Dr Mathis Wackernagel

Measure What You Treasure: From the global Ecological Footprint to that of North-Rhine Westphalia

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We go to the refrigerator and it's full. Our shopping centres are even fuller, with an overwhelming range of products. And at the holiday party, the conference dinner or the hotel breakfast, there is the infinitely inviting buffet. It takes everything we have to convince ourselves not to have another croissant, another salmon roll, another sausage or some more Black Forest cake. We fight against the temptations of constant excess – but in reality our global resource situation looks very different. This excess goes hand in hand with the global overexploitation of our planet. How exactly? And what does it mean for us?

It's easy to measure things in terms of money: Every company listed on the German Share Index (DAX) has a market value, every public transport ticket has a fare, every commodity has a price tag. But what is the cost our need for goods and services produced and consumed daily, in another, crucial currency – that is, environmentally? The answers to these questions enable us to carry out a kind of ecological accounting. We call it the Ecological Footprint. This kind of accounting provides answers to fundamental questions: How much nature do we need, and how much do we have? We measure nature's supply on the basis of its biologically productive land area – its biocapacity. What is the world's biocapacity? What is Germany's or North-Rhine Westphalia's share of it? The Footprint is the demand we place on nature. It provides us with answers to questions such as: How much biocapacity does it take to provide us with everything that we use in our lives?

Obviously, this kind of resource accounting does not measure every aspect of sustainability, but it illuminates a necessary, quantitative bottom-line condition for sustainability: how much a state, a nation or humanity requires overall in comparison with what nature can regenerate. This kind of knowledge is crucial for understanding a population's sustainability situation. This is why North-Rhine Westphalia chose to focus on examining its overarching demand on nature, and called in an international team of scientists from Global Footprint Network to measure its Footprint.

Global Footprint Network
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"We at Global Footprint Network are convinced that it is possible for everybody on this planet to thrive. But in order for that to become a reality, we have to take resource security seriously. The environment also has a budget."

Ecological Footprint: The Ecological Footprint is an accounting system that shows how much biologically productive land and water area an individual or a population uses to produce all of the resources it consumes and to absorb the waste it produces. The Footprint of a country or region quantifies the environmental impact of the way a population consumes products and energy, regardless of where it takes place in the world, thus taking into account both imports and exports.

Biocapacity: Biocapacity quantifies an ecosystem's ability to produce biologically useful material and to absorb the waste produced by humans under today's prevailing technology. It is calculated by multiplying the amount of land actually available by what are referred to as yield and equivalence factors. We can use these to convert differences in productivity within a certain land-use category in different countries, as well as different land-use categories such as cropland or forest, into global hectares.

Global hectare: The central unit of measurement for the Footprint and biocapacity is the global hectare (gha). This "single currency" accounts for different levels of fertility in different soils, as land in a cropland area is able to produce more than the same surface area in a semi-desert. The gha is a surface area of 100 meters by 100 meters with average global productivity. This standardized measurement unit enables us to compare different countries and regions worldwide.

Carbon Footprint: The carbon Footprint (CO_2 Footprint) refers to the biocapacity that is required in the form of forest land to sequester all CO_2 emissions minus the emissions that are sequestered by the oceans. The amount of land needed reflects the amount of land required to burn fossil fuels.

Global Footprint Network Glossary
www.umwelt2016.nrw.de/002

Methodology: The calculations for North-Rhine Westphalia are based on the current data and methods of the National Footprint Accounts 2016. The basis for this was a high-resolution input-output model used to analyze the flow of goods and services, from which a consumption and land-use matrix was derived for Germany. This, in turn, was adjusted using an abundance of state-specific data, for example using remote sensing data, overall economic calculations, emissions inventories, census data, energy balances, traffic statistics, information about the way food is consumed, regional heating behavior and much more.

How we measure our resource consumption

Let's start with the supply side: Earth's surface measures 51 billion hectares. Three quarters of this area is barely biologically productive at all: deserts, high-altitude mountains, sheets of ice and open seas that are low in fish, as well as land that has been buried under infrastructure. Only about one quarter of the earth is biologically productive: cropland, grazing land, wetland, fishing grounds (in lakes and especially in the oceans' coastal waters) and forests. This adds up to a total of around 12 billion gha in credit. This is nature's supply we have to contend with.

This biocapacity of roughly 12 billion gha is the budget for humanity's Footprint. But human beings should not exploit the world's entire biocapacity as it also needs to serve wild species: whether it's the whales in the oceans, orangutans in tropical rain forests or the 43,000 species of animals and plants at home in North-Rhine Westphalia. The International Union for the Conservation of Nature and Natural Resources (IUCN), which maintains the international Red List of Threatened Species for animals and plants, estimates that, at the moment, only around 15% of the world's landmass and 10% of its coastal waters are protected, representing possibly far less than 10 percent of the biocapacity since much of it is area with low productivity. In his book "Half-Earth: Our Planet's Fight for Life," Edward O. Wilson, an expert in the field of biodiversity, calls for us to leave half of the earth exclusively to wild animal and plants species in order to preserve biological diversity as an important foundation of human welfare.

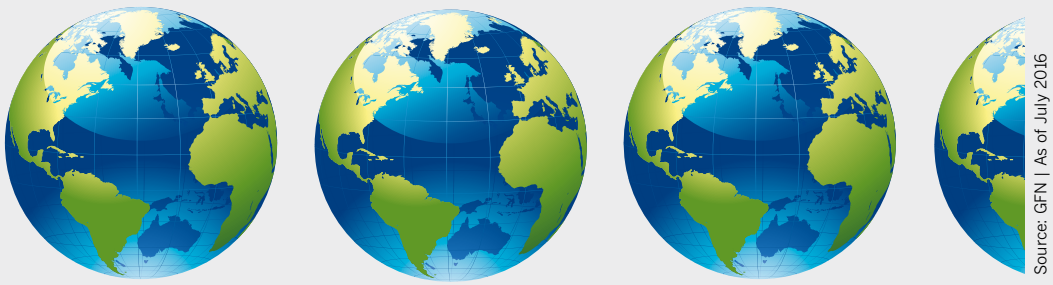
With a global population of more than 7 billion people, biocapacity currently averages at roughly 1.7 gha per capita. Germany has 2.3 gha of biocapacity per capita. Ecologically speaking, in spite of its high financial earnings, Switzerland is comparatively poor, with 1.3 gha of biocapacity per capita. In comparison, France has a biocapacity of 3.1 gha per capita. Sparsely populated but relatively dry Australia has as much as 16.6 gha per capita. And North-Rhine Westphalia? Its biocapacity is significantly lower than the global average and is currently only 1.1 gha per capita due to its comparatively high population density of more than 500 inhabitants per square kilometre.

How much biocapacity on average does a human being living in North-Rhine Westphalia need today? To calculate the Ecological Footprint, we have to take into account all of the materials consumed in the state, including food, raw materials, energy, car kilometres, and products such as cell phones and clothing. We also must consider all of the resulting waste and emissions – especially emissions of carbon dioxide (CO_2) from fossil fuels, and from providing the corresponding residential areas and traffic infrastructure. We also consider the Rhine and the Ruhr, which are natural resources that account for part of this consumption and waste absorption. Taking all these variables into account allows us to determine that North-Rhine Westphalia has an Ecological Footprint of 5.8 gha per capita, according to most recent figures. Annualized, North-Rhine Westphalia is only able to cover 68 days of its requirements with its own ecosystems or biocapacity. This means that North-Rhine Westphalia has already exhausted its "eco-budget" for the year by March 8. The state runs a significant "ecological deficit."

In 2012, North-Rhine Westphalia's Footprint was roughly 9% higher than the German federal average of 5.3 gha per capita. At the same time, biocapacity in North-Rhine Westphalia in 2012 was less than the federal average of 2.3 gha per capita, dropping by about 53% – and was about 38% below the biocapacity available globally of 1.7 gha per capita. North-Rhine Westphalia's "ecological deficit," based on the state's available biocapacity of 1.1 gha and consumption of 5.8 gha per capita, was therefore 4.7 gha per capita in 2012. This means that the North-Rhine Westphalian Footprint was 5.4 times larger than the biocapacity available in the state. It was also 3.3 times higher than the biocapacity available globally per capita. In 2012, it would have taken the biocapacity of more than three earths to enable the global population to live the lifestyle of North-Rhine Westphalians (see figures 1 to 7).

The Ecological Footprint of Nations
www.umwelt2016.nrw.de/003

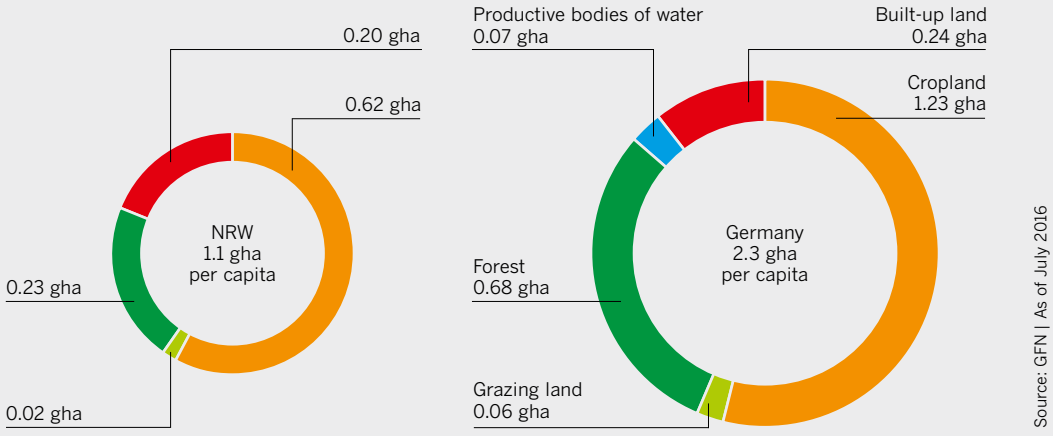
Figure 1 **The North-Rhine Westphalian Footprint, projected onto the global population in 2012**



Source: GFN | As of July 2016

Based on a global population of roughly 7 billion people, the results of the most recent data collected by Global Footprint Network showed an average Footprint of 2.8 gha per capita with a biocapacity of 1.7 gha per capita. Annual consumption amounted to a total of about 1.6 times what is renewed during the course of one year. The figures calculated for North-Rhine Westphalia with the living standards of a industrialized country with high incomes are even larger: If all of the world's 7 billion people led a North-Rhine Westphalian lifestyle with its current levels of resource consumption and its energy mix, we would need about 3.3 earths in the long term.

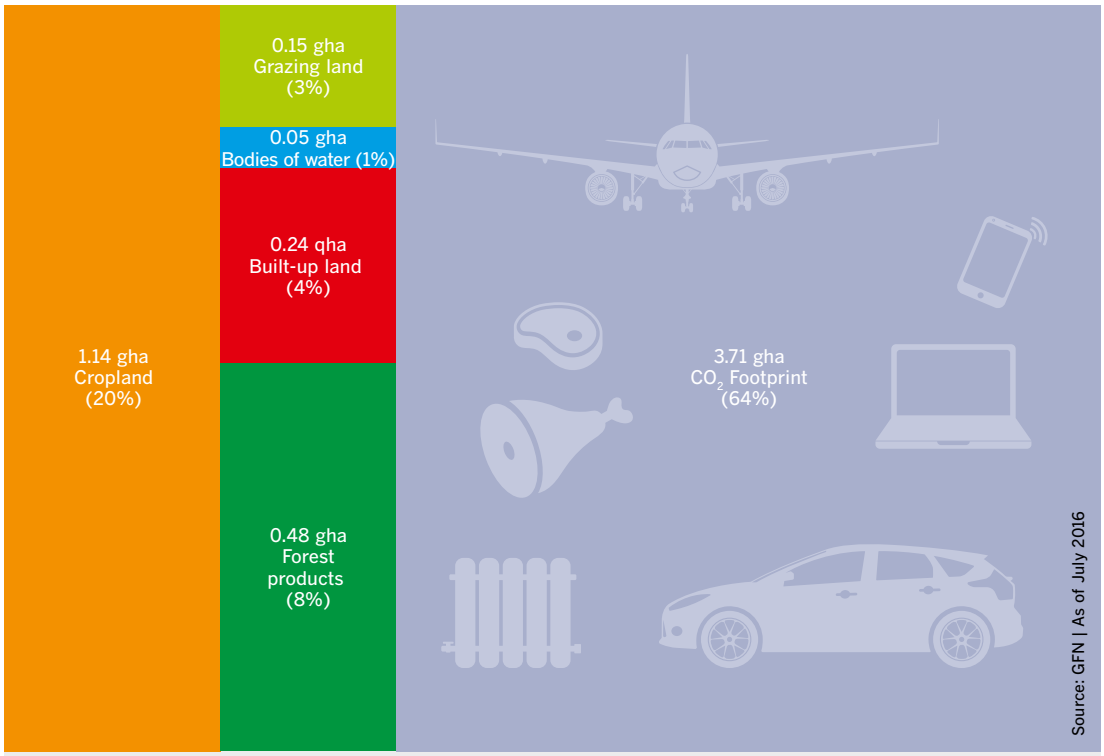
Figure 2 **Biocapacity per capita for NRW and Germany by land-use category in 2012**



Source: GFN | As of July 2016

Germany had a biocapacity – ecosystems able to produce biologically useful material and to absorb the waste produced by people including CO_2 – of around 2.3 gha per capita. North-Rhine Westphalia's biocapacity, on the other hand, amounted to around 1.1 gha per capita, partially due to its population density which, at 500 inhabitants per square kilometer, is more than twice that of Germany as a whole. The largest share was comprised by cropland and grazing land at a combined 0.64 gha per capita (48% of land area is agricultural land), followed by the forest category at 0.23 gha per capita (for forest products and CO_2 sequestration). A similar area is occupied by built-up land and infrastructure at 0.20 gha per capita. North Rhine Westphalia does not have any noteworthy productive bodies of water.

Figure 3 NRW Footprint per capita by land-use category in 2012



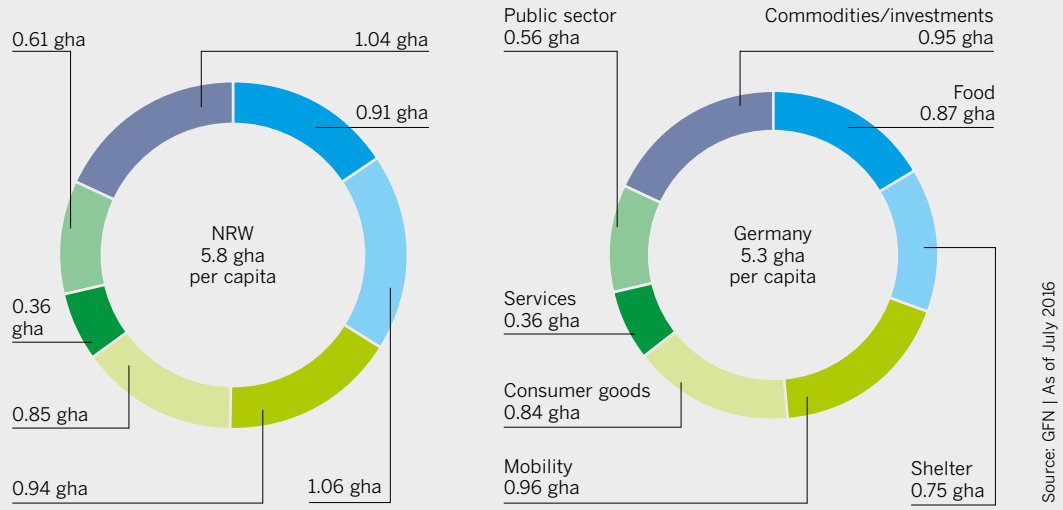
A Footprint of around 5.8 gha per capita for North-Rhine Westphalia is represented here by surfaces sized in proportion to each category's share. The breakdown by land-use categories shows that, at 3.7 gha per capita, 64% corresponds to the CO_2 Footprint alone: land for the sequestration of CO_2 emissions caused by the combustion of fossil fuels for power, heating, mobility and consumption (estimated in the form of forest land needed to sequester the CO_2). There is great potential here to reduce the Footprint (climate mitigation). The second largest portion is "cropland" at 1.1 gha per capita for food, animal feed and clothes fibers. The third largest is forest area for extracting wood.

This places North-Rhine Westphalia in the upper-third of European Footprints. At the same time, North-Rhine Westphalia performs similarly to the German federal average in all aspects of consumption – with the exception of energy use. The reason for its large Footprint and less favourable results when compared with Germany overall is, in particular, the energy mix in North-Rhine Westphalia, or more specifically its carbon intensity of electricity. Electricity in North-Rhine Westphalia is often generated with carbon intensive lignite and stone coal.

Can we afford to live like kings?

North-Rhine Westphalia needs more than five times the amount of resources that its own ecosystems are able to renew. Why do we care? North-Rhine Westphalia is a strong economic power and can use its money to buy what it does not have from elsewhere. The greenhouse gases that it emits into the Earth's atmosphere only incur seemingly negligible costs since we do not pay monetarily for CO_2 emissions. But for how long? North-Rhine Westphalia is competing with the rest of the world: The global Ecological Footprint is 2.8 gha per capita with a biocapacity of 1.7 gha per capita. This means that the world's citizens are now using roughly 60% more than they have available in the long term or that the Earth can regenerate. The competition for resource access might increase, or lead to disruptions in supply chains. This global over-demand leads to increases in CO_2 in the atmosphere, the depletion of groundwater reserves, overexploited soils, or the disappearance of tropical rain forests.

Figure 4 NRW and German Footprints per capita by consumption category in 2012



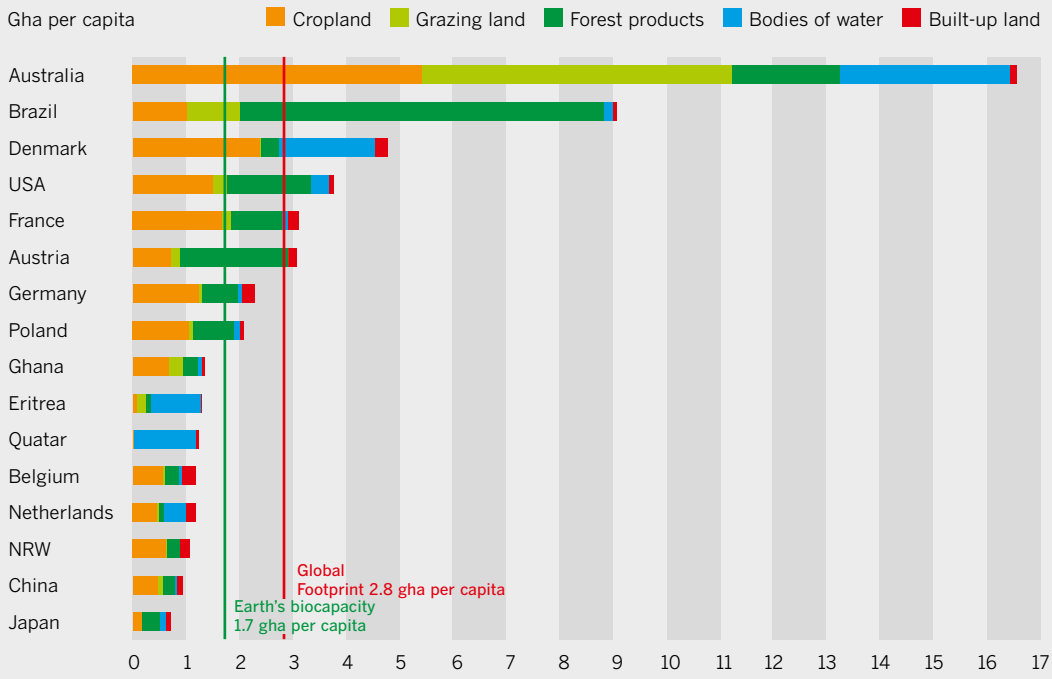
The categories food, shelter, mobility, consumer goods and services add up to around 4.1 gha per capita for North-Rhine Westphalia; the impact of the public sector and commodities/investments adds up to 1.7 gha per capita. In comparison to Germany's Footprint of 5.3 gha per capita, the 41% difference in shelter is striking, due to North-Rhine Westphalias unfavorable, coal-heavy energy mix with a larger CO_2 Footprint per kilowatt hour of electricity. Important factors with high savings potential include the consumption of meat and animal-based products that can contribute up to 75% of food; power and heating, which constitute almost 90% of shelter; fuel-burning combustion engines in the "mobility" category; and lifestyles shaped by consumption.

It remains to be seen where North-Rhine Westphalia will turn to import all of the resources necessary to maintain its current lifestyles in the future. For mathematical reasons, not all states can import more than they export. Also, because, supplies of land and raw materials are limited, growing demand will increase competition for those natural resources. The portion of the world's income that a German or North-Rhine Westphalia resident captures has been decreasing rapidly, as incomes are growing faster in emerging markets such as Germany or Brazil. Today, Germany's average share of global earnings is only half of what it was 35 years ago. Given the large resource dependence of Germany vis-à-vis the world, shrinking relative income combined with a large ecological deficit could become a risk for Germany – and thus, for North-Rhine Westphalia.

The setting of the two-degree Celsius goal at the World Climate Summit in Paris on December 12, 2015, represented an implicit resolution to entirely abandon the use of fossil energies well before 2050. Globally, the remaining CO_2 budget available in order not to miss the two-degree target is significantly less than 800 Gt of CO_2 emissions (which is about 20 years of humanity's current CO_2 emissions). Although humanity will most likely have less biocapacity available in a world two degrees Celsius warmer, it would have even less biocapacity available in the future if it accelerates climate change through "business as usual" economics. For instance, if we continue to use fossil fuels without significant restraint, we stand the risk of losing much more biocapacity. If we prolong the age of coal and oil, extreme climate change and its consequences will significantly weaken the globe's biocapacity.

The Paris Agreement was initially signed by 190 countries, confirmed by most of them on April 22, 2016, and enacted on November 4 2016. In spite of its clarity, there is almost no country that is preparing itself quickly enough for a significantly "scarcer" world. Economic strategies are being laid out as if resource security could last forever. The situation is often played down in a fatalistic manner by people who interpret our resource and climate challenge as a diffuse, global tragedy, believing that we as individuals or even as a significant, industrialized country cannot deal with this resource challenge on our own.

Figure 5 Biocapacity of select nations (with populations of over 2 million) and NRW per capita in 2012



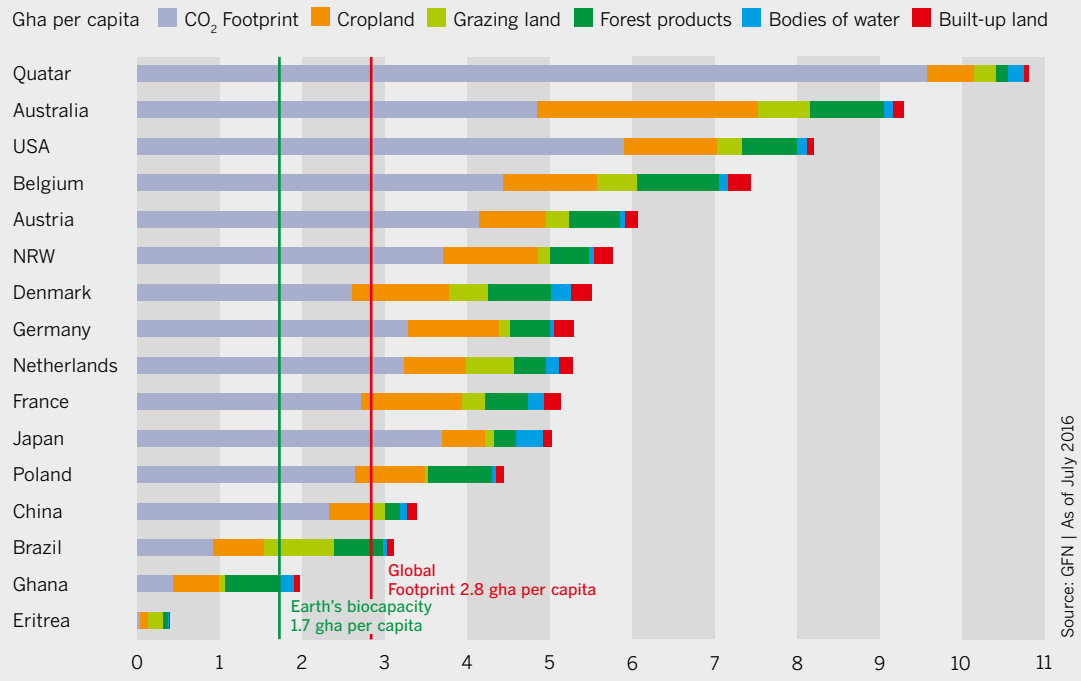
Australia, with its sparse population of 4 inhabitants per square kilometer, has a biocapacity of around 16.6 gha per capita, putting it in second place globally behind Bolivia with 16.7 gha per capita, a country that is criss-crossed by the Andes, by savannas and rain forests (Footprint 3.0 gha per capita). The island nation of Japan has the lowest biocapacity in the diagram at 0.7 gha per capita (population density roughly 335 inhabitants per square kilometer). But worldwide, the two countries in last place are Jordan in the Middle East with its high proportion of dessert and a biocapacity of 0.2 gha per capita (Footprint 2.1 gha per capita) and Singapore – the South-East Asian nation with more super-rich citizens than anywhere else – with 0.1 gha per capita (Footprint 8.0 gha per capita).

An example: How is my native country, Switzerland, reacting?

It's not as if there wasn't enough information available or enough awareness of the risks. North-Rhine Westphalia is not the first state to measure and report its Footprint. The Swiss Federal Statistical Offices tested the Ecological Footprint calculations for the first time in 2006, and published recently that, in 2012, Switzerland's Ecological Footprint was 5.8 gha per Swiss citizen, or four times that of Switzerland's biocapacity of 1.3 gha per capita. 3.3 Earths would be required for everybody to live like the Swiss. This ecological deficit cannot be maintained in the long term, especially in light of rapid income and demand growth in China and India. And pressure will increase even more as the global population continues to grow.

The Swiss Federal Councillor Doris Leuthard, heading Environment, Transport, Energy and Communication, makes reference to the Footprint in her speeches. In spite of this, the Swiss Federal Chancellery asked us if one-planet living – or the goal of living with a Footprint that can be replicated worldwide – is "realistic." But the much more essential question is whether living on the equivalent of three planets is "realistic." On September 25, 2016, the Swiss population voted on a popular referendum that proposed to establish a "Green Economy." Its goal was to lower the Swiss Footprint to a "one earth" level by 2050 (currently, that would mean less than 1.7 gha per capita). At the end of the day, 36% of the voting public did vote in favor of this proposition.

Figure 6 Footprints of select nations (over 2 million residents) and NRW per capita in 2012



The emirate of Qatar on the Arabian Peninsula, which has become incredibly rich from its oil reserves, has the world's largest Footprint at 10.8 gha per capita (with one third of the land area of North-Rhine Westphalia), followed by Australia with 9.3 gha per capita and the U.S. with 8.2 gha per capita. Tailing the bunch worldwide is Eritrea in North Africa at 0.4 gha per capita, a country shaped by poverty and political challenges. Within a reasonable margin of error, Germany is basically on par with neighboring countries like Austria, Denmark, the Netherlands and France. The global Footprint was 2.8 gha per capita. If the average Footprint was less than 1.7 gha per capita, humanity would be using the entire capacity of the planet. To leave capacity for wild species, the average Footprint would therefore need to be even lower.

Raising basic questions and showing that one-planet living is possible!

Just as the Fifth Assessment Report of the UN's Intergovernmental Panel on Climate Change (IPCC) documented that a corresponding reduction would be practicable for maintaining the two-degree goal, the World Business Council for Sustainable Development's Paper Vision 2050 is showing us ways in which we can achieve Footprint reductions on a global scale that are in line with the Earth's biocapacity. Scenarios like this focus heavily on human potential for innovation and technical advancement. Idly sitting by and letting the resource situation get out of hand would, on the other hand, mean an inevitable global resource collapse and social chaos.

Synthesis Report of the Fifth IPCC Assessment Report
www.umwelt2016.nrw.de/004

Vision 2050 – The New Agenda for Business
www.umwelt2016.nrw.de/005

We at Global Footprint Network are convinced that it is possible for everybody on this planet to thrive. But in order for this to become a reality, we have to take resource security seriously. The environment also has a budget. For this reason, promoting this topic and working together with decision makers is Global Footprint Network's "raison d'être," its core purpose.

One obstacle preventing people from understanding the Footprint could be that they can't or don't want to believe our figures of. There are also critics who are bothered by the Ecological Footprint. It is not always clear if they are upset by our views or if they think that our methods are not insightful. But ultimately, everybody has to ask themselves two fundamental questions: What do we have to know about current conditions in order to ensure the quality of our lives and economies in the future? And, how significant is resource security as a parameter for long-term prosperity?

The answers are easier than we think: We human beings, with our food, our consumption and our lifestyles, require resources. Even the manufacturing of ecological flagship products like the classic bike requires resources. Resource security is a significant statistical value.

Not all resources have to be available locally, as, ultimately, there is also foreign trade. But, worldwide, we cannot all be net importers. And if our earnings are not higher than those of other countries, it becomes less and less likely that we will be able to continue buying resources from others. Biocapacity is a limiting factor in a world where burning fossil fuels such as coal, gas and oil – still our most frequently used sources of energy – is limited due to the biosphere's (in)ability to absorb them. We humans, and all other species, are competing for productive land. People use it for the production of food, animal feed, plant fibers and wood, sequestration areas for carbon dioxide, urban use and biodiversity.

What do the Footprint results tell us?

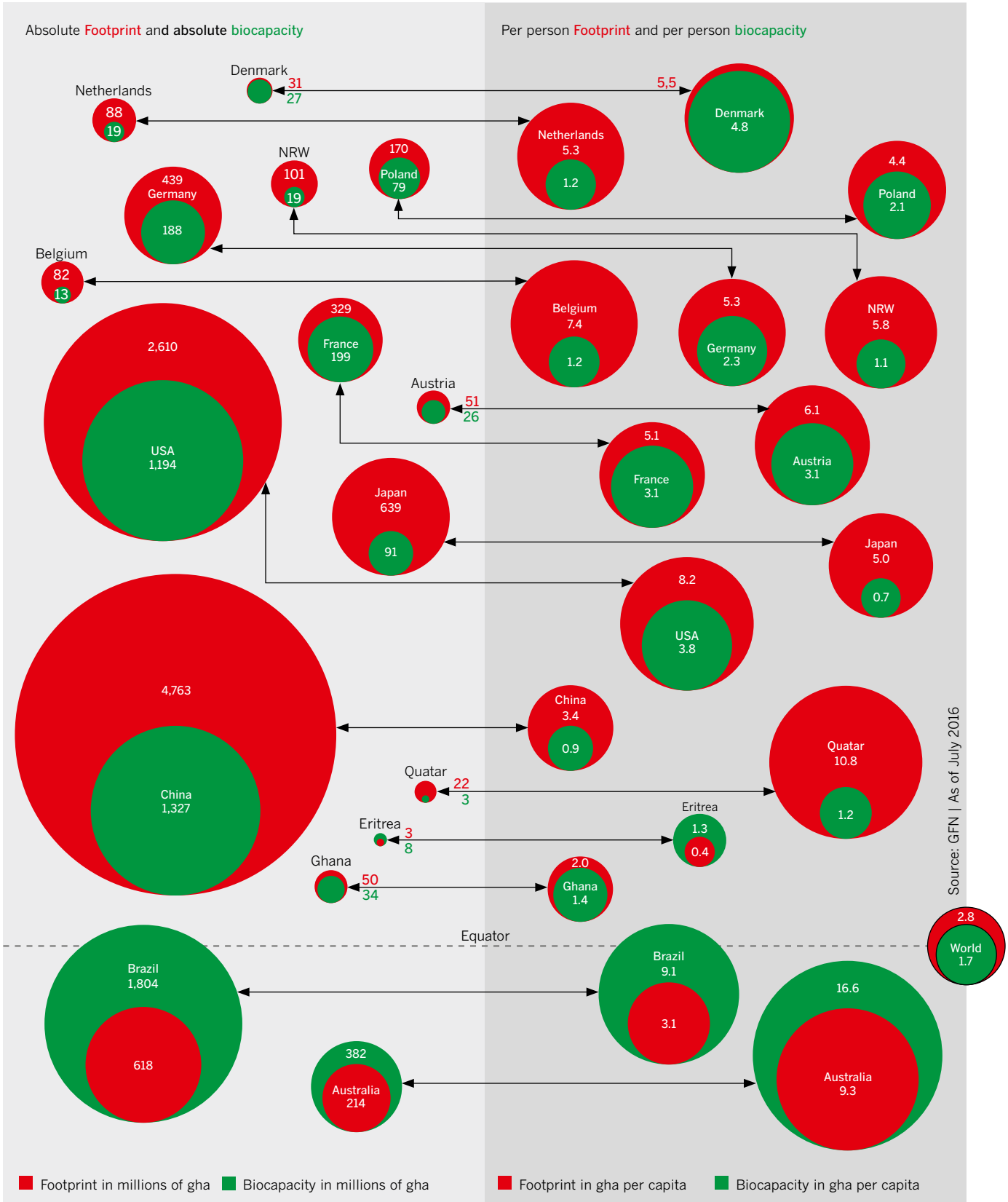
Does the Footprint tell us all we need to know about sustainability? No, it only provides us with a size comparison of human consumption relative to the environment's regenerative capacity. Does it tell us if ecological farming is better than conventional farming? No, at least not here in this brief analysis. Does the Footprint precisely describe the amount of resources that we over-exploit? No, it is primarily a conservative estimate. The Footprint does not describe all factors exactly. In particular, biocapacity is probably portrayed too optimistically, as many kinds of over-exploitation are not included due to a lack of reliable data. Examples are activities that lead to land degradation, loss of freshwater reserves, eutrophication of groundwater, or depletion of soils. This means that – even if over a billion data points go into our global National Footprint Accounts – the Footprint ultimately remains a simplified observation.

To evaluate some of the criticism directed toward the Ecological Footprint, I recommend considering the following chain of four questions: 1) Are you critical because the Footprint assessment does not build upon a clearly enough defined research question? 2) If that is not the problem, is the question not sufficiently relevant? 3) If that is not the problem, are there more precise methods available to give you a better answer to this question? 4) If that is not the problem, are the results just so misleading that society would be better off without these results?

My answers to these four points are: Yes, the Footprint's indicators build upon a clear question: how much productive land does a population use compared to how much productive area is available? Yes, it is a relevant question: if we consume more than what nature can renew it leads inevitably to over-exploitation and ecological deterioration, ultimately undermining our economies' ability to operate. No, there are no other methods available yet that provide sharper and more precise answers to the research questions. Or at least, I do not know of any better assessment than the Footprint, and would be eager to learn about them. And no, the results of the Footprint are not misleading. The results of the Global Footprint Network's accounts are consistent and coherent, even if national estimates may have an accuracy of +/-20%. The over-exploitation of the planet is at least 60% above Earth ability to renew. In the case of North-Rhine Westphalia, its Footprint demand exceeds its biocapacity by 440%, meaning that even deviations of +/-20% do not significantly change the conclusions of the results.

In my opinion, this leads to the following questions for North-Rhine Westphalia: NRW requires 5.4 times as much as its own ecosystems can yield. Is this a significant risk for North-Rhine Westphalia, particularly in light of the fact that humanity's demand is already exceeding the planet's rate of renewal by more than 60%? Is it a top-100 risk or a top-5 risk? How quickly can North-Rhine Westphalia adjust its consumption patterns to new global conditions, if it needs to? And what happens if it does not manage to do this quickly enough?

Figure 7 Footprints of select nations and NRW in total and per capita in 2012



The left half shows the total Footprint and biocapacity of select countries to scale in million gha. Here you can see the contributions made to the global Footprint and to the biocapacity available worldwide. The right half visualizes the per person Footprints for these countries and the whole world, as well as their respective biocapacity in gha per capita. This is where it becomes clear how much is available for each individual on average – and therefore in total for all nations on the planet. This diagram also reveals ecological deficits (red circle outside) and reserves (green circle outside). In addition to this, it shows how problematic discussions can be if they only deal with total per country figures and do not mention per-capita figures.