Greenwashing & high tech!

FAKING IT: (UN-)SUSTAINABLE SOLUTIONS FOR AGRICULTURE

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PREFACE MARTIN HÄUSLING

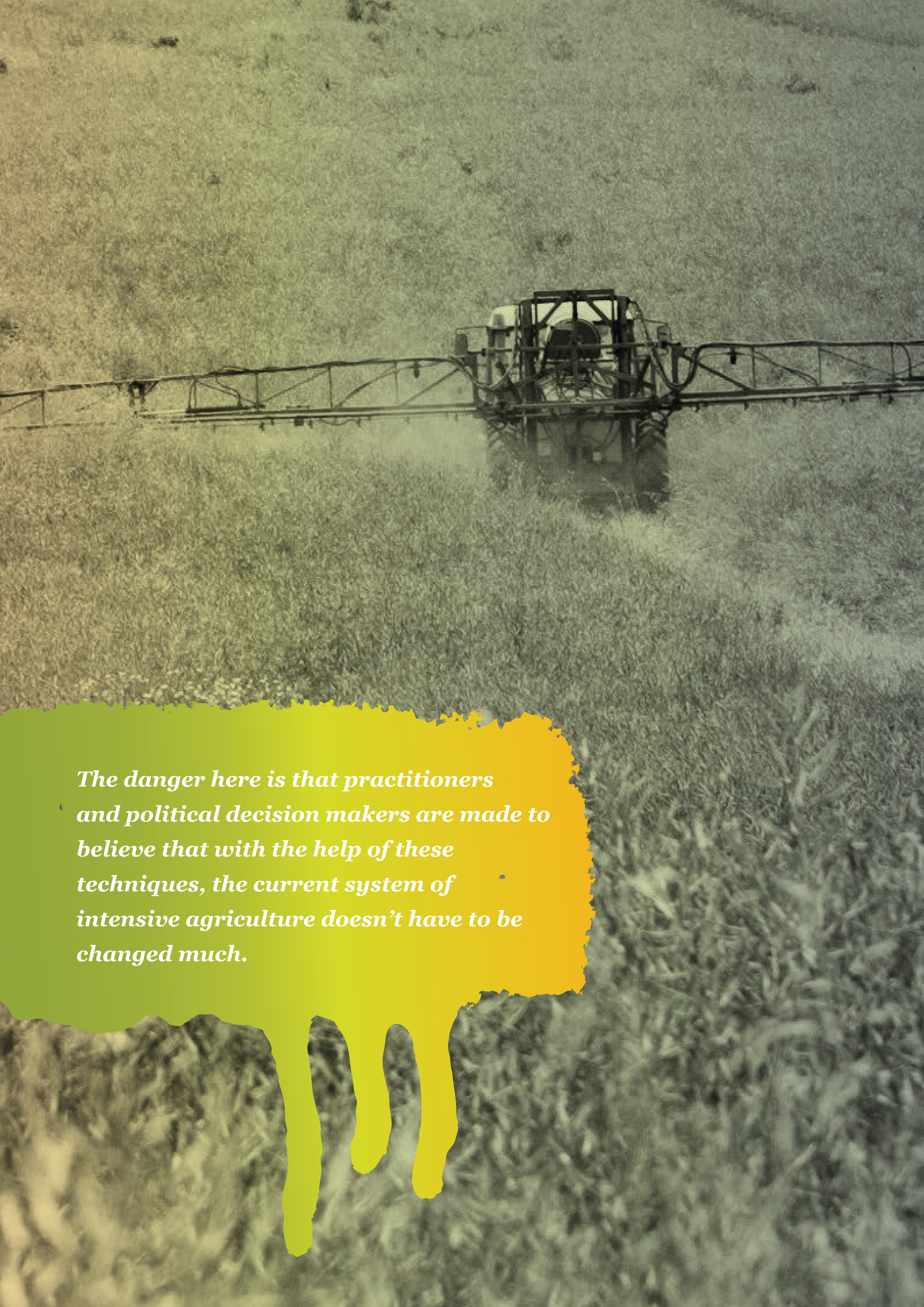
The climate crisis and species extinction are the biggest challenges for agriculture at present. Every study and international report correctly says: agriculture is both, perpetrator and victim. The vast majority of international and European scientists agree that the manner in which we farm has to change fundamentally. It is uncontested that intensive animal agriculture and intensive nitrogen fertilisation are harming the climate and that monocultures and high pesticide use contribute significantly to species extinction.

The obvious solution would be to promote agricultural systems which, by definition, rear animals less intensively and use far less synthetic nitrogen and fewer pesticides and thereby are proven to allow for more biodiversity as well as lower nitrogen levels in water courses – systems such as organic agriculture. But instead something strange happens: new, supposedly innovative techniques keep cropping up and find their way into political policy papers even though they have nowhere near the same synergetic potential for positive effects on the agroecosystem.

On the contrary: what has been proven to be correct, sometimes for years and is relatively obvious even for most interested lay people: techniques such as no-till agriculture, precision agriculture, biomass use, indoor farming or genetic engineering positively impact only a fraction, if any, of the underlying problems. At times, negative impacts have been documented or are considered probable. Really astonishing is the fact that these techniques are regarded as THE innovative solutions even though their negative impact has been widely documented.

As critical questions and negative consequences very often will not be discussed outside of expert circles, I am really excited about this study. The author, Andrea Beste, takes a closer look at several of the current, hotly discussed "sustainability solutions" and comes to the conclusion: "this is fake sustainability".

Have fun reading, and hopefully some interesting insights, too!



The danger here is that practitioners and political decision makers are made to believe that with the help of these techniques, the current system of intensive agriculture doesn't have to be changed much.

Introduction

Even though it has been clear for many years that conventional agricultural systems in Europe are unsustainable and need to be fundamentally changed[1], time and again attempts are made to promote techniques or products addressing only parts of the system as the big solution. Every few years, a new super-technology is making headlines and soon finds its way into all kinds of political strategy papers. Again and again, something is hailed as a breakthrough for sustainability, even if the effects are much overrated and, at times, not yet backed up by research.

Rather than being sustainable, some of these techniques and products are even harmful. Others are beneficial, but only have a very limited scope and a much lower positive impact than is being claimed. And still others would be useful as part of a system change, but they do not turn agriculture per se into a sustainable technology - often the claims of sustainability are simply fake.

What the technologies and products discussed here have in common is that in their evaluation the systemic context is often neglected and they fail to deliver the overpromised benefits for sustainability they supposedly have. We know this from product advertisement where it is considered to be normal. We've become used to it long ago. But when it comes to changing the way we live on planet earth, so that future generations, too, can live here in some comfort, we definitely don't need products sold through glossy brochures, instead we need to develop technologies that really work. As far as possible, the focus should be on scientific neutrality and diligence and not on positivistic product research and praise. This is not about marketing, it's about keeping planet earth inhabitable and achieving the goal of letting no one go hungry without exhausting and destroying our resources!

What's below the surface?

Often, it's not the advertised techniques themselves that are dangerous. What's dangerous is that practitioners and policy-makers are led to believe that with these techniques the current system of intensive agriculture doesn't really have to be changed much. Time and again, the thus promoted techniques contribute to excuses being made for not investing into well-known considerably more sustainable concepts and systems. One example is the so-called "climate smart agriculture". The pesticide industry in particular invests heavily into advertising "climate protection strategies" and "regenerative agriculture" or "carbon farming"[2]. Bayer for example promotes its "smart field" strategy[3]: *" Digitalization in farming can help us deploy our resources efficiently and sustainably, enabling farmers to get the best out of their fields with minimal environmental impact."*

Tech fixes:

Pseudo-sustainable techniques which help to maintain the obsolete and inefficient model of intensive industrial agriculture with its high energy needs and high fertiliser and pesticide inputs.

If one takes this dazzling, "green" sounding rhetoric seriously, research money, funding and advisory capacities will continue to go towards pseudo-sustainable techniques which help to maintain the obsolete and inefficient model of intensive industrial agriculture with its high energy needs and high fertiliser and pesticide inputs. These are tech fixes rather than a system change – with fatal consequences for our ecosystems, our animals and our societal common good.

What you are about to read aims to deflate some of the over exaggerated claims which are made for certain technologies which, supposedly, achieve mega effects for sustainability. Very often, all that remains of one of these hot air balloons is a tiny piece of cloth.

„Precision farming" or „The emperor's new clothes"...

For about five years, the so-called "precision agriculture" has been promoted increasingly loudly and frequently. It is now listed next to agroforestry and agroecology among the eco-schemes recommended by the EU Commission for funding through the Common Agricultural Policy (CAP).

According to the Commission, eco-schemes should meet the following requirements:

- they should include activities related to climate, environment, animal welfare and antimicrobial resistance;
- their level of ambition must exceed the legal minimum requirements and obligations (conditionality).

In the following, we want to take a critical look at precision agriculture (also called "smart farming" or "precision farming") and assess whether it can fulfil the above criteria in regard to arable farming.

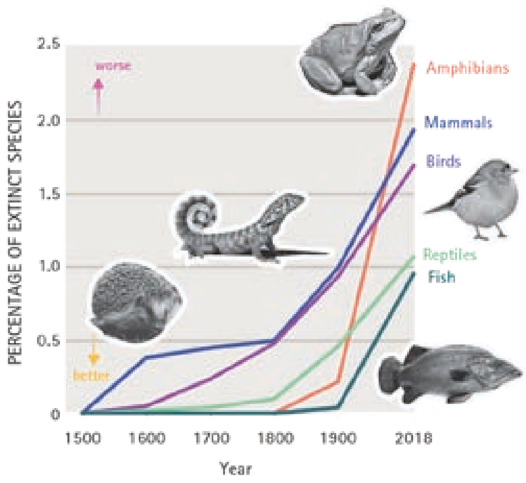
THE TWO BIGGEST THREATS: CLIMATE CHANGE AND EXTINCTION OF SPECIES

Climate change and species extinction are the world's most threatening challenges for securing our survival.

Climate change and species extinction are the world's most threatening challenges for securing our survival and therefore they are also the particular focus of the EU Commission's "Green Deal". Approximately 1.2 per cent of the world's energy consumption is needed for the manufacture of mineral fertiliser based on the Haber-Bosch synthesis for the production of ammonia from atmospheric nitrogen[4]. More than 90 percent of the fertiliser industry's energy needs go into this production[5]. In the agricultural production of many field crops as well as fruits and vegetables, more than a third of the energy consumed goes into the manufacture of agrochemicals (fertilisers and pesticides)[6]. In 2013, the German Federal Environment Agency included the greenhouse gas balance and found that for 2010, the GHG emissions for agriculture in Germany amounted to

13 percent[7] rather than seven percent of the emission total. In its report on climate and agriculture, the EU Court of Auditors criticises that the 100 billion Euros spent on climate protection measures during the last EU agricultural policy funding period achieved next to nothing[7a].

Species extinction is speeding up



Fertiliser production: Responsible for most GHG emissions in agriculture but largely forgotten in climate models.

In its final report in 2019[8], the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES, warned of a dramatic loss of species in the coming decades. The report identifies the changing nature of land use as the main driver for the loss of nature in Europe in particular. Their conclusion: in particular the loss of natural habitats and pollution through fertiliser use and pesticides, have led to conservation efforts often being in vain. Some scientists consider the loss of biodiversity to be worse than climate change[9].

„PRECISION FARMING" – A SOLUTION?

The purported solution repeatedly and loudly touted by many is the "digitalisation of agriculture" or so-called "precision farming". High tech on farmland is supposed to preserve climate and biodiversity. Sensors and drones are to let farmers know what is needed and where. Application technology should then accomplish the precise on demand delivery. While the lobbies for the agricultural machinery, the chemical and the seed industry are pushing for this technology to now be funded with CAP money, there is little discussion over what proof there is that these innovations indeed provide environmental services, who has access to these technologies and who controls the data. Now no one will object to fertiliser being applied more efficiently and fewer pesticides being used. But to what degree can precision farming actually help to achieve this? How effective are they really in making agriculture more sustainable? Is the exuberant advance praise justified?

16 methods and none can measure the organically bound phosphorus

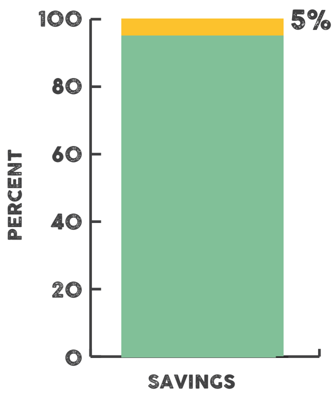
HIGH – TECH WITH PATCHY DATA COLLECTION

For example, by using colour-reading technology to evaluate chlorophyll in leaves, precision agriculture is to ensure a more efficient application of nitrogen fertiliser which should reduce the amounts of nitrogen fertiliser used and thus save GHG emissions. Measuring the leaf green provides an indirect and only relatively rough estimate on whether the plant receives sufficient nitrogen. Other soil parameters are even less precise: even today, humus content and quality in the soil, for example, cannot be measured satisfactorily over a wide area, and certainly not during a flyover. Up to now, there are no valid measurement methods for phosphorus that could serve as a data basis for a "precise" application: in Europe, for example, up to 16 different methods are used to measure the amount of phosphorus in soils. None of these 16 methods can be used to determine the total amount of plant-available phosphorus in the soil, as organically bound phosphorus cannot be measured. However, this can amount to between 25 to 65 percent of the phosphorus present in the soil[10]. In regard to humus and phosphorous content a "precise" satellite-controlled fertiliser system so far has only imprecise data to work with, and for sure none will be available in real time. The same remains true for many other soil factors, such as soil structure, for example. Up to now, scientifically speaking, there are "approximations", which is a far cry from "precision".

MINIMAL SAVINGS

Cultivation methods that don't use mineral fertilisers or synthetic pesticides have been known for quite a while, but now the hope rests on the potential of precision agriculture to support savings and deliver environment benefits. In 2018 the German Ministry for Agriculture (BMEL) published "Digitalisation in Agriculture. – Using Opportunities – Minimising Risks". The publication cites a BMEL funded impact assessment by the Thünen Federal Research Institute as follows:

"The greatest benefit of digitisation in agriculture lies in the potential increase in productivity through savings in man hours and farm inputs. Sustainability can be increased through reduced needs for fertiliser, pesticides, fuel and better animal welfare. The savings in fertiliser, pesticides and fuel identified so far lie in the low single-digit percentage range."[11]



Not a lot: precision agriculture delivers savings of pesticides and fertiliser < 5 percent

In regard to the environmental problems that scientists attribute to intensive fertiliser and pesticide use, savings in the low single-digit percentage range don't indicate a trend reversal. This may seem barely sensible in terms of efficiency, but a considerable amount of capital and technical expenditure is a necessary prerequisite for the reduction of just a few percentage points. The question is not only whether this makes sense environmentally, but financially, too.

By the way, the 2021 BMEL brochure with the same title does no longer contain the above quote and the reference to the impact assessment by the Thünen-Institut has been deleted. Quoting these figures doesn't fit the current political agenda, it seems.

However, even with the most precise application, if the number of animals isn't reduced, too, the question remains: what does a farmer do if, despite precision application, time and again slurry is left over? When there is too much slurry, it has to go somewhere.

And there is another problem that simply gets overlooked: even less or more accurately applied nitrogen fertiliser will pollute the soils if no sensible crop rotations are in place and if no high-quality organic fertilisers, such as compost (which cannot be given in small, precisely measured doses) is supplied to nourish soil life and build up humus. If the mix of nutrients isn't right, plants and soil ecology will be malnourished even if the wrong mix is more accurately dosed. The result is "precise malnutrition". The negative impact on the system remains the same. Plants that are intensively fertilised with nitrogen are susceptible to diseases and pests and require more "plant protection"[12].

What to do with the slurry if there are too many animals?

Measurements with remote controlled sensors are ill suited for diverse cropping systems

In regard to species diversity, sensor measurements have so far required very homogeneous crops, species diversity within the system, such as mixed crops, undersown crops, trees or hedges, have been rather disruptive. But it's the diversity in the system which is important for endangered species as well as beneficial insects. It promotes biological pest control which is a precondition for saving on the use of pesticides. That's a lot of technology with little effect to show for – which means the environmental balance isn't looking good. In addition, the rebound effect usually is not taken into account: employing technologies that help save resources make the use of the resources more profitable and incentivise an even more intensive use of the resource – which would be counterproductive.[12a]

So far, diversity scuppers sensor measuring. But it's that diversity that makes nature-based pest control possible.

Who holds the power of data?

Equipment paid for but only “on loan”?

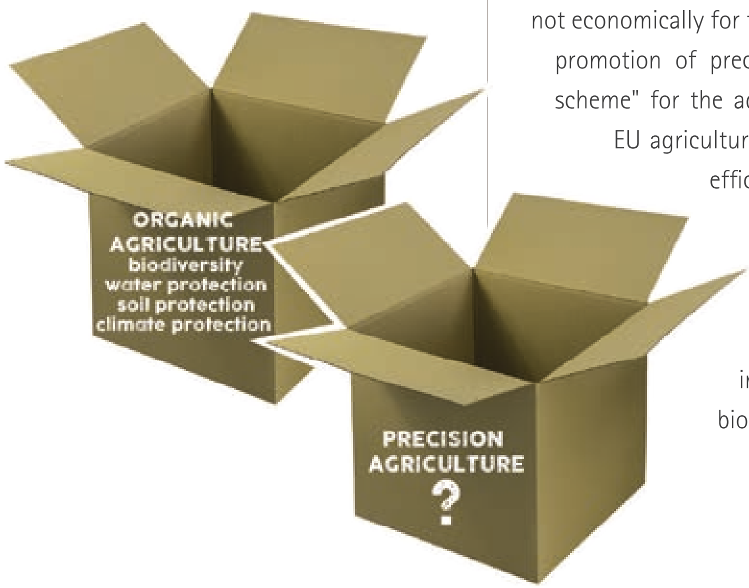
WHO CONTROLS THE „FUTURE TECHNOLOGIES“?

Additional questions in regard to the sovereignty of operational data need to be raised over terms such as “smart farming” and “big data”: Who has the rights to such data and who ultimately owns them? The past decade has seen a rapid development of start-ups in the digital agriculture sector. The market for precision and digital farming products is estimated to grow by 12 percent annually and will likely amount to 10 billion Euros by 2025. In 2013 for example, Monsanto bought Climate Corporation, a company that provides products for digital agriculture, for $1 billion, while Bayer has invested more than $200 million in the digital agriculture sector. Following the acquisition of Monsanto by Bayer, the company claims to have the world's leading platform for digital agriculture. Other major agriculture corporations, including global grain traders, agrochemical companies, the agricultural machinery industry and technology companies, are also investing in digital ag companies or buy them outright. Increasingly, the technology lies in the hands of the same global players who also dominate the markets for high-yielding seed varieties, fertilisers and pesticides markets.[13]

Scepticism is warranted as to whether suppliers with a major commitment to precision technology will take steps to significantly shrink the markets for their own products. In view of the sustainability discussion, there is good reason to assume that instead these companies will make efforts to secure their markets by declaring the use of such means of production as "smart", "precise", "efficient" and "sustainable". This new form of vertical integration also allows these corporations to extract farm data and use them to guide their product selection. The farmers are integrated into the company's value creation chain, which limits their technical flexibility. As in other sectors of the digital economy, "one-stop-shop" platforms are being created which offer farmers a comprehensive service package and thereby influence decisions in a targeted way. Already, the sovereignty over the data and the technical ownership no longer lies in the hands of the farmers. Example USA:

John Deere prevents farmers from repairing any equipment fitted with highly sophisticated software such as tractors, and forces them to hire outside contractors instead. The company argues, that farmers do not "own" their tractors, but only "acquired a licence to operate the vehicle "[14].

So far, neither precision nor potential savings merit the financial and technical expense, not economically for the farmers, nor in their contribution to sustainability. The massive promotion of precision agriculture and its recommendation as a suitable "eco-scheme" for the advancement of environmental services within the framework of EU agricultural policy is disproportionate to its (minimal) potential to provide efficient and targeted environmental services for climate protection and the conservation of biodiversity. The EU Commission's farm-to-fork strategy requires the expansion of organic farming systems but in that respect precision farming has little to offer. For many decades, organic farming has proven its sustainability in every relevant area of resource protection, from soil and water to biodiversity and climate[15].



There is always potential for improvement, but the positive impact on ecosystem services organic agriculture can already deliver today exceeds the potential of precision farming by a multiple. In its reminiscence of Hans Christian Andersen's "The Emperor's New Clothes"; precision agriculture seems more like a déjà vu and a throwback to childhood: the beautiful clothes only exist in the imagination.[16]

ADAPTING DIGITAL TECHNOLOGY

Of course, there are also application for digital technology that make absolute sense: parasitic wasps for biological pest control with the aid of drones or remote-controlled chopping robots can also be used in diversified systems. These are customised solutions with low technical, capital or data costs. Open source platforms for knowledge sharing and networking among practitioners worldwide are a very useful application of digital technology too – if the infrastructure is sufficient. By using such platforms, farmers become increasingly independent and autonomous in their judgement and depend less on the industry recommended timings for spraying and fertiliser applications which corporations use to keep product sales at a steady level.

Rather than further the costly digital upgrading in the field which adds little to a practitioner's knowledge about his agroecological system and the observation of ecological processes and, at worst impedes them, we should invest more into interlinking knowledge, sharing know-how and experience as well as communication with each other.

A little more humus building will not recapture all that's released into the air.

Carbon farming

„Carbon farming" is the new buzz word that is hotly discussed in the EU Commission, in ministries and chambers of agriculture across Europe and in many projects. With the adoption of the accounting rules for land use, land-use change and forestry (LULUCF) in 2017, greenhouse gas emissions (GHG) from these sectors should be included in the new EU energy and climate policy framework for the 2012-2030 period. They are to contribute to the EU goal of reducing greenhouse gas emissions by at least 55 percent by 2030, compared to 1990 levels. In this context, the EU Commission's Farm to Fork strategy supports CO_2-certificates for agriculture. In April 2021, the Commission published a paper, including guidelines, which describes in detail the areas that need to be taken into account, the shortcomings of measurement and the difficulties for implementing a fair and legally robust remuneration structure.

THE EU COMMISSION'S CARBON FARMING INITIATIVE

Regarding measurability and questions of legally protected remuneration, the paper comes to similarly critical assessments as the study by Wiesmeier et al. 2020. But while the Commission paper reaches the overall conclusion that CO_2-certificates for agriculture are feasible, the study by Wiesmeier concludes that they may not be such a good idea after all. One positive aspect of the EU Commission paper is that animal husbandry has been taken into consideration, even if only the management is taken into account and not the wider climate potential: the reduction of animal numbers. It is a positive that agroforestry systems feature prominently and that synergy effects, such as the promotion of biodiversity, water storage capacity and erosion protection are being considered. Nevertheless, the Commission prefers "outcome-based" models, which are fraught with considerable technical difficulties because the basis for payment is the measured carbon sequestration in the soil, over "action-based" models which base payments on the implementation of measures for climate change mitigation and adaptation (which also benefit many other ecosystem components), rather than measurements. The question as to why the Commission makes this choice remains unanswered.

GHG EMISSION REDUCTION HAS TO BE A PRIORITY

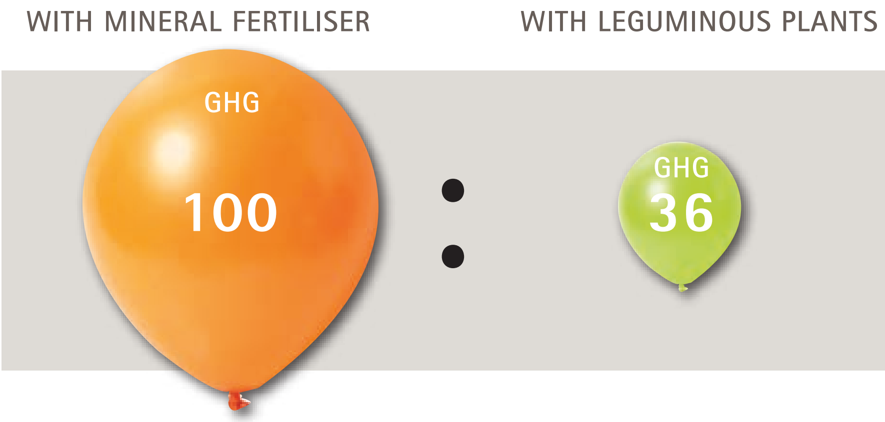
This much is certain: The exploitation of fossil carbon stores in solid or gaseous form (energy for industry, transport, heating, cooling, etc.) is responsible for the main share of greenhouse gases (GHG) in the atmosphere. According to the IPCC report on land use and the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD)[17], agriculture is a relevant driver, but also a dramatic victim of climate change. A little discussed fact is that agriculture's biggest contribution to climate change stems from the production and application of synthetic nitrogen fertilisers. Globally, the emissions from agriculture mainly caused by nitrogen inputs in arable production have increased by 30 percent over the past four decades[18].

If the use of mineral fertilisers were to be reduced in favour of nitrogen fixing legumes, greenhouse gas emissions through agriculture would be more than halved while simultaneously humus would be built. This is one of the reasons why N_2O emissions from organic agriculture are 40 percent lower[19].

EU Commission paper:

CO_2 sequestration in soils is unstable, difficult to measure and remuneration is legally uncertain.

Fabulous nevertheless?



The greenhouse gas potential of nitrogen fertilisation through leguminous plants compared to mineral fertiliser-based fertilisation is proportional to a ratio of 36 to 100.

Source: calculation by the author according to Robertson et al. 2000 in Köpke/Nemecek 2010

Photo: Idel

On pasture cattle are active climate protectors.

Another major way of adjustment is the reduction of animal numbers, linking animal numbers to the size of the area needed for self-feeding and the promotion of grazing. Because of the humus stored under grassland, grazing is of particular importance for climate protection. Apart from soils in permafrost regions, moor and grasslands contain most of the carbon sequestered in soil.

Protecting these biomes must be the top priority. Next to forests, grasslands are the largest biome on the planet and cover about 40 percent of the vegetated land surface[20]. Ruminants are essential for the protection of grassland, if it's not to deteriorate, grassland needs to be grazed, and the more regular the grazing the more humus is built. Against this backdrop, ruminants have to be assessed differently – it's not just about their methane emissions, on pasture ruminants are active climate protectors. In comparison with the use of mineral fertiliser, the assessment suddenly shifts significantly[21]. If they are intact, agricultural soils contribute substantially to the maintenance of our ecosystems. For that to happen they need a high humus content and an active soil life. But it cannot be the job of agriculture to 'capture' the greenhouse gasses emitted during industrial production and permanently store them in soils. An active soil life means humus build-up, but at the same time there will be continuous conversion and decomposition (which always releases CO_2 - the so-called "soil continuum model, SCM "[22]). Soils are not suited as permanent carbon stores.

CLIMATE RELEVANCE

During the 2015 UN Climate Change Conference in Paris a global programme to build humus was started, the 4 per mil initiative, which envisages an annual increase of global carbon stocks in soils by 4 per mil (= 0.4%). Supposedly, anthropogenic CO_2 emissions can be almost completely offset that way. No one will object to promoting humus build up in soils the world over. With few exceptions, and if done correctly, it will have a positive impact on soil structure and substance exchange. However, it is highly questionable to link the need for more humus in soils with a free pass for other industries by releasing them from the obligation to lower their CO_2 emissions.

This kind of argument reduces humus building to a tool for those buying into the logic of CO_2 certificates. At least for agriculture that's not helpful because it ignores the enormous relevance of humus building not only for the preservation of soil fertility and the ecosystem services soils provide, but also for global food security. To ensure soil fertility we need living soils with high biological activity and biodiversity. Decomposition is part and parcel of biodiversity[23]. And another question remains: over time the amount and speed of humus building decreases. So how should farms be assessed that enter a payment scheme with an already higher than average humus content in the soils? Another unsolved question is for how long a particular agricultural practice has to be maintained until the carbon storage can seriously be considered to be permanent and stable. From a climate point of view, even 50 years are actually too little. What happens if there is a change in farming system, a new owner, a successor? And, in the course of climate change and without any intervention by the land managers, stored carbon could leak into the atmosphere once more as CO_2 [23a]. Would there then be a threat of repayments?

As early as 2012, the German Thünen-Institute said in regard to the potential of carbon sequestration in soils for climate protection: *„In general, the additional storage capacity of organic soil carbon through sustainable humus management is limited in time and quantity, as the humus stock develops a new equilibrium. If management practices change once more, the organic carbon, which may have accumulated over decades, can be mineralised within a short time."* [24]

The conclusion: humus building is important for soil fertility, erosion protection, groundwater formation and flood protection and it renders agriculture climate resilient. It is not suitable for CO_2 certificates. A 2018 statement by the Thünen-Institute on the 4-Promille-Initiative reemphasises this view[25].

The above mentioned study by Wiesmeier et al., 2020: *„CO_2 certificates for carbon sequestration in soils: methods, management practices and limitations"* [26] which was conducted as part of the "BonaRes"-Project (soil as sustainable resource for the organic economy) and funded by the German Ministry of Education and Research, also clearly points out the limits of CO_2 certificate trading. Sequestration fluctuates and is reversible and measurement is difficult. As a result, the authors of the study currently view the instrument of CO_2 certificates critically:

Even though increasing the carbon content in agricultural soils through good management is definitely a positive for both agricultural and climate protection, the instrument of private CO_2 certificates might be unsuitable.

What's particularly important: raising the carbon content in soil is not necessarily the same as a sustainable agricultural model and the building of high-quality humus. Some measures can also have an adverse effect on soils or have the potential to introduce pollutants into soils (e.g. plant charcoal/biochar). A narrowed focus on aspects of climate protection in agriculture can harm other environmental media.[27]

Similarly, in its 2012 comments on climate protection policies, the Thünen Institute in Germany said: *„Climate protection measures in agriculture should be implemented first where great synergies with other environmental goals are given and where environmental policy obligations exist."*

BIOCHAR – NOT ACHIEVING ITS OBJECTIVE

In this context, the introduction of carbon into soils by means of plant charcoal/pyrolysis charcoal/biochar is a topic of much discussion and intense lobbying efforts – because it is supposedly particularly stable and does not degrade so quickly. But the support for techniques that aim to store carbon as long-term as possible in the soil and stabilise it against degradation overlooks the fact that - at least in the temperate climate zones - the delivery of soil ecosystem services is primarily down to soil life. Good soil properties and healthy plant nutrition as well as bio-pores for water storage and purification can only be achieved through a high degree of biological activity. In general, this involves humus building but also processes of humus decomposition[28]. And dead plant charcoal is not suitable as a starting material for high levels of biological activity and humus building. The strong effects of carbonised substrate - for example, on water and nutrient storage - in the so-called "Terra Preta" soils can only be measured because due to their genesis, tropical soils contain hardly any of the clay minerals needed for nutrient exchange and water storage and humus building in general is difficult. This is completely different in mid-latitude soils. In addition, without prior inoculation with nutrients the strong nutrient storage capacity of the pyrolysis charcoal contributes to nutrient immobilisation, which is extremely counterproductive especially in organic farming[29].

Carbon doesn't equal humus!

An active soil life involves humus building but also processes of humus decomposition. It hampers the long-term stable storage of carbon in the soil.

A critical meta-study which reviewed a large number of publications (>300) concluded that there is insufficient empirical evidence to support the potential of plant carbon application to mitigate climate change[30]. In order to have an impact on the climate, enormous amounts of plant carbon would have to be applied. A model calculation came to the conclusion that about 1 percent of the greenhouse gas reduction target for Germany for the year 2030 could be achieved through the production of biochar. For that, all available biomass in Germany would have to be processed into biochar[31].

In comparison to agricultural techniques that have been tried and tested for centuries and optimised by organic farming, such as a balanced crop rotation with diverse and deep root penetration[32], permaculture, agroforestry, the recycling of organic matter by way of solid manure, crop residues and compost[33], the incorporation of plant charcoal into the soil is far inferior in terms of humus build-up and positive effects on soil ecology. Moreover, it is not a nature-based adaption but a high technology method and the resulting product has chemically nothing in common with original "Terra Preta" [33a].

Here, once more a quote from the 2018 soil condition report by the Thünen Institute for climate protection in agriculture: *„Does the use of biochar have potential? In soils, biochar from pyrolysis is very stable and therefore could contribute to the stable fraction of permanent humus. Up to now, positive yield effects from biochar application could only been demonstrated in nutrient poor tropical soils, but not in the more nutrient rich soils of temperate climate zones. Open questions regarding the availability of suitable initial substrate for biochar, its pollutant content, its profitability and the legal framework as well as the overall energetic and ecological assessment remain and prevent a positive evaluation of biochar use in our arable soils."* [33b]

COMPOST DOES MUCH BETTER

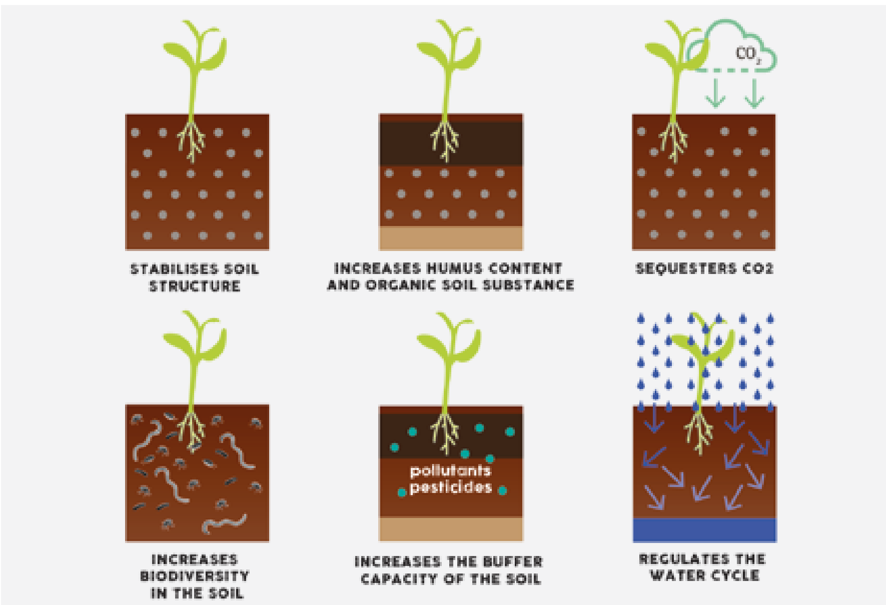
The positive effect of carbon-rich fertilisers in the soil depends to a large degree on how and in what form the carbon is introduced into the soil. Not every organic fertiliser has a consistency that is advantageous to soil life (slurry or large volumes of fresh biomass for example are not beneficial for soil life). Compost does an excellent job at improving the soil as well as increasing humus content and soil fertility and it is much more efficient than biochar.

The positive effect of carbon-rich fertilisers in the soil depends to a large degree on the form in which the carbon is introduced into the soil.

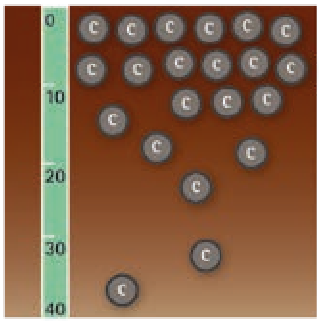
Over many years, positive effects of compost (without biocarbon enrichment) on the soil have been proven:[34]

- increased aggregate stability, improved soil structure
- increased pore volume coinciding with improved water retention and filter capacity
- increased biological activity
- increased humus content
- decreased erosion susceptibility, flood protection
- increase in mycorrhiza and thus improved nutrient supply
- decreased N leaching
- decreased disease susceptibility in field crops

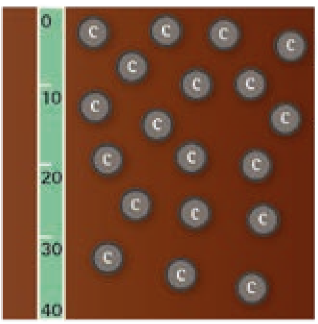
Positive effects from compost



Pollutants such as polycyclic aromatic hydrocarbons (PAHs) are carcinogenic and mutagenic. They are too strongly bound to the biochar and therefore not recorded through most measuring methods.



No-till



Ploughed

No humus enrichment, just displacement!

From what we know today, biochar provides at most 1-3 of the positive effects on this list (and it varies greatly from study to study [35]). Conclusion: The benefits for soil and climate are much greater when the available biomass is converted into quality compost rather than biochar.

Pollutants in biochar

Furthermore, there is a potential for long-term pollution through biochar. When biochar is produced through pyrolysis, organic material is carbonised at temperatures > 350°C and an oxygen content of < 2 percent. The higher the temperature, the more stable the charcoal will be. During this process and no matter what raw material is used, a large number of aromatic organic substances are formed. Among them are a number of pollutants that are difficult to break down, such as polycyclic aromatic hydrocarbons (PAHs), which are carcinogenic and mutagenic[36]. These pollutants cannot be removed because they are too strongly bound to the material. For the same reason they cannot be measured, readings from any of the available measuring methods say very little about the actual pollutant load[37]. This includes the potential hazard to soils when biochar is applied. For this reason, the guidelines of the EU Commission's Carbon Farming Initiative also include a possible ban on biochar under the eligibility criteria for programmes aimed at preserving and improving organic carbon in mineral soils.[38]

CONSERVATION AGRICULTURE

Over the past few years, the European Agriculture Conservation Federation (ECAF) in particular, championed the claim that no-till is good for the soil and the climate, because it helps to augment the humus content. For years, the ECAF has been cooperating closely with Monsanto, the company that invented glyphosate (and is today part of Bayer). Other advocates of glyphosate use repeatedly point out that humus can be built through mulching or direct seeding. This claim is simply false. The primary question is how much and what kind of organic material is introduced into the soil and not whether it is ploughed under or not. Contrary to often repeated assertions, just going no-till does not lead to a noteworthy increase in humus. This was confirmed by the evaluation of 69 comparisons worldwide[39].

The German Thünen Institute 2015 reaches this conclusion: *„With regard to reduced tillage under Central European conditions, a shift of humus between horizons was observed, but no sequestration of carbon"*[40] Studies that noted carbon sequestration had measured only down to a depth of 15cm or less, but not below.

Nevertheless, at EU level and in some policies for agriculture support programmes (2nd pillar of the CAP, agri-environmental schemes) many recommendations on climate protection measures still mistakenly assume carbon sequestration. With regard to climate relevance, however, the technique is even counterproductive because nitrous oxide emissions increase. Soils that are not ploughed have higher density which favours the formation of nitrous oxide.[41]

Soil protection? Just kidding...

Glyphosate not only inhibits the metabolism in plants but that of fungi and microorganisms too. A 2015 study by the University of Natural Resources and Life Sciences in Vienna concluded, that pesticides with glyphosate as active ingredient, lead to increased phosphate and nitrate levels in soil and reduce the activity and reproduction of earthworms[42]. The analysis showed that the application of pesticides dramatically reduced the activity of deep-burrowing earthworms. With horizontally burrowing earthworms, the number of offspring was reduced by half compared to specimens in soils without herbicide application.

Other studies show the effects of glyphosate use on the composition and activity of different bacteria strains. Glyphosate disrupts bacteria such as pseudomonas fluorescens, a very important strain that protects against fungal diseases. In general, glyphosate seems to disrupt the soil food-web of bacteria, fungi and microorganisms and thereby promote the growth of harmful fungi[43]. The claim that a glyphosate ban would endanger soil and climate protection in agriculture belongs into the category of "brazen twisting of facts"!

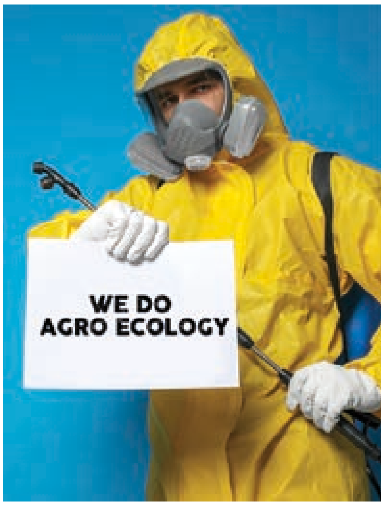
It is a brazen twisting of facts to claim that glyphosate helps to protect soils.

A GOD CONCEPT, MISAPPROPRIATED FOR GREENWASHING

Initially, "regenerative agriculture" came out of the movement for sustainability in the US, originating from the Rodale Institute which pursues goals very similar to those of the organic pioneers in Europe[44]. Many excellent projects use this concept. But the term is not precisely defined and is therefore undergoing intensive greenwashing. Here's an example that demonstrates this rather well: At the climate summit in New York in September 2019, 19 global corporations formed a coalition for "alternative farming practices". They call it "One Planet Business for Biodiversity". Danone initiated the coalition. Among the members are the Kellogg Company, L'Oreal, Mars, Nestlé, Unilever and Yara. The initiative introduces "regenerative agriculture" as a basic term. PepsiCo is another example. In April 2021, the group announces the 2030 target to expand "regenerative farming practices" to 7 million hectares and once again organic farming is not part of the solution[45].

Nestlé, Yara & Co appropriate the term "regenerative agriculture". It's not defined and can be use to sell stuff. Why not "organic"? Because it makes too little money.

There are reasons for the appropriation of this term: for most of the corporations gathered here, certified, legally regulated organic production does not fit into their business concept which is based on the input intensive, industrial production of cheap raw materials. For some, the concept of organic farming would actually undermine their business model. Take Yara, the world's largest synthetic fertiliser producer and trader, for this group, organic farming is a serious threat to their business model as it prohibits the use of synthetic fertiliser. "Regenerative agriculture" does not, and therefore, one simply appropriates a term that has not yet been clearly defined scientifically or by law, but has a positive image and uses it to further one's own interests.



Another example: CropLife, the largest lobby group for pesticides and genetic engineering[46] has now discovered "agroecology" as a very useful concept and defines it somewhat vaguely as similar to a circular economy. Of course, mineral fertiliser, pesticides and genetic engineering – all applied with precision – are key in maintaining "sustainablility"[47].

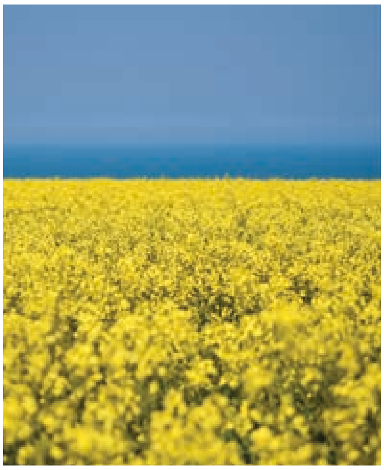
It is therefore very important to look closely at what is behind a project with the label "regenerative agriculture" or "agroecological". It can be a very good one or simply greenwashing!

Bio energy: A lot of space for little energy

The IPCC special report 15 „Global warming of 1.5 °C" continues to recommend renewable resources as sources for energy. Alcohols (methanol, ethanol) are to replace petrol, diesel fuel is to be replaced by plant oils and biogas should replace natural gas. This completely overlooks the limitation of available land: Half of all habitable land is used for agriculture – which is mostly used for the production of animal feed [48]. It's rightly criticised. The scientific advisory board of BUND (Friends of the Earth Germany) says that the price for the 10 percent of global usable energy supply, which today comes from biomass, is that it amounts to 40 percent of worldwide biomass Net Primary Production (HANPP Human Appropriation of Net Primary Production). They say that even at this level, the use of biomass is partly responsible for the global loss of biodiversity – which is illustrated by the limited potential of bioenergy. From an ecological perspective, a significant expansion of the global growing area would be irresponsible[49].

KILLING BIODIVERSITY

There is not a sufficient quantity of biomass available to make it a substitute for conventional energy sources[50] and the intensification of its use, beyond the processing of residual material (bio waste, edible oil, etc.) offers only limited potentials before the delivery of ecosystem services becomes endangered[51]. On a small-scale, energy from biomass in a local cycle is often ecologically positive, but even the current large-scale facilities pose considerable problems. Because biomass production is subsidised, the intensification of currently extensively used areas becomes profitable. As a result, they, too, lose their value for biodiversity: grassland habitats and former set-aside areas are ploughed and cultivated with energy crops. In the process, species rich habitats, which are often essential for ground dwellers and nesting birds, get destroyed. They are replaced by oil seed rape and maize monocultures which endanger biological diversity.



Oil seed rape monoculture

As early as 2011, in joint letter to the EU, 168 international scientists warned against so-called "bio petrol". Science clearly does not support the view that "biofuel" is climate neutral, the scientists say[52]. For agro-energy, rainforests are cut down and small farmers evicted, they say. The United Nations (UN) supported this view in 2011. Since then, ten international organisations have recommend to the governments of the G-20 countries to end the subsidies for "biofuel". The governments of the G-20 countries should "remove provisions in their national directives that subsidise or mandate the production and consumption of biofuel", the authors write. Among them are the World Food Programme (WFP) and the Food and Agriculture Organisation (FAO) of the United Nations, the World Bank, the Organisation for Economic Co-operation and Development (OECD) as well as six other international institutions[53]. In 2012, the German national academy of sciences, Leopoldina, too, advocated in general against the use of "bio energy", one of the reasons being its energy intensive production[54].

Biofuel and bio-energy: time and again labelled as "sustainable" despite international warnings from scientists.

Burning wood, too, isn't climate neutral!

PRE-PROGRAMMED: LOSS OF HUMUS

What is unfortunately hardly ever discussed: for many years now, shorter rotations and the substitution of cover crops that have a high humus building potential with humus consuming energy crops have led to humus depletion which is absolutely counterproductive for soils [55]. Decades long, expensive research projects for more diversity in energy crop production do not change that because the gas yield per hectare from maize is still unsurpassed. But during the production of agro-gas additional carbon is removed from the cycle ("bio gas" = CH_4), it is not returned via the C-reduced digestates and that causes additional humus depletion[56].

WHY TAKING THE PLANT ROUTE MAKES SENSE

Recently, an interdisciplinary team of American researchers has re-confirmed that photovoltaics (PV) are significantly more efficient than plants at converting solar energy. Whereas plants convert solar energy into energy packets by way of organic molecules in order to store it, normal photovoltaics requires only the first step, the conversion of energy to animated electrons[57]. Even with the most unfavourable calculation, a photovoltaic system requires only one tenth of the arable land that is required for the cultivation of energy crops. A dual use of energy production and nature conservation-oriented extensive agriculture, such as grazing sheep, is possible with PV systems. Ground-mounted photovoltaic systems can now be installed vertically or seamlessly integrated into fields for growing arable or speciality crops, thus avoiding competition over land use for food production. In this way, agriculture can even be combined with energy production[58]. The sustainable replacement of our fossil fuel consumption with plant-based energy, on the other hand, is an illusion: Without a drastic reduction of individual transport and systemic mobility concepts we will not achieve an acceptable sustainability status.

On a tenth of the area the same energy as from biomass.

Currently calls are growing louder again: we need the new genetic engineering techniques (CRISPR/CAS and Co) to finally be able to breed drought or salt resistant plants.

Genetic engineering rebooted

Currently calls are growing louder again: we need the new genetic engineering techniques (CRISPR/CAS and Co.) to finally be able to breed drought or salt resistant plants. Usually it is not about drought or salt resistant plants which one could find rather than breed. Usually it is about creating new (plant) products, it's about patents and profits.

BYPASSING THE NEEDS OF SMALLHOLDER FARMERS...

The initiative "Water Efficient Maize for Africa" (WEMA) is funded by the Gates Foundation and Monsanto and considered to be a flagship project for "Climate Smart Agriculture". It is supposed to help smallholder farmers to adapt to climate change by using drought tolerant seed varieties. However, it's mainly hybrid maize and genetically engineered varieties that are being promoted. Such seeds cannot be saved or propagated for the next growing season, farmers have to buy costly fresh seed every year. In addition, high yielding varieties need large amounts of agrochemicals. If it were any different, it wouldn't be worthwhile for the suppliers. A 2015 analysis by the „African Centre for Biodiversity" points to the limited benefits of GM varieties and warns of dependencies that threaten the livelihood of smallholder farmers, such as indebtedness, the loss of the traditional diversity in seed varieties, as well as the increasing influence of multinational agricultural corporations in the African seed market[59].

There is no evidence that genetic engineering helps to increase yields as such or even reduces hunger[60]. On a general level, experts have been saying for years, that the causes for hunger are more related to social and economic issues (conflicts, poverty, exclusion etc.) than to yield gaps[61]. On the contrary, a number of widely accepted expert reports have advised a rapid shift from input-intensive industrial farming practices to agroecological farming methods[62].

Even more than 25 years after its inception, the so-called "Golden Rice", which was supposed to improve vitamin supply, has to be considered a failure. The Golden Rice variety was hampered by low yields, stunted growth, pale leaves, late flowering and low fertility[63].

DROUGHT RESISTANT SPECIES AND SUPER FOOD PLANTS?

Some believe things will be very different with the "new genetic engineering" methods. Complex traits, i.e. traits mediated by a range of environmental and genetic factors, are supposed to herald a new era of climate-resistant or nutritionally improved crops. But up to now, such crops have not yet been developed - not even in countries with little regulatory oversite, where, according to proponents, "innovation" is held back less. One example is the "drought tolerant maize" developed by Bayer (erstwhile Monsanto). In the US it is already commercially available and it was to go on sale in the African market, but regulators in South Africa denied approval because the variety does not increase yields and there is no evidence for drought tolerance [64].

A 2015 analysis by the „African Centre for Biodiversity" points to the limited benefits of GM varieties and warns of dependencies that threaten the livelihood of smallholder farmers.

Golden Rice: low yields, stunted growth, pale leaves, late flowering and low fertility

New gene editing techniques are better? Supposedly drought tolerant maize was rejected by the authorities in South Africa: It provides no benefit.

Traits are not defined through one individual gene but through several and through the interaction of outside influences and between genes. The new gene editing techniques cannot control this with precision.

Finding is often more efficient than "constructing".

THE TECHNOLOGY IS NEW, THE FLAWED REASONING ISN'T...

It's actually not surprising because the flaw in reasoning is always the same: when single genes in the DNA of a plant are manipulated, the new traits are anchored a lot less strongly than they are through traditional breeding. New traits in traditional breeding are anchored genetically much more broadly because the biochemistry within the plant determines how its genetic material will react to the new combination. In addition: the effects genetic engineering and the introduction of a new gene has on the genome as a whole are completely unpredictable.[64a]

The seed from naturally heterogenic open pollinated varieties has a much broader genetic base and less uniformity in the field, than the high yielding varieties that are currently being used. Less uniformity isn't a disadvantage, it is an advantage because of the high potential to deal in a natural way with changing environmental conditions and environmental stresses such as pests and weather extremes. It is impossible to create such flexibility and resilience through genetic engineering.

For example, while Dupont Pioneer (now part of Corteva) together with the Donald Danforth Center for Plant Research and with funding from the Bill and Melinda Gates Foundation is using genetic engineering to create cassava varieties resistant to viral diseases, only recently traditional breeders have developed varieties displaying natural resistance [65].

FINDING INSTEAD OF BREEDING

Sometimes, in order to be successful, there is no need for breeding and it's sufficient to find traditional varieties: the MASIPAG network collected over 2000 rice varieties and found 12 which survive when they are flooded for a number of days; 18 varieties coped well with drought, 20 showed tolerance to salt water and 24 were resistant to certain local pests [66].

It would be more efficient to first look for already existing drought or salt tolerant varieties than release new constructs into the world. Traits such as drought or salt tolerance are polygenetic characteristics, i.e. they are based on several genes. They cannot be achieved through simple change, such as point mutation, instead, several genes would need changing – and we're not even sure which ones. And in case this should work, it still would be far from certain, that yields, too, would be sufficient.

What we really need to change are our growing systems, not individual plants: instead of monocultures we need more crop rotations and biodiversity and we need to optimise the interaction between plant and soil. And we should have trust in plants which have been fine tuning their genetics for millennia. We are far from understanding the underlying rules and reaction of the genome (and are thus unable to predict them), tinkering with the genome therefore is the opposite of "precision" and defined by hubris rather than a spirit of scientific innovation.

OPTIMISING THROUGH OMISSION

Since the beginning of the 1990s, the research of mycorrhizal fungi has increased continuously, since the beginning of the 2000s, scientists also consider the impact on soil and plant health in agricultural systems.

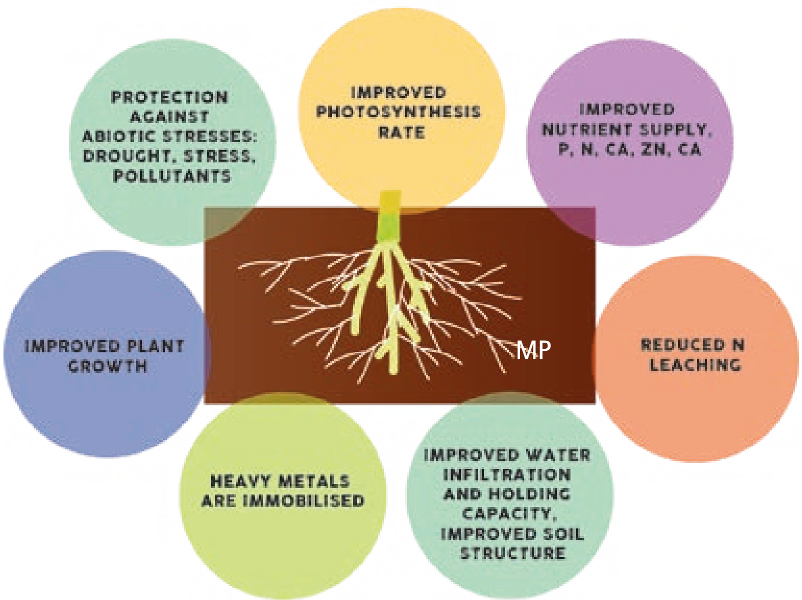
With (old and new) methods of genetic engineering we supposedly can achieve benefits such as drought resistance, resistance to pollutants and salination as well as disease and harmful organisms. Today, we could make almost all of it happen in agriculture, if we were able to make better use of the symbiotic relationship between mycorrhizal fungi and plants. Population with mycorrhiza improves plant health through an improved nutrient status which, in return, results in the agricultural system delivering better ecological services[67]. Mycorrhiza fungi not only stabilise soil aggregates and prevent soil erosion; through their interaction with other soil organisms they also prevent pathogens from establishing themselves on plant roots, they considerably improve the plant's nutrient absorption and make them more resilient to water stress [68].

But we've also known for quite some time, that mineral fertilisers and pesticides can harm mycorrhiza. The extremely efficient interplay between fungi and root is disturbed and the absorption of nutrients decreases. The one-sided plant nutrition becomes dominated by nitrogen which makes the plant susceptible. This triggers the (wrong) reaction, which is to apply "plant protection' - i.e. biocides – because they disrupt the ecosystem and the soil microbiome even more [69].

There is a huge potential for optimisation in arable farming which, for years, "innovative" techniques such as genetic engineering have promised to deliver and failed. We could achieve most of it simply by abandoning practices that are inefficient and harmful and supporting the highly efficient mechanisms occurring in nature.

Mineral fertiliser and pesticides harm mycorrhiza fungi. The extremely efficient interplay between fungi and root gets disturbed and the absorption of nutrients decreases.

Schematic representation of the way mycorrhizal fungi (MF) enhance plant nutrition and strengthen their defence mechanisms.

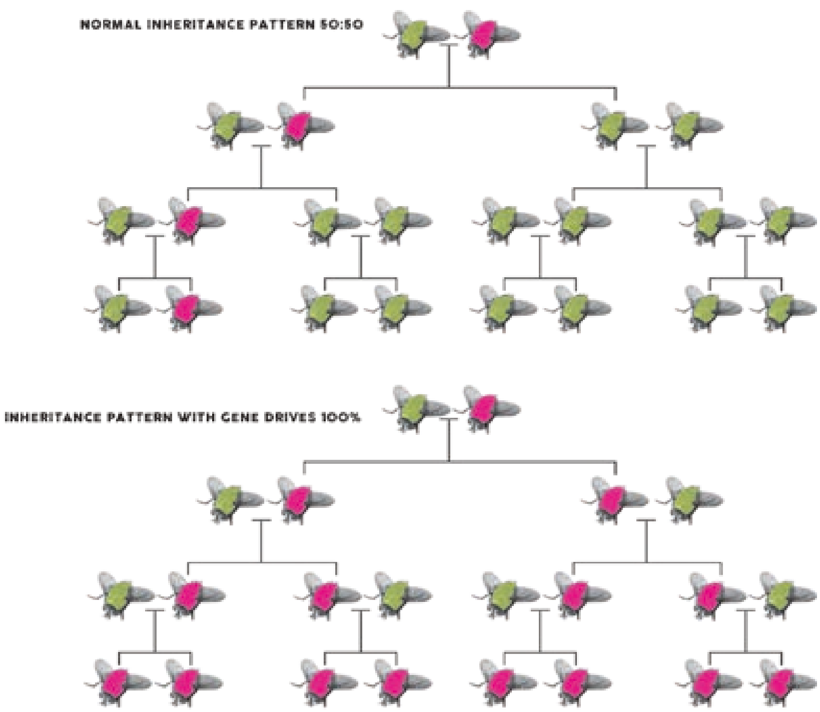


Source: Simplified representation according to Solanki (2021)

Gene Drives – the hubris of controlling populations

Gene drives are biotechnological applications that have been in development for a number of years. It's a technology that intervenes at a deep level and has far reaching implications. "Turbo genetics" may be the best way of putting this. The technology disables the natural rules of genetic inheritance and evolution: genetic engineering is used to introduce new traits into the genome of organisms which are passed on to all their offspring in their entirety with 100 percent certainty. Gene drives interfere to a much larger degree in a natural organism than all previous genetic engineering tools – old and new. Up to now, genetic engineering focussed on change in single organisms, now whole species and ecosystems are to be genetically changed. The forced inheritance patterns circumvent the normal rules of genetic inheritance in nature. It triggers a genetic chain reaction through which the genetic engineering tool CRISPR/Cas9 and sometimes an additional gene is passed on from generation to generation. The changes induced through a gene drive can lead to sterility or to changes in the sex ration among offspring which lead to the collapse of a population. The long-term effects cannot be predicted.

Up to now, genetic engineering focussed on change in single organisms, now whole species and ecosystems are to be genetically changed. The forced inheritance patterns circumvent the normal rules of genetic inheritance in nature.



Quelle: https://www.saveourseeds.org, Gene Drives

Important to know – in Germany, too, research with gene drives is underway – as reported by Testbiotech (a German institute for independent impact assessment of biotechnology in March 2017. Flies used in a lab in the city of Göttingen were to introduce a sex change in offspring: females were to become males. The aim of the research, which was funded by the US military agency DARPA (Defense Advanced Research Projects Agency), among others, is to reduce or even eradicate populations of "undesirable" insects – in this instance, Mediterranean fruit flies are the target. But unlike the other than the Mediterranean fruit flies, the flies used in the Göttingen experiment passed on the artificial genetic information only partially. And after about a dozen generations, the gene drive had caused so many unintended mutations in the genome that the trait no longer persisted.[70]

It is near impossible to assess the risks this entails:

- Invasiveness and uncontrolled, cross-border spread: gene drive organisms will spread into every ecosystem in which they can survive – and across national borders too, which could lead to conflicts.
- Persistence over generations: gene drive organisms can survive in the environment over generations and spread.
- Irreversibility: gene drive organisms cannot be recalled, their spread in the environment cannot be undone and will eventually lead to changes in ecosystems. The genetic composition of the natural population can be disrupted.
- Unintended genetic effects: CRISPR/Cas9 is an active genetic engineering tool, once it's been introduced into an organism it can cause and spread unintended new reactions and mutations.
- Transfer to non-targeted species: gene drives can be transferred to related species and spread there. Unforeseen consequences: because of the complexity of nature and the unlimited spread and persistence of gene drives in nature over many generations, the effects of their population dynamics and in ecosystems are highly unpredictable.
- Disruption of food networks and ecosystems: the suppression or eradication of wild population or species has negative consequences for food networks and could lead to the breakdown of ecosystems[71].

THE LOBBY GETS INTO POSITION

A 2018 report by Corporate Europe Observatory demonstrates how a Dutch government representative is active across a number of networks, in which large biotechnology companies, pro-industry scientists and policymakers that favour GM coordinate in order to influence the outcome of EU and UN negotiations on these issues to benefit their interests. This is evident from documents that came to light in the course of a Freedom of Information Act enquiry and can be viewed on a Dutch government website[72]. There is a need for much more independent risk and technology assessment research in Europe, so that decisions on technologies of such scope are not only dependent on the "consultancy" through lobbyist- "experts".

DEFENDING FOOD SOVEREIGNTY

More than 200 leading representatives of organisations of the global movement for food sovereignty and climate friendly agriculture are now calling for a moratorium on the release of gene drives; among them the current UN Special Rapporteur on the Human Right to Food Hilal Elver, and her predecessors Olivier de Schutter and Jean Ziegler[73].

The myth of the high-performance animal: time and again, it is being claimed that, allegedly, milk production in organic agriculture is less climate friendly because the milk yields are lower and the methane emissions per litre therefore higher.

This is not true!

The myth of the high-performance animal

SUPER COWS ARE INEFFICIENT

Time and again, it is being claimed by conventional farmers' organisations that, allegedly, milk production in organic agriculture is less climate friendly because the milk yields are lower and the methane emissions per litre therefore higher [74]. The following is correct: with increasing milk yield the methane emission per cow increases, but per kilogram of milk it drops. The reason for this is that with increasing yield the emissions spread over more litres. The result looks very different once the system in which the animals are kept, feed and lifetime are taken into account. To achieve a high milk yield a lot more intensively grown concentrate feed is used. The 2018 Cattle Report Schleswig-Holstein found that dairy farms with a milk yield of less than 7,000 kilograms used 1.77 tonnes of concentrated feed per cow and year, while those with more than 10,000 kilogrammes used 3.19 tonnes (i.e. 1.8 times as much)[75]. The production of concentrate feed causes higher emission than the production of fodder such as grass. This is partly due to soy meal, its production is associated with high GHG emissions. Organic farms use significantly less concentrate feed and which is the main reason for the lower milk yield mentioned above. High milk yields put a strain on the cow's organism, as a result the risks for animal welfare and life cycle increase [76].

However, a longer life cycle is an advantage, because the emissions caused during rearing (the time in which no milk is produced yet) are distributed across a higher milk yield. High yielding cows rarely live longer than three years, organic cows often live to five years or longer. In addition, when considering milk yield and methane emissions, the system in which the animals are kept is disregarded. Grassland is a CO_2 sink and is therefore important for climate protection. Organic farms have a significantly higher proportion of grassland (according to the 2016 agricultural structure survey 56.3 percent vs. all farms 28.2 percent).

The efficient super cow? No way!

GRAZING ANIMALS PROTECT THE CLIMATE

Next to forests, grassland is the world's largest biome and makes up close to 40 percent of the vegetative cover of planet earth [77]. Of the world's designated agricultural land one third is cropland and two thirds are grassland [78]. The latter provides the livelihood for one tenth of the world's population[79]. But this only works with grazing animals. The Food and Agriculture Organization of the United Nations (FAO) estimates that for 100 million people in arid regions and probably for another 100 million people in other regions, grazing animals are the only available source for protein and income [80]. For reasons of climate protection which necessitates the protection of pastures, grassland and prairies as well as the need to supply people worldwide with enough protein, we are reliant on animals that can digest grass. It is therefore not possible for everyone on this planet to have a vegan diet. Above all, a vegan diet is in no way more climate-friendly than a mixed diet that helps to preserve grasslands and prairies and uses the planet's food bases efficiently. Unfortunately, 2017 EAT Lancet report on sustainable nutrition does not consider this context [80a].

For the protection of pastures, grassland and prairies as well as the need to supply people worldwide with enough protein, we are reliant on animals that can digest grass.

High tech and high energy – Indoor farming

Over the last three years, indoor farming increasingly has been hailed as the solution.

Urbanisation progresses, open space in cities shrinks. In agriculture therefore, efforts are made to grow food in a limited space as efficiently as possible. Over the last three years, indoor farming increasingly has been hailed as the solution. With the help of LED lighting plants are grown in indoor spaces, (mostly) using closed nutrient and water cycles. As of now, the same method features under a number of different labels: indoor farming, vertical farming, hydroponics, aquaponics, Aquaponic Controlled Environment Agriculture (CEA), urban farming.

Many reports and promotional texts list as advantages that less transport energy is needed because the produce is grown in the city, they say water requirements are lower and no pesticides are used. The "controlled environment" in which the plants grow is described as beneficial to their quality, too. But even the protagonists are critical of the high energy needs. A closer look shows that in comparison with produce grown naturally, in a field outside of the city, only one of the advantages holds up to scrutiny: the short transport distance to consumers. And even this benefit does not really hinge on the existence of an artificial system – "urban farming" is possible in a city, in open air, in good soil (in raised beds) and with natural sunlight.

Let's take a closer, critical look at these supposed advantages and compare them with so-called "nature-based solutions" [81] for a modern agricultural system as promoted by the FAO.

FEWER PESTICIDES

True, in such a sealed techno-sphere, certain harmful organisms can be kept at bay and therefore fewer "classic" pesticides are needed to regulate them. But in regard to energy use and plant health the price is high (see below). By comparison, organic agriculture, too, reduces synthetic chemical pesticide amounts, it uses solar energy directly and delivers a whole host of benefits for soil health, water filtration and biodiversity [82].

CONTROLLED ENVIRONMENT

Even a hospital is not completely sterile and particularly in clinical facilities resistant bacteria become a problem fast. With indoor farming too, there is a risk that humans cannot fully control such germs. No artificial techno-sphere will ever compare to the equilibrium microorganisms achieve naturally [83]. No living being survives for long in a completely sterile environment. The more disinfectants are used to keep the tech-farms clean, the higher the risk that individual bacterial strains develop resistance and are able to multiply because there are no antagonists that could keep them in check. Today we know that the guiding principle for the balance of ecosystems also applies to an environment (such as our gut) that is inhabited by different strains of bacteria (microbiomes): the higher the diversity the healthier. A "germ free" environment is therefore highly vulnerable to the infestation with single strands of bacteria [84]. Moreover: a food production system that is completely dependent on functioning power circuits is very vulnerable to power cuts and sabotage.

A "germ free" environment is therefore highly vulnerable to the infestation with a single strain of bacteria.

QUALITY OF PLANTS

Plants react to stress by producing secondary plant compounds which are particularly valuable to human health [85]. It is difficult to produce high quality food without stimulants in the natural biosphere and the interaction with soil organisms which have a considerable influence on the resilience and health of plants. In the wild, plants mainly live in symbiosis. They have access to a microbiome that takes care of a variety of processes within the plant. One of them is the defence against pests [86]. A completely artificial nutrient solution can hardly replace the quality of the nutrition naturally provided by the soil. For that reason, a hundred years ago, organic agriculture decided against the use of artificial, synthetic fertilisers (which destroy the finely tuned interplay between plant and soil). For that reason, the EU regulation on organic farming does not allow for plants to be grown in nutrient solutions [87]. In Europe, plants from indoor farms therefore cannot get organic certification. Whether through cleanliness – and the thus missing biome – the resulting weak immune system of plants could endanger the human immune system and possibly carry a higher risk of autoimmune diseases and allergies, up to now remains an unanswered question. More research is needed.

Artificial nutrient solution cannot replace a natural biosphere.

LOW WATER CONSUMPTION?

The arguments the proponents of indoor farming make regarding water consumption can only be called frivolous. Statements about low water consumption may be appropriate in comparison to highly industrialised irrigated monocultures in a desert. Compared with sustainable agroecological field systems however, the argument is utterly lopsided. Agroecological systems not only absorb, retain and filter rainwater which then goes towards groundwater recharge, such systems also protect from erosion and flooding, and they have a positive influence on microclimates and thereby help balance local temperatures and precipitation. Indoor farming can do none of the above, on the contrary, through its existence it prevents water and substance exchange between soil and atmosphere.

Sustainable plant growth in the wild does not "consume" water, it produces it!

On a superficial level, indoor farming seems to compare rather well with the industrial agriculture as it is currently practiced. But, as the above mentioned points show, it is frivolous to present the concept of indoor farming as a solution to the problems inherent to industrial agriculture. To argue, that the current problems of soil-based management systems – the stress of industrialisation and urbanisation as well as the intensive use of fertilisers and pesticides in agriculture which lead to a loss of soil fertility – can be solved by shifting plant production into automatically controlled artificial technospheres looks, from the point of a soil ecologist, rather like generation X capitulating to the ag industry which, in turn, is hiding behind tech euphoria.

Overall balance vs tech fixes

DO THE MATH

To honestly assess the sustainability of agricultural systems we have to take all benefits and costs to society into account. Only then it is possible to decide which systems and growing techniques are better suited for long-term and sustainable agricultural production. The "Calculate it right method for agriculture" uses 200 index figures to calculate sustainability [88]. Agricultural policies aim to grant public money for public good and the "Calculate it right method for agriculture" would be a well thought through concept on which to base the assessment of what is sustainable.

A good example was developed by a Dutch wholesaler for organic fruit and veg. For some of the produce sold under their own brand "Nature & More", Eosta B.V. communicates the hidden costs through a so-called True Cost Flower. This approach takes six cost factors into account:

Climate: greenhouse gas emissions
Soil: over fertilisation and overgrazing
Water: residues, drinking water treatment
Biodiversity: chemical fertiliser and pesticides
Social issues: loss of inhabitable spaces, conflicts over raw materials
Health: diet related diseases

What our food really costs

Example pear growing

The company has calculated that for soil alone, conventional pear production has a negative impact on soil quality amounting to a cost of 1.163 Euro per hectare and year. Organic production on the other hand has a positive impact amounting to 254 Euro. An organic pear therefore comes with a cost advantage of 1.317 Euro compared with the supposedly cheaper pears from conventional production – and that's only considering the cost factor soil [89]. A calculation model to apply this to balance sheet management is the "Calculate it right " model developed by the German Regionalwert-AG [90].

This type of approach is important because unlike climate labels it does not focus solely on CO_2-emissions, nor does it only take yields into account as has been customary in agriculture up to now. Such calculations are complex and depend on carefully researched data. This is where the much discussed digitalisation actually can be of real value because complex data from different systems can be processed. In future, it will be necessary for any concept of sustainable food and nutrition to take such approaches into account. Efficient agriculture with long term sustainability is not the type that produces the highest yields per hectare by investing lots of energy while creating high costs to society.

Organic pears have a cost advantage of 1317 Euro per hectare

A system that results in diseased plants and depleted soils is supposed to be the yardstick for success?

Biodiversity results in higher yields

THE MYTH OF FEEDING THE WORLD WITH HIGH INPUT PRODUCTION

The argument that yields in organic agriculture are too low has been made repeatedly, but repetition does not make it become more true: it almost completely ignores our current knowledge about the ecosystem services provided by agricultural systems:

1) Instead of efficiency per hectare which only calculates the yield of the commodity crop, organic agriculture has a higher overall efficiency: the bottom line is far better in regard to energy use, climate protection and mitigation, humus building, water storage, ground water renewal, flood protection and biodiversity [91].

2) The current reference level for yield is the productivity of high yielding but vulnerable plants in a non-sustainable system such as conventional agriculture. In other words: we know that the system isn't working but we use it as a yardstick nevertheless. Many comparisons between organic and conventional agriculture are based on this yardstick and that's absolutely inappropriate because it stems from a dysfunctional system.

3) Highly adapted mixed culture systems such as agroforestry and permaculture systems produce much higher yields per hectare than conventional monocultures. Therefore, organic agriculture in the tropics already reaches 174 percent compared to conventional agriculture reference spaces (average from the analysis of 133 studies). The University of California, Berkley, calculated that on average yields were only 19.2 percent lower for US growing systems. The difference is halved again if not only the yields of single cultures are compared (for example maize with maize and wheat with wheat), but whole growing systems [92]. Take an example from one of the most important agroecological growing systems, rice production: the concept is based on extensification, and yet the yields are higher. Because neither synthetic nitrogen nor pesticides are used, the soil quality is better and water use is halved which is beneficial for the climate as the wet phase in rice growing, during which methane is produced, can be largely omitted. The success of the system is based in the increased spacing of the rice plants which have more room to grow roots and shoots. That way the yield per hectare can on average be increase from two to eight tons [93].

4) A question of area: all scenarios for agriculture demand a future decrease in meat production and a reduction of animal numbers, if the necessary climate goals are to be reached. With a comprehensive conversion to organic agriculture such a reduction would be system inherent because the rules for organic agriculture link animal numbers to hectares; as a result, the area available for growing plant based foods and even raw materials would increase significantly.

5) A new peer reviewed study, published in „Rethinking Agriculture: New Ways Forward", looks at models for global food systems proposed by the FAO and others which are the primary data base for predictions of global shortages.

The paper shows that food models are flawed because the global availability of food is underestimated while the future demand is overestimated. In other words: the predictions of future shortages are solely based on faulty modelling [94].

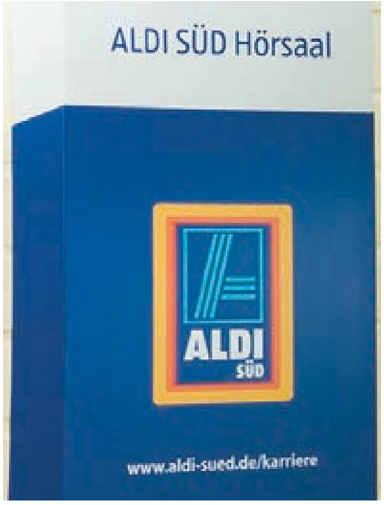
When science becomes a lab for product development

WEIGHTED INTERESTS

For years, public funding for science in Europe has decreased. From 2000 to 2010 for example, third party funding for German universities has more than doubled, from 2.8 billion Euro to roughly 5.9 billion Euro. By now, in Germany, every second Euro in science funding comes from the private sector[95]. The EU research programme "Horizon Europe" heavily relies on private-public funding, too. However: no large company is interested in giving away money. There is usually a purpose for donating money, for example towards endowed chairs: the purpose is to increase profits. Corporations aren't charities [95a].

More and more research is geared towards a product or a technology that is ready to sell – that's particularly true for the environment and sustainability market. Often the market is developing in parallel to the research, as a result there is little interest in "discrediting" the product or the technology through critical research or by coming to the realisation that doing without a harmful technology may be better than switching to a new, superficially beneficial new technology.

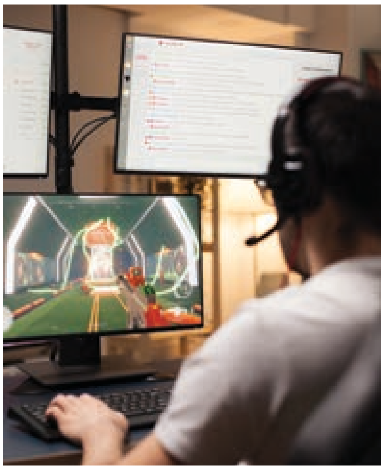
At the same time, less and less fundamental research is done – independent research that deals with risks and technology assessments without fixed expectations or simply asks the question whether a newly invented "innovation" actually makes sense. Whether it is gene technology, bioenergy, biochar, or digital technology for agriculture, for years the assessments of such technologies were rarely based on scientific approaches and critical questions. With increasing frequency, the early evaluation of these one-sided positive reviews of certain techniques and, more often than not, their unmasking, is up to NGOs. Today, NGOs do their work to a much more professional standard and they count many proven experts among their staff and support networks, but it definitely isn't their job to replace publicly funded risk research. In Europe, much more independent risk and technology assessment is needed so that decisions about technologies which often enough lead to far reaching interventions and have wide social and ecological implications are not only dependent on assessments by "lobby experts".



As economic interests gain ever more influence on research, practical application becomes a must and critical questions are not asked.

Whether it is gene technology, bioenergy, biochar, or digital technology for agriculture, for years the assessments of such technologies were rarely based on scientific approaches and critical questions.

Solutions are mostly considered to be "innovative" if they involve complicated technology that few people understand and they are based on the assumption that all aspects of an ecosystem can be controlled.



Apparently, the dream of the technical controllability of biological systems still is far from over.

NARROWING THE VIEW

A one sided approach to research is not necessarily always connected to third party funding. University education has been split up into ever more specialised disciplines. And within these bubbles of specialisation the quest for solutions is increasingly shaped by a one-problem-one-solution approach. Fitting into complex ecosystems (even if they have not been fully understood) is less and less perceived as innovation. Solutions are mostly considered to be "innovative" if they involve complicated technology that few people understand and they are based on the assumption that all aspects of an eco-system can be controlled. But what may yield very good results in engineering can be counterproductive, inefficient and sometimes even dangerous when applied within the context of ecology.

Apparently, the dream of the technical controllability of biological systems still is far from over. For years, agriculture's fascination with the possibilities of interference that technology and chemistry can provide was the result of the (wrong) impression that such fixes are simple, targeted, controllable and without negative side effects.

Today we know that in many instances this was a total misconception. It's been mentioned already that it is often far more effective to "search" than to "construct". The technique of searching before starting to construct has a long tradition: in indigenous, highly adapted network systems, in organic agriculture but also in bionics. This approach observes patterns of action in nature which have successfully stood the test of time and evolution and then copies them. In terms of the overall energy investment and the cost-benefit analysis, this is often much more effective. We need to get away from "tech fixes", instead our use of ecosystems needs to be better adapted to their functionality which has been shaped through evolution. From a geo-ecological time-perspective, we have been on this earth for less than it takes to bat an eyelid. Should that not be a good enough reason to value and use the "experience" that organisms and ecosystems all around us have gathered over millennia?

A look ahead

In March 2021, the international group of experts for sustainable food systems (IPES Food)[96] reiterated the main conclusions of the 2009 World Agriculture Report: It is clear that, if the future continues to be dominated by industrial agriculture, the planet and our food systems will not reach a state, in which their survival seems possible. On the contrary: it will continue to provoke inequalities, deepen the stress of safeguarding livelihoods and food security and carry adverse environmental effects in its wake. In contrast, changing the systems towards food sovereignty and agroecology could reduce greenhouse gas emissions through food production by 75 percent and, within the next 25 years, bring about invaluable advantages for the lives and livelihoods of billions of people.

It is clear that, if the future continues to be dominated by industrial agriculture, the planet and our food systems will not reach a state in which their survival seems possible. *IPES Food 2020*

POLITICAL DEMANDS

Martin Häusling the Greens/EFA

Demands of the Greens /EFA regarding climate protection, climate mitigation and increased biodiversity in agriculture.

1 Organic agriculture has to become the guiding principle. There is enough evidence of the many positive effects for climate protection, climate mitigation, protection of biodiversity and the benefits to all ecosystem services.

2 No-till agriculture is only beneficial in highly biodiverse farming systems. For funding, long rotations, under-sowing and cover crops need to be obligatory.

3 Precision agriculture reduces fertiliser and pesticide use only in the low single digit percentage range. It increases efficiency but serves neither climate protection nor biodiversity. It must not be subsidised through climate protection or biodiversity funds.

4 Carbon farming only makes sense if the goal is natural humus building to enhance soil functions and soil biology. Potential input of pollutants through biochar have to be excluded.

5 Instead of banking on expensive risk technologies that rely on the imprecise manipulation of the genome, funding should go towards the screening of climate adapted, robust seed varieties and the improvement of genetically flexible, more adaptable population breeding.

6 Patents on plants and animals as well as biological sustainability techniques need to be banned.
To secure our survival in harmony with the planetary ecosystems we don't need patent laws with exclusion mechanisms to protect economic profits but open-source systems that grant access to everyone.

REFERENCES

1 Selection of expertises:

ECA (2017): Greening: a more complex income support scheme, not yet environmentally effective

ECA (2018): Future of the CAP.

Pe'er, G. et al.(2019) *A greener path for the EU Common Agricultural Policy.* Science, 365

ECA (2020): Sustainable use of plant protection products: limited progress in measuring and reducing risks

ECA(2020): Biodiversity on farmland: CAP contribution has not halted the decline

2 Kelly, S. and Rankin, F. (2020): *Investigation: How Pesticide Companies Are Marketing Themselves as a Solution to Climate Change*

3 Access 7/12/20: *https://www.bayer.com/en/news-stories/digital-farming-driving-sustainability*

4 Sutton, M., Howard, C. et al. (Eds.) (2011): *The European Nitrogen Assessment: Sources, Effects and Policy Perspectives. Cambridge University Press.*

5 Bernstein, L., et al. (2007): Industry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

6 Clausing, P. (2014): *Energieschleuder Agrarindustrie. In: Ökologie & Landbau 172.*

7 Umweltbundesamt: *Klimaschutz und Emissionshandel in der Landwirtschaft. Dessau-Roßlau 2013.*

7a ECA (2021): *EU agricultural spending has not made farming more climate-friendly*

8 150 leading scientists from 50 countries spent three years analysing almost 15,000 studies for the IPBES report.

IPBES (2019): *Nature's Dangerous Decline 'Unprecedented' Species Extinction Rates 'Accelerating'*

9 Science Daily, 20 January 2012; Access 04/12/20: *https://www.sciencedaily.com/releases/2012/01/120120010357.htm*

10 Böcker, H. (2018): Phosphat verfügbar machen. In: Landwirtschaftliches Wochenblatt 21/18

Schubert, S. (2019): Phosphataneignung verschiedener Kulturpflanzen und Konsequenzen für die Bodenanalytik. Vortrag Institut für Pflanzenernährung (iFZ) Justus-Liebig-Universität.

11 BMEL (2018) *Digitalisierung in der Landwirtschaft.* The 2021 BMEL brochure with the same title, which you can find under this Link does no longer contain the above quote and the reference to the impact assessment by the Thünen-Institut has been deleted. If you would like to have the original publication, please contact the author at: www.gesunde-erde.net

12 Beltran-Garcia, M. et al. (2021): *Nitrogen fertilization and stress factors drive shifts in microbial diversity in soils and plants. In: Symbiosis 84/2021*

Beste, A.; Idel, A. (2019): *The belief in technology and big data. The myth of climate smart agriculture – why less bad isn't good.* P. 18 et seq.

12a Carten P. et al. (2019): *Rebound effects in agricultural land and soil management: Review and analytical framework. In: Journal of Cleaner Production* 227

13 FEE (2020): *What will digital farming mean for agriculture in Europe?*

14 Access 12/01/21: *https://foodtank.com/news/2021/01/farmers-fight-for-right-to-repair-their-own-equipment/*

15 ARC2020 (2016): *Organic vs Conventional – which is the most sustainable?*

Reganold, J.; Wachter, J. (2016): *Organic agriculture in the twenty-first century. In Nature Plant 2*

16 Access 07.01.2021: *"The Emperor's New Clothes" by Hans Christian Andersen*

17 *IPCC (2000): Landuse, Landuse Change and Forestry.*

International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) (2009): *Agriculture at a Crossroads. Washington.*

18 Sutton, M., Howard, C. et al. (Eds.) (2011): The European Nitrogen Assessment: Sources, Effects and Policy Perspectives. Cambridge University Press.

Tian, H. et al. (2020): *A comprehensive quantification of global nitrous oxide sources and sinks. Nature 586*

19 Beste, A.; Idel, A. (2019): *The belief in technology and big data. The myth of climate smart agriculture – why less bad isn't good*

Köpke, U.; Nemecek, Th. (2010): *Ecological services of faba bean.* In: Field Crops Research 115.

Skinner, C.; Gattinger, A. (2019): *The impact of long-term organic farming on soil-derived greenhouse gas emissions. In: Sci Rep 9, 1702*

20 R.P. White,S. Murray and M. Rohweder (2000): *Pilot Analysis of Global Ecosystems: Grassland Ecosystems.* World Resources Institute, Washington, DC.

21 Beste, A.; Idel, A. (2019): *The belief in technology and big data. The myth of climate smart agriculture – why less bad isn't good*

22 Lehmann, j.; Kleber, M. (2015): *The contentious nature of soil organic matter.* In: Nature 528

23 Beste, A. (2021): *A Soil Scientist's Perspective – Carbon Farming, CO2 Certification & Carbon Sequestration in Soil.* On ARC2020

23a Paustian, K. et al. (2016): *Climate-smart soils.* Nature, 532.

Wiesmeier, M. et al. (2019): 2019. *Soil organic carbon storage as a key function of soils - A review of drivers and indicators at various scales.* Geoderma, 333.

24 Thünen-Institut (2012): *Studie zur Vorbereitung einer effizienten und gut abgestimmten Klimaschutzpolitik für den Agrarsektor,* Sonderheft 361

25 Thünen-Institut (2018): Thünen Working Paper 112. *Die 4-Promille-Initiative „Böden für Ernährungssicherung und Klima" – Wissenschaftliche Bewertung und Diskussion möglicher Beiträge in Deutschland.*

26 Wiesmeier, M. et al. 2020: *CO_2 certificates for carbon sequestration in soils: methods, management practices and limitations.*

27 Beste, A.; Idel, A. (2019): *The belief in technology and big data. The myth of climate smart agriculture – why less bad isn't good , P. 18 et seq.*

28 R.P. Vorney, R.P. (2007): The soil habitat. In: Soil Microbiology, Ecology and Biochemistry (Third Edition)

29 Gul, S. and Whalen, JK. (2016) Biochemical cycling of nitrogen and phosphorus in biochar-amended soils. Soil Biology and Biochemistry. Elsevier Ltd 103: 1–15. Available at: *http://dx.doi.org/10.1016/j.soilbio.2016.08.001.*

30 Gurwick, N.P. et al. (2013). *A Systematic Review of Biochar Research, with a Focus on Its Stability in situ and Its Promise as a Climate Mitigation Strategy.*

Bach, M. et al. (2016): *Current economic obstacles to biochar use in agriculture and climate change mitigation, Carbon Management, 7*

31 Teichmann, I., 2014. *Klimaschutz durch Biokohle in der deutschen Landwirtschaft: Potentiale und Kosten.* DIW Wochenbericht Nr. 1+2.

32 Lange, M. et al. (2015): *Plant diversity increases soil microbial activity and soil carbon storage. Nat Communications 6.*

Gentsch, N. et al. (2020): *Catch crop diversity increases rhizosphere carbon input and soil microbial biomass.* In: Biology and Fertility of Soils, 56

33 M.; Montemurro F. (2010): *Long-term effects of organic amendments on soil fertility.* A review. Agron Sustain Dev 3

Ingham, E. (2006): How the soil food web and compost increase soil organic matter content. In Org. Solut. Clim. Change 13

Beste, A.; Faensen-Thiebes, A. (2015): Terra Preta / Pyrolysekohle. BUND - Einschätzung ihrer Umweltrelevanz.

33a Humic Products Trade Association (HPTA) Science Committee Report (2015): *"Biochar and humic substances: a comparison".*

33b Thünen/BMEL (2019): Humus in landwirtschaftlich genutzten Böden Deutschlands. Ausgewählte Ergebnisse der Bodenzustandserhebung.

34 Gilbert J. et al. (2020) *Quantifying the Benefits to Soil of Applying Quality Compost.* ISWA

Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Österreich (2006): *Evaluierung der nachhaltig positiven Wirkung von Kompost auf die Fruchtbarkeit und Produktivität von Böden.*

Adugna, G. (2016): *A review on impact of compost on soil properties, water use and crop productivity.* In: Agricultural Science Research Journal Vol.4

ECN (2017): *Sustainable Compost Application in Agriculture.*

Gilbert, J, et al. (2020): *Quantifying the benefits and costs of parental care in assassin bugs*

35 Jeffery S., Verheijen FGA, van der Velde M. and Bastos AC. (2011): *A quantitative review of the effects of biochar application to soils on crop productivity using meta-analysis.* Agriculture, Ecosystems and Environment. Elsevier B.V. 144(1): 175–187.

Wu H. et al. (2016): *Responses of bacterial community and functional marker genes of nitrogen cycling to biochar, compost and combined amendments in soil.* Applied Microbiology and Biotechnology 100(19)

Zhang, et al. (2019) *Biochar for environmental management: Mitigating greenhouse gas emissions, contaminant treatment, and potential negative impacts,* in: Chemical Engineering Journal, Vol. 373

Ding Y. et al. (2016): *Biochar to improve soil fertility. A review.* Agronomy for Sustainable Development 36(2).

Liesch, AM. et al. (2010*) Impact of Two Different Biochars on Earthworm Growth and Survival.* 4(320)

36 Bucheli, T. et al. (2015). *Polycyclic aromatic hydrocarbons and polychlorinated aromatic compounds in biochar.* In: Lehmann J, Joseph S (Eds.), Biochar for Environmental Management. Earthscan, London, pp. 593–622.

UBA (2016): *Polyzyklische Aromatische Kohlenwasserstoffe. Umweltschädlich! Giftig! Unvermeidbar?*

De la Rosa, JM. et al. (2019): *Effect of pyrolysis conditions on the total contents of polycyclic aromatic hydrocarbons in biochars produced from organic residues: assessment of their hazard potential.* Sci Total Environ 667

Zhang, et al. (2019) *Biochar for environmental management: Mitigating greenhouse gas emissions, contaminant treatment, and potential negative impacts,* in: Chemical Engineering Journal, Vol. 373

37 Oral information 22.03.202, Prof. Große Ophoff, chemist, pyrolysis expert and, since 2001, head of the Centre for Environmental Communication of the Deutsche Bundesstiftung Umwelt (DBU)

38 EC (2021): *Commission sets the carbon farming initiative in motion.*

39 Luo et al. (2010): *Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments.* Elsevier 139

40 Thünen-Institut (2015): *Informationen über LULUCF-Aktionen.*

41 Gensior et al. (2012): *Landwirtschaftliche Bodennutzung. Eine Bestandsaufnahme aus Sicht der Klimaberichterstattung.* In: Bodenschutz 3/12.

Catch-C (2014*): Compatibility of Agricultural Management Practices and Types of Farming in the EU to enhance Climate Change Mitigation and Soil Health.*

Holland, J. M. (2004): *The environmental consequences of adopting conservation tillage in Europe*: reviewing the evidence. Agriculture, Ecosystems and Environment 10.

Pflanzenforschung.de (2014): *Pflügen oder nicht pflügen. Das Direktsaatverfahren speichert weniger Kohlenstoff im Boden als angenommen.*

42 M. Gaupp-Berghausen et al. (2015*): Glyphosate-based herbicides reduce the activity and reprduction of earthworms and lead to increased soil nutrient concentrations.* In: Scientific Reports 5.

top agrar online (2015): *Glyphosathaltige Pflanzenschutzmittel beeinträchtigen Bodenleben*

43 T. Philpott (2011): *USDA scientist: Monsanto's roundup herbicide damages soil.*

K. K. Sailaja and K. Satyaprasad (2006): *Degradation of glyphosate in soil and its effect on fungal population.* In: Journal of Environmental Science and Engineering 48

44 Beste, A. (2019): *Comparing Organic, Agroecological and Regenerative Farming.*

45 Access: 03.03.2021: *https://www.pepsico.com/news/press-release/pepsico-announces-2030-goal-to-scale-regenerative-farming-practices-across-7-mil04202021*

46 Members are, among others: Bayer, BASF, Syngenta, Corteva und Sumitomo Chemical.

47 Access 05.03.2021: *https://croplife.org/news/what-is-agroecology/*

48 Richie, H. (2019): *Half of the world's habitable land is used for agriculture.*

49 IPBES (2019): Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. *The IPBES Global Assessment on Biodiversity and Ecosystem Services.* Bonn, Germany.

Spangenberg J. et al. (2020): *Falsche Hoffnungen, vertane Chancen: Wie ökonomische Modelle die Vorschläge des IPCC im Special Report 15 „Global Warming of 1.5°C" beeinträchtigen.*

50 Ulgiati, S. (2001): *A Comprehensive Energy and Economic Assessment of Biofuels: When „Green" Is Not Enough.* Critical Reviews in Plant Sciences 20(1).

51 EEA European Environment Agency (2006): *How much bioenergy can Europe produce without harming the environment?* EEA Report 7/2006. EEA. Copenhagen, EEA.

52 *International Scientists and Economists Statement on Biofuels and Land Use. A letter to the European Commission.*

53 FAO (2011): *Price Volatility in Food and Agricultural Markets: Policy Responses.*

54 German National Academy of Sciences Leopoldina (2012): *Bioenergy – Chancesand limits.* Halle (Saale).

55 SOILSERVICE (2012): *Conflicting demands of land use, soil biodiversity and the sustainable delivery of ecosystem goods and services in Europe.*

Beste, A.; Idel, A. (2019): *The belief in technology and big data. The myth of climate smart agriculture – why less bad isn't good*

56 Beste, A. (2007): *Klimaschutz auf Kosten des Bodenschutzes.* In „local land and soil news", the bulletin of the European Land and Soil Alliance (ELSA) e.V., 22/23

Guteser, R.; Ebertseder, TH. (2006): Die Nährstoffe in Wirtschafts- und Sekundärrohstoffdüngern – ein unterschätztes Potential im Stoffkreislauf landwirtschaftlicher Betriebe. In KTBL (Hg.): Verwertung von Wirtschafts- und Sekundärrohstoffdüngern in der Landwirtschaft, Nutzen und Risiken. = KTBL 444

57 Access: 03.03.2021: *https://msutoday.msu.edu/news/2011/solar-cells-more-efficient-than-photosynthesis-*

58 *Access 10/12/21: https://www.sciencedaily.com/releases/2019/07/190729123751.htm*

59 African Centre for Biodiversity (2015): *Profiting from the Climate Crisis, Undermining Resilience in Africa: Gates and Monsanto's Water Efficient Maize for Africa* (WEMA) Project

60 Deutsche Welthungerhilfe (2010): „Gensaat ist keine Lösung". In: Welternährung, 2. Quartal.

Brot für die Welt (2014): *Global food security does not need genetic engineering Agri-genetic engineering – a means for fighting hunger?.*

61 Latham, J. (2020). *The Myth of a Food Crisis. Rethinking Food and Agriculture.* Elsevier.

Lappé, F. M., & Collins, J. (2015). *World hunger: Ten myths.* Grove Press.

Sen, A., (1981) *Poverty and famines: an essay on en-titlement and deprivation.* Oxford University Press, New York

62 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) (2009): *Agriculture at a Crossroads. Washington.*

The World Agricultural Council was initiated in 2002/2003 by the World Bank and the United Nations (UN) with the aim of reducing global malnutrition and poverty. It should investigate how the world's population can be fed sustainably. The aim was to assess the relevance, quality and effectiveness of agricultural knowledge, research and technology for reducing hunger and poverty among the world's rural population, taking into account the aspects of climate compatibility, preservation of biodiversity as well as social and health aspects. In particular, the report calls for an expansion of organic farming and agro-ecological methods and the promotion of small farmers. Green genetic engineering, agrochemicals and intellectual property of seeds are critically questioned.

63 Bollinedi H. et al. (2017). *Molecular and Functional Characterization of GR2-R1 Event Based Backcross Derived Lines of Golden Rice in the Genetic Background of a Mega Rice Variety Swarna.* PLoS One. 12(1)

Stone, GD. ; Glover, D. (2017). *Disembedding grain: Golden rice, the green revolution, and heirloom seeds in the Philippines.* Agriculture and Human Values, 34(1)

64 ENSSER; CSS (2021): *Scientific critique of Leopoldina and EASAC statements on genome edited plants in the EU.*

64a Keller, E. F. (2000): The Century of the Gene. Harvard University Press, Cambridge, MA, 100.

Schubert, D. (2002): A Different Perspective on GM Food. Nature Biotechnology 20: 969

65 Sheat, S. et al. (2019): *Resistance Against Cassava Brown Streak Viruses From Africa in Cassava Germplasm From South America.* Front Plant Sci. 10

66 Access: 30.04.2021: *https://www.globalagriculture.org/flagship-projects/seed-network-masipag.html*

67 Gianinazzi, S. et al. (2010): *Agroecology: the key role of arbuscular mycorrhizas in ecosystem services.* Mycorrhiza 20.

68 Solanki, M. K. et al. (2021): *Mycorrhizal fungi and ist importance in plant health amelioration.* In: Micribiomes and Plant Health.

69 Oehl, F. et al. (2005): *Community structure of arbuscular mycorrhizal fungi at different soil depths in extensively and intensively managed agroecosystems.* N. Phytol. 165

SOILSERVICE (2012): *Conflicting demands of land use, soil biodiversity and the sustainable delivery of ecosystem goods and services in Europe.* Lund, Sweden

Solanki, M.K. (2021): *Mycorrhizal fungi and its importance in plant health amelioration.* In: Microbiomes and Plant Health.

70 Testbiotech (2017): *Gene drive made in Göttingen, Risk of uncontrolled release of genetically engineered flies.*

71 The current report provides a background to the topic: *Forcing the Farm – How Gene Drive Organisms Could Entrench Industrial Agriculture and Threaten Food Sovereignty*

72 CEO (2016): *Biotech Lobby's push for new GMO to escape regulation.*

CEO (2021): *Derailing EU rules on new GMOs. CRISPR-Files expose lobbying tactics to deregulate new GMOs.*

73 A Call to Protect Food Systems from Genetic Extinction Technology: *The Global Food and Agriculture Movement Says NO to Release of Gene Drives.*

74 German Farmers' Union (DBV): *Klimastrategie 2.0.*

75 Hörning, B. (2021): *Tierschutz versus Klimaschutz? - Anmerkungen zu (vermeintlichen) Zielkonflikten.* In KAB 2021

76 Busse, Tanja (2015): Die Wegwerfkuh.

77 R.P. White,S. Murray and M. Rohweder (2000): *Pilot Analysis of Global Ecosystems: Grassland Ecosystems.* World Resources Institute, Washington, DC.

78 M. Roser and H. Ritchie (2018): Yields and land use in agriculture. Our world in data 2018.

79 J. L. Peyraud et al. (2014): *Multi species swards and multi scale strategies for multifunctional grassland base ruminant production systems: An overview of the FP7 MultiSward project.* In: Grassland Science Europe 19.

See also: *https://ec.europa.eu/eip/agriculture/en/find-connect/projects/multi-species-swards-and-multi-scale-strategies*

UBA Umweltbundesamt (2013*): Globale Landflächen und Biomasse nachhaltig und ressourcenschonend nutzen.* Position. Dessau-Roßlau, Umweltbundesamt.

80 Food and Agriculture Organization of the United Nations (FAO) (2020): *Livestock on grazing lands.* Rome.

80a *Sustainable Food Trust (2017): EAT-Lancet report's recommendations are at odds with sustainable food production.*

81 Nature-based Solutions (NbS) are measures to protect, sustainably manage and restore natural and modified ecosystems in a way that effectively and adaptively addresses societal challenges to achieve both human well-being and biodiversity. They are based on the benefits that healthy ecosystems bring and target key challenges such as climate change, disaster risk reduction, food and water security, health and are critical for economic development.

https://www.iucn.org/theme/nature-based-solutions/about

82 Acess 10/12/21: *https://www.thuenen.de/en/cross-institutional-projects/public-services-of-organic-agriculture-for-the-environment-and-society/*

83 Solanki, M.K. (2021): Mycorrhizal fungi and its importance in plant health amelioration. In: Microbiomes and Plant Health.

84 Okada, H., Kuhn, C., Feillet, H., & Bach, J. F. (2010). The 'hygiene hypothesis' for autoimmune and allergic diseases: an update. Clinical and experimental immunology, 160(1), 1–9. *https://doi.org/10.1111/j.1365-2249.2010.04139.x*

85 Schek, A. (2002c). Sekundäre Pflanzenstoffe. Leistungssport, 32 (5).

Vallverdú-Queralt, A. et al. (2012): Evaluation of a Method To Characterize the Phenolic Profile of Organic and Conventional Tomatoes. In: Journal of Agricultural and Food Chemistry 2012 60 (13), 3373-3380, 2. März 2012, *doi: 10.1021/jf204702f.*

86 Solanki, M.K. (2021): Mycorrhizal fungi and its importance in plant health amelioration. In: Microbiomes and Plant Health.

87 Access: 1.10.2020 *https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32018R0848*

88 Die Argonauten (2019): Final report on the research project "Calculate it right": *Implementation of extended financial accounting in agriculture, including monetary valuation ofexternal effects.*

89 Access 30/05/2020: *https://www.food-monitor.de/2018/05/wahre-kosten-der-lebensmittelproduktion-die-true-cost-blume/*

90 Die Argonauten (2019): Final report on the research project "Calculate it right": *Implementation of extended financial accounting in agriculture, including monetary valuation of external effects.*

91 Schader, C. et al. (2012): *Environmental performance of organic farming.*

Reganold, J.; Wachter, J. (2016): *Organic agriculture in the twenty-first century.*

Access 10/12/21: *https://www.thuenen.de/en/cross-institutional-projects/public-services-of-organic-agriculture-for-the-environment-and-society/*

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92 Badgley, C. et al. (2007): *Organic Agriculture and the global food supply. Renewable Agriculture and Food systems. 22*

Ponisio, L. et al. (2015): *Diversification practices reduce organic to conventional yield gap.*

93 SRI-Rice (2014). *The System of Crop Intensification: Agroecological Innovations to Improve Agricultural Production, Food Security, and Resilience to Climate Change.* SRI **93** InternationalNetwork and Resources Center (SRI-Rice), Cornell University, Ithaca, New York

94 Latham, J. (2020). *The Myth of a Food Crisis. Rethinking Food and Agriculture.* Elsevier

95 *Interview with Prof. Christian Kreiß, on BR, 19.6.2018; in German*

95a Kreiß C. cited in Röhrlich, D. (2015): *The credibility of third-party funded research. Deutschlandfunk 8.6.2015; in German.*

96 Access: 2.3.2021 *http://www.ipes-food.org/pages/LongFoodMovement*

97 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) (2009): *Agriculture at a Crossroads. Washington.*

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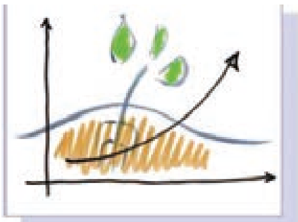

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Greenwashing & high tech!

FAKING IT: (UN-) SUSTAINABLE SOLUTIONS FOR AGRICULTURE

DR. ANDREA BESTE

Commissioned by Martin Häusling, MEP

Fitting into a complex ecosystems (even if they are not yet fully understood) is hardly perceived as an innovation anymore. Instead, solutions are mostly considered to be "innovative" if they involve complicated technology that few people understand and they are based on the assumption that all aspects of an ecosystem can be controlled. But what may yield very good results in engineering can be counterproductive, inefficient and sometimes even dangerous when applied within the context of ecology. Apparently, the dream of the technical controllability of biological systems still is far from over. For years, agriculture's fascination with the possibilities of interference that technology and chemistry can provide was the result of the (wrong) impression that such fixes are simple, targeted, controllable and without negative side effects. Today we know that in many instances this was a total misconception.

The climate crisis and species extinction are the biggest challenges for agriculture at present. Every study and international report correctly says: agriculture is both, perpetrator and victim. The vast majority of international and European scientists agree that the manner in which we farm has to change fundamentally. The obvious solution would be to promote agricultural systems which by definition, rear animals less intensively and use far less synthetic nitrogen and fewer pesticides and thereby are proven to allow for more biodiversity as well as lower nitrogen levels in water courses – systems such as organic agriculture. But instead, something strange happens: new, supposedly innovative techniques keep cropping up and find their way into political policy papers even though they have nowhere near the same synergetic potential for positive effects on the agroecosystem. In this study, Dr Andrea Beste has taken a closer look at several of the current, hotly discussed "sustainability solutions" and comes to the conclusion: "this is fake sustainability".