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Sustainable Farming Systems: Elements of agreement and disagreement in recent international debates

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1. Introduction

The NRP 73 aims at differentiating between sustainable and unsustainable food production, with a view to conceptualizing a trade system that incentivizes sustainable food production. But how can a line be drawn between what is sustainable and what is not? This is a challenging question, as food is a highly diverse good produced under very different conditions around the world, using different methods and by different types of producers. Some of these producers are highly capitalized, large-scale commercial businesses, while many others are small-scale – sometimes marginalized – producers, who possess very limited machinery and infrastructure and often use very few inputs.

Of the approximately 570 million farms globally, over 80% are small-scale farmers. In low- and middle-income countries, small farms manage a large share of farming land, estimated at 30–40% (Lowder et al., 2016). However, so-called large-scale agriculture is the largest in terms of *total area* worldwide, although this category also technically includes a significant share of medium-sized farms (between 2 ha and 50 ha). Environmental outcomes are very diverse, and differ in terms of intensity, scale, and severity of impacts. Some of the negative outcomes of food production are more of local concern, while others are of global concern, the latter including climate impacts and biodiversity destruction. However, positive impacts of food production can also include creation of biodiverse production systems, carbon storage in soils, and water management. In addition, the social impacts of food systems are similarly diverse. Food systems can create livelihoods and income but can also include negative outcomes such as occupational health impacts, child labour, abusive labour conditions, displacements, or exclusion from communal lands.

The challenge, therefore, is to find ways of defining production systems that should be supported because they are already meeting sustainability criteria or have the potential to be transformed to meet such criteria. Systems that should be supported are those that have minimal negative impacts and simultaneously create positive impacts that contribute to maintaining, improving, and restoring productive capacities and the local and global environment.

The issue is not simply theoretical, but rather has very practical implications in trade policy terms. Under international trade law, countries have some scope to discriminate between products based on legitimate sustainability concerns. The tricky question is how to draw a line between sustainable and non-sustainable products in ways that do not result in arbitrary or unjustifiable discrimination. International standards (and short of standards, internationally agreed objectives, guidelines, and criteria) can play a role in this context, in several respects. Take the example of import restrictions on sustainability grounds, such as when a country bans imports of fish caught according to certain techniques: if the restriction reflects internationally agreed standards/objectives, the country may have grounds for justification of its ban (as an exception) under WTO law. Or, as another example: Switzerland makes its official "incentive" programmes on animal welfare mandatory and limits (in-quota) imports of meats to countries that have equivalent animal welfare standards. If equivalence means adoption of the specific Swiss incentive programmes, then the Swiss restriction would likely be WTO inconsistent. If instead, the basis of equivalence is an international standard (for example, the OIE Terrestrial Code), then the restriction has chances of withstanding a WTO claim.

More generally, internationally agreed objectives and criteria (even short of technical standards in the narrow sense) can play a role in the assessment process of equivalence. Equivalence implies that two different standards (for example, animal welfare programmes in two countries) are assessed as equivalent because they adequately fulfil the same objective. Hence, to assess equivalence, you need to identify a common set of specific reference objectives. The reference objectives are sometimes elaborated in the base standard, against which you compare the foreign standard. More often, they are derived from internationally agreed norms. The norms that are identified in the screening exercise of this study provide useful reference objectives, criteria, and benchmarks that can play a role in the equivalence assessment process.

In summary, if a country discriminates between products based on international standards, there is a presumption of WTO-consistency: the country is seen as differentiating between product categories for legitimate policy purposes unrelated to protectionist objectives and its regulation is presumed not to create unnecessary obstacles to trade.

Thus, within the present learning field, we strive to identify a set of common principles and criteria to define sustainable agricultural systems and to differentiate between more and less sustainable ways of food production. Given this objective, we review efforts by public and private actors towards definition of sustainable agricultural production in order to identify and assess what we can learn from these efforts. Further, we discuss some of the persistent elements of disagreements that continue to create difficulties when trying to draw a clear distinction.

In recent years, significant progress has been made towards the creation of internationally agreed objectives and norms that are relevant to our study. It is, therefore, appropriate to start our review with internationally agreed norms and targets, and base our definition as much as possible on these agreed norms and principles.

Most prominently and significantly, with the adoption of **the UN Sustainable Development Goals (SDGs**), sustainability objectives in the field of agriculture have been defined at the international level. Of specific relevance are the goals (and some of their specific objectives and targets) related to food security, employment, and decent work, as well as climate, land, water, and biodiversity. Other significant steps include the formulation of the **concept for agroecology** (AE) by the Committee on World Food Security (CFS) and the internationally agreed formulation of **10 elements of agroecology** by FAO. In addition, the **Voluntary Guidelines on the Responsible Governance of Tenure (VGGT),** as well as several human rights norms such as the Right to Food, or the UNDROP and UNDRIP, should be considered.

Apart from these normative efforts by international organizations, **individual states or groups of states** have also introduced norms that are of relevance here. These include rules for specific production systems (for instance EU organic, USAID organic, Swiss Organic Farming Ordinance 910.18), rules regarding animal welfare, and many specific rules and regulations that have an impact on production (pesticides, environmental regulations, labour standards, etc.). For our study, such norms are of special interest when they are applied similarly by many states (as is the case for organic production).

Many **private standards and benchmarks** have also been elaborated. Some of them are well-established and well known, nevertheless, they often only apply to certain market segments or products and are not (yet) recognized as universal principles defining sustainability. Well-known examples include fair trade standards, private organic standards (for instance BioSuisse), or specific standards for major agricultural commodities such as coffee, cacao, or palm oil (for instance RSPO). However, these private standards have also been criticized as being dominated by commercial interests, while still others argue to the contrary (Dauvergne 2018, Abdul Majid, Ramli et al. 2021, Genoud 2021, Watts, Pasaribu et al. 2021). Nevertheless, if selected with our objective in mind, they can be used to give credibility and substance to some of the principles and indicators that will be defined. Further, as the example of organic standards or RSPO shows, some of these standards have evolved to a sort of hybrid status, informed and influenced both by private and public actors.

Issues of sustainability standards have also been discussed in the scientific literature (Alvarez and Von Hagen 2011, Boiral and Gendron 2011, Vermeulen 2015, Brandi 2017, DeFries, Fanzo et al. 2017, Henry and Pechevy 2017, Janker and Mann 2018, Mann 2018, Janker, Mann et al. 2019), including earlier efforts by the FAO to define "**good agricultural practices**"(Poisot 2003, Poisot, Speedy et al. 2004, Pandit, Nain et al. 2017). Some authors concluded that these endeavours to define a set of basic universal principles had not been successful (Boiral and Gendron, 2011; Brandi, 2017; Delmas and Blass, 2010; Vermeulen, 2015), but their assessment is worth re-examining in light of more recent improvements at the international level towards reaching a consensus on particular questions. FAO has also

published guidelines for sustainability assessment of food and agriculture systems (SAFA), focusing on value chains, but they do not have normative implications (FAO 2014).

2. Objectives

This study assesses initiatives of international organizations, as well as other public and private stakeholders and the scientific literature, in order to identify elements of agreement and disagreement regarding product differentiation on sustainability grounds. While acknowledging that sustainability cannot be easily measured and defined for all site-specific conditions, and recognizing that the assessment of sustainability is also influenced by stakeholders' values, we nevertheless believe that it is possible to identify a number of core common benchmarks for differentiation regarding the social, economic, and environmental dimensions of sustainability.

Our objective is to identify commonalities (and differences) in the definition and measurement of products originating from "sustainable" versus "unsustainable" food systems.

We consider the following key questions:

1. How can we define and differentiate sustainable and unsustainable food systems?
2. What are the challenges of differentiating between sustainable and unsustainable products in the context of trade?
3. What can we learn from already existing definitions and standards?

3. Methodological considerations

3.1. Diversified, sustainable, and small-scale farming systems vs large scale, agro-industrial systems – a feasible approach?

A proposal for a possible definition of the two broadly defined systems (*diversified and small-scale farming systems vs. large-scale, agro-industrial systems*) and their distinction was formulated at the inception of the project.

Of the estimated 570 million farms worldwide, 74% are located in Asia. China alone represents 35% of all farms and India 24% (Lowder, Skoet et al. 2016). There is agreement in the literature that smallholders are the largest group in terms of number of farms. Globally, it has been estimated that 84% of farms are smaller than 2 ha and that they operate on between 12% (Lowder, Skoet et al. 2016) and 24% (Ricciardi, 2018) of all agricultural land. Notably, in low- and lower-middle-income countries, the share of land operated by small farms is even higher, estimated at 30–40% of all land used by farming systems in such countries (Lowder, 2016).

Smallholder systems are often defined as smaller than 2 ha. However, other distinctions are also used, including the quality of land, ecological conditions, as well as economic and social contexts, such that farms with larger land sizes are also sometimes considered "small" based on varying criteria. Finally, smallholder and family farms cannot be simply equated, as it was recently estimated that 98% of all farms worldwide are "family" farms – many of them very large, for instance in countries like the US or Brazil (Graeub, Chappell et al. 2016).

Data on food production by smallholders are often contradictory, due to use of different data sets, methods and definitions of smallholders. Recent analyses have found that the often-cited figure of smallholders' contributing over 75% of global food production is not based on solid data and should be revised (Herrero, Thornton et al. 2017, Ricciardi, Ramankutty et al. 2018). A new analysis found that farms under 2 ha globally produce 28–31% of total crops and 30–34% of food supplies on 24% of gross agricultural area (Ricciardi, Ramankutty et al. 2018). Smallholders are therefore important contributors to global food security. Furthermore, and relevant to our key questions, , smallholders (defined in this case as farmers with less than 5 ha) contribute over 70% of the food produced in developing countries and regions.

The farms and farming landscapes in these areas also feature very high biological diversity (Samberg, Gerber et al. 2016), making them of particular interest for biodiversity conservation. Indeed, such diversified farms and landscapes deserve to be supported because they are important contributors and custodians of agrobiodiversity (Samberg, Gerber et al. 2016). Therefore, smallholders in these areas could particularly benefit from a trade system aimed at promoting biodiversity and furthering development objectives simultaneously. Incentivizing the production of farms that generate important synergies between food production and biodiversity conservation could be an essential and important strategy to reach the SDGs (Messerli, Murniningtyas et al. 2019).

However, it is important to note that small-scale cannot simply be equated with sustainability[1]. Size alone is not a useful distinction. Indeed, the smallholder system is not uniform. The biggest smallholder groups (those in China, India, and other regions in Asia) have become highly input dependent, for example, using comparatively high amounts of fertilizers and pesticides (and achieving yields similar to those in Europe). Other smallholders are particularly resource-poor and have no access to inputs, and in some regions, their production systems contribute to soil erosion, nutrient mining, or deforestation through slash-and-burn systems with short fallow cycles.

Further, a definition of 2 ha farm size would exclude many larger farms in different regions that are also producing according to relatively high sustainability standards, such as many commercial organic farms. Moreover, depending on the region, even resource-poor farmers may require large land areas to maintain diversified livestock-cropping systems in relative marginal regions (for instance in the Sahel). Finally, other production systems such as pastoralism (Central Asia, South Asia, Sahel and others) or the production of Non-Timber Forest Products in forested regions simply do not fit definitions based on farm size.

In conclusion, it is not possible to make a meaningful distinction based on only the criterion of size. There are small, medium, and large farms; low-, medium-, and high-input farming systems; manual or animal traction, and machines of different sizes may be used; and specialized and diversified field plots, farms, and landscapes are possible. Importantly, there are also changes and evolutions in these systems, some of them driven by policies, others

[1] *A good starting reference is the **CFS report on Agroecology**. (HLPE, 2019). Some quotes from the report, which give some insights into the issues to be discussed:*
"Farm size is relative, and context-specific, based on historical, social, economic and ecological conditions: for instance, a farm called 'small' in the United States of America can be considered as 'large' in many African countries. Family farms, however, both in developed and developing countries, may share common features with regard to innovation, agrobiodiversity, intensification strategies and links to territories (Sourisseau, 2014)"
"They also found that the diversity of agricultural and nutrient production diminished as farm size increased, but that, regardless of farm size, areas of the world with higher agricultural diversity produce more nutrients. (Herrero et al., 2017) This analysis provides evidence that both small and large farms are important contributors to food availability, but that very small, small and medium-sized farms produce more food and nutrients in the most populous (and food-insecure) regions of the world than large farms (Samberg et al., 2016)."
"Yet, diversification is not an exclusive characteristic of small-size farms, nor are all small farms diversified. This suggests that diversification might be explored across a range of small to large farm sizes through supportive public policies, research and civil society initiatives" (Ricciardi et al., 2018)."

evolving according to demographic, economic, and ecological trends. In the following chapters, we will, therefore, focus on a larger set of criteria, which should be promoted on behalf of more sustainable systems including a just transition towards more sustainability. To this end, we will propose to define some common principles covering the main relevant dimensions of sustainable production systems. For this, we investigate whether internationally agreed and widely recognized principles exist that can be used to distinguish between farming systems and products that should be supported in a sustainable trade system.

Another challenge is that of deciding how restrictive the criteria should be. On the one hand, being too restrictive by imposing very strong criteria could exclude farms that should be supported for a *transition* towards more sustainability. The objective might be to motivate farmers that currently use unsustainable practices to evolve towards more sustainable practices. On the other hand, being too "soft" might enable farms to qualify which are not likely to meet stronger criteria and allow them to continue with unsustainable practices while benefiting from preferential treatment. But such questions will need to be addressed in other work packages of our project.

3.2. Addressing ecological, social, and economic objectives

There is a broad consensus in the academic literature, but also in the policy arena and among practitioners, that sustainability in agricultural production needs to consider environmental, social, and economic objectives (McIntyre 2009, IPES-Food 2016, Wezel, Herren et al. 2020). It is widely acknowledged that agriculture is a field where ecological, economic, and social processes are highly interlinked, and therefore attempts to distinguish sustainable agricultural production must address this wide range of objectives.

The scientific discussion on sustainability has not produced one universally agreed definition of what sustainability is and how it can be measured (Parris and Kates 2003, Sneddon, Howarth et al. 2006). While the world has agreed on a set of SDG goals, the literature also indicates that to navigate the many trade-offs between these goals – considering different spatial and temporal scales, and the different priorities and needs of stakeholders – implies that sustainable development objectives must be defined in specific contexts (Wiesmann 1998) and stakeholder perceptions are needed to assess whether a system is sustainable or not. This calls for a set of objectives and indicators that can be further defined in context and can be subject to public deliberation.

Therefore, we conclude that differentiation between sustainable and unsustainable systems must be based on normative considerations agreed upon at the international level, and must address the most important social, economic, and environmental dimensions using clear objectives and indicators. At the same time, the definition of indicators must be flexible enough to enable adaptation to individual contexts. Specific benchmarks should be set with caution, only where clear normative agreement exists. The flexibility should enable setting priorities according to each context, and should also enable a focus on the most important improvements in the system. Moreover, adaptations over time should be possible.

3.3. The need to focus on agreed principles at a relatively high level of aggregation

Our study screened initiatives and guidelines of international organizations that aim at developing principles, criteria, or standards in the context of agricultural production and trade. Objectives and standards developed by public and private actors in general address ecological, social, and economic objectives, albeit with different foci and emphases.

A review of existing standards revealed that many different standards have already been developed for different purposes and different actors. The International Trade Centre (ITC), a joint agency of the World Trade Organization

and the United Nations through its Trade for Sustainable Development (T4SD) programme, maintains a database of sustainability standards. According to its own communications, it currently encompasses over 230 standards initiatives applicable to more than 80 sectors and 180 countries.[2] It lists 168 standards related to agriculture (www.sustainabilitymap.org; accessed 12 Mar.2021). The vast number of these standards shows that there is a need to focus not on detailed technical definitions and criteria, but on the *underlying principles*, which need to be further defined according to the local context and for specific products.

The crops with the highest level of certification are those that are heavily traded, such as coffee, cocoa, tea, and palm oil (Tayleur, Balmford et al. 2017). Nonetheless, the sustainability impact remains still unclear, as most standards focus either on socio-economic or environmental impacts and fail to address trade-offs between them (Vanderhaegen, Akoyi et al. 2018).

Many standards do not establish strict criteria or benchmarks, but rather define systems of quality assurance and indicators to measure progress.

Against this background, we primarily investigated the most important efforts by governmental organizations, as such principles have already been discussed and formulated on a sufficiently aggregated and globally acceptable level. We sought to focus on those that have already worked based on common principles and standards for many years, have gained a certain level of credibility and standing, and are relevant and of practical importance to our key questions.

To address certain areas where agreed standards are lacking, we instead refer to guidelines developed by some of the most important standard-setting bodies from the private sector or public–private organizations or initiatives.

3.4. Issues of measurements, benchmarks, and trade-offs

Once commonly agreed principles and objectives are identified, the **problem of measurement and appropriate thresholds** remains. What exactly do we measure when some principles or objectives have been agreed upon? Even when a more detailed list of indicators has been agreed upon, a whole range of more detailed questions arise, as many indicators require additional specifications such as the meticulous definition of spatial and temporal scale, benchmarks and adaption to the context remain.

For instance, how could an indicator such as the prevalence of soil degradation be measured? Which definition of soil degradation should be used? Any type of soil degradation and any degree of severity? Or only certain types and beyond a certain threshold of severity? And how is this threshold defined? Do we measure at the plot level, farm level, or landscape level?

Trade-offs between different objectives: A crucial question is how to rate farming systems that have both positive and negative impacts concerning different objectives. Ultimately, this will typically require making trade-offs between the different objectives. What method should be used to give value to ecological and social impacts and compare them to economic impacts? And how should a corresponding scoring system look? Would a minimal score for each dimension be required, or rather a minimal mean of the scores from all dimensions?
Do we accept that certain systems exhibit some negative impacts if they seem small compared to their positive impacts? Similarly, can a farming system that does not meet our benchmarks still be considered acceptable if it shows potential for future improvement?

[2] Thanks to Gabi Sonderegger, PhD candidate at CDE, for help obtaining an overview of the data.

- *Examples might include: income-generating production of horticulture crops, which uses some pesticides to avoid crop losses; (2) a minimum tillage system, which protects the soil and uses less energy, but depends on use of herbicides.*
- *And what about ecological beneficial practices which, however, demand high labour inputs or high technical skills that are not available to local farmers in certain contexts? Would it be possible to support such farming systems with a view to improving their performance, possibly by strengthening them through better prices, until their social performance meets the required standards?*

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Use of negative lists for inputs

Neither the SDGs nor the agroecology elements contain negative lists for certain inputs (pesticides) or breeding technologies (GMOs). This is probably due in part to high-stakes commercial interests, but also to diverging assessments of the scientific consensus. However, based on our intention to promote sustainable food systems, some limits to use of certain technologies and inputs could be made if we invoke the precautionary principle and apply it to certain well-known and highly relevant issues, especially GMOs and pesticides, which play a major role in current food systems.

Genetically Modified Organisms (GMOs):

GMOs are typically used in large-scale monocultures, with the important exception of GMO cotton, which is also used by smaller farmers. The benefits and risks of GMO crops are still contested, however, in varying degrees by consumers and farmers in the countries they are used, with several countries even instituting bans (19 of 27 European Countries have partial or full bans[3]). According to IAASA, 190.4 million hectares of biotech crops were planted by up to 17 million farmers in 29 countries, of which 92 million hectares were soy, 61 million hectares maize, 26 million hectares cotton and 10 million hectares canola (rapeseed)[4].

Debates on the impacts and risks of GMOs remain ongoing. For instance, the Committee on World Food Security (CFS) report on Agroecology (HLPE, 2019) notes regarding GMOs*: "The World Health Organization (WHO) confirmed that existing regulations have ensured that GM foods currently on the market entail no confirmed health hazards but cautioned against overextrapolation".* The same report also says*: "In other words, these major health authorities all confirmed the need for further safety testing and evaluation of GM foods on a case-by-case basis. Other scientific assessments have noted the lack of scientific consensus on GM safety, and have called for ongoing, rigorous and unbiased testing of biotechnology food and food products (Hilbeck, Binimelis et al. 2015, Krimsky 2015)."*

In Switzerland, NRP 59 on the "Benefits and Risks of the Deliberate Release of Genetically Modified Plants" concluded in 2012 that GMOs do not carry higher risks for the environment compared with other, more conventional breeding techniques (Leitungsgruppe des NRP 59, 2012). However, the programme also recommended further investigation into the possible health risks of new GMOs and new technologies.

It is important to note that current use of GMOs on large-scale field crops is associated with harms that go beyond the possible health impacts of GMOs themselves. Specifically, GMO use is a part of a broader technical package that promotes rapidly expanding monocultures, in particular soy in Latin America, leading to destruction of forests and biodiversity, including wide use of pesticides. However, some observers argue that use of GMO crops also enables minimum and no-till systems, which promote soil cover and reduce soil erosion and have been described by others as "sustainable" practices (Kassam, Friedrich et al. 2009).

As long as there is no consensus on the safety risks of GMOs, it can be argued that such products and the farming systems based on them should not be included in preferential trade agreements. The precautionary principle can be used to support this argument. At the same time, others may say it is ultimately a political decision of how to weigh the risks and possible benefits of GMOs.

Given the ongoing debate and the fact that GMOs have not been allowed in Switzerland to date, GMO products could be excluded from preferential treatment in trade agreements as long as the moratorium remains in place.

[3] https://ec.europa.eu/environment/europeangreencapital/countriesruleoutgmos/ accessed 29 Oct. 2021

[4] https://www.isaaa.org/resources/publications/pocketk/16/. Accessed 13 Oct. 2021

Pesticides:

Another issue arises regarding pesticides and other harmful substances used in agriculture. There is no scientific or societal consensus regarding the risks of pesticides in general. Several international assessments on agriculture have not been able to come up with clear indications on the best policies regarding the use of pesticides – the views of different stakeholders diverge widely on these issues (McIntyre 2009). While there are no universally agreed list of harmful and potentially harmful substances, there exist inventories which could be used as a basis.

Several lists of the most harmful substances exist, and those substances deemed to be most dangerous have been banned by different conventions. However, these lists established by internationally agreed conventions (refer also to annex 2) or agreements have been criticized as lacking in comprehensiveness. Therefore, certain organizations have created more comprehensive lists of harmful and potentially harmful substances. In particular, PAN (Pesticides Action Network) International[5], an international NGO, currently maintains a list[6] of 534 hazardous pesticide active ingredients or groups of active ingredients (PAN List of HHPs, 2022). It shows that countries differ greatly with regard to pesticide bans: the EU and UK have banned 195 pesticides, whereas others have banned very few – for example, only 14 pesticide substances are banned in Kenya. Further, only a tiny fraction of substances (such as DDT) have been banned in a majority of countries, i.e. over 140 countries[7]. The PAN List of HHPs includes substances banned by particular countries, and those judged hazardous according to the criteria established by the FAO/WHO Joint Meeting on Pesticide Management (JMPM) and according to additional criteria established by PAN[8]. According to the latest information at our disposal, neither the FAO[9] nor the Rotterdam Convention have published a similarly detailed list of HHPs or substances[10]. The WHO has a classification of pesticides by hazard (WHO 2020)[11], which could also be used.

A (shorter) Red List can be downloaded from PlantWise (CABI) which lists "Class Ia and Ib Pesticides" according to the WHO Recommended Classification of Pesticides by Hazard, as well as pesticides that have been banned or restricted by the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, the Stockholm Convention on Persistent Organic Pollutants, and the Montreal Protocol on Substances that Deplete the Ozone Layer (2019).[12]

Glyphosate is a good example of a highly contested product. It is included in the PAN list of HHPs[13], having been banned by four countries (Luxembourg, Mexico, Sri Lanka and Vietnam). Restrictions and bans by local and sub-national governments have been documented in numerous countries[14]. These bans are mainly based on the WHO's International Agency for Research on Cancer (IARC) which concluded in 2015 that glyphosate is "probably carcinogenic to humans" (International Agency for Research on Cancer 2015). The likely risks have also been reinforced by several court cases in the US. Nevertheless, glyphosate is still widely used in vast monocultures of soy and other crops worldwide. Further, in the WHO recommended classification of pesticides by hazard and guidelines

[5] PAN International Consolidated List of Banned Pesticides 5th Edition, March 2021. Explanatory note. https://files.panap.net/resources/Consolidated-List-of-Bans-Explanatory.pdf. It contains information from 162 countries "The countries with the most known bans are those of the EU and the UK (175 banned + 208 specifically 'not approved' pesticides which are Highly Hazardous Pesticides (HHPs)1 and/or banned by another country), Switzerland (140), Brazil (131), Egypt (76), Saudi Arabia (73), Indonesia (61), Cambodia (60), India (55), Mauritania (52), Palestine (52), and China (51)." It does not include those banned pesticides regarded as being obsolete according to the 2009 WHO Recommended Classification of Pesticides by Hazard." As a comparison, Kenya is listed with 7 banned pesticides, and USA with 22.

[6] https://pan-international.org/pan-international-consolidated-list-of-banned-pesticides/ (accessed 16/6/2022)

[7] The list of PAN was established with help of the criteria for Highly Hazardous Pesticides (HHPs), as defined by the FAO and completed with additional criteria considered important by PAN (inhalation toxicity, endocrine disruption; toxicity to bees and aquatic organisms; persistence in water, soil or sediment; and bioaccumulation). It also used criteria by the Rotterdam Convention (PAN International Consolidated List of Banned Pesticides 5th Edition, March 2021.)

[9] FAO lists conventions and treaties responsible for such bans https://www.fao.org/pesticide-registration-toolkit/information-sources/restrictions-and-bans/en/

[10] The Rotterdam Convention has a list of pesticides and chemicals that are subject to rules for handling and exportation and importation. Stockholm Convention on Persistent Organic Pollutants has listed the POPs listed for elimination (it evolved from the "dirty dozen").

[11] https://apps.who.int/iris/bitstream/handle/10665/332193/9789240005662-eng.pdf?sequence=1&isAllowed=y (accessed 28.10.2021)

[12] https://www.plantwise.org/wp-content/uploads/sites/4/2019/05/Plantwise-Pesticide-Red-List.pdf

[13] https://pan-international.org/pan-international-consolidated-list-of-banned-pesticides/ (accessed 16/6/2022)

14 https://www.baumhedlundlaw.com/toxic-tort-law/monsanto-roundup-lawsuit/where-is-glyphosate-banned-/ (accessed 16/6/2022)

to classification (WHO 2020), glyphosate is listed as merely "slightly hazardous", highlighting the difficulty of agreeing on a definitive list.

Finally, a long list of hazardous materials has also been elaborated by Fairtrade (Hazardous Materials List 1.12.2016 v 1.4). The Fairtrade list includes materials that are identified as "highly hazardous" by the Code of Conduct on Pesticide Management adopted by FAO and WHO in 2013. The list also includes information from the PAN International List of Highly Hazardous Pesticides (HHP)[15].

In the absence of internationally agreed guidelines, we recommend using the Fairtrade list of pesticides that should not be allowed in the food systems promoted.However, it will be the task of other work packages in this project to clarify whether the list of pesticides banned or restricted in Switzerland could also serve as a benchmark for use more broadly, or whether another list should be used, for example from international conventions or private organizations such as PAN or Fairtrade.

4. Analysis

4.1. SDG objectives and indicators

The SDGs are the most comprehensive attempt by the international community to define a set of commonly agreed objectives and targets for sustainable development. It should therefore serve as our primary reference to derive agreed principles for distinguishing sustainable and unsustainable food systems.
In the following, we review these SDG targets and indicators. We list those that are most relevant and best support a selection of objectives and indicators.

SDG 1: End poverty in all its forms everywhere

> **SDG Target 1.2** *By 2030, reduce at least by half the proportion of men, women, and children of all ages living in poverty in all its dimensions according to national definitions*
>
> **SDG Indicator 1.4.2** *Proportion of total adult population with secure tenure rights to land, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure*

SDG 2: Zero hunger

> **SDG Target 2.4** *By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality*.

The FAO[16] is the custodian on behalf of target 2.4, which is of particular relevance to our own research question. The FAO is the most important UN organization dealing with standards and norms in the field of agricultural production.

[15] https://files.fairtrade.net/standards/Hazardous_Materials_List_EN.pdf

[16] Discussions were held with the FAO (Plant Production and Protection Division) to discuss the current work of the organization, and the literature regarding standards and principles for sustainable agriculture was consulted. It became clear that earlier attempts to define good agricultural practices at the global level had stalled, but currently the work focussing on SDG-related indicators and on agroecology has become an important avenue for the FAO.

Overall, this target is very broad in ambition and scope. It addresses various wide-ranging objectives, reflecting the complexity of agricultural production as a socio-ecological system. This can be seen when looking at the sub-indicators as defined by the FAO.

Indicator 2.4.1 reflects the multiple dimensions of sustainability (economic, environmental, and social). The corresponding indicator was defined as follows:

(**SDG Indicator 2.4.1** *Proportion of Agricultural Area Under Productive and Sustainable Agriculture)*

A set of 11 sub-indicators were defined, organized in themes, each mapped to one of the three dimensions:

Dimensions	No.	Theme	Sub-indicators
Economic	1	Land productivity	Farm output value per hectare
	2	Profitability	Net farm income
	3	Resilience	Risk mitigation mechanisms
Environmental	4	Soil health	Prevalence of soil degradation
	5	Water use	Variation in water availability
	6	Fertilizer pollution risk	Management of fertilizers
	7	Pesticide risk	Management of pesticides
	8	Biodiversity	Use of biodiversity-supportive practices
Social	9	Decent employment	Wage rate in agriculture
	10	Food security	Food insecurity experience scale (FIES)
	11	Land tenure	Secure tenure rights to land

Table 1: Sub-indicators for SDG 2.4.1 (Source: FAO website[17])

These 11 indicators already map to a large extent the issues involved. In particular, they show that sustainability must include all of the three dimensions. Nevertheless, these 11 sub-indicators, in our view, are not comprehensive, as other SDGs and their targets, as well as other issues and international commitments, should be considered.

SDG 3 Ensure healthy lives and promote well-being for all at all ages

Given the importance of agriculture for many people, as a place of work and place of living, this goal is also highly relevant to our research.
Most directly linked to agriculture is Target 3.9, relating to the use of inputs in production:

> **SDG Target 3.9** *By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination*

SDG 5. Achieve gender equality and empower all women and girls

> **SDG Indicator 5a.1** *(a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure. Also:*
> **SDG Indicator 5.a.2** *Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control*

SDG 6 Ensure availability and sustainable management of water and sanitation for all

[17] FAO, 2019: Guidelines on Data Analysis and Reporting http://www.fao.org/3/cb0617en/cb0617en.pdf and http://www.fao.org/3/ca5157en/ca5157en.pdf Accessed 22.7.2021

Agriculture in particular irrigation is one of the big water users worldwide. Agriculture can also significantly harm the environment through nutrient leaching, run-off and erosion, leading to eutrophication of surface water and contamination with pesticides.

Various targets here are important, in particular (but not exclusively):

SDG Target 6.4 *By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.*

SDG Target 6.5 *By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.*

Further, **SDG 14** ***Conserve and sustainably use the oceans, seas and marine resources*** *for sustainable development* is also important, as these waters can also be impacted by agriculture.

SDG 8 Promote inclusive and sustainable economic growth, employment, and decent work for all. Several targets (8.5-8.9) are of particular relevance here**.** Wage rate (a sub-indicator for SDG 2.4.1) is only one dimension of employment and labour standards. Many more issues such as occupational health, number of jobs, labour rights, child labour (SDG Target 8.7), and others play key roles.

SDG 12: Ensure sustainable consumption and production patterns.

Target 12.2 *By 2030, achieve the sustainable management and efficient use of natural resources.*

SDG Indicator 12.2.1 *Material footprint, material footprint per capita, and material footprint per* GDP.

Working towards this indicator could imply reducing the use of material inputs in agricultural production, for instance through the use of fertilizers, pesticides, or plastic and other materials.

SDG 13 Take urgent action to combat climate change and its impacts

Although changing diets to reduce meat consumption is not listed in any of the SDGs indicators, doing so has been identified as an important strategy to mitigate against climate change – as feed production massively contributes to deforestation (through soy production), as does methane emission from ruminants (Obersteiner, Walsh et al. 2016, Shukla, Skea et al. 2019) see also the LF 6 Report). With this knowledge regarding the impact of meat consumption on deforestation, SDG 13 points towards the need to reduce large-scale animal feed production, in particular soy production in Latin America.

SDG 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss

A specific target points to biodiversity conservation*:*

SDG Target 15.5: *Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.*

Other, even more specific targets have been defined by the **Convention on Biodiversity Conservation** (CBD), known as the **Aichi targets**. Of particular relevance is i.a. Aichi Target 3[18] which calls for incentives to be created for the

[18] By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed to minimize or avoid negative impacts; and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio-economic conditions.

conservation and sustainable use of biodiversity. Other targets must also be considered, for instance, Aichi Target 7, which calls for sustainable management of agricultural areas. Aichi Target 13 calls for the maintenance of genetic diversity of cultivated plants and domesticated animals. Food systems can also endanger biodiversity-rich areas (tropical forests, and other high-value ecosystems) through the expansion of land exploited. These issues are not addressed adequately in SDG2.4.1 sub-indicator 8 ("Use of biodiversity-supportive practices"). Stronger criteria may be needed here, such as prevention of destruction of such ecosystems (Aichi Target 5).

4.2. Principles of Agroecology

The **concept for agroecology** (AE) is another important basis on which we can build (Gliessman 2014, Gliessman 2016, Altieri 2018, Barrios, Gemmill-Herren et al. 2020, Mottet, Bicksler et al. 2020, Wezel, Herren et al. 2020). It has found recognition both within FAO and the Committee on World Food Security (CFS). The FAO, based on a series of regional seminars (FAO 2018b), published in 2018 a set of ten elements of agroecology . These elements or principles are intended to support countries in operationalizing agroecology. The FAO council[19] reviewed the ten elements of agroecology in 2019 (FAO 2019c), and finally "*approved the revised version of the Ten Elements of Agroecology (CL 163/13 Rev.1) as a living document"* (FAO 2019a). Furthermore, the High-level Panel of Experts on Food Security and Nutrition (HLPE), on request of the Committee on World Food Security (CFS), reviewed the nature and potential of agroecology and formulated recommendations for policy and private actors. The final HLPE report (HLPE 2019) formulates 13 principles. They are broadly equivalent to the ten elements formulated by FAO but are expanded to include also in particular soil and animal health, fairness and participation explicitly. In 2021, the CFS formulated "policy recommendations on agroecology and other innovative approaches" based on the HPLE report, however without restating and reaffirming the principles in detail (CFS 2021). Importantly, the CFS cites FAO's "Ten Elements of Agroecology "*as an internationally agreed formulation of the main elements that characterize agroecology"* (CFS 2021). The CFS, as it embraces an inclusive approach with all stakeholders, carries from the perspective of many stakeholders, considerable legitimacy regarding the governance of the global food system.

The elements of agroecology take into account biophysical, social, economic, and cultural aspects in a common and coherent set of basic principles. It is important to acknowledge that these principles provide flexibility to account for context and capacities. The CFS notes: "*The challenges food systems face are highly complex, context-specific and often unpredictable. Transformation to sustainable food systems is needed, in a coherent manner, as appropriate, and in accordance with and dependent on national context and capacities. There is no single approach for achieving food security and nutrition and all food systems have the potential to contribute further to sustainable agriculture and food systems that enhance food security and nutrition by following context appropriate transition pathways*" (CFS 2021).

The FAO has also elaborated a framework to monitor the transition to agroecology, known as the Tool for Agroecology Performance Evaluation, or TAPE (FAO 2019b, Mottet, Bicksler et al. 2020).

[19] Composed of forty-nine member nations elected for three years

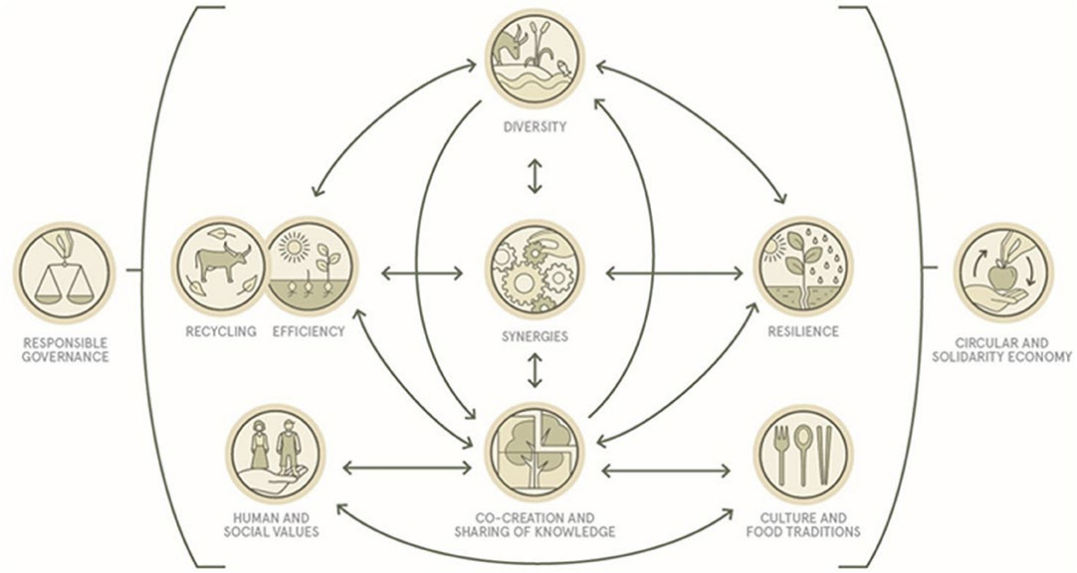

Figure 1: The 10 Elements of Agroecology (FAO 2018a)

The TAPE tool attempts to operationalize a system to monitor agroecology, comparing also with other earlier attempts to assess the sustainability of farming systems. Mottet et al. (2020) provide scales and scores to assess each of the indicators. Refer to Table 2 for the example of diversity. This shows how indicators can be assessed using semi-quantitative ratings. Such a system could be used to measure progress towards the dimensions of agroecology. However, the Table 2 also illustrates how questions could arise for each indicator and the scoring matrix. For instance, regarding diversity, the scoring distinguishes between "some trees", a "significant number of trees" and a "high number of trees". While this is an easily understandable scoring, it still gives room for interpretation. Should this be applied for one plot, a farm, or the landscape? What is the difference between some trees and a significant number of trees? This is only one example, but the same could be said for most indicators and scoring scales. This type of measurement is useful to monitor progress in a given context, or roughly compare between different farms, as long as stakeholders agree on it. However, it is questionable whether it could withstand a challenge in a trade dispute.

	Index	0	1	2	3	4
DIVERSITY	**Crops**	Monoculture (or no crops cultivated)	One crop covering more than 80% of cultivated area	Two or three crops	More than 3 crops adapted to local and changing climatic conditions	More than 3 crops and varieties adapted to local conditions. Spatially diversified farm by multi-, poly- or inter-cropping
	Animals (including fish and insects)	No animals raised	One species only	Several species, with few animals	Several species with significant number of animals	High number of species with different breeds well-adapted to local and changing climatic conditions
	Trees (and other perennials)	No trees (nor other perennials)	Few trees (and/or other perennials) of one species only	Some trees (and/or other perennials) of more than one species	Significant number of trees (and/or other perennials) of different species	High number of trees (and/or other perennials) of different species integrated within the farm land
	Diversity of activities, products and services	One productive activity only (e.g., selling only one crop)	Two or three productive activities (e.g., selling two crops, or one crop and one type of animals)	More than 3 productive activities	More than 3 productive activities and one service (e.g., processing products on the farm, ecotourism, transport of agricultural goods, training etc.)	More than 3 productive activities, and several services

Table 2. Characterization of agroecological transitions (CAET): Descriptive scales and scores for the element "Diversity" (Mottet et al. 2020).

Table 3 shows the main indices for all the 10 elements.

Element	CAET indices
Diversity	• Crops • Animals, including fish and insects • Trees and other perennials • Diversity of activities, products and services
Synergies	• Crop-Livestock-Aquaculture integration • Soil-Plants management system • Integration with trees (agroforestry, silvopastoralism, agrosilvopastoralism) • Connectivity between elements of the agroecosystem and the landscape
Efficiency	• Use of external inputs • Management of soil fertility • Management of pests and diseases • Productivity and household's needs
Recycling	• Recycling of biomass and nutrients • Water saving • Management of seeds and breeds • Renewable energy use and production
Resilience	• Stability of income/production and capacity to recover from perturbations • Mechanisms to reduce vulnerability • Environmental resilience and capacity to adapt to climate change • Average diversity
Culture and food tradition	• Appropriate diet and nutrition awareness • Local or traditional identity awareness • Use of local varieties/breeds and traditional knowledge for food preparation
Co-creation and sharing of knowledge	• Platforms for the horizontal creation and transfer of knowledge and good practices • Access to agroecological knowledge and interest of producers in agroecology • Participation of producers in networks and grassroot organizations
Human and social values	• Women's empowerment • Labor (productive conditions, social inequalities) • Youth employment and emigration • Animal welfare (if applicable)
Circular and solidarity economy	• Products and services marketed locally (or in fair trade schemes) • Networks of producers, relationship with consumers and presence of intermediaries • Local food system
Responsible governance	• Producers' empowerment • Producers' organizations and associations • Participation of producers in governance of land and natural resources

Table 3. Indices used for each of the 10 Elements of Agroecology (Mottet et al. 2020).
The complete set of scores can be found in Mottet et al. (2020), supplementary material.

Wezel, Herren et al. (2020) describe how these 10 elements of AE can be formulated in 13 consolidated principles, indicating the level at which they can be applied, and articulating requirements of soil and animal health more explicitly while distinguishing between biodiversity and economic diversification. This list is comprehensive and covers all the dimensions of sustainable food systems that we propose. However, the orientation regarding the climate objectives are more implicit (see Table 4)

Principle	Scale of application	Correspondence to FAO elements
1. Recycling. Preferentially use local renewable resources and close as far as possible resource cycles of nutrients and biomass.	FI, FA	Recycling
2. Input reduction. Reduce or eliminate dependency on purchased inputs and increase self-sufficiency.	FA, FS	Efficiency
3. Soil health. Secure and enhance soil health and functioning for improved plant growth, particularly by managing organic matter and enhancing soil biological activity.	FI	Reflected in diversity, synergies and resilience
4. Animal health. Ensure animal health and welfare.	FI, FA	Reflected in resilience
5. Biodiversity. Maintain and enhance diversity of species, functional diversity and genetic resources and thereby maintain overall agroecosystem biodiversity in time and space at field, farm and landscape scales.	FI, FA	Part of diversity
6. Synergy. Enhance positive ecological interaction, synergy, integration and complementarity amongst the elements of agroecosystems (animals, crops, trees, soil and water).	FI, FA	Synergies
7. Economic diversification. Diversify on-farm incomes by ensuring that small-scale farmers have greater financial independence and value addition opportunities while enabling them to respond to demand from consumers.	FA, FS	Parts of diversity as well as circular and solidarity economy
8. Co-creation of knowledge. Enhance co-creation and horizontal sharing of knowledge including local and scientific innovation, especially through farmer-to-farmer exchange.	FA, FS	Co-creation and sharing of knowledge
9. Social values and diets. Build food systems based on the culture, identity, tradition, social and gender equity of local communities that provide healthy, diversified, seasonally and culturally appropriate diets	FA, FS	Human and social values Culture and food traditions
10. Fairness. Support dignified and robust livelihoods for all actors engaged in food systems, especially small-scale food producers, based on fair trade, fair employment and fair treatment of intellectual property rights.	FA, FS	Part of human and social values
11. Connectivity. Ensure proximity and confidence between producers and consumers through promotion of fair and short distribution networks and by re-embedding food systems into local economies.	FA	Part of circular and solidarity economy
12. Land and natural resource governance. Strengthen institutional arrangements to improve, including the recognition and support of family farmers, smallholders and peasant food producers as sustainable managers of natural and genetic resources.	FA, FS	Responsible governance
13. Participation. Encourage social organisation and greater participation in decision-making by food producers and consumers to support decentralised governance and local adaptive management of agricultural and food systems.	FS	Part of human and social values

Text in italics show the titles of the repective principle

Table 4: Consolidated List of 13 agroecological principles, their scale of application and correspondence to FAO elements of agroecology.*FI: field; FA: farm, agroecosystem; FS: food system*. Source: Wezel et al, 2020.

The concept of AE includes a number of principles that we will not include in our proposed list of objectives and criteria (see chapter 5), mainly because they are difficult to measure, thus complicating establishment of clear criteria and benchmarks. In particular, the following principles of AE are not covered by our list but could be included as transversal requirements to be integrated in eventual mutual agreements between trading partners.

Co-creation and sharing of knowledge: agricultural innovations respond better to local challenges when they are co-created through participatory processes.

Circular and solidarity economy: circular and solidarity economies that reconnect producers and consumers provide innovative solutions for living within our planetary boundaries while ensuring the social foundation for inclusive and sustainable development.

Synergies: building synergies enhances key functions across food systems, supporting production and multiple ecosystem services.

Finally, we consider that protecting and improving rural livelihoods, equity and social well-being is essential for sustainable food and agricultural systems. Therefore the principle of Human and social values, also included in the concept of agroecology, will be included in our list of objectives. This principle can be supported through specific international norms, such as the right to food, decent work, occupational health, access to land, and adaption to climate change, as well as animal welfare and biodiversity conservation as intrinsic human values.

4.3. Other important issues and corresponding norms of importance

Labour, decent employment, and quality of life

As we have noted above, **SDG 8** already provides objectives in this field.

Further, we propose consideration of the following normative documents related to labour rights:

- **UN Declaration on the Rights of Peasants and Other People Working in Rural Areas (UNDROP),** adopted in 2018, affirms the rights of smallholders as an important element, given the high number of smallholders in the world.
- **UN Declaration on the Rights of Indigenous Peoples (UNDRIP)** specifically addresses indigenous people as a group of actors especially affected by many forms of land use for agricultural purposes in the context of trade.
- **ILO Declaration on Fundamental Principles and Rights at Work (1998)**[20] commits the Member States to respect and promote principles and rights in four categories:
    - freedom of association and the effective recognition of the right to collective bargaining;
    - the elimination of all forms of forced or compulsory labour;
    - the effective abolition of child labour;
    - the elimination of discrimination in respect of employment and occupation

  Of particular interest are:

    - **ILO Convention 182 (Worst Forms of Child Labour Convention)** requires countries to take immediate, effective, and time-bound measures to eliminate the worst forms of child labour as a matter of urgency.[21]
    - **ILO International Labour Organization Convention 138** (on the minimum age for admission to employment) requires countries to: (1) establish a minimum age for entry into work or employment; and (2) establish national policies for the elimination of child labour.
    - **ILO Recommendation 146** stresses that national policies and plans should provide for poverty alleviation and the promotion of decent jobs for adults, so that parents do not need to resort to child labour; free and compulsory education and provision of vocational training; extension of social security and systems for birth registration; and appropriate facilities for the protection of children, and adolescents who work.

Private standards regarding employment have defined indicators in more detail and tailored them to the specific requirements of the goods produced. It is important to include such norms in our set of principles. Janker and Mann (2018) have analysed 87 farm-related sustainability assessment tools to examine how they operationalize the social dimension. Recurring topics identified were human rights, labour conditions, life quality, and societal impacts. They also identified different approaches to defining criteria. Some use international norms such as human rights and the ILO conventions, others assess farmers' perception of quality of life. Janker and Mann found a lack of definition of social sustainability and a lack of consensus on what it should entail. They identified human rights and labour conditions as the most feasible for global application. However, they also point out that while human rights can be used as the bottom threshold (the minimum that must be guaranteed) they are not an appropriate objective to be achieved. They note "The fulfilment of needs, well-being or other perceived life satisfaction might be more adequate approaches, but these are more difficult to operationalize within farm sustainability assessments". For our purpose, we conclude that human rights and the ILO conventions can be used to set a minimum standard, but that local

[20] https://www.ilo.org/declaration/lang--en/index.htm
[21] 2020, ILO Convention No. 182 became the first ILO convention to achieve universal ratification.

objectives aimed at improving quality of life and societal impact should be added, as well other objectives defined for the given context.

Labour and human rights norms are also recognized in the agroecology principles, and are thus consistent.

Land tenure

Land tenure need not only be secure, but also equitable as well as upholding the rights of indigenous people, women, and other potentially marginalized groups such as pastoralists, fishermen, and local communities. These principles, also recognized by SDG indicator 2.4.1 and the agroecology principles, have been further described and specified in the **Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGTs)**(FAO 2012). The VGGTs, although termed voluntary, have been signed by 123 states[22], and constitute an important set of commonly agreed guiding principles. Some of the requirements in the VGGT are completer and more stringent than those mentioned in TAPE. For instance, the VGGTs require that "*Responsible investments should do no harm, safeguard against the dispossession of legitimate tenure right holders and environmental damage, and should respect human rights*" (VGGT: 12.4), aspects not measured in TAPE. The latter simply calls for participation in land governance.

Animal welfare

Based on universal ethics principles, the consideration of animal welfare should also be included. According to the OIE (World Organisation for Animal Health) and its *Terrestrial Code*, animal welfare refers to "the physical and mental state of an animal in relation to the conditions in which it lives and dies". The guiding principles which inform the OIE's work on the welfare of terrestrial animals include the "Five Freedoms". Developed in 1965, and widely recognized, the five freedoms describe society's expectations for the conditions animals should experience when under human control (OIE website). The **Five Freedoms include**:(1) freedom from hunger, thirst, and malnutrition; (2) freedom from fear and distress; (3) freedom from physical and thermal discomfort; (4) freedom from pain, injury, or disease; and (5) freedom to express normal patterns of behaviour.[23]

Several existing norms – at the EU level, at the national level, and in certain organic standards (organic, Demeter) – lend further legitimacy to such principles. We identified the European Convention for the Protection of Animals kept for Farming Purposes, as well as the Demeter Standard, well known as having a well-developed and strong standard on animal welfare, focussing on the integration of livestock keeping in the farming systems, but not opposing livestock keeping. In Switzerland, two well-known standards, incentivized through subsidies, are ***BTS*** (*Besonders tierfreundliche Stallhaltungssysteme*) and RAUS (*Regelmässiger Auslauf im Freien*), which both aim to set standards that provide animals with more space and the ability to express normal patterns of behaviour.

Animal welfare is not captured in the 11 sub-indicators of SDG 2.4.1, nor in the elements of agroecology. (However, TAPE now includes it under social and human values.) Still, livestock keeping and animal welfare can be linked indirectly to agroecology based on its approach to agricultural production and manifold synergies, in particular nutrient recycling (Wezel, Herren et al. 2020).

[22] http://www.fao.org/docrep/meeting/025/md958e.pdf

[23] See World Organisation for Animal Health (OIE) Guiding Principles on Animal Welfare in the Section 7 of the Terrestrial Animal Health. OIE website, accessed 19. Jul. 2021C

Last but not least, animal protein is a key part of the human diet for much of the global population, firmly linking it to SDG 2. Based on this emphasis on synergies as well as nutrient recycling in the agroecology principles, some elements of animal welfare can be addressed, for example based on the need to set limits on livestock numbers and intensity. While we acknowledge the benefits of vegan diets, we believe that based on the current food preferences of most consumers, a modest level of animal protein will foreseeably remain part of a sustainable diet in most regions and for most households.

Organic agriculture

Under the label of organic agriculture, a lot of important experience, methods, and principles have been developed, which are widely known and recognized. Despite its recognition, still only a tiny fraction of global producers practises organic agriculture (2019: 3.1 million producers on 73 million hectares, just 1.5 % of global farmland) (Willer 2021). At the same time, well-defined and established standards exist, which have officially been recognized or adapted and used in 108 countries, including the US, the EU, Switzerland, and many developing countries (Willer 2021). At the international level, the Codex Alimentarius Commission has published guidelines for the Production, Processing, Labelling, and Marketing of Organically Produced Foods[24] and IFOAM has published norms for its Organic Guarantee System[25]. These guidelines and norms offer principles that have proven widely applicable and useful. According to IFOAM, organic agriculture is based on four principles: the principle of health; the principle of ecology; the principle of fairness; and the principle of care. Many of the principles of organic production are similar to those of agroecology.

There is, however, no agreement among major stakeholders as to whether the organic system is the only or the most appropriate way to define sustainable food systems. These standards cannot be used as a simple template to formulate criteria, as they apply to a specific model of agriculture that is not necessarily acceptable and adaptable to every context (Seufert and Ramankutty 2017).

Organic standards and the corresponding system of certification have been criticized as too costly for small producers. Others have criticized it as being too rigid and not giving enough room for innovation.
However, the cost of certification can be reduced through group certification and Participatory Guarantee Systems (PGS) with locally focused quality assurance systems. Indeed, PGS are growing in importance, and are appropriate for small farmers (Vandecandelaere 2010, Loconto and Hatanaka 2018, Hruschka, Kaufmann et al. 2021, Willer 2021). In our view, the definition of a sustainable food system should include organic farming, but be broader and further encompass additional criteria, which we derive from internationally agreed norms.

Comments on other standards

Other international standards were identified in the literature and via internet research. In particular, the present study also reviewed the following guidelines, but found them too unspecific and/or not properly focussed on our question:

- **Responsible Agricultural Investments (RAI principles)**, developed by the Committee on Food Security (CFS) (FAO, 2012). These principles affirm mainly norms already mentioned, namely, that investments should respect the Right to Food; generate positive impacts; respect labour rights and the VGGTs; use, develop, and regenerate natural resources; and contribute to climate adaptation and mitigation.

[24] CAC/GL 32, Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods. https://www.fao.org › input › download › standards › 360 › cxg_032e.pdf

[25] https://www.ifoam.bio/our-work/how/standards-certification/organic-guarantee-system/ifoam-norms

Additionally, they also mention maintaining respect for cultural heritage and traditional knowledge, and the need to consider local and relevant stakeholders' views on these.

- **Principles for Responsible Agricultural Investment**; PRAI (World Bank, 2010). This document mainly also recalls similar principles that should be upheld when promoting or investing in agricultural projects. They do not offer additional details that could be used for our purposes.
- **OECD-FAO Guidance for Responsible Agricultural Supply Chains** (OECD and FAO 2016): these guidelines are intended to provide business with support to observe relevant standards for operations in the agricultural sector. They refer principally to the standards that we have listed above, in particular the VGGTs, PRAI, RAI, and the OECD Guidelines for Multinational Industries. Topics addressed include human rights, labour rights, health and safety, food security and nutrition, ensuring rights over and access to natural resources, animal welfare, environmental protection and sustainable use of natural resources, governance, and technology and innovation.

5. Results

5.1. Proposed objectives, criteria, and benchmarks

The result of our investigation is a list of proposed objectives, criteria, and benchmarks *based on internationally agreed objectives and norms* (see Table 2). The objective is to distinguish *sustainable agricultural production systems* for preferential treatment in the framework of a sustainable trade system.

Table 2: Objectives, criteria, and benchmarks to differentiate sustainable agricultural production systems *Note: AE=10 Principles of Agroecology (FAO-CFS)*

Proposed objectives	Internationally agreed objectives	Reference	Criteria and benchmark for inclusion	Criteria and benchmark for exclusion	Comments on criteria	Indicators	Reference
Promote food security and right to food	Right to food, reduce hunger	SDG Indicator 2.4.1, Right to food, AE	From areas with sufficient land resources, or where competition with food can be compensated via high-income earning potential	Must not compete with food security, but rather support food security synergistically (by creating income and producing food for subsistence)	High-value crops such as coffee, cacao from diversified smallholder production (such as agroforestry), and/or from diversified and ecologically rich areas. Capacity in the food system to produce, process, store ,and provide access to food is strengthened.	FAO: Food Insecurity Experience Scale (FIES) Availability of food at affordable prices Sufficient land for food products remains available	Organic coffee Fairtrade IFOAM USAID organic EU organic Organic products from PGS systems
Promote equitable and secure access to land	Access to land for all	SDG 1 Indicator 1.4.2, SDG 2, Indicator 2.4.1. Sub-indicator 11, VGGT, AE	From areas with secure land rights for smallholders, pastoralists, indigenous people, women, or from areas where land rights of marginal users can be supported through inclusion in a preferential system of trade.	Must not compete with land rights of smallholders, pastoralists, or indigenous people Must not be produced in illegally logged areas	Excludes in practice soy production from Brazil (as legal deforestation cannot be proven in most cases)	Land rights and laws are respected. Land rights provide security for small land users. Transparency on large-scale land concessions is provided. Countries provide evidence that they comply with VGGTs. Rights of indigenous people are respected.	https://www.rspo.org Dummett, Cassie& Blundell, Arthur. 2021. Illicit Harvest, Complicit Goods. Forest Trends. Large-scale land acquisitions are transparent and can be monitored through land inventories such as www.landmatrix.org or equivalent national databases
Promote decent employment, gender equity, freedom of association, fair prices	Adequate working conditions Gender equity in labour conditions Prevention of abusive child labour Occupational health	SDG 1 (Poverty) UNDROP ILO Declaration on Fundamental Principles and Rights at Work ILO Conventions 138 and 182; ILO Recommendation 146; Universal Declaration of Human Rights, Article 23 (ILO Conv. 95 and	Salaries clearly above minimum wage and social benefits (for employees) Prices perceived as fair by producers (stable and well above the lowest market prices in the past). Freedom to join worker unions	Violation of ILO conventions Abusive child labour Absence of freedom of association	Not minimal wage but decent living wage (including social benefits in the case of employees). Prices for smallholders to be agreed with the participation of producers in negotiation. Measures to strengthen well-being, livelihoods, and income opportunities for all	National labour laws respected ILO conventions respected Producer prices agreed in multi-party negotiations, PSGs, or through Fair Trade Label or equivalent.	Global Living Wage Coalition (GLWC) Living Income Living Income Community of Practice https://www.living-income.com

Proposed objectives	Internationally agreed objectives	Reference	Criteria and benchmark for inclusion	Criteria and benchmark for exclusion	Comments on criteria	Indicators	Reference
		131, ILO Rec. 131 and 135).					
Assure animal welfare	Animals kept enjoy the "five freedoms"	OIE standards and principles Organic Farming Regulation, European Convention for the Protection of Animals Kept for Farming Purposes	Improve animal welfare delivering on the five freedoms and related OIE standards and principles, including through capacity building programmes, and supporting voluntary actions in the livestock sector to improve animal welfare	All products not corresponding to high standards of animal welfare and from farms not well integrated into closed nutrient cycles are not included.	Standards must be adjusted to the context. Standards must take into account the circumstances of small producers, who cannot comply with the same measures with sanitary and other measures as large industrial livestock systems.	Evidence on livestock management provided by farmers or government. Evidence on measures to develop and introduce alternatives.	OIE (World Organisation for Animal Health) and its *Terrestrial Code*
Enhance and restore biodiversity	Not only reduction of biodiversity losses, but also active restoration of biodiversity	SDG 15, Aichi Targets 3,7,13, AE	Crop diversification and crop rotation. Conservation of agricultural landraces and species. Establishment of biodiversity-rich production areas. Preservation and reclamation of zones of particular ecological value (wetland, hedges, riparian zones, etc).	Must not be associated with large-scale deforestation or the destruction of other valuable biomes. Must not be associated with monocultures (at a large spatial and temporal scale), which are leading to the deterioration of soils and biodiversity over time.	Benchmarks to be defined in the country of origin with the participation of local stakeholders.	Evidence on conservation planning and implementation with regard to the concerned production systems (farm or landscape level)	Aichi Targets
Contribute to climate change adaption, resilience and sustainable resource use	Actions that increase resilience and improve adaption	SDG 13, Paris Declaration	Crop diversification, climate-smart production techniques, soil and water management	Monocultures of annual crops without crop rotation, without adequate soil cover. Crop production depleting or polluting water resources, soil management practices that degrade soil quality.	Benchmarks to be defined in the country of origin with the participation of local stakeholders.	Evidence on adaptation planning and implementation with regard to the concerned production systems (farm or landscape level)	Examples of best practices can be found in the UNCCD SLM knowledge base https://qcat.wocat.net/en/wocat/ IPCC, 2019: Climate Change and Land IPCC 6th report 2021: re extreme events

Proposed objectives	Internationally agreed objectives	Reference	Criteria and benchmark for inclusion	Criteria and benchmark for exclusion	Comments on criteria	Indicators	Reference
Contribute to climate change mitigation	Actions that contribute to reducing greenhouse gas emissions or improving carbon storage	SDG 13, Paris Declaration	Promote carbon sequestration in soil and above ground, reduce other greenhouse gas emissions	Must not be associated with large-scale deforestation, depletion of peatland, or highly intensive use of fossil fuel. No need for air freight.	Benchmarks to be defined in country of origin with participation of local stakeholders. Data on transportation from importers and retailers.	Evidence on mitigation planning and implementation with regard to the concerned production systems (farm or landscape level)	Examples of best practices can be found in the UNCCD SLM knowledge base https://qcat.wocat.net/en/wocat/ IPCC, 2019: Climate Change and Land
Close nutrient cycles	Close nutrient cycles to reduce transport, contamination, and eutrophication of water, integration of livestock, production and field crops	AE; Organic Farming	Close nutrient cycles through recycling, composting, integration of livestock and crop production at the farm level or local level	No livestock production without sufficient land where manure can be used productively (on-farm or in exchange with other farms). No livestock production without sufficient land to produce adequate amounts of fodder (at least 90%) on-farm or in the vicinity in exchange with other farms), with exceptions for resource-poor farms.	A stocking rate for different livestock species that allows closed nutrient cycles. Maximum size of herds Inorganic fertilizers at a low and moderate level complement nutrient deficiencies where no organic manure is available. Standards must consider the circumstances of small producers.	Nutrient balance for farms and landscape. Evidence on measures to develop and introduce alternatives.	IFOAM, but with higher restrictions regarding the transport of manure and fodder than is presently the case. USAID organic. PGS systems that include this topic
Recycling and minimizing of raw material	Reduce waste generation through prevention, reduction, recycling, and reuse	SDG 12, Target 12.5 AE	Recycling of material used (plastic, metals, other materials) including nutrients. Reduce fertilizer and pesticide inputs	Excessive use of plastic and materials that cannot be recycled	In addition to health requirements, sanitary standards must consider the need for minimal use of raw materials.	Evidence of management of raw materials aimed at recycling and avoidance. Evidence on measures to develop and introduce alternatives.	TBD
Reduction and avoidance of harmful inputs	Reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination	SDG Target 3.9; SDG 2.41, SDG 6, SDG 15, AE (recycling), Organic farming	Management of pesticides. Pesticides on Red List excluded; and Material on Orange List only used according to precise conditions as outlined in Fairtrade List. Preferable only substances on the list of allowed substances in organic agriculture.	Fairtrade International Red List of Prohibited Materials Any use of substances in CABI List.	Consolidated list from different sources, to be defined and regularly updated.	Updated list of excluded and restricted inputs Evidence on management (information, regulation, enforcement) Evidence on measures to develop and introduce alternatives.	Fairtrade Hazardous Materials List https://files.fairtrade.net/standards/Hazardous_Materials_List_EN.pdf Red List (CABI) https://www.plantwise.org/wp-content/uploads/sites/4/2019/05/Plantwise-Pesticide-Red-List.pdf

5.2. Discussion of the proposed objectives, criteria, and benchmarks

Promote food security and the right to food
The Right to Food as a human-rights norm defines specific state obligations to protect it. At the same time, SDG 2 provides a strong justification for inclusion of food security in the criteria of sustainable food systems.

When agricultural goods are produced for international markets, there can be a trade-off in terms of land used which could otherwise be exploited for smallholder self-consumption or production of food for the domestic market. Further, there may also be ambiguous effects on land rights and gender equity. In many contexts, however, locals need higher agricultural incomes in order to complement self-produced food, as well as to cover various cash needs, such as for schooling, health care, and additional necessities. Notably, export crops often fetch relatively high prices compared to domestic sales, and many smallholders react accordingly to these price signals.

This export vs. domestic price dilemma has long been discussed within the fair trade community (Vellema, Casanova et al. 2015, Schleifer and Sun 2020). Research in West Africa has shown that when export production is aimed at high-value crops, the income benefits can outweigh the loss in potential land for domestic food production (Knößlsdorfer, Sellare et al. 2021). However in a meta-review, this positive relationship between certification, farmers' income, and local food security was found to be weak and highly context-dependent (Schleifer and Sun 2020). One problem affecting the potential benefits of fair trade standards are the high cost of certification. Therefore, other types of certification such as PGS are important tools.

We conclude that an objective of increased food security is important to include in our list of criteria. Nevertheless, food security is a complex issue and has different dimensions including availability, access, utilization, and stability (Pinstrup-Andersen 2009, Hendriks 2015). The FAO proposes the Food Insecurity Experience Scale (FIES) as a specific sub-indicator to monitor SDG 2.4.1. This approach is now used by the FAO to monitor Food Insecurity on a regular basis (Smith, Rabbitt et al. 2017, Cafiero, Viviani et al. 2018). Monitoring this indicator and others related to food security can contribute to developing concrete benchmarks for each context.

The agroecology concept also emphasizes culture and food traditions. By supporting healthy, diversified, and culturally appropriate diets, agroecology contributes to food security and nutrition while maintaining the health of ecosystems. Such aspects could also influence local definitions of these indicators, but it would be difficult to include them in a binding form in the list of indicators.

Promote equitable and secure access to land
Given highly unequal access to land in most countries and lack of other employment opportunities, smallholders' rights to keep or obtain access to land is a criterion that must be fulfilled. This objective can be monitored using the VGGTs, which detail the issues associated with this topic and list many recommendations and state obligations related to sustainable and equitable land tenure. Of particular importance are issues of land access on behalf of smallholders, pastoralists, traditional communities, and indigenous communities. Adherence to these principles will in many contexts exclude large-scale monocultures and plantations that restrict or destroy access to land for such land users.

Promote decent employment, gender equity, freedom of association, fair prices
Poverty remains a pervasive issue in many contexts and is an important development priority in many countries. While there are many poverty-focused norms available, their implementation typically remains partial at best. An ILO study (Henry and Pechevy 2017) has compared five voluntary standards – Fairtrade

International (FLO), GLOBALG.A.P, Social Accountability International (SAI), Sustainable Agriculture Network (SAN), Rainforest Alliance, and UTZ Certified – and found that they all include some ILO norms but do not comply with the full complexity of these norms. In terms of reach, all the voluntary standards tended to focus on large farms and post-harvest handlers in agro-food global supply chains, thus providing little support to small-scale farmers. With the exception of FLO, the contributions of buyers to the selected schemes were found to be limited to participation in the standard-setting process. Only two (FLO, UTZ) provided a price premium.

As with other objectives, many criteria are not easy to measure. For instance, what is a fair price? Should the reference be a market price, with a price premium added? Or should stable producer prices be guaranteed? If yes, at what level? Should this system apply only to small farmers or also to large producers, for instance, plantations? These are difficult questions, but must play a role in any efforts to promote sustainable trade of agricultural goods.

In addition to private standards, state interventions to improve prices are also possible. Experiences with organizations managing price stabilization schemes appear mixed. However, innovative solutions could be developed, considering new possibilities to manage and oversee resource flows.

Assure animal welfare

Ethical considerations demand that animal welfare also be included in the system of objectives. Eating less meat should be an objective for societies that have achieved a high level of food security and currently exceed widely recommended levels of dietary meat consumption. At the same time, animals are also an important source of nutrients in many regions of the world. It is debatable whether a transition to more strict vegetarian diets will be socially acceptable and feasible in the future.

Many observers view ruminants, in particular, as a very well-adapted way of using the world's vast areas of rangelands, as has been done by pastoralists for thousands of years. Demeter organic standards, for example, even require certified farmers to keep animals as an integral and necessary part of the farm. Animals can also be an important source of manure in mixed production systems, for instance.

Therefore, we propose inclusion of animal production in the definition of sustainable food systems, but recommend adding specifications regarding animal husbandry management, stocking rates, breeding, mutilation prevention, nutrition, veterinary medicine, etc. Such standards exist but are not the same in each country or for each animal species. One option would be to refer to the best standards in Switzerland (BTS and RAUS), in addition to other standards derived from the Swiss Animal Welfare Act[26] – especially regarding breeding, killing and slaughter, the dignity of animals and corresponding transportation. It is also possible to refer to the OIE (World Organization for Animal Health) and its *Terrestrial Code,* for which guidelines have been developed that could be used.

Enhance and restore biodiversity

The Aichi Targets have defined clear objectives and targets for biodiversity conservation. Unfortunately, the world is not on track to meet these targets. Contributions to achievement of these targets should therefore be an important element of the objectives. It should include on-farm and off-farm biodiversity, and also consider the role of production systems on the landscape level (such as measures to enhance biodiversity conservation through wildlife corridors, riparian zones, and protection or creation of high-value conservation areas).

[26] https://www.blv.admin.ch/blv/en/home/tiere/tierschutz.html

Such objectives would need to be agreed upon between producers and governments, and monitored at regular intervals. Products certified under PGS systems that include biodiversity conservation targets (on-farm and off-farm, including wildlife corridors, protection of high-value conservation areas, and others).

Further support for the biodiversity dimension can also be derived from the nature-based solutions (NbS) concept, developed in recent years, and supported by the International Union for Conservation of Nature (IUCN), CBD, and the EU commission. NbS are defined by the (IUCN) as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and *biodiversity benefits"* (Cohen-Shacham, Andrade et al. 2019).

Contribute to climate change adaption, resilience, and sustainable resource use
Climate adaptation and resilience are essential objectives and are of particular relevance, as it is widely recognized that agriculture in the global South is one of the sectors which will be (and already is) affected by climate change. Such objectives should be pursued in any sustainability effort. They need to be tailored to the specific context, and with particular measures, technologies, and approaches defined at the local level. IPPC has identified broad measures, and many concrete applications are already implemented in many different contexts. Such measures should be identified in strategic assessments, piloted, implemented, documented, and monitored. In the context of the UNCCD, SLM technologies and approaches are documented on a global scale. This and other repositories of practice could be used to monitor climate-related objectives.

Contribute to climate change mitigation
Contributions to climate mitigation such as promotion of carbon storage may be possible. Even more important is avoiding deforestation, destruction of peatlands, and high use of fossil fuels in agricultural production.

Close nutrient cycles
An important issue regarding sustainability in agriculture includes nutrient cycles. In many situations globally, nutrient cycles are not closed, causing off-site harms and environmental, human, and social costs.

In some of the world's most intensive agricultural production areas (i.a. Europe, China), high amounts of fertilizers are used, fuelling eutrophication of waterbodies, contamination of groundwater and drinking water, and emission of greenhouse gases. In other parts of the world, production leads to mining of nutrients in the soil, or soil erosion, and nutrient cycles are not closed. Excessive use of fertilizers without closing of the nutrient cycle leads to high energy consumption for the production of N-fertilizers, or to the unsustainable use of non-renewable sources of mineral fertilizer, also causing environmental harms such as contamination of soils with toxic substances (e.g. uranium, chrome).

Clearly, fully closing nutrient cycles will not be possible where products are sent to distant markets, but at least crop residues or manure from livestock keeping can be used in production. Closing nutrient cycles is intrinsically linked to integrating livestock in farming systems, rather than separating these systems, as currently occurs in many agricultural contexts due to excessive specialization (on crop or animal production).

Recycling and minimizing of raw material
Plastic is used in agricultural production and resulting traded goods (greenhouses, packaging, etc.). It cannot be easily replaced. However, innovation will enable use of more biodegradable materials and further minimize the use of plastics.

5.3. Elements of disagreement

Genetically Modified Organisms (GMO)

This issue remains highly contested. While for a few crops (soya, maize, rapeseed, sugar beet, and cotton) GMO technology has been deployed on a large scale, for other crops it has remained marginal. Many GMO crops are not directly used for human consumption, but rather used for fodder, biofuels, or processed food. Despite making important contributions to food markets, they also contribute to problems of obesity and malnutrition through fast food and high-calorie soft drinks.

The impacts of large-scale use of these GMOs are subject to wide disagreement with regard to environmental, social, and economic impacts. Use of these technologies in smallholder systems remains marginal, with the exception of cotton (mainly in India). Use of these technologies for soya and maize has facilitated rapid expansion of the agricultural frontier in Latin America, harming forests and – contestedly – human health.

Application of GMOs to improve nutritional content (e.g. "Golden Rice") is still delayed, mainly due to unresolved regulatory issues and safety concerns on the part of regulators and the public in many countries. Experimentation and modification of a number of crops to improve their nutritional content are ongoing, but public opinion continues to be divided or is – at least in Europe – generally negative. Also, the costs of obtaining regulatory approval are very high[27], which also prevents wider application – including among those who are not beholden to big agribusiness and have no immediate profit motive. However, it is conceivable that such technologies could one day be used for the benefit of smallholders and consumers.

Ongoing innovation in this field, such as the development of CRISPR technology that allows precise targeting of gene modifications (Gao 2018), could complicate distinction between GMO and Non-GMO crops, as it could allow "nature-identical" traits (Gao 2018), i.e. mimicking breeds achieved through traditional methods. This will raise new regulatory issues, but it could also change public perceptions of modified crops, for example by focussing on key incremental changes such as pest resistance or resistance to heat and water stress.

However, the prospects of this technology remain contested among specialists, farmers, and consumers. As a result, differentiating between sustainability and non-sustainability in this area could only be based on current regulations in concerned countries, probably using the more restrictive regulations as the benchmark.

Pesticides

As described above, there are different lists of hazardous pesticides, and different countries have different rules and regulations.

It is also important to note that very strict rules could also put smallholders at a disadvantage. First, it could be costly for them to implement systems that prove such pesticides are not used in production. Second, safer pest control substances may not be affordable to them. Finally, misleadingly packaged dangerous products can easily be used by mistake when farmers are not trained. However, on the other side, strong regulations can also protect farmers from endangering their health, by keeping such products out of the market. Hence

[27] https://www.nytimes.com/2021/07/20/magazine/gmos.html?referringSource=articleShare

such regulations should be coupled with measures that support farmers to meet these obligations, and not put the cost of compliance on their side. Hence such issues need to be considered when proposing appropriate rules for preferential treatment.

Transport and Air Freight

Transport costs are an important element of carbon emissions over the total lifecycle of agricultural production (Jones 2002). Air freight is energy intensive, but many fresh products nowadays travel with air freight. Should such means of transport be totally excluded from support for sustainable agriculture? Or should support be allowed for certain high value products? There is no agreement on this question (Gibbon and Bolwig 2007, Saunders and Hayes 2007, Sim, Barry et al. 2007). For certain products, it has been shown that lower energy inputs in production can compensate for higher energy needs for transport to consumers (Brenton, Edwards-Jones et al. 2009), even when they travel long distance by air (e.g. when comparing flowers from Kenya with flowers from greenhouses in the Netherlands). Also, dietary choices (reducing meat consumption) may be more important than reducing distances to markets (Weber and Matthews 2008).

Land sparing debate

Intensive agricultural production using large amounts of inputs is often associated with negative external effects (pollution, reduction of agrobiodiversity, health risks). However, it can also be argued that intensive production results in avoidance of deforestation or transformation of other biodiverse areas (e.g. wetlands, savannahs) (Villoria 2019, Folberth, Khabarov et al. 2020), as less land is needed for the production of the same amount. This debate remains unresolved (Grau, Kuemmerle et al. 2013, Phalan, Green et al. 2014, Feniuk, Balmford et al. 2019). The net impact on biodiversity is ambiguous, as many species are endemic, and it thus depends on where land is put into production, and whether this can be offset by sparing land in other regions (Carrasco et al., 2014). For instance, saving areas in Europe may not have the same positive effect as reducing deforestation in biodiversity-rich areas in the tropics.

6. Conclusions

The present study identifies the main criteria and benchmarks that could enable differentiation between sustainable food systems and unsustainable food systems. Selection of these criteria is based on international norms agreed at the global scale, such as objectives and targets in the framework of the SDGs and other important agreements that are relevant to our topics. We also propose indicators to measure these production systems in line with these criteria. We have kept these indicators generic, based on the understanding that they can be refined in more detail for specific sectors and for specific contexts.

When taking a synoptic view of our proposed objectives (Figure 2), it becomes apparent that farming systems that can fulfil these objectives and related criteria will be clearly distinct from large-scale, monoculture operations or massive animal farms far removed from their fodder bases. Farm and farming systems that meet these criteria will make important contributions to food security, income creation, and fair employment

conditions as well as to the environmental criteria of biodiversity, climate change adaptation, and mitigation. They will recycle as much as possible, limit inputs of pesticides, and manage soils sustainably.

While the farms that meet these criteria may be very diverse, and exhibit different characteristics depending on the region and context where they are situated, our criteria will help to draw distinctions and differentiate these farms from less sustainable farms. Supporting such farming systems through preferential trade systems could incentivize a transformation towards more sustainable food systems.

Figure 2: Synoptic view of the objectives proposed

Overall, we aim at a transformation towards sustainability of farming systems. With these objectives and criteria, we seek to create synergistic impacts between the individual objectives. Our list of objectives should be analysed with this intention in mind, and not only each objective and criterion in isolation.

Promotion of synergies through the different criteria is important, as it would make it possible to foster a "sustainability package" that would incentivize more sustainable practices than those which currently dominate. Ultimately, the positive discrimination we are aiming at should foster development in this direction.

At the same time, the corresponding indicator system should not be made too rigid, as this would slow down innovation. Innovation is needed, as most of today's production systems have their share of shortcomings – and improvements are both necessary and possible. Related criteria and indicators should thus be used not only to differentiate between sustainable and unsustainable systems, but also to measure improvements. Within a system aimed at sustainable trade, such improvements should be tangibly encouraged. This does not rule out supporting systems that do not fully meet all our proposed criteria, as long as there is credible evidence that their performance is improving over time.

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Annex 1: Sources of principles and indicators used to define common core principles

Source	Link/reference	Definition/Scope	Comments
SDG 2 (Zero Hunger) Indicator 2.4.1 (FAO as custodian).	SDG Indicator 2.4.1 - Proportion of agricultural area under productive and sustainable agriculture (fao.org)	Proportion of agricultural area under productive and sustainable agriculture (fao.org)	Set of 11 indicators available, covering the three dimensions of sustainability[28], farm questionnaire, no benchmarks
SDG 15: Life on Land Target 15.1	https://sdgs.un.org/goals/goal15	"Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species"	
Biodiversity: **Aichi Targets** **Target 3, 7, 13**	https://www.cbd.int/sp/targets/	Target 3: "…positive incentives for the conservation and sustainable use of biodiversity are developed and applied…." Target 7: "By 2020, areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity." Target 13: "…the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained….."	
Agroecology: **FAO and CFS**	https://www.fao.org/3/i9037en/i9037en.pdf (FAO 2018, CFS 2019)	10 general elements that describe principles of agroecology.	Set of indicators available, farm questionnaire, no benchmarks
Land Tenure: **FAO: VGGT, 2012**	http://www.fao.org/cfs/home/activities/vggt/en/	Aims at land tenure policy. Is voluntary	Guidelines regarding land tenure policy.
UN Declaration of the Rights of Peasants (UNDROP), 2018	https://digitallibrary.un.org/record/1650694	The declaration asks states to respect, protect and fulfil the rights of peasants and other people working in rural areas. It list a comprehensive set of actions that aim at strengthening these rights with regard to many issues such as i.a. labour rights, access to land, a clean and healthy environment.	
United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), 2007	https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html	Indigenous peoples have the right to own, use, develop and control the lands, territories and resources. In particular Indigenous People are protected against relocation without Free Prior and Informed Consent.	
Right to Food (article 11 of the International Covenant on Economic, Social and Cultural Rights (ICESCR); and General Comment Nr 12	https://www.ohchr.org/EN/Issues/Food/Pages/AboutHRFood.aspx	To fulfil (facilitate) or pro-actively engage in activities intended to strengthen people's access to and utilization of resources, and means to ensure their livelihood, including food security; "The accessibility of such food in ways that are sustainable and that do not interfere with the enjoyment of other human rights"	
ILO Declaration on Fundamental Principles and Rights at Work. Convention 138; ILO Recommendation 146; ILO Convention 182	ILO website NORMLEX (Henry & Pechevy, 2017)	These norms mainly aim at - freedom of association and the effective recognition of the right to collective bargaining; - the elimination of all forms of forced or compulsory labour; - the effective abolition of child labour; - the elimination of discrimination in respect of employment and occupation	
Organic farming: **Codex Alimentarius Commission** **IFOAM** **EC** **USAID Organic**	IFOAM https://www.ifoam.bio/en/coros https://www.ifoam.bio/sites/default/files/ifoam_norms_july_2014_t.pdf Codex Alimentarius Commission USAID Organic, EC	In its Council Regulation (EC) No 834/2007 (EC 2007), the European Commission lists its overall principles for organic agriculture: (a) the appropriate design and management of biological processes (b) the restriction of the use of external inputs (c) the strict limitation of the use of chemically synthesized inputs to exceptional cases (see also Migliorini and Wezel, 2017); (d) the adaptation, where necessary, of the rules of organic production as per the EC Regulation No 834/2007 taking account of sanitary status, regional differences in climate and local conditions, stages of development and specific husbandry practices.	Well developed standards, lists of allowed inputs, etc
Animal welfare: **World Organisation for Animal Health (OIE): Terrestrial Code**	https://www.oie.int/en/what-we-do/standards/codes-and-manuals/ https://ec.europa.eu/food/animals/welfare_en BWL: Tierwohlbeiträge (BTS/RAUS) various other standards	European Convention for the Protection of Animals kept for Farming Purposes. It reflects the so-called 'Five Freedoms':1) Freedom from hunger, thirst and malnutrition; 2) Freedom from fear and distress; 3) Freedom from physical and thermal discomfort; 4) Freedom from pain, injury or disease; 5) Freedom to express normal patterns of behaviour	

[28] 11 sub-indicators for SDG Indicator 2.4.1 as defined by FAO

Fair Trade International	https://www.fairtradecertified.org/ https://www.fairtrade.net/standard/aims https://www.fairtrade.net/standard/spo https://www.fairtrade.net/standard/hl https://www.fairtrade.net	Fairtrade changes the way trade works through better prices, decent working conditions and a fairer deal for farmers and workers in developing countries	Fair Trade has established a red list of hazardous substances.
Roundtable on Sustainable Palm Oil	https://www.rspo.org Round Table on Responsible Soy (RTRS)	RSPO has developed a set of environmental and social criteria which companies must comply with in order to produce Certified Sustainable Palm Oil (CSPO)	Principles &Criteria are further adapted for use by each country through National Interpretations.
Non-GMO	Non-GMO Project (Bain and Selfa 2017)	Labelling of non-GMO products	Lack of scientific consensus regarding sustainability of these technologies. Distinction of GMO and non-GMO is no longer clear, due to new technologies.
Participatory Guarantee Systems (PSG)	https://www.ifoam.bio/our-work/how/standards-certification/participatory-guarantee-systems http://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1175521/ (Vandecandelaere, 2010) (Loconto & Hatanaka, 2018)	Participatory Guarantee Systems (PGS) are locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are built on a foundation of trust, social networks and knowledge exchange (IFOAM)	PGS is not a standard with its own criteria but a way to guarantee that principles of organic are followed, without a costly third party certification. Such systems can also be applied to guarantee adherence to other standards than organic.
OECD FAO Guidance for Responsible Agricultural Supply Chains	https://doi.org/10.1787/9789264251052-en (OECD and FAO, 2016)	The guidance covers agricultural upstream and downstream sectors from input supply to production, post-harvest handling, processing, transportation, marketing, distribution and retailing	List of measures to reduce risks, covering social, health, land tenure, environment , animal welfare and governance
Principles for responsible agricultural investment that respects rights, livelihoods and resources (PRAI).	https://unctad.org/en/Pages/DIAE/G-20/PRAI.aspx	Defines 7 principles	Guides investment decisions. not precise enough Cannot be used for our purpose
Responsible Investment in Agriculture and Food Systems RAI	http://www.fao.org/cfs/cfs-home/activities/rai/en/	Defines 10 principles and a "framework to guide the actions of all stakeholders" Voluntary and nonbinding	Guide for investment decisions. not precise enough Cannot be used for our purpose
Good Agricultural Practices (GAPs)	FAO (Poisot, 2003)	GAP cannot be defined at the global level, but their elaboration at country level and for specific topics is possible	FAO is not working on this currently, some regional sector guidelines/manuals exists.
Committee on Sustainable Agriculture	Master List | COSA | Committee on Sustainability Assessment (thecosa.org) https://thecosa.org/master-list/	COSA indicators are designed to quantify and clarify information in a manner that promotes the understanding of key environmental, social, and economic issues.	Set of indicators available, farm questionnaire, no benchmarks
GlobalG.A.P.	www.globalgap.org (Squatrito, Arena et al. 2020)	GlobalGAP is an industry standard, and an important certification scheme, aiming at safeguarding food safety, environmental protection and animal welfare. All Farm Base Module GLOBALG.A.P. | labelinfo.ch	GLOBALG.A.P. is not labelling directly products, but defines standards for production which can be applied in the industry.
UTZ/Rainforest Alliance	UTZ.org https://utz.org/what-we-offer/certification/the-standard/	UTZ is an industry benchmark for the sustainable production of coffee, tea (including rooibos and herbal teas) and cocoa	Provides checklists for management. Pesticides are allowed but need to be used as little as possible, must be documented. Global Living Wage Coalition is setting standards for incomes.
ISO standards	ISO 14001:2015	It does not state requirements for environmental performance but rather maps out a framework that a company or organization can follow to set up an effective Env. Management System.	This is a management system, benchmarks are likely covered by standards listed above.
Phytosanitary, health, pesticides	Codex alimentarius	The Codex Alimentarius aim at protecting consumers' health and ensuring fair practices in the food trade.	Collection of internationally adopted food standards and related texts presented in a uniform manner

Note: List sorted according suitability for the analysis. Those that are given priority are in bold.

Annex 2: Important international agreements regarding chemicals and hazardous substances[29]

The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (PIC) (Adoption 1998 and entry into force 2004)

The chemicals refer to the following categories: industrial and pesticide (including severely hazardous pesticide formulations). Specially, 24 pesticides and 4 severely hazardous pesticide formulations are listed under the Annex III of the Convention.

The Stockholm Convention on Persistent Organic Pollutants (POPs) (Adoption 1998 and entry into force 2004)

The POPs are organic compounds that possess the following characteristics: they are resistant to environmental degradation, persistent in the environment for long periods, bioaccumulate in human and animal tissue and long-range transport through air and water. 16 from the 28 POPs are pesticides. [30]

International Code of Conduct on the Distribution and Use of Pesticides (FAO) (Adoption 1985, amended 1989 and revised 2002). It states voluntary standards for all public and private entities engaged in or associated with the distribution and use of pesticides, particularly where there is inadequate or no national legislation to regulate pesticides.
WHO collaborates with FAO in promoting the Code and its implementation.
http://www.fao.org/3/y4544e/y4544e00.htm

The Codex Maximun Residue Limits (MRLs) (1963) for pesticides residues in food and feed crops states standards for food safety. Its establishment is responsibility of the Codex Alimentarius Commision created under the Joint FAO/WHO Food Standards Programme.
http://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/pesticides/en/

The Intergovernmental Forum on Chemical Safety (IFCS) recommendations on acutely toxic pesticides (2003) include policy, regulatory and communication actions in order to provide guidance for risk management and risk reduction actions for national governments especially those from developing countries and countries with economies in transition.
https://www.who.int/ifcs/documents/forums/forum4/final_report/en/

[29] Based on: Jacobi J, Ottiger F, Kiteme BP, Delgado Burgoa JMF, Winkler MS, Lannen A. 2019. . CDE Policy Brief, No. 15. Bern, Switzerland: CDE.

[30] See http://chm.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx (last accessed 12 September 2019)