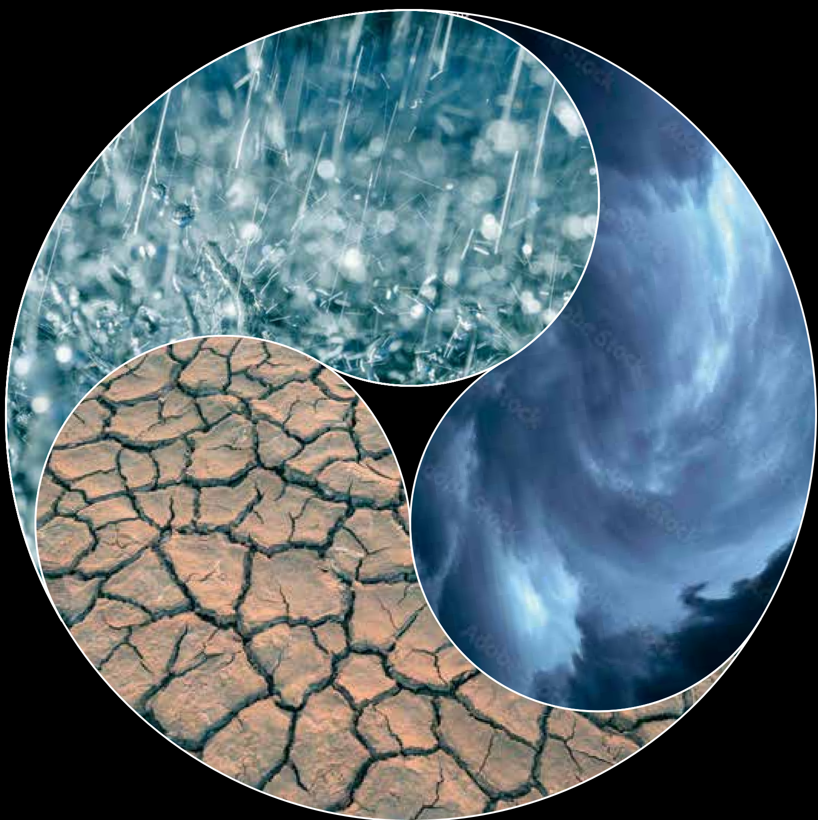
Climate change, agriculture and the role of biotechnology

Report of the Federal Ethics Committee on Non-Human Biotechnology (ECNH)




Executive summary

In the Paris Agreement, Switzerland made a commitment under international law to achieve the 1.5 °C target and the net zero target. Irrespective of this obligation under international law, Switzerland has a moral obligation to meet these targets in view of the scientific scenarios concerning the damaging effects of climate change. Accordingly, Switzerland must make an appropriate contribution to limiting global warming. 'Appropriate' also implies that Switzerland must do more than other countries, in line with its capabilities, because it can do so and because the damage scenarios if the 1.5 °C target is not met are unacceptable. At the same time, food security in Switzerland and globally must be safeguarded in the long term. 'Food security' means that all people have access to sufficient food in accordance with the right to adequate food.

Switzerland's Long-Term Climate Strategy sets a target of cutting greenhouse gas (GHG) emissions from agriculture by at least 40 % by 2050. As a minimum target, this is significantly lower than in all other relevant sectors. This gives agriculture a special status that can be ethically justified only if a greater reduction is neither technically possible nor politically feasible. In the ECNH's view, there are not sufficient grounds for either claim. The special status for agriculture cannot be justified and the reduction target currently set politically is therefore ethically inadequate.

On the other hand, a reduction to zero GHG emissions does not seem possible, not even if livestock farming (which is responsible for a large part of the emissions) and hence the import of animal feed and the cultivation of feed in Switzerland – as well as the import of animal products – were to be completely abandoned. A 'residue' of GHG emissions will still remain, owing to fertilisers and soil management. These will have to be offset using negative emissions technologies (NETs) in order to meet the net zero target.

As a general principle, the measures that should be taken are those that are likely to prove most successful, i.e. most efficient and effective, at meeting the target. In this regard, there are justified reservations about NETs. In

particular, it is questionable whether they can be developed and implemented quickly enough and whether they will be sufficiently effective. Even so, we will presumably still be reliant on such technologies to be able to hit the net zero target. From an ethical perspective, this means – given the urgency of the climate goals – that NETs must be developed as quickly as possible and in an internationally coordinated way. However, in view of the uncertainty associated with NETs, the overall mitigation process should be designed in such a way that, ultimately, the smallest possible amount of GHG emissions has to be offset using these technologies. As far as agriculture is concerned, in this situation there is no getting away from the need to significantly reduce the number of livestock globally and nationally and to grow more plant-based food for human consumption – even if it proves possible to cut GHG emissions from livestock farming to some extent using genetic engineering, among other things.

In terms of adapting to climate change, measures must be taken in such a way that national and global food security is safeguarded as far as possible in the short and long term. In this context, the question arises as to the relevance of genetic engineering techniques in the area of crop breeding. Whatever their potential, it currently seems rather unlikely, given the short time available, that these technologies will be able to make a decisive contribution, in terms of climate change, to securing or increasing crop yields by means of genetically modified plants. This does not mean that genetic engineering should not be used, but the great urgency of adapting to climate change requires that this be done in a way that leverages existing technologies and promotes alternative solutions that can help to achieve the 1.5 °C target.

1 Background

1.1 Climate change

Human-influenced climate change assumed to be proven. The global climate has been warming for around 200 years in a way that is no longer attributable to natural fluctuations in cold and warm periods, but is significantly influenced by humans. The ECNH assumes this to be proven on the basis of the relevant scientific findings.

Greenhouse gases the main mechanism. Greenhouse gases (GHGs) are the main mechanism of climate change. Emissions of GHGs from human activities have accumulated in the atmosphere on a scale that is causing changes in global heat transfer and thus in the climate. The main drivers of global warming include energy-intensive sectors such as buildings, transport and industrial processes. The main GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).[1] Methane and nitrous oxide are particularly generated in agricultural production due to the use of nitrogen fertilisers and the keeping of livestock. The effect of GHGs varies in duration

1 An overview table of anthropogenic GHGs can be found on the website of the Federal Office for the Environment (FOEN): https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/fachinfo-daten/vom_menschen_verursachtetreibhausgase.pdf.download.pdf/Treibhausgase_2020_EN.pdf.

and intensity. While CO_2 remains in the atmosphere for several centuries and nitrous oxide for around 100 years, methane breaks down within around a decade. However, during this period its impact is many times greater than that of CO_2.

To enable the effects of different GHGs to be compared, the United Nations Intergovernmental Panel on Climate Change (IPCC) established the 'CO_2 equivalent' (CO_2eq or CO_2e) as a unit of measurement. One unit of methane gas is equal to 28 CO_2eq, while the climate impact of nitrous oxide is approximately 300 CO_2eq. The relevant reports refer only to CO_2. For example, if they talk about cutting methane emissions from agriculture by approximately 4–5 million tonnes of CO_2eq per year, this means that the same amount of CO_2 would have to be removed from the atmosphere annually.

Climatic changes and associated damage scenarios. Based on scientific data, researchers have identified drastic changes linked to the changing climate. These changes are already causing harm and scenarios entailing further damage on a massive scale are set to play out. Melting polar ice and rising sea levels endangers coastal areas and islands and their inhabitants. As the oceans warm and their acidity increases, biodiverse marine habitats such as coral reefs are lost. Extreme weather phenomena such as heatwaves and droughts, accompanied by forest fires, increase; hurricanes, storm surges and heavy rain become more frequent and intense, leading to an increase in floods and more landslides as the soil is no longer able to hold the huge volumes of water. This damages fertile land and leads to heavy fluctuations in crop yields, both of which jeopardise food security. In short, climatic changes pose a fundamental threat to humans, animals and the environment, and the associated damage scenarios range from major social and cultural upheavals through to hunger, suffering and death.

Global and national. At a global level, some scientific models suggest that the earth will warm by an average of 5 °C or more by the end of the century, unless appropriate countermeasures are taken. However, it must be borne in mind that the climate is a complex system that does not behave in a linear fashion. Climatic changes may occur suddenly and abruptly, and a host of feedback effects may also cause processes to reinforce themselves. In this case, a tipping point may be reached beyond which the previous state cannot be restored, even with radical measures. For Switzerland, it is currently assumed that, without additional climate change mitigation measures, temperatures will be 3.3 to 5.4 °C warmer by the end of the 21st century than they are today. Even if the increase were moderated by mitigation measures, the climatic changes would still be significant by that date.

1.2 International law response to climate change

Agreement to limit the temperature increase to 1.5 °C by 2100. Under the 1992 United Nations Framework Convention on Climate Change (UNFCCC), the international community agreed to slow down human-caused global warming and mitigate its effects. Building on the UNFCCC and the Kyoto Protocol of 1997, the 2015 Paris Agreement established the common goal of limiting the increase in the earth's average temperature to well below 2 °C above pre-industrial levels. Moreover, efforts are to be made to keep the temperature rise to 1.5 °C above pre-industrial levels. Although the 1.5 °C target is not formulated in binding terms, it is clear that the goal should be to hold average global warming by the end of the century to well below 2 °C compared with pre-industrial times, and to pursue efforts to limit the temperature increase to 1.5 °C.[2] Despite the vagueness of the wording in the Paris Agreement, the ECNH is guided throughout the following by the 1.5 °C target and considers this target to be ethically binding.

Use of negative emissions technologies a prerequisite for 'net zero'. The extent to which global GHG emissions need to be reduced for there to be a sufficient likelihood of meeting the 1.5 °C target is set out in the IPCC expert reports. In its 2018 Special Report, the IPCC states that all human-induced GHGs would have to be reduced to zero by 2050 in order to stabilise the global climate at a maximum average warming of 1.5 °C and prevent the harmful effects feared.[3] However, even the most optimistic scenarios with regard to possible GHG reductions assume that it will not be possible to cut all GHG emissions to zero. There will be a residue of GHG emissions that will have to be offset. The aim is to use negative emissions technologies (NETs) to remove from the atmosphere the amount of CO_2 that is still being released into it and so achieve the net zero emissions target.[4] It should also be borne in mind that the global GHG budget available for the 1.5 °C target could be used up within ten years. This would leave an interim period, up to 2050, in which the budget would be exceeded. This would have to be offset by a 'net negative' in the second half of the century if the 1.5 °C target is to be maintained.

Nationally determined contributions (NDCs). The 1.5 °C target is linked to a global GHG budget. Once this budget has been used up, the amount of GHGs in the atmosphere must not increase any further if a further temperature rise is to be avoided. This applies indefinitely. Based on this GHG budget, the Paris Agreement obliges all parties to set their NDCs and strive to achieve them. For the transition phase until net zero emissions are achieved, each country sets its own climate change targets for the next ten years in these NDCs. Every five years, a Global Stocktake reviews collective progress towards the agreement and assesses this progress in terms of meeting the long-term climate target.[5]

2 The wording about pursuing efforts to limit the increase to the lower value was included in the Paris Agreement under pressure from the countries of the 'South'. These nations are already suffering from prolonged droughts, severe storms and floods, causing many fatalities and massive damage. Some coastal and island states are existentially threatened by rising sea levels. Scientists warn that we are already on course to exceed average warming of 1.5 °C. See Raftery, A. et al. (2017), Less than 2 °C warming by 2100 unlikely, in: Nature Climate Change 7, 637–641. https://doi.org/10.1038/nclimate3352.

3 IPCC Special Report, Global Warming of 1.5 °C – An IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, 2018.

4 According to Switzerland's Long-Term Climate Strategy, "Net zero refers to the balance between the emission of greenhouse gases, on [the] one hand, and their removal and storage in sinks on the other." Switzerland's Long-Term Climate Strategy, 2021, p.7 (https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/emission-reduction/reduction-targets/2050-target/climate-strategy-2050.html); see also IPCC, Climate Change 2021, The Physical Science Basis (IPCC_AR6_WGI_Full_Report.pdf, TS-5).

5 Even if the NDCs submitted so far were implemented, the 1.5 °C target would be missed. However, there are no legally defined consequences (e.g. sanctions) if the self-declared goals are not met. They are to be understood as declarations of intent.

The parties are committed to improving on their previous contribution in each of their NDCs and to being as ambitious as possible at all times. The central legal principle of the UNFCCC and the Paris Agreement requires that countries take into account common but differentiated responsibilities and the respective capabilities of states when defining their targets. This means that all countries have the same responsibilities to achieve the net zero emissions target, even if they do not have to contribute to it to the same extent. According to their capabilities, industrialised nations must do more than emerging and developing countries.

1.3 Focus of the report

Reduction targets for agriculture. While GHG emissions in Switzerland are to be reduced to zero in industry, trade, catering and consumption as well as mobility, housing and energy, the reduction targets for agriculture in Switzerland's climate strategy are lower. It is true that, in terms of the Paris Agreement, relatively large emission reductions are also set for this sector, but some GHG emissions from agriculture are classified as technologically unavoidable.[6] The agricultural sector is therefore not required to reduce emissions to zero, but to cut them by 22 % by 2030 and by at least 40 % by 2050, compared with 1990.[7]

Agriculture's share of GHG emissions. In Switzerland, the agricultural sector currently emits around 14 % of the GHGs imputed to Switzerland under the Paris Agreement. Methane and nitrous oxide emissions are particularly significant here, with over 80 % of methane and over 60 % of nitrous oxide originating in agricultural production. In addition, the cultivation of agricultural land releases further greenhouse gases.[8] Owing to the territorial principle of the Paris Agreement, the 14 % figure does not include imported inputs such as the cultivation of animal feed or the manufacture of mineral fertilisers abroad. Emissions generated after outputs leave the farm are also not ascribed to agriculture, but to the industrial and service sectors.

Crop losses due to climate change. While agriculture is contributing to climate change through GHG emissions, the rapid climatic changes of recent decades are in turn affecting agricultural production. For Switzerland, global warming and the more unstable climate it generates mean that rivers carry more water in winter due to more frequent and intense precipitation, while water resources become scarcer in summer. In summer and autumn, more frequent and longer dry periods are to be expected, at a time when both temperatures and agricultural demand for water are high.[9] In addition, the rising CO_2 concentration in the atmosphere reduces agricultural productivity, impacting both the quantity and quality of yields.[10]

Mitigation and adaptation measures. At a global level, the growing world population and changing diets among the increasingly affluent pop-

6 Switzerland's Long-Term Climate Strategy, p. 13.

7 Switzerland's Long-Term Climate Strategy, p. 38. These reduction targets are also stipulated in the Federal Council report 'Zukünftige Ausrichtung der Agrarpolitik' (Future Orientation of Agricultural Policy) of 22 June 2022. The report (available in German, French and Italian) shows how the Swiss agri-food industry could increase its contribution to food security, based on considerations encompassing the entire food system from production to consumption (https://www.admin.ch/gov/de/start/dokumentation/medienmitteilungen.msg-id-89439.html#:~:text=So%20soll%20die%20Landwirtschaft%20im,dem%20Niveau%20von%201990%20).
But see also Switzerland's Long-Term Climate Strategy, p. 21, according to which a reduction of up to two thirds could be achieved if the potential for emissions reduction in the agricultural and food sectors was fully harnessed. "In the related message, the Federal Council proposed a domestic reduction contribution for the agricultural sector of 20 to 25 per cent by 2030 compared with 1990. This target is derived from the Climate Strategy for Agriculture in which the Federal Office for Agriculture assessed the potential for reducing emissions in the food and agriculture sectors in 2011. According to this climate strategy, emissions in agriculture can be cut by a third by 2050 compared with 1990. If the potential of the agricultural and food sectors is fully harnessed, a reduction of up to two-thirds can be achieved according to the Climate Strategy for Agriculture."

8 FOEN, Kenngrössen zur Entwicklung der Treibhausgasemissionen in der Schweiz 1990–2020, updated April 2022 (Indicators for the development of greenhouse gas emissions in Switzerland 1990–2020) (in German at https://www.bafu.admin.ch/dam/bafu/de/dokumente/klima/fachinfo-daten/kenngroessen_thg_emissionen_schweiz.pdf.download.pdf/Kenngr%C3%B6ssen_2021_D.pdf.); see also: Switzerland's Long-Term Climate Strategy (2021), p. 11.

ulations of large emerging economies such as China, Brazil and India are leading to further large-scale deforestation, by felling or slash-and-burn, to make way for agricultural land. Such clearance releases further CO_2 previously stored in forests,[11] adding to the existing pressure from the dietary habits of industrialised nations. To tackle these climate change challenges, there are essentially two complementary approaches with regard to agriculture. On the one hand, mitigation measures need to be taken to reduce agricultural GHG emissions. On the other hand, adaptation measures are required to tailor agricultural processes to changing climatic conditions.

The role of biotechnology. The ECNH is legally mandated to advise the Federal Council and the federal authorities on the regulation of non-human biotechnology from an ethical perspective. Intensive discussions are currently under way at the political level about developments in genetic engineering techniques and their legal classification. The direction this regulation takes will be decided in the next few years. In the context of the climate goals for agriculture, the opportunities offered by biotechnology solutions, among others, are relevant to both mitigation and adaptation. In order to properly assess these opportunities, the complex interrelationships and tensions between agriculture and the entire food system as well as climate change must be taken into consideration.

1.4 Structure of the report

In its report, the ECNH begins by examining the normative status of the 1.5 °C target. It then weighs the 1.5 °C target against the ethically indispensable tasks of agriculture to derive the requirements applying to emission reduction targets for agricultural production. As a third step, it discusses the technical options available to agriculture, to both reduce its emissions and adapt to the challenges of climate change. In this context, it examines in particular the role of genetic engineering. Moral obligations imply the possibility of their implementation. Assuming that the climate goals are technically achievable, the report therefore also examines, in a fourth step, ethical considerations regarding political feasibility.[12]

Based on this overall view, the Committee formulates, from an ethical perspective, the action needed with regard to the GHG reduction targets for agricultural production and assesses the role of biotechnology options for mitigation and adaptation in agriculture.

The ECNH would like to thank the external experts who made their specialist knowledge available upon request and in discussions with members at Committee meetings. In chronological order, they were: Robert Finger (ETH Zurich), Bruno Tinland (Semafort), Teea Kortetmäki (University of Jyväskylä),[13] Sophie Wenger Hintz (Federal Office for the Environment FOEN), Daniel Felder (Federal Office

9 See National Centre for Climate Services (NCCS) (2021), Auswirkungen des Klimawandels auf die Schweizer Gewässer (Effects of climate change on Swiss water bodies), commissioned by the Federal Office for the Environment (FOEN). As well as emerging conflicts of use, for example between agriculture and energy generation, the report also points to risks such as more frequent local flooding, the thawing of permafrost and the related instability of mountain flanks, as well as the warming – and even drying up – of water bodies, and the resulting pressure on biodiversity.

10 Although an elevated CO_2 concentration increases biomass in the crops studied (to varying degrees), this does not correlate with an increase in nutrient yield. In fact, the plants have lower nutrient levels. Wheat grains contain 9% less zinc, rice about 8% less protein, maize 6% less iron, and potatoes have lower concentrations of proteins and potassium (Myers, S. et al. (2014), Increasing CO_2 threatens human nutrition, in: Nature 510, 139–142. https://doi.org/10.1038/nature13179).

11 Afforestation enables the long-term sequestration of CO_2. However, to create CO_2 sinks on the scale necessary to offset GHG emissions, an area of land one to two times the size of India would be required. Anderson, K. & Peters, G. (2016), The trouble with negative emissions, in: Science, 354(6309), 182–183. https://doi.org/10.1126/science.aah4567.

12 Just because there is political resistance to an ethically justified demand does not diminish the moral obligation to act. See also section 4.

13 T. Kortetmäki (2022), Agriculture and Climate Change. Ethical Considerations. Report commissioned by the ECNH (https://www.ekah.admin.ch/en/external-reports/series-contributions-to-ethics-and-biotechnologyagriculture-and-climate-change).

for Agriculture FOAG) and Regina Birner (University of Hohenheim). The ECNH is responsible for the content of this report.

2 Ethical considerations on the relationship between climate change and agriculture

2.1 The normative status of the 1.5 °C target

2.1.1 Uncertainties over achievement of the target

Some climate researchers doubt that the measures called for by the Paris Agreement are sufficient to achieve the 1.5 °C target and avert the serious adverse consequences of not doing so. Furthermore, some consider the probability of meeting the target inadequate in view of the gravity of the harm. They are therefore calling for a bigger reduction in GHG emissions. How should we deal with the ongoing uncertainties regarding the consequences of climate change which are due to a lack of causal and risk knowledge? This concerns two aspects in particular. On the one hand, there are uncertainties regarding the remaining global GHG budget. According to the IPCC, there is a 66 % probability of achieving the 1.5 °C target if the GHG budget set by the IPCC is not exceeded. Conversely, this means that, in the IPCC's view, there is a 34 % probability that the goal of 1.5 °C will not be met, even if the GHG budget is adhered to. On the other hand, there is uncertainty and vagueness about what would happen if the 1.5 °C target were to be missed.[14]

2.1.2 Appropriateness of measures

From an ethical point of view, it is important what kind of knowledge we have about the consequences. Are there scientifically plausible hypothetical damage scenarios? Or can quantitative or at least qualitative probabilities be assigned to certain damages, enabling statements to be made about the risks? In risk situations, one can make (more or less) reliable statements about the probability of occurrence of a damage (or benefit). In precautionary situations, this is not (yet) possible. These considerations are relevant to the question of the normative status of the 1.5 °C limit and the directly related goal of preventing potential massive damage. For on the one hand, they can be used to work out how to deal with conflicting objectives, and on the other hand, they can, to a certain extent, serve to determine the choice of normatively appropriate

14 The ECNH distinguishes between uncertainty and vagueness. Uncertainty relates to action in risk situations, while vagueness concerns action in precautionary situations. See also ECNH (2018), Precaution in the environmental field. Ethical requirements for the regulation of new biotechnologies.

measures. However, it can also be argued that the potential damages are so immense that their occurrence must be prevented at all costs. This would not change even if it turned out that the probability of occurrence was very low. However, in terms of the degree of urgency to take action, would anything change if the probability of damage was high or if we actually knew that the damage would occur if the target was missed? The more important and urgent it is to avoid plausible serious damage scenarios from materialising, the more drastic are the measures that may be justified.[15]

The climate change scenarios due to anthropogenic GHG emissions, developed by researchers based on plausible scientific models, pose existential threats to humans, animals and the environment even where the average global warming is 1.5 °C. Damage of such magnitude is unacceptable and its probability of occurrence must therefore be reduced as far as possible. Even if the damage were to be very unevenly distributed and not threaten all of humanity equally, and even if the probability of occurrence of these damage scenarios were uncertain or low, the damage must be prevented. If we also consider that, according to the IPCC, even if the GHG budget is adhered to there is only a 66 % probability of achieving the 1.5 °C target and preventing the damage associated with exceeding the target, then any exceedance of average global warming of 1.5 °C is still too much. Given the damage scenarios, a probability of 66 % is not sufficient. Viewed from a precautionary standpoint, the GHG budget would have to be reduced much more and the probability of meeting the 1.5 °C target would have to be higher. The ECNH therefore assumes that the 1.5 °C target set by the international community is justified and ought to be achieved.

15 It is assumed that measures must meet the criteria of appropriateness and proportionality.

16 On the terms ‘ethics’ and ‘morality’ as distinguished in this report: By ‘morality’ we mean the values and norms held by a community or by individuals, not necessarily codified in law, which express expectations about what one must and may do or not do, regardless of whether they are justified. ‘Ethics’ is the systematic reflection on these values and norms with the aim of establishing which ones are justified.

17 In this respect, however, a distinction is made between perfect and imperfect obligations. Perfect: the obligation defines a specific act or omission. Imperfect: the agent has scope for decision-making. For example, one can argue that there is a moral obligation to help people in need, but one can usually decide for oneself who exactly falls into this category, and what help one gives to whom and in what way.

Moral obligation.[16] This 'ought to' may be understood morally, in which case achieving the target is a moral obligation. Moral obligations are associated with the claim to be justified moral commands or prohibitions. Those to whom they are addressed ought to do or not do something, regardless of whether it is in their (immediate) self-interest. In this sense, moral obligations leave no room for manoeuvre[17] – at least as long as nothing impossible is demanded. For a moral obligation presupposes that one is also able to fulfil that obligation. These obligations apply either prima facie or absolutely. If they apply absolutely, this means that they apply without exception. If they apply prima facie, they apply so long as they do not conflict with other moral obligations. In the event of conflicting prima facie obligations, the obligations must be weighed up to determine which of them takes precedence in the case at hand.

Prudential 'obligations'. Distinct from moral obligations are prudential 'obligations', meaning that one ought to do something in order to achieve something else. In political contexts, for example, it is argued that achieving the target is in our self-interest. As a rule, 'self-interest' is understood primarily in economic terms. The required reduction in GHGs, the argument goes, offers enormous economic opportunities, whereas massive economic damage is to be expected if the 1.5 °C target is missed. 'Self-interest' can also be understood as 'enlightened self-interest': achieving the 1.5 °C target is in the long-term existential self-interest of every human being. In this case, to achieve the target is not a moral obligation, but the result of a prudential consideration.[18] The requirement thus has the status of an imperative of prudence. To act against it would be irrational.

Legal obligations. Legal obligations are to be distinguished from moral obligations and prudential considerations. Legal norms and the resulting legal obligations arise in a different way from moral obligations. They are also enforceable, unlike moral obligations, with which one can only demand compliance.[19] Whether a moral obligation should also become a legal obligation is in part an ethical question. Even if avoiding a certain climate-relevant activity were a moral obligation, this would still not be sufficient to justify – with regard to those who do not refrain from this activity – a legal obligation binding on all.

Moral commitment. In the context of the subject under discussion, some also appeal to a voluntary moral commitment of the kind exemplified by professional ethics in farming. Farmers ought to contribute to reducing GHG emissions because it fits with their self-image as 'good farmers'. These obligations do not apply to everyone, but only to those who, because they belong to the group, commit themselves to them. On a critical note, it should be pointed out that the image farmers have of themselves is heterogeneous. It is shaped by many factors, such as what they produce, the topographical location of their farm and its size. Farmers are also partly bound by specific practical constraints and structures linked to production and marketing processes, which they find difficult to escape.[20]

Who bears the obligation? If complying with the 1.5 °C target has the status of a moral obligation, it needs to be clarified who bears that obligation in the present context. Bearers of moral obligations can only be entities that are able to act and be responsible for their action (acts and omissions). However, in the context of climate change, individuals alone cannot fulfil these obligations. They can only be fulfilled collectively.[21] Individual legal entities must therefore partially transfer the tasks to higher-level bodies that can undertake this responsibility. Ultimately, this is the only way to safeguard the moral rights of all concerned, i.e. each and every individual. This ethical line of argument also fits with the situation under international law, where, in the context of climate agreements, states are the main actors and primary addressees of obligations and/or (urgent) recommendations.[22]

18 Whether something is a moral or a prudential obligation often only becomes apparent in context. However, the distinction is normatively relevant with regard to the question of the appropriateness of measures and regulatory instruments, as well as the political room for manoeuvre in the event of conflicts and the question of whether the ethical or the prudential approach then has priority.

19 This has to do with the fact that the sanctions differ in law and morality. Unlike morality, law has institutionalised sanctioning bodies such as the police and courts, which punish violations of the law with specific sanctions such as fines or imprisonment and can thus enforce certain courses of action. Morality has no such bodies and can only sanction 'informally', be it through internal sanctions such as instilling a guilty conscience or through reprimand and criticism, up to and including ostracising those who do not abide by the moral rules.

20 For a discussion of the term 'good farmer' and the moral commitment it underpins, see T. Kortetmäki (2022), pp. 61 ff.

21 In the context of the challenges of climate change, the argumentation centres on the fact that individuals are not the sole bearers of obligations. To what extent they bear responsibility within the framework of these collective obligations will be left open here. – On the moral responsibility of individuals with regard to sustainable consumption decisions, see for example Christine Clavien (2022), Le bal des responsabilités et la nécessité de réduire l'altruisme pour promouvoir les choix durables (The ball of responsibilities and the necessary mitigation of altruism to promote sustainable choices), in: Communications, 2022, vol. 1, no. 110, 115–126. Clavien argues that holding individuals responsible for the impact of their lifestyle and consumption decisions on global warming is only permissible to the extent that they are free to make their own choices and are able to recognise the impact of their choices. The article also sets out arguments why public decision-makers should take more responsibility in the face of the climate emergency: at the individual level, decisions to act sustainably are currently too often altruistically motivated. However, relying on people's altruism to curb global warming is not the right approach. It is the public decision-makers and not the individual inhabitants of a country who have the power to quickly create incentives (compensation, direct support) or organise votes on obligations (binding laws) that make environmentally friendly behaviour attractive or at least acceptable to individuals.

22 From an ethical point of view, it is not a matter of democratic legitimation via majority decision, but of moral legitimation of a mandate to the state as the executing or implementing authority.

2.2 The reduction target for agriculture and its ethical assessment

2.2.1 Urgency of measures

While GHG emissions from the agricultural sector are to be cut by at least 40 % by 2050 according to Switzerland's Long-Term Climate Strategy (2021) and the agricultural report 'Zukünftige Ausrichtung der Agrarpolitik' (Future Orientation of Agricultural Policy, 2022), overall emissions in Switzerland and worldwide must be reduced to net zero by 2050. Without further measures to reduce GHGs, the global budget will be exhausted in seven to ten years or, according to some calculations, even earlier. On the one hand, mitigation measures could 'stretch' the – still available but rapidly diminishing – GHG budget until offsetting measures take effect.[23] Once the remaining GHG budget has been used up, no more GHGs may be emitted than can be offset. If this does not succeed, overcompensation will be required in the second half of the century, i.e. 'net negative' rather than 'net zero' GHG emissions.

2.2.2 Negative emissions technologies (NETs) as an offset option

The climate strategy relies on being able to fully offset the remaining GHG emissions from agricultural production using NETs. Generating 'negative emissions' involves leveraging both biological processes and engineering approaches. The decisive factor here is not that emissions are reduced or avoided altogether, but that excess emissions from agriculture are removed from the atmosphere by means of NET.[24]

Biological approaches are based on the fact that plants convert CO_2 from the air into biomass through photosynthesis and store it, thus removing CO_2 from the atmosphere. Changes in forest and soil management, for example, are intended to increase the storage capacity of trees and soils. Research is also being carried out into possible biotechnology solutions, with faster plant and tree growth induced by genetic engineering resulting in more CO_2 storage.

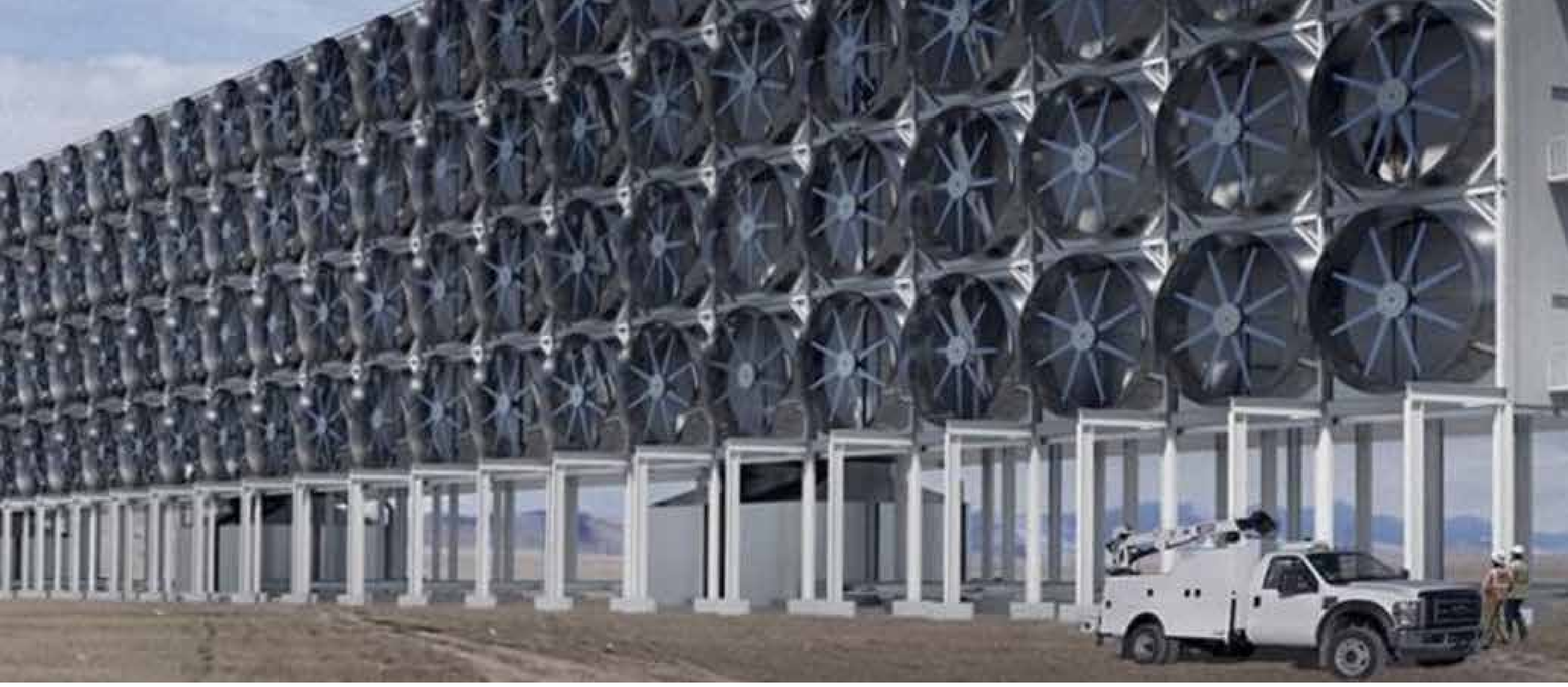
The engineering approaches are based on carbon capture and storage (CCS). Bioenergy with carbon capture and storage (BECCS) technology uses biological processes, i.e. planting energy crops, to remove CO_2 from the atmosphere. CO_2 generated from the use of this biomass is not released but captured and stored permanently underground. Direct air carbon capture and storage (DACCS) technology captures CO_2 directly from the ambient air. The air flows through a filter system that removes some of the CO_2 from the atmosphere. This CO_2 then also has to be stored permanently.[25]

2.2.3 Ethical assessment of NETs

To achieve the 1.5 °C target, emissions from all human processes must not only be reduced but avoided as far as

23 It should be noted that there are no binding national GHG budgets. While it may be possible to calculate the remaining global GHG budget, it is unclear how this is distributed among individual countries and thus how large the remaining budget for Switzerland is.

24 For definitions and explanations of terms, see Von welcher Bedeutung könnten negative CO_2-Emissionen für die künftigen klimapolitischen Massnahmen der Schweiz sein? (What significance could negative CO_2 emissions have for Switzerland's future climate policy measures?). Federal Council report in response to postulate 18.4211 submitted by Thorens Goumaz, 12 December 2018, 2020, p. 7f. (in German at https://www.parlament.ch/centers/eparl/curia/2018/20184211/Bericht%20BR%20D.pdf); CO_2-Abscheidung und Speicherung (CCS) und Negativemissionstechnologien (NET). Wie sie schrittweise zum langfristigen Klimaziel beitragen können (Carbon capture and storage (CCS) and negative emission technologies (NETs): how they can gradually contribute to the long-term climate goal). Federal Council report, 2022 (in German at https://www.newsd.admin.ch/newsd/message/attachments/71551.pdf); Parlamentarische Initiative Indirekter Gegenentwurf zur Gletscher-Initiative. Netto-Null-Treibhausgasemissionen bis 2050 (Parliamentary Initiative: Indirect counter-proposal to the Glacier Initiative. Net zero greenhouse gas emissions by 2050). Report by the National Council Environment, Spatial Planning and Energy Committee (ESPEC-N), 2022 (in German at https://www.newsd.admin.ch/newsd/message/attachments/71764.pdf). The definition of NETs proposed in Article 2 of the draft Federal Act on Climate Protection Targets (Bundesgesetz über die Ziele im Klimaschutz (KIG)) corresponds to that given in the text. Article 2a reads: "Negative emission technologies: biological and technical processes to remove CO_2 from the atmosphere and permanently sequester it in forests, soils, wood products or other carbon reservoirs."



possible. At the same time, emissions from agricultural production are considered diffuse and can therefore only be captured to a limited extent. The standard argument is that anything that cannot be avoided must be offset. Moreover, if the target agreed for 2050 is not reached, emissions must not only be offset but more than offset, i.e. a net negative must be achieved. This argument implies that we will be reliant on generating negative emissions.

Techniques for producing negative emissions are still in the development phase. Such techniques must be effective, environmentally sound and socially acceptable, and there are still many unanswered questions in this regard. How quickly can NETs be developed and how fast could they work on the scale required? How permanently can the CO_2 be stored? What are the associated environmental risks and are they acceptable? How feasible are they – economically, politically and socially? These questions about opportunities and risks must be answered in order to be able to assess the urgency of measures to avoid GHG emissions from agriculture. The less likely it is that NETs will be effective on the required scale within a useful time frame, the more urgent will be the measures to avoid GHG emissions instead – and the more radical these measures will need to be. If, on the other hand, no statements can be made about the probability, the concept of precaution comes into play. This means that we cannot assume it will be possible to offset the emissions arising from agricultural production. Moreover, in this case it would be out of the question to assume that carbon offsetting approaches would be sufficiently effective, in view of the rapidly dwindling global GHG budget.

2.2.4 On the special status of agriculture

Against this backdrop, the question as to the justification for the special status of agricultural production becomes all the more urgent, even bearing in mind that reducing emissions to zero will not be possible due to the inherent way in which agriculture operates. The special status might be justified, on the one hand, by the fact that even this maximum possible reduction is not technically feasible within the specified time frame (by 2050) unless we accept that agriculture is no longer able to perform those tasks for which ethical obligations exist. Another reason might be that a bigger reduction of emissions in the agricultural sector is not politically feasible.[26] These two justifications for a special status need to be examined separately.

2.2.5 Indispensable tasks of agriculture

If we accept that meeting the 1.5 °C target is a moral obligation or – as the outcome of a prudential consideration in the aforementioned sense – an imperative of prudence, then we must first clarify what the ethically indispensable tasks of agriculture are.[27]

25 Since there is not enough storage space available in Switzerland, it will be necessary to set up and use an international infrastructure. In order to be stored, the CO_2 must be liquefied and transported by ship, rail or pipeline (most pipelines will need to be built from scratch) to the storage site, where it can be stored in suitable underground conditions, e.g. depleted natural gas sites or in the North Sea. Some of the energy previously recovered by the process must be expended both for the capture of the CO_2 and for its compression, transport and geological storage.

26 Agricultural production is usually also very bound by practical constraints, such as integration into collectively organised or highly regulated production and marketing structures. Since these are ultimately dependent on the regulatory framework, they are also addressed here in relation to political feasibility.

27 In the following, we argue primarily from an ethical perspective.

Food security and food sovereignty paramount. Chief among the tasks to which agricultural production must make a decisive and indispensable contribution is food security.[28] According to the Food and Agriculture Organization of the United Nations (FAO), food security means that "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life".[29] The four dimensions of food security according to FAO are:

1 **Availability of food:** a quantitatively sufficient supply of food;

2 **Access to food:** the food is affordable;

3 **Utilisation of food:** the food is safe (i.e. not harmful), contains the necessary essential nutrients and can be stored and prepared appropriately;

4 **Stability:** availability, access and utilisation are secure over time. In particular, access to food is not threatened by economic crises or the climate crisis, or even by cyclical events such as seasonal food insecurity.

The question arises as to what food all people have a justified moral claim to, if we start from an anthropocentric position. To answer this, we need to look at the 'food system' as a whole. This includes not only agriculture in the narrower sense, but also the environment as the basis for agricultural production, including biodiversity conservation, as well as social and cultural aspects, among others.[30] Precisely what one is entitled to is a complex normative question. A distinction can be made between two claim rights and one liberty right with different scopes, which may be curtailed to differing degrees depending on the conditions.

1 **Claim right to fulfilment of basic nutritional needs.** All people have a right, in the sense of a justified moral claim, to that food which is necessary to satisfy basic nutritional needs. Regardless of whether one understands 'food security' in deontological terms as an individual right based on human dignity or rational self-interest; or in consequentialist terms as the form of security that ensures that the global net benefit in terms of nutrition is maximised in the long run; or as a distribution of food that gives priority to the worse off over the better off up to a certain threshold; all positions seem to agree that more than a minimum must be permanently ensured. In this respect, this claim right is matched, first of all, by a duty to ensure that hunger and malnutrition are eliminated.[31] Yet merely eliminating deficiency is not enough; more must be guaranteed. However, it is difficult to determine exactly what this 'more' consists of.

2 **Claim right to adequate food.** One suggestion of what is meant by this 'more' in human rights discourse comes from the United

28 The ECNH does not discuss the constitutional mandates of agriculture here. It is concerned with the ethical discussion. If it turns out that there are discrepancies vis-à-vis the relevant constitutional articles, a second step would be to consider – from both a legal and a legal-ethical perspective – how to deal with them.

29 This definition can be found in the 1996 Rome Declaration on World Food Security (https://www.fao.org/3/w3613e/w3613e00.htm). The Paris Agreement (2015) also refers to food security, which it links to climate change. The preamble states that the Parties to the Agreement recognise "the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change".

30 See also the IPCC Special Report on Climate Change and Land (2019), Chapter 5 (https://www.ipcc.ch/site/assets/uploads/sites/4/2021/02/08_Chapter-5_3.pdf).

31 "Despite decade-long international efforts to achieve 'zero hunger' (SDG No. 2), the world is anywhere but on track to reach this goal. Updated methods taking into account household data show that the 'decades-long decline in hunger in the world (...) had unfortunately ended' (...). As of 2020, nearly 690 million people are hungry (i.e. suffering from undernourishment), which is 8.9 % of the world population (...). This number was up by 10 million people in the last year, and by nearly 60 million in the past five years (...). By 2030, the number of hungry people is expected to exceed 840 million (...)." (C.E. Blattner, O. Ammann (2021), 54. Food security and symbolic legislation in Switzerland: a false sense of security? In: H. Schübel, I. Wallimann-Helmer (eds.) (2021), Justice and food security in a changing climate (https://www.wageningenacademic.com/doi/epdf/10.3920/978-90-8686-915-2_54).

Nations Economic and Social Council. It attempts to concretise the human right to adequate food enshrined in Article 25 of the Universal Declaration of Human Rights and Article 11 of the International Covenant on Economic, Social and Cultural Rights in a way that also contains ethically plausible statements about this 'more'. In its view, this right implies "the availability of food in a quantity and quality sufficient to satisfy the dietary needs of individuals, free from adverse substances, and acceptable within a given culture" and "the accessibility of such food in ways that are sustainable and that do not interfere with the enjoyment of other human rights". This provision goes beyond the minimal concept of food security in two respects. Firstly, there is the idea of matching food to the needs of individuals. Secondly, cultural values influencing the types of food consumed should also be taken into account as far as possible.

This second claim-based scope of food security also seems able to accommodate the aspect of food sovereignty.[32] This encompasses, among other things, the freedom of producers to determine what food they produce and how, and the freedom of consumers to choose to eat what they want. It also includes respecting cultural dietary and eating habits, as long as this does not cause harm to third parties. In particular, food security and the right to adequate food must not be compromised. This implies that production must be 'sustainable' in the sense that distribution within and between generations is equitable. It also implies that the biodiversity and resources needed for this, such as water and soil, are suitably protected in terms of their quality and quantity, and that measures are taken to ensure a fairer distribution of food – of which more than enough is available globally – and to reduce food waste.

3 **Liberty right not to be prevented from eating what one wants.** While claim rights 1 and 2 are linked to a positive obligation of the state towards all individuals to ensure that they receive the appropriate nutrition, the third scope is not a claim right but a liberty right. This – in principle unlimited – liberty right is linked to a negative obligation of the state not to prevent individuals from eating what they want, provided they can afford it.

2.2.6 How do the indispensable tasks of agriculture relate to the 1.5 °C target?

How the claim rights and liberty right relate to the 1.5 °C target depends on the normative status of the 1.5 °C target on the one hand and the scope of the claim rights or liberty right in relation to food and thus the indispensable tasks of agricultural production on the other.

The claim right to fulfilment of basic nutritional needs (1) is understood as a prima facie right, with a corre-

32 Historically, 'food sovereignty' is a political concept coined by the international small farmers' and agricultural workers' movement La Via Campesina during the World Food Summit in 1996. It is understood exclusively or at least primarily as a collective right to self-determination.

sponding obligation to guarantee its fulfilment. It must be safeguarded and must not, for example, be restricted in favour of overall economic benefit considerations that go beyond questions of livelihood security. However, this claim right does not apply without exception. It may conflict with other moral rights of equal weight. In such cases, it is impossible to guarantee all the relevant rights equally. Since there is no general rule for determining precedence among prima facie rights, it must be determined in such a case which right carries greater weight. This situation would exist if the 1.5 °C target were an obligation also based on a justified moral claim, such as that of being protected from possible catastrophic damage in the event of a temperature rise above 1.5 °C. Specific justification would then have to be given as to which right carries greater weight, with the consequence that compromises would need to be made, either on the right to satisfaction of basic nutritional needs or on the right to protection from catastrophic damage. However, a conflict of this kind would only exist if it were impossible for technical or political reasons or entailed unacceptable risks to achieve the 1.5 °C target while at the same time ensuring food security in the minimal sense referred to above.

The same applies to the claim right to adequate food (2).

The liberty right (3) not to be prevented from freely choosing what one wants to eat, as long as this does not infringe the rights of others, has a lower normative status. While claim rights 1 and 2 must be guaranteed, with claim right 1 to the fulfilment of basic nutritional needs having normative priority over claim right 2 to adequate food, the liberty right not to be prevented from eating what one wants is only to be taken into account to the extent that it is compatible with, or can be made compatible with, the 1.5 °C target. Whether and to what extent this is possible is an empirical question.

2.2.7 What does this mean for the special status of agriculture?

A special status for agricultural production essentially presupposes that the excess emissions can be offset by means of NETs. For this to be the case, it must be ensured that NETs are able, with sufficient certainty, to remove enough CO_2 from the atmosphere within the required time. In the ECNH's assessment, the risk that this will not be achieved and thus that the 1.5 °C target will be missed is too high. Therefore, all possibilities must be exhausted to prevent GHG emissions from entering the atmosphere and to transform agricultural production in such a way that there is no need to gamble on offsetting by NETs.

The ECNH therefore *unanimously* considers a special status for agricultural production to be justified only to the extent that this is technically required to guarantee sufficient and adequate food.

If even the guarantee of sufficient and adequate food were to be jeopardised


or made impossible due to activities aimed at achieving the 1.5 °C target, it would have to be examined whether and, if so, to what extent the claim right to adequate food would have to be compromised in order to meet basic nutritional needs; or whether the non-achievement of the 1.5 °C target would have to be accepted.

By contrast, the liberty right of individuals to eat what they want, as long as they can afford it, would have to take a back seat if this resulted in emissions that destroyed the production bases needed to guarantee sufficient and adequate food. Whether this right can be guaranteed therefore depends on whether associated agricultural emissions can be offset. As things stand, the ECNH considers this eventuality to be too uncertain. The climate change goals outweigh the guarantee of this liberty right. The ECNH attaches great importance to the liberty right, but a special status for agriculture with regard to GHG emissions, in order to guarantee this right, cannot be justified.[33]

33 These ethical considerations are also reflected at the political level. States and supranational entities such as the EU have a responsibility for their own populations in terms of food security and the right to adequate food. Their primary obligation is to ensure at all times that no person under their authority goes hungry. According to the United Nations Sustainable Development Goals (SDGs), the right to adequate food (claim right 2) is to be fully achieved by 2030. Looking at the global level, it is possible to derive a negative obligation – at least on the part of rich industrialised nations – not to violate the right to adequate food of people living in other countries. On the other hand, a positive global responsibility cannot be justified if it is possible in principle to produce sufficient food locally or regionally everywhere in the world, in line with claim rights 1 and 2. The situation is different if this is not or no longer the case. If neither claim right 1 nor claim right 2 can be fulfilled in more and more parts of the world as a result of climate change (or other curbs on production such as those resulting from acts of war), a direct transfer of food to these areas must take place. This could affect domestic agricultural production if it meant that it had to stop making non-essential products, for instance so that arable land in Switzerland and abroad previously used for animal feed could be used to produce food in order to guarantee claim right 1.

3 Technical options in agriculture and their ethical assessment

Mitigation measures. Measures aimed at reducing and avoiding GHG emissions are referred to collectively as 'mitigation'. Given the normative status of the 1.5 °C target, the primary obligation from a climate ethics perspective is to reduce the negative impacts of agriculture on the climate. Even if Swiss agriculture is to be granted a special status, agricultural production must align all its activities with the net zero target.

Adaptation measures. At the same time, agricultural production must adapt to changing climatic conditions. Measures with this objective are referred to as 'adaptation'. The aim of adaptation measures is to help agriculture cope with the negative effects of climate change. The net zero target is not the primary focus of adaptation. Adaptation measures must first and foremost be geared towards ensuring food security. Adaptation measures span all agricultural production processes, from breeding and selecting livestock and crops, improving soil management to maintain soil fertility,[34] enhancing the efficiency of water use as water resources become scarcer and subject to greater fluctuations, through to adapting to new pests and diseases and processing products.[35]

Potential biotechnology solutions. Mitigation and adaptation measures may have drastic consequences for agricultural production. This report will examine, with regard to both mitigation and adaptation, which potential biotechnology solutions are available to achieve the set goals and how they are to be assessed from an ethical viewpoint.

As a framework, the urgency aspect must be taken into account in all possible solutions. The net zero target has to be achieved by 2050 in order to prevent the massive-damage scenarios associated with a failure to do so. This target can only be reached if, on the one hand, the remaining global GHG budget is not exceeded by that time and, on the other hand, any further GHG emissions are fully offset by natural and artificial sinks. At the same time, food security and food sovereignty must be guaranteed. Protection of biodiversity and respect for the environment and resources will be

34 Soil fertility is understood here in the broad sense, not only in relation to productive function.

35 The rise in average temperature and greater temperature fluctuations leads to an increase in extreme weather phenomena. Rising temperatures reduce soil moisture and increase surface runoff, meaning that even regions that are not expected to see an overall reduction in precipitation will face dry periods. Agriculture must respond to more frequent periods of heat and drought, associated periods of water scarcity on the one hand and flooding on the other, and many other changing factors affecting agricultural production.

instrumental in achieving these goals. In addition, the dignity of living beings and animal welfare must be taken into account. Which mitigation and adaptation measures have the best chance of achieving the above-mentioned goals? And what technological risks should society take to meet the 1.5 °C target?

3.1 Options for reducing greenhouse gas emissions (mitigation)

3.1.1 Reduction options in livestock farming

The bulk of emissions come from livestock farming. The IPCC's 2019 Special Report states that around 21 – 37 % of global GHG emissions are attributable to the food system, i.e. agriculture and land use, storage, transport, packaging, processing, retail and consumption. This includes emissions of 9 – 14 % from crop and livestock activities within the farm gate, and 5 – 14 % from land use and land-use change including deforestation and peatland degradation.[36]

In Switzerland, half of the food produced domestically comes from animal production. Of the climate-relevant GHG emissions currently caused by agriculture in Switzerland, animal production accounts for a good 85 %.[37] Around half of these are methane gas emissions from livestock digestion. Manure management and biodegradation of commercial fertilisers and other nitrogen inputs (such as crop residues) release further GHGs in the form of methane and nitrous oxide.[38] About 70 % of land used for agricultural purposes is managed as pastureland, and animal feed is grown on around 60 % of arable land. Imported feed requires another 250,000 hectares of arable land abroad. Some of this arable land is created by forest clearance – which also releases CO_2 stored in the forests. Arable land for feed cultivation could also be used to grow crops for food production. Livestock farming and soil management are thus in the spotlight not only globally but also in Switzerland when it comes to mitigation measures in agricultural production.

To reduce emissions from livestock farming, work is under way on stall management measures, such as covering slurry tanks to curb GHG emissions from manure and slurry. In addition, efforts are being made to capture methane gas emissions in order to use them for energy generation.[39] Research is also being conducted on feed composition to influence the microbes in the digestive tract so that methane emissions from livestock are reduced.

However, Switzerland's climate strategy assumes that agricultural emissions from livestock production cannot be completely avoided as things currently stand, despite measures targeting stall management and feed.[40] The most immediately effective mitigation measure would therefore be to reduce the number of livestock. Calls for such a reduction also feature in the political debate.

36 IPCC Special Report (2019), p. 439. The report also notes that 5 to 10 % of GHG emissions come from supply chain activities within the food system; this includes emissions from food loss and waste.

37 Bretscher D. et al. (2018), Reduktionspotenziale von Treibhausgasemissionen aus der Schweizer Nutztierhaltung (Potential for reducing greenhouse gas emissions from Swiss animal husbandry), in: Agrarforschung Schweiz 9 (11 – 12): 376 – 383 (available in German and French at https://www.agrarforschungschweiz.ch/en/2018/11/potential-for-reducing-greenhouse-gas-emissions-from-swiss-animal-husbandry/#links).

38 The remainder of the GHGs generated in agriculture are CO_2 emissions, arising in particular from the use of fossil energies (Switzerland's Long-Term Climate Strategy, p. 38).

39 The CO_2 produced during the combustion process is to be captured and permanently stored using CCS technologies (see section 2.2 under 'Negative emissions technologies').

40 Switzerland's Long-Term Climate Strategy, p. 13.

1 **Option: 'Reducing livestock numbers'.** Reducing livestock numbers,[41] or even abandoning livestock farming altogether, would be the most effective way to avoid emissions. However, this would have more or less far-reaching economic and structural consequences. These would hit farms first and foremost, which would have to switch (for the most part) to arable farming for food production. The entire upstream and downstream production chain would also be impacted by the changeover. These structural changes would affect the self-perception of all the actors involved, and the countryside and hence the landscape of Switzerland would be altered as well. Last but not least, this would have to entail a change in dietary habits, which would need to become much more (if not exclusively) plant-based.[42] In order for the emission reduction to actually take effect and for the global target of 1.5 °C not to be circumvented by imports, the reduction in Switzerland's livestock numbers would also have to be accompanied by import regulations. Meat could only be imported if its production was subject to the same requirements as domestic agricultural production.

2 **Option: 'Genetic engineering to reduce emissions from livestock farming'.** To soften the impacts for those involved in the food system, which would be more or less drastic depending on the extent of livestock reduction, one option that comes into play is the application of genetic engineering techniques. This entails genetically modifying both animals and feed in such a way as to minimise the cuts needed in the production and subsequent consumption of meat and milk, notwithstanding the 1.5 °C target.[43] Genetic engineering would serve to both increase the meat and milk yield per animal unit and decrease methane emissions. Both these objectives are also being pursued with conventional animal and plant breeding methods, but biotechnology processes, especially genome editing techniques,[44] should now enable further and faster progress.

3.1.2 Ethical assessment of the reduction options in livestock farming

Switzerland's Long-Term Climate Strategy states that all stall management and feed-related measures will not be sufficient to avoid emissions from livestock farming. In this context, the question arises: to what extent is the demand for a reduction in livestock ethically justified to address the substantial remainder of emissions? The Committee members consider this essentially dependent on the assessment of two factors: (1) the effectiveness of NETs in being able to offset emissions from livestock farming on the necessary scale, and (2) the potential of genetic engineering to contribute substantially to emission avoidance within the required time frame.

41 The wording 'reducing livestock numbers' reflects the language generally used in the literature on this subject. Rather than livestock numbers, it would be more accurate to speak of reducing GHG emissions per livestock unit. This unit varies greatly depending on the type of animal.

42 For a detailed discussion of the implications of such a fundamental transformation of agriculture and food, see T. Kortetmäki (2022).

43 Measures to cut food waste should also be mentioned here. These also make a relevant contribution to reducing GHG emissions. See for example https://www.bafu.admin.ch/bafu/en/home/topics/waste/guide-to-waste-a-z/biodegradable-waste/types-of-waste/lebensmittelabfaelle.html.

44 Various techniques are referred to as genome editing, including zinc finger nuclease (ZFN) and transcription activator-like effector nuclease (TALEN), but the main focus of attention at present is CRISPR (clustered regularly interspaced short palindromic repeats).

1 **On the effectiveness of NETs.** The Committee members are *united* in their assessment that it is questionable whether NETs will be developed and implemented on the scale necessary to offset GHGs from livestock farming as currently practised within the required time frame. This assessment of the inadequate effectiveness of NETs, combined with the unacceptable damage scenarios if the climate target is not achieved, requires that emissions be avoided as far as possible, rather than relying on the assumption that they can be offset. In the ECNH's view, pinning hopes on NETs is only permissible for the 'remainder' of emissions that cannot be avoided and are at the same time necessary to ensure food security.

2 **On the potential of genetic engineering.** Assessments of the potential of genetic engineering techniques to contribute to additional emission avoidance vary within the ECNH.

The *clear majority* of members do not rule out in principle the possibility of reducing GHG emissions from livestock by means of genetic engineering techniques. However, they consider the chance of these techniques making a substantial contribution to the necessary emission reduction within the required time frame to be too small for them to be relied upon with reference to the urgency of the climate goals or to be promoted for this reason. In addition, it should be noted that under Swiss law, any genetic modification of an organism constitutes an interference with the dignity of living beings. Such interference is legally permissible if a harm-benefit analysis can demonstrate that the interests of the genetic modification of the animal outweigh the strain associated with the intervention. The strain on the animal would have to be checked on a case-by-case basis. On the interests side, it would have to be shown that the genetic engineering intervention is not only suitable but also necessary to achieve the climate target. In assessing this necessity, a relevant factor is what alternatives exist. The majority of ECNH members consider that genetic engineering interventions causing strain in livestock are not only unsuitable to achieve the necessary emission reduction within the required time frame, but also unnecessary, since the quickest and most effective way to avoid emissions from agricultural production is to reduce the livestock population.

The *minority* consider that the potential of genetic engineering to reduce GHGs is already discernible today. According to this minority, the speed of research and technological development justifies the hope that this technology will be able to reduce GHGs from livestock farming to a certain extent even before 2050. In order to maximise the potential, this technology should also be used, alongside others, with a view to achieving the climate goals.

All members *agree* that, regardless of their differing assessment of the potential, the fundamental problem of emissions from livestock farming cannot be solved by these genetic engineering techniques. Given the uncertainties surrounding NETs, the only effective way to achieve the urgent climate target remains a significant reduction in livestock numbers.

3.1.3 Transformation of the food system as a realistic prospect

A reduction in livestock numbers on this scale would undoubtedly have drastic consequences for agricultural production and the agricultural sector. It would also have an impact on the entire food system and therefore the current dietary habits of the Swiss population. Given the urgency of the climate goals and the devastating damage scenarios if they are not achieved, including in terms of ensuring food security, there is no alternative to transformative changes.

These changes will be challenging. However, Switzerland has both the expertise in agricultural research and the financial means and regulatory freedom to support and assist such a transformation and make it fair for all those affected. A structurally and economically assisted transformation of agriculture and food, associated with a reduction in livestock and an increasingly plant-based diet, is therefore a realistic prospect for Switzerland. While the transformation of agricultural production will be drastic, the agricultural system in Switzerland can, in principle, be changed quickly. Livestock numbers can be cut within a relatively short time and suitable pastureland converted into arable land and managed accordingly. Likewise, the effects on the import and export of agricultural goods are manageable for Switzerland. For the transformation to succeed and to avoid undermining the climate goals, imports of livestock farming products will have to be subject to the same rules as domestic production. The structural and social costs for the agricultural sector will be undeniably considerable. Livestock farming involves long-term investments. In order to make the changes more socially acceptable, they will therefore need to take place gradually, for example as part of generational change on farms.

Such a transformation of agricultural production will require fundamental behavioural changes from everyone. The theory that individuals have no incentive to modify their behaviour unless they are certain that everyone else will do the same falls short both ethically and scientifically. From an ethical perspective, it is about more than just an incentive: there is an imperative to act. This imperative remains, even if others do not heed it. However, they must also have the opportunity to do so. It is therefore important to create the framework conditions so that individuals can act on this imperative in a coordinated way. While a number of different approaches to the transformation would be pursued on a voluntary basis, the normative status of the

1.5 °C target means that state intervention would also be required if the target could not be achieved otherwise.

3.1.4 Reduction options in arable farming and soil management

With regard to soil management, research is under way into different methods, technological approaches and machinery so that less of the CO_2 contained in biomass is released through soil cultivation. This includes breeding and developing plant varieties and mixed cultures that are better adapted to such soil cultivation methods.

The role of genetic engineering. Ploughing up arable land releases GHGs. To avoid ploughing and hence emissions, no-till farming is therefore increasingly being used. This method leads to increased pressure from pathogens. As well as conventional breeding methods, genetic engineering solutions are also being pursued to develop crops that can respond to this pressure with as little yield loss as possible. Among other things, this should help to ensure that less forest or savannah land is converted into cropland, as such conversions are also associated with high GHG emissions. Another genetic engineering approach aims to develop plants that can store more CO_2 in their roots.[45]

3.1.5 Ethical assessment of the reduction options in arable farming and soil management

In view of the normative status of the 1.5 °C target and the urgency with which this target is to be met, the use of genetic engineering techniques in the context of emission reduction must be assessed – including with regard to arable farming – according to what contribution the techniques are able to make to achieving the 1.5 °C target.

The *clear majority* of Committee members do not in principle rule out the possibility of a contribution being made by genetic engineering techniques in arable farming in the context of mitigation. However, with regard to Switzerland and especially in view of the urgency of the climate goals, they consider the potential to be too insignificant overall to rely on these techniques.[46,47]

On the other hand, a *minority* of members consider the signs from genetic engineering research with regard to possible contributions to mitigation to be promising, insofar as these technological approaches are relied upon in addition to other measures.

Irrespective of their importance, the Committee is *unanimous in its view* that potential contributions to mitigation by genetic engineering techniques in arable farming do not obviate the need to transform agricultural production and consumption towards a more plant-based diet. The great urgency

45 Popescu, A. (2019), This scientist thinks she has the key to curb climate change: super plants, in: The Guardian, 17 April 2019 (https://www.theguardian.com/environment/2019/apr/16/super-plants-climate-change-joanne-chory-carbon-dioxide).

46 Whether this also applies to other parts of the world is left open here. This would have to be examined on a case-by-case basis.

47 For an in-depth risk discussion on the use of biotechnology processes in the environment, see previous ECNH reports, in particular: ECNH (2012), Release of genetically modified plants – ethical requirements; ECNH (2016), New Plant Breeding Techniques – Ethical Considerations; ECNH (2018), Precaution in the environmental field. Ethical requirements for the regulation of new biotechnologies.

of cutting emissions also requires the use of existing technologies and the promotion of alternative solutions that can help to achieve the 1.5 °C target.

3.2 Options for adapting to climate change (adaptation)

For its considerations on adaptation, the ECNH takes as its basis the scenario drawn up by the IPCC based on its scientific assessments and considerations from a precautionary perspective (see section 1.2). Viewed globally, the scenario means a geographical shift in agricultural production away from regions worst affected by soil degradation and drought or even desertification. For Switzerland, in the framework of the IPCC scenario, adaptation entails not only assiduous efforts to preserve soil fertility in the broad sense and to care for water resources, but also selecting and developing the right varieties for changed cultivation methods. In this context, the present report discusses potential biotechnology solutions and assesses them from an ethical standpoint. Here too, the alternatives available to achieve the adaptation goals will play a role in the assessment.

Given the responsibility that agricultural production has in relation to food security at a global level – including in terms of increasing food needs among the populations of emerging economies and the continued growth of the world's population – this scenario may also mean that such production needs to be adapted in a way that contributes more to global food security. This would be possible if Switzerland either produced more or imported less. Since Switzerland's arable land area is so small as to be barely relevant to global crop production, the scenario – viewed also from an adaptation perspective – would primarily oblige Switzerland to reduce its livestock farming. This is because the production of animal feed abroad takes up land that could be used to grow crops for direct consumption by humans. Moreover, insofar as Switzerland could and would have to increase its own cultivation of crops due to the changed climatic conditions, it would also be obliged to import not only less feed but also fewer plant-based products overall.[48]

3.2.1 Genetic engineering approaches to crop adaptation

To meet the challenges of climate change, new genetic engineering techniques are being brought into play as one possible solution for crops. Conventional breeding methods are also being used to adapt crops to the changing climate. Naturally occurring genetic variations with the desired characteristics are sought, but since desirable characteristics are often found together with undesirable ones, this is a time-consuming process. Several breeding cycles are necessary to achieve the desired genetic recombination.[49] New genetic engineering techniques such as CRISPR enable multiple simultaneous changes within the genome, something that is hardly possible with conventional methods. This raises the hope of speeding up research and breeding to identify ben-

48 For a discussion of the challenges that such a transformation would entail for agriculture and the eating habits of the Swiss population, and for an ethical assessment, see section 3.1.

49 Also, the genetic variability of the most commonly grown crops has been greatly reduced over thousands of years of breeding, in order to fix the desired characteristics. Random mutations generated by chemical mutagens or physical irradiation could produce new genetic variants, and marker-assisted selection approaches are helping to speed up breeding. However, new genetic engineering techniques could bring about a further significant acceleration.

50 Massel K. et al. (2021), Hotter, drier, CRISPR: the latest edit on climate change, in: Theoretical and Applied Genetics, 134:1691 – 1709 (https://link.springer.com/content/pdf/10.1007/s00122-020-03764-0.pdf).

51 For example, it was possible under laboratory conditions to add increased drought resistance to the model plant Arabidopsis thaliana (thale cress). See Kawall K. (2021), Mit den neuen Gentechnikverfahren dem Klimawandel trotzen? (Defying climate change with new genetic engineering techniques?) In: Der kritische Agrarbericht 2021, 300 – 305 (in German at https://www.kritischer-agrarbericht.de/fileadmin/Daten-KAB/KAB-2021/KAB_2021_300_305_Kawall.pdf).
A gene has been identified in rice plants that is thought to confer durable and broad-spectrum resistance to bacterial blight. Bacterial blight is a disease of rice plants that causes major crop losses worldwide. Plants with the newly inserted resistance gene react less sensitively to higher temperatures. Previous genetically engineered resistance genes do not have a durable effect in changing climatic conditions. See Zhao, K., Zhang, Q. (2021), A climate-resilient R gene in rice traps two pathogen effectors for broad and durable resistance to bacterial blight, in: Molecular Plant 14, 366 – 368; Chen, X. et al. (2021), Xa7, a new executor R gene that confers durable and

eficial traits and develop novel combinations more quickly than before. In view of, among other things, the urgency of adaptation measures, the new techniques should therefore be integrated into existing breeding strategies in order to speed up the production of crops that are more tolerant of climatic challenges and more resistant to pest attacks. In this way, climate-related yield losses could be avoided or yields even increased, thus contributing to food security.[50]

Examples of such genetic engineering solutions are often but not exclusively in the realm of basic research. The techniques are used to study the regulation of genes and their involvement in the response to climatic stress factors.[51] Creating stress tolerances in plants using genetic interventions remains challenging, even with new genetic engineering approaches.[52] Plants respond in a variety of ways to stress factors such as lack of water, for example with deeper, wider or more branched root growth, with thicker wax layers on the leaves or more trichomes (leaf hairs) to reduce evaporation, with osmotic adaptations or changes in circadian rhythm. The ability to respond, for example to cope with both extremely dry and exceptionally wet conditions within a short period, depends on the genetic predisposition of the individual plant or the genetic range of a plant variety.

3.2.2 Ethical assessment of genetic engineering approaches to adaptation

Even if new genetic engineering methods are able to shorten breeding times considerably, the fundamental problem remains that every plant variety in Switzerland will increasingly have to contend with volatile climatic conditions. Irrespective of the breeding method, this problem cannot be solved by equipping plants with, say, resistance to drought or to specific diseases. The real issue is the volatility of climatic conditions. It will hardly be possible to genetically equip a single variety to produce maximum yields in all expected climatic extremes. With a view to ensuring food security, other research approaches are focusing on reducing the risk of major crop failures by adapting the type of arable farming and relying more on mixed cultures.[53] These may not produce maximum yields under volatile climatic conditions, but they optimise yields by having one crop at least partially offset the yield loss of another.

The Committee is *agreed* that the goal of adaptation must therefore be to find or develop the right mixed cultures and cultivation methods for Swiss agriculture that can cope with climatic volatility. Climate-relevant projects involving new genetic engineering techniques are largely at the stage of basic research. This contrasts with the expectations of the potential of genetic engineering, as formulated for example in the EU's Green Deal. Whether these projects will prove successful in practice is a matter of debate within the ECNH.

broad-spectrum resistance to bacterial blight disease in rice: Plant Communications 2, 100143. In tobacco and wheat plants, it was possible to reduce the number of stomata in the epidermis. These are used for gas exchange and a moderate reduction in their density should boost the plants' water-use efficiency in the field. In this way, genetically modified crops can be developed that require less water per production unit and should therefore be better able to withstand dry conditions without yield loss. The genetically modified wheat plants also showed comparable productivity to control plants under conditions of drought and elevated CO_2. See Dunn, J. et al. (2019), Reduced stomatal density in bread wheat leads to increased water-use efficiency, in: J Exp Bot 70, 4737–4748; Glowacka, K. et al. (2018), Photosystem II Subunit S overexpression increases the efficiency of water use in a field-grown crop, in: Nature Communications 9, 868. For an example of a biotechnological adaptation to drought in rice, see: Babar Usman et al. (2020), Precise Editing of the OsPYL9 Gene by RNA-Guided Cas9 Nuclease Confers Enhanced Drought Tolerance and Grain Yield in Rice (Oryza sativa L.) by Regulating Circadian Rhythm and Abiotic Stress Responsive Proteins, in: Int. J. Mol. Sci. 2020, 21, 7854; doi:10.3390/ijms21217854. Arabidopsis, tobacco and rice plants have been genetically modified to reduce their need for nitrogen fertiliser and so lower the environmental impact of cultivation, with higher crop yields under both normal and heat stress conditions. The plants' nitrogen use efficiency was improved by better protecting the photosynthetic processes from heat stress. This enhances net CO_2 assimilation, boosting both biomass and grain yield. See Chen, K.-E. et al. (2020), Improving nitrogen use efficiency by manipulating nitrate remobilization in plants, in: Nature Plants 6, 1126–1135; Chen, J.-H. et al. (2020), Nuclear-encoded synthesis of the D1 subunit of photosystem II increases photo-

The *clear majority* of members are sceptical about the ability of new genetic engineering approaches to make a relevant contribution to the adaptation of agriculture in the required time frame.

The *minority* consider that these techniques have a real prospect of making a relevant contribution to adaptation in the required time frame. However, they also assume that these methods can only be part of the solution.[54]

In terms of ensuring food security, the ECNH assumes a claim right to sufficient and adequate food, but not the guarantee of an unrestricted liberty right to eat what one wants, provided one can afford it. Agricultural production faces rapid climatic changes that will heavily affect cultivation conditions and may also lead to a geographical shift in cultivated areas. In view of this, guaranteeing food security requires an urgent move towards more plant-based agricultural production and diets. This whole situation is fraught with such great uncertainties that it is the *ECNH's unanimous view* that, here too, path dependency must be avoided in both research and practice. Other research and breeding approaches must be neither neglected nor impeded by investing in only one technological approach. For precautionary reasons, they must be organised in such a way that multiple paths remain open for agriculture to fulfil its ethically indispensable tasks, namely ensuring adequate food as well as protecting biodiversity.

synthetic efficiency and crop yield, in: Nature Plants 6, 570–580.

52 Stress regulation in plants is complex. On the one hand, an intervention in one of the phytohormones also influences other plant processes. On the other hand, it must be possible to understand and control the interactions between the plant and its environment in order to be able to have a targeted impact on stress regulation.

53 Rüegg P. (2021), Mixed cultures for a greater yield (https://ethz.ch/en/news-and-events/eth-news/news/2021/06/mixed-cultures-for-a-greater-yield.html); Chen JG et al. (2021), Diversity increases yield but reduces harvest index, in: Nature Plants, 2021, doi: 10.1038/s41477-021-00948-4.

54 Meanwhile, precautionary and risk considerations regarding the applications of genetic engineering techniques in the environment continue to apply. See footnote 47.

4 Ethical considerations on political feasibility

If the reductions in GHG emissions and the associated changes in agricultural production are ethically necessary to achieve the 1.5 °C target, then measures to this end must be implemented politically. Compromises would have to be made on the 1.5 °C target only if the measures required to achieve it were ethically unacceptable. It should be emphasised that one must not confuse what is ethically unacceptable with what is considered politically unacceptable.

If a measure is ethically required, this implies that it can be performed, according to the principle 'ought implies can'. In the ethical discussion, it must not be prematurely assumed that something is not feasible because it is not politically achievable – not even if what might be considered politically drastic measures have to be implemented. If something is of such great political importance for ethical reasons, then it is a political task to take responsibility and also to stand up robustly for the goal politically. The debate should not then be about whether the goal is achieved, but only about how it can be achieved in an ethically acceptable way. This is not to say that the responsibility lies solely with political leaders. In a democracy, citizens also have a non-delegable responsibility for the implementation of measures to achieve key ethical and political objectives. They cannot use the failure of policymakers to take the politically necessary measures as justification for their own inaction. On the other hand, policymakers cannot shift the responsibility onto individual citizens by invoking 'personal responsibility' and thereby justify not taking measures that may have serious consequences for the lives of the population.

These fundamental considerations on the relationship between ethical demands and their political feasibility also apply to the transformation of agriculture in the light of climate change. Objections to this transformation are raised in the public political debate. It is argued that such demands are 'unrealistic' and would not be supported by the majority of the population. It is true that, in a democracy, the majority decides. However, this does not absolve those in positions of political responsibility from the task of doing

everything they can to convince this majority of the measures that need to be taken with regard to the transformation of agriculture, based on the point of view outlined above.

In this context, lines of argument frequently deployed in the political debate must be questioned. A common example is the argument that a small country like Switzerland cannot do much about global climate change and therefore it is not right to demand 'sacrifices' from Switzerland while the big 'climate offenders' are not doing enough to change their own behaviour. From an ethical viewpoint, this argument does not stand up.[55] Granted, Switzerland's share of global GHG emissions is small in absolute terms, even if the territorial perspective is supplemented by a consumption perspective. Nevertheless, it shares responsibility for the damage caused by the climate change associated with these emissions. From an ethical point of view, it should live up to this shared responsibility. The attitude of behaving in a morally right way only if others do the same is ethically unjustifiable. In view of the 1.5 °C target and the enormous damage that could occur if the target is missed, Switzerland as a rich country could even be called upon to do more than what its share of climate-related emissions would suggest, based on its ability to do so.

The change in diet associated with a transformation of agricultural production may entail certain restrictions. The ECNH is aware that talk of restrictions sometimes triggers knee-jerk rejection. A distinction should be made here between the basic ethical arguments and the way they are communicated politically. As far as the basic arguments are concerned, it is appropriate to speak of restrictions when there is a curtailing of liberty rights. If, in the present context, livestock numbers have to be massively reduced in order to achieve the 1.5 °C target, this implies that the freedom not to be prevented from eating as much meat as one wants, provided one can afford it, is rightly restricted under certain circumstances.

If this is a valid argument, the question arises at the level of political communication as to how consumers can be persuaded to change their eating behaviour accordingly. The ethical argument implies that this is in principle possible. On the other hand, it is often argued that this would be perceived, if not as 'food dictatorship', then at least as a call for a kind of renunciation that is politically unfeasible in a democracy. Of course, changing people's eating habits is no easy matter. It is the job of politicians to inform the population appropriately and also to show them alternatives. Exactly how such communication can be designed so that it motivates consumers to switch to a more plant-based diet must remain open here. In general, it can be said that the state should address consumers, who are also citizens, as autonomous beings. This means that it communicates transparently and honestly. It may be, for example, that there is scientific evidence that excessive meat consumption increases

55 See also the arguments from an economic perspective: McKinsey & Company (2022), Klimastandort Schweiz. Schweizer Unternehmen als globale Treiber für Netto-Null (Climate location Switzerland. Swiss companies as global drivers for net zero) (in German at https://www.mckinsey.com/ch/~/media/mckinsey/locations/europe%20and%20middle%20east/switzerland/our%20insights/klimastandort%20schweiz/klimastandort-schweiz.pdf).

health risks such as diabetes, cardiovascular disorders or bowel cancer. This would be an argument in its own right in favour of lower meat consumption. It would be problematic if this argument were 'pushed forward' as cover for the fact that meat consumption should be reduced for reasons of climate change. Reducing meat consumption for climate change reasons is an argument separate from the health argument and should be used as such. As regards the issue of political feasibility, the question is rather whether there are ethically justifiable ways to 'sell' these arguments not as 'renunciation' arguments but as something that will, at least, not impair people's quality of life. Regardless of this, it should always be clear that there is no way around this change in eating habits, and that the state reserves the right to take restrictive measures, i.e. obligations and prohibitions, as a 'last resort', provided that this appears appropriate from a proportionality perspective.

The more state communication is backed up by corresponding action, the more credibility it has. If the state advocates alternative consumption patterns, highlighting the implications of the associated changes in consumption, it should at the same time make it clear that it is not transferring all the responsibility to consumers. Therefore, it should simultaneously initiate the necessary adaptations on the production side as well, in agriculture and the food system as a whole, by establishing an appropriate regulatory framework, in an effort to make these adaptations as socially acceptable as possible. In so doing, it should communicate clearly what is expected of the agricultural producers concerned, even if that may involve changes they will find challenging. It should also not disguise the fact that, despite state support, there will be losers as well as winners in this process.

Against this backdrop, it becomes clear once again that a special status for agriculture as formulated in Switzerland's climate strategy – a 40% reduction in GHG emissions by 2050 as a minimum target – cannot be justified. If a reduction to zero is not technically possible by transforming agricultural production,[56] then a reduction that goes beyond 40% and is at the same time compatible with ensuring the right to sufficient and adequate food, certainly is. The minimum reduction target of 40% laid down in the climate strategy is also unjustifiable in that it is linked to development of the NETs required to achieve net zero by 2050 – something that is far from certain. This imponderability should not be accepted in view of the alternative available. Furthermore, there is no compelling reason why such a reduction should be politically unfeasible.

56 There will always be some emissions. For example, emissions are returned from the atmosphere to the ground by precipitation, through the process known as atmospheric deposition. Plants absorb nitrogen through fixation by nodule bacteria on their roots and release it again when they rot. In the soil there are denitrification and nitrification processes that form nitrous oxide. Nitrogen is and will remain part of the system.

5 Action required from an ethical perspective

5.1 Reduction targets for agriculture

- In principle, agriculture must achieve the same emissions target as all other sectors. The currently formulated minimum target of a 40% cut in GHG emissions by 2050 should therefore be tightened. Two limiting conditions must be taken into account here. Firstly, a complete reduction of agricultural emissions to zero is not possible. Secondly, technically possible reductions must not endanger food security.
- The reduction targets for agriculture must be achieved as far as possible without NETs. This is because it is questionable whether NETs can be developed and implemented quickly enough and how effective they will be in meeting the reduction targets in agriculture. NETs should only be used to offset those remaining emissions that cannot be cut in any other way.
- Livestock numbers and thus meat consumption must be considerably reduced. The import of animal feed should be abandoned and the cultivation of feed in Switzerland reduced substantially. The aim should be for livestock farming to be largely grassland-based. Instead, more plant-based food should be produced for human consumption.
- The legal framework should be designed in such a way that the reduction in domestic production of animal products is not undermined by the import of animal products that do not come from grassland farming.
- Assessments of the potential of genetic engineering techniques to contribute to additional emission avoidance vary within the ECNH.
  A *minority* consider that the potential of genetic engineering to reduce GHGs is already discernible today. According to this minority, the speed of research and technological development justifies the hope that this technology will be able to reduce GHGs from livestock farming and in the context of arable farming to a certain extent even before 2050. In order to maximise the potential, use should also be made of genetically modified livestock and crops, with a view to achieving the climate goals.

The *clear majority* consider the chance of these techniques making a relevant contribution to the necessary emission reduction within the required time frame to be too small. The quickest and most effective way to avoid emissions from agricultural production is to reduce the livestock population. Genetic engineering interventions causing strain in livestock are neither suitable nor necessary to achieve the climate goals and are therefore ethically unjustifiable. Similarly, with regard to genetically modified crops, the majority consider their chances of making a relevant contribution to the reduction targets to be too small for them to be relied upon on the grounds of the urgency of the climate goals or even to be promoted for this reason.
- Since NETs will in all likelihood be needed to achieve the net zero target despite the remaining emissions, it is *the ECNH's unanimous view* that NETs should be developed on the basis of international coordination and cooperation, in view of the urgency of the climate goals. In so doing and given the uncertainties associated with NETs, care must be taken not to create any technological path dependency that precludes alternative solutions for cutting the remaining emissions.

5.2 Adaptation targets for agriculture

- Agriculture in general should be reorganised so that it can adapt to climate change in a way that safeguards long-term food security. In view of the already observable effects of climate change and emerging global developments, this adaptation is a matter of great urgency for Swiss agriculture as well.
- One goal of adaptation must be to find or develop the right crops and cultivation methods for Swiss agriculture that can cope with climatic volatility, i.e. the unpredictable alternation of extremely dry and exceptionally wet conditions. In the ECNH's view, it is not out of the question that biotechnology processes in the field of plant breeding may contribute to the adaptation of crops to climate change. However, on the question of how great their potential is and how quickly this can be leveraged, there are differing assessments within the Committee:
The *clear majority* are sceptical about the ability of genetic engineering approaches to make a relevant contribution to the adaptation of agriculture in the required time frame. Relying on them, promoting them and permitting them even in simplified processes if need be, and potentially accepting path dependencies, on the grounds of the urgency of the climate goals, is something that the majority consider ethically unjustifiable.
The *minority* consider that these techniques have a real prospect of contributing to adaptation. While assuming that this approach can only be part of the solution in terms of producing appropriate crops, they believe that it should be adopted and promoted.
The members agree that, in view of the associated uncertainty and the short time available, this technology – provided that its risks are acceptable – should be used in such a way that no path dependencies arise here either. Alternative approaches must always be pursued, and in such a way that there is as realistic a chance as possible of achieving the target, even if biotechnology processes are not able to fulfil the hopes and expectations that are sometimes placed in them.

5.3 Political responsibility

- Urgent long-term climate goals must not be postponed because of short-term commitments. They must also be taken into account in day-to-day politics. In all aspects of day-to-day politics, care must be taken to ensure that the urgent long-term goals are not jeopardised.
- Both the complexities of global trade and the global impacts of climate change show that individuals can make a difference if they act accordingly and, moreover, that this is something that can be demanded of them. However, they can only do this in coordination with others. That is why there is a need not only for private incentives, but also for state, supranational and international action. In view of the urgency of the climate goals, the state and its representatives should assume their political leadership responsibility. This includes realistically assessing the prospects of technological options and communicating trans-

parently and honestly. They should avoid creating the impression that technologies such as genome editing could make the decisive contributions and that NETs will be available by 2050 on the scale necessary to successfully shape the transformation process required to meet the climate goals, thereby obviating the need for other painful measures to reduce GHG emissions.

– Agricultural production is usually very bound by practical constraints, such as integration into collectively organised or highly regulated production and marketing structures. These are in part dependent on the regulatory framework (e.g. subsidies, obligations and prohibitions) and must be designed in such a way that they support the long-term climate goals.

Pictures:

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