran, Chlorophenoxyacetic acid Dimethoate Dimethoate, paraquat, phorate, Trifluralin, Benfluralin, Terbacil, Bromacil propachlor S-Ethyl cyclohexylethylthiocarbamate Simazine, Naled, Metiram, Atrazine, Prometryn, Phosphine, Diquat, Dicamba, Fluometuron, Dichlobenil, Butylate, Dichlorvos, Triphenyltin hydroxide, Bensulide, Thiabendazole, Streptomycin, Alachlor, Tetrachlorvinphos, Methomyl, Carbophuran, Chloroneb, Ametryn, propargite, Phosmet, Ethopropp, Phosalone, Aldicarb, tribuphos, Propanil, Chlorothalonilk, Formetanate hydrochloride, Phenmedifam, Zinc Phosphide, Amitraz, Thiocyanomethylthio)benzothiazol, Formetanate hydrochloride, Methanearsonic acid, Pentachloronitrobenze, Pichloram, Endothall, N-1-Naphthyl phthalamic acid, Methidathion, Dicrotophos, Ethephon, Carboxin, Oxamyl, Oryzalin, Cacodylic acid, Triallate, Methamidophos, Pyrazon, Propyzamide, 4-(2-Methyl-4-chlorophenoxy) butyric acid, Bromoxynil, Napropamide, S-(2-(Ethylsulfinyl)ethyl) O,O-dimethyl phosphorothioate and still many, many more*

The list is much, much longer, but I don't want to subject readers to a seemingly endless enumeration of toxic chemicals; just a sample of the terms (which are all toxic to pests, but also to some extent to consumers of the products protected by their application).

Food additives

Another transformation of food production is concerned with additives.

Processed food may possibly contain fewer trace elements (BBC programme, 1 October 2009, 13.30pm), but more manmade substances: more added salt, with some brands containing more salt than others, and also sugar, e.g. those little jars of baby food, e.g. one brand of a chicken and vegetable mixture, containing 1.8 grammes of sugar per 100 grammes. Different cornflakes brands ranging from 2.3 to 8 grammes of sugar per 100 grammes. Then there is acrylamide, found in starchy processed products heated to high temperatures, in breakfast cereal and crisps (homemade fare only contains it, if you favour burnt toast). Below a sample of food additives:

Table 2: Common food additives

Acids etc.	Flavours	Best not consumed
Acidity regulators	Flavour enhancers	**Aspartame**
Anticaking agents	Flour treatment	**Corn syrup**
Antifoaming agents	Humectants	**Olestra synthetic fat**
Antioxidants	Tracer gas	**Potassium bromate**
Bulking agents	Preservatives	**Trans fat**
Food colouring	Stabilizers	**Artificial colour**
Colour retention agents	Sweeteners	**e.g. Sudan red, Citrus red**
Emulsifiers	Thickeners	**Banned `in some countries**

Data from Lawrence (2008) and the Internet

I also recently came across an article in the Guardian Weekend Magazine about a trade fair in Frankfurt, called 'Food Ingredients' (Blythman 2015). Showcased food additives, or possibly major constituents of products such as cakes, apparently make it possible to produce these entirely without eggs, cream or butter, instead containing a substitute that made them look and taste like ordinary cakes. This may be a boon for vegans, but it doesn't inspire great trust in the current food system.

4. Conclusions

According to the results of the survey described in section 2, the level of knowledge of the Planetary Boundary framework is still fairly low, even among members of groups campaigning on environmental and social areas.

From the twenty-eight respondents of the interview in early July, thirteen were aware of the Planetary Boundaries framework. Ten of these thought the framework was relevant to the Right to Food and one that it was irrelevant. Twelve had no knowledge of the Planetary Boundaries framework and three had heard the term, but didn't really know what it meant. Twelve respondents were unsure whether it would be relevant, that is to say two from those who were aware of the concept as well as ten from those who had no knowledge of the framework, were unsure whether it was relevant, while two who had not heard about the framework thought it might well be relevant.

The online survey described in section 2 asked respondents three questions. 1) Whether they were concerned about one or more of the following issues, namely: environmental issues, climate change, loss of biodiversity, women and children coming last, new technologies, the arms trade, GM foods, inequality, unconventional fuels such as tar sands and fracking, ocean acidification, loss of tropical forests, degradation of soils, fresh water scarcity, and/or 'other'. 2) Whether they were familiar with the concept of the planetary boundaries framework. And finally: 3) whether they thought it of relevance to the Right of Food.

From the 65 respondents 38 were aware of the concept, 23 were unaware, while 4 had heard of Planetary Boundaries, but were not sure what they were. 38 respondents thought they were relevant to the Right to Food, one thought it was not relevant, while eleven thought the framework might be and ten had no opinion regarding the matter while five did not provide an answer.

The majority of the respondents were concerned about the issues mentioned, while several indicated other issues, such as: i) lack of viable colonization and use of space and other planets, ii) our existence and its quality through us as PEOPLE, iii) future of work plus many other issues, iv) paucity of wisdom, v) nuclear weapons and WMD, vi) electromagnetic pollution, vi) lack of control of small farmers over seeds and land, vii) Economic collapse, TTIP, corporate power, erosion of democracy & freedom, viii) The subversion of democracy, the rise of religious fanaticism, the further loss of commons, ix) the whole unsustainable system that we live in! x) Rare breeds and traditional farming methods, xi) Declines in mental and physical connectivity to planet and each other and resulting soul pain, xii) lack of carbon tax,

xiii) disability rights, xiv) spirituality for sustainability, xv) population pressure, xvi) roads, cars, electromagnetic fields, xvi) food resilience, xvii) reliance on meat as source of food, xviii) Arctic ocean warming and Methane releases, xix) food supplies and mass migrations, xx) Overfishing, pollution of oceans.

The responses regarding the groups respondents belonged too is quite interesting, many different organisations were mentioned and some respondents wrote a great deal about their interests. This would be far too long to describe at this time.

As the respondents may be assumed to be somewhat better informed on environmental issues than the general public, the level of awareness of the concept will undoubtedly be lower than indicated by the results of both the interviews and the survey, which amounts to less than half of those who might be assumed to have some knowledge of the concept.

3.4. I trust that my quick overview of the Planetary Boundaries concept and its implications has convinced readers of its relevance to the 'Right to Food' pledge as well as its general importance. Even though the Food and Agricultural Organisation (FAO) assures us, that the right is legally binding, good will and the genuine wish to feed the world population still fall short if the food system is badly impaired. And all too often the will is not even there. We can only concur with the sentiment of the first Special Rapporteur, Jean Ziegler, that:

> "In a world overflowing with riches, it is an outrageous scandal that almost 900 million people suffer from hunger and malnutrition and that every year 6 million children die of starvation and related causes. We must take urgent action now. This is my ongoing fight for the right to food"

The moral case for mitigation of climate change and other types of degradation inflicted on the earth by human beings, which inevitably affect the poorest human beings most, is also made powerfully in the Papal Encyclical *Laudato Si*, issued by the Vatican on 17th of June 2015, for instance in paragraph 25:

> "Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods. It represents one of the principal challenges facing humanity in our day. Its worst impact will probably be felt by developing countries in coming decades. Many of the poor live in areas particularly affected by phenomena related to warming, and their means of subsistence are largely dependent on natural reserves and ecosystemic services such as agriculture, fishing and forestry"

The indisputable fact that the State owes a duty of care to its citizens – which surely includes the provision of adequate sustenance - has recently been affirmed by a judgment in favour of Foundation Urgenda with 886 co-plaintiffs against the State of the Netherlands. The judge directed the State to cut greenhouse gas emissions by at least 25 per cent below 1990 levels by 2020. Here the main consideration being that

> "The State must do more to avert the imminent danger caused by climate change, also in view of its duty of care to protect and improve the living environment,"

in recognition of the fact that human beings are adversely affected by climate change, (Case /09/456689 / HA ZA 13-1396).

What is necessary is a worldwide commitment to strive towards sustainability and inclusiveness. This is perhaps best illustrated by the Oxfam doughnut image by Kate Raworth: it consists of double ring, the outer ring housing the planetary boundaries, defining the safe and just operating space for humanity, while the inner circle contains the social and economic requirements. Significantly food and water are located at the top of the figure. The safe space where humanity ought to have its abode lies between the physical and social fields.

Acronyms and what they stand for:

Acronym	Full expression
CFC	Chlorofluorocarbon
CO_2	Carbon Dioxide
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organization
GM	Genetic Modification
HCFC	Hydrochlorofluorocarbon
ICESCR	International Covenant on Economic, Social and Cultural Rights
IUCN	International Union for the Conservation of Nature
NOAA	National Oceanographic and Atmospheric Administration
NASA	National Aeronautics and Space Administration
NGO	Non Governmental Organization
PB	Planetary Boundaries
pH	Potential of Hydrogen - measure of acidity
PNAS	Proceedings of the National Academy of Sciences
UN	United Nations
UNDP	United Nations Development Programme
UV	Ultra-violet

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Appendix

Interview and survey data presented in table form

a) **Interviews at 'Breaking the Frame' meeting, July 2015**

Aware of Planetary boundaries framework	Unaware of Planetary Boundaries framework	Heard of Planetary Boundaries, but unsure what they stand for	Think the PB framework is relevant to the Right to Food	Thinks it is not relevant	No opinion or unsure whether it is relevant	Unaware of PB framework but think it may be relevant to the Right to Food framework, but	Totals
13	12	3	10	1	15	2	28

b) **Online survey data**

Aware of Planetary boundaries framework	Unaware of Planetary Boundaries framework	Heard of Planetary Boundaries, but unsure what they stand for	Think the PB framework is relevant to the Right to Food	Thinks it is not relevant	No opinion or unsure whether it is relevant (or square left blank)	Unaware of PB framework but think it may be relevant to the Right to Food framework, but	Totals
38	23	4	38	1	15	11	65