CODEX PLANETARIUS

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Implications for the Global Trade in Agricultural Commodities

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About *Codex Planetarius*

Codex Planetarius is a proposed system of minimum environmental performance standards for producing globally traded food. It is modeled on the *Codex Alimentarius*, a set of minimum mandatory health and safety standards for globally traded food. The goal of Codex Planetarius is to measure and manage the key environmental impacts of food production, acknowledging that while some resources may be renewable, they may be consumed at a faster rate than the planet can renew them.

The global production of food has had the largest impact of any human activity on the planet. Continuing increases in population and per capita income, accompanied by dietary shifts, are putting even more pressure on the planet and its ability to regenerate renewable resources. We need to reduce food production's key impacts.

The impacts of food production are not spread evenly among producers. Data across commodities suggest that the bottom 10-20% of producers account for 60-80% of the impacts associated globally with producing any commodity, even though they produce only 5-10% of the product. We need to focus on the bottom.

Once approved, *Codex Planetarius* will provide governments and trade authorities with a baseline for environmental performance in the global trade of food and soft commodities. It won't replace what governments already do. Rather, it will help build consensus about key impacts, how to measure them, and what minimum acceptable performance should be for global trade. We need a common escalator of continuous improvement.

These papers are part of a multiyear proof of concept to answer questions and explore issues, launch an informed discussion, and help create a pathway to assess the overall viability of *Codex Planetarius*. We believe *Codex Planetarius* would improve food production and reduce its environmental impact on the planet.

This proof-of-concept research and analysis is funded by the Gordon and Betty Moore Foundation and led by World Wildlife Fund in collaboration with a number of global organizations and experts. For more information, visit www.codexplanetarius.org

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Abstract

Codex Planetarius[1] is a proposed set of environmental production standards for application to the global trade in agricultural commodities. The intention is to establish minimum acceptable levels across a range of measures such as habitat and biodiversity loss, GHG emissions, soil health, water take and effluent, agrochemicals, waste, and illegality. These will focus on environmental performance rather than agricultural practice to ensure wide applicability and will differ from other standards by targeting the worst, rather than the best, producers. This is critical because the impact of individual farms can vary by up to 10x between different production systems for the same commodity crop. Because of this, the poorest performing 25% of production is estimated to represent more than half of all agricultural emissions.[2]

In terms of implementation, *Codex Planetarius* will be modelled on the *Codex Alimentarius* and is intended to have legal force through country-level regulation in key markets. A basket of commodities and their associated standards will be selected through extensive peer review and real-world pilots to ensure that they are robust, practical, and effective. Given these uncertainties and the complexity of international food systems, any discussion of the implications of *Codex* on trade need to be directional rather than specific and based on historical experience of other environmental standards. This paper, therefore, outlines a set of assumptions to frame discussion of *Codex* including the fifteen core commodities that have the highest potential impact, scale, and contribution to world trade and draws from experience of three existing models. The first is environmental protection legislation, traditionally used to regulate minimum pollution levels in the manufacturing sector. The second is voluntary sustainability standards with environmental measures for large scale commodity agriculture such as the Round Table on Responsible Soy Association (RTRS). Finally, it looks at the impact of Non-Tariff Measures (NTMs) such as those relating to Maximum Residue Levels for pesticides to provide parallels for *Codex*.

Using these examples as a foundation, this paper looks at the trends and potential costs and benefits of *Codex* across the supply chain for farmers, traders, and markets. This shows that the mitigation impact of *Codex* will be net positive after an initial period of adjustment and that, while the costs related to this adjustment may require support to producers in Least Developed Countries (LDCs), this will be short-term and unlikely to be large in global terms.

Estimated costs for global implementation of *Codex* are estimated at up to $4 billion annually with a conservative benefit of up to $200 billion – a 50x return on investment. As importantly, the bottom performing 25% of farms represents more than half of all emissions depending on the product, but only 5.4% of global food production and 2% of trade. And while the impact on specific products, such as soy and coffee, is likely to be significantly higher than the average, the overall impact of *Codex* on markets and prices is not likely to be material to trade flows, food security, or livelihoods.

1. Assumptions

Codex Planetarius (CP) will differ fundamentally from other standards in that it will look to improve the worst environmental performers rather than improving the average. This is because impacts between farms producing the same crops can vary up to 100x.[2] This approach should also, in theory, limit the potential costs of implementation nationally and maximise its impact globally. However, in practice, this will depend on the precise standards and commodities selected as well as how *Codex* is implemented and enforced for national production and global trade. The topics below outline a series of assumptions to allow a structured discussion of *Codex* implications for trade in this paper.

Standards

Codex will propose draft minimum acceptable levels of habitat loss, biodiversity loss, soil health, water take and effluent, and GHG emissions. and explore the issues of agrochemicals connected to specific crops. It will also look at food waste and illegality across food systems and will be peer reviewed and tested through real-world pilots. As a starting point, this paper will therefore assume that standards are unlikely to exceed reasonable national or regional averages for specific crops and production systems. This limits the number of farms impacted in the short term, but continuous improvement will be required in the medium term as climate change accelerates pressures on resources, and yields. Waste is a growing issue, representing losses of up to 40% of production at both ends of the supply chain, but its complexity means that it will be considered in a separate paper.

Commodities

Figure 1 **(page 12)** shows the value of the fifteen largest export commodities against their total carbon footprint. This includes emissions from all domestic production and labels each with the percentage of each product that is exported. In total, these represent 65% of agricultural exports globally, 49% if we take the top 10 in the red circle only, and 72% of all emissions.

In the same way as standards, the final commodities selected for *Codex* will be subject to peer review and real-world pilots. However, if we take only the top 10 commodities above, these represent 49% of global agricultural exports and each product listed contributes a minimum of 750 million metric tonnes of carbon anually to global emissions — 72% of the farm-level total. It also includes the poultry, pork, and beef production that represents a significant portion of exported indirect emissions through soy and maize as feed, as well as processed consumer products, such as margarine through inputs such as palm oil.

Throughout this paper, we will therefore look at the top 15 traded products above with a focus on the top 10. These include – soy, wheat, beef, maize, palm oil, rice, chicken, pork, milk, coffee, sugar, rapeseed, sunflowers, tomatoes, and bananas. It is noteworthy that the vast majority of these high-impact, high-value, traded products are traditional cash crops or livestock. The list does not include tubers such as potato, yam, and cassava that are produced in large quantities – 793 million tonnes in 2021 – for domestic consumption but represent minimal exports and a low emissions profile – only 1% of the impact of the beef industry across 10x the production volume. This will need to be evaluated, refined, and expanded to incorporate fisheries and aquaculture in the future.

Countries

The producer countries and end markets that will be primarily impacted by *Codex* will be determined significantly by the commodities selected. However, any implementation should include the top 10 producers of the most widely exported commodities to have a meaningful environmental impact. This is not because they are necessarily the worst polluters but because they dominate global markets and have an outsized impact on practices, pricing, trade flows, and standards. This includes China, India, and the USA as the three most important producers and importers of agricultural commodities globally with a share of over 50% of production in eight of the 15 core products defined above. It is also likely to need to involve other key producers, including Brazil, Argentina, Australia, Canada, Indonesia, Russia, Malaysia, Nigeria, and South Africa which dominate categories such as soy, beef, oil palm, wheat, and maize, and the largest importers of agricultural products, including Japan, UK, and the EU, with a focus on Germany, France, and the Netherlands.

Illegality

This paper assumes that *Codex* will take a similar form to the *Codex Alimentarius* with legal force through country-level regulation in key agricultural markets. However, 49% of tropical deforestation between 2000 and 2012 was caused by illegal agriculture and up to half of all agricultural commodities are estimated to involve some sort of illegality either through land-use change or labor abuses[3], making enforcement of standards such as those proposed in *Codex* challenging. For this reason, this paper assumes that, while new standards would be applied to all producers as per the *Codex Alimentarius* model, compliance is only likely to improve in the short term for exports where common trade mechanisms provide both incentives and enforcement tools.

Codex will therefore have a significantly larger short-term impact for commodities such as soy, palm oil, wheat, maize and beef where exports are between one-fifth and two-thirds of production of rice; or chicken, pork, or milk where exports represent 4-17% of the total. In the medium term, better measurement, national regulation and associated enforcement would be expected to start to have a significant impact on non-export commodities. **(See Figure 2, "Agricultural exports", page 12.)**

Quantifying the bottom 25% of producers

An underlying principle of *Codex* is that impacts from different producers producing the same crops can vary up to 100x. This is based on a number of studies including Poore & Nemecek, who find that, “Across all products, 25% of producers contribute on average 53% of each product’s environmental impact. For scarcity-weighted freshwater withdrawals, the skew is particularly pronounced: Producing just 5% of the world’s food calories creates ~40% of the environmental burden.”[2] This and related studies form the starting point for many of the assumptions in this paper.

However, there are a number of gaps and uncertainties to note. Datasets generally include only commercial farms, missing many of the smallholder farms under two hectares that make up 84% of all producers, 24% of agricultural land, and 32% of the world’s food.[4] This means that analysis is concentrated in Europe, North America, Oceania, Brazil, India, and China, creating geographic blind spots in Africa and Central Asia.

In addition to this, there are several issues that complicate both measurement and trade assumptions. These include the fact that studies sometimes use “producers” (farmers), “production” (volume, mass, or value, often without specifying which) and “food” (calories) interchangeably which makes accurate analysis difficult. Expressing units by live weight, dry weight, protein, or calories, for example, makes a huge difference to relative impact measures between products. This is further complicated for the purposes of *Codex* by the difficulty of defining environmental ”performance.” This is generally taken to mean emissions (most often CO2e) but isn’t always clear in studies.

Even where performance is clearly defined, different methodologies can lead to marked differences for the same crops or supply chains. There is also not always a correlation between good performance in one indicator, such as emissions, and others, such as water take or eutrophication depending on the product.[5] There is also the fact that variability, the cornerstone of *Codex*, makes global analysis extremely complex. Generalising is difficult between different geographies for the same crop, let alone between crops, farm types, and conditions. There is, for example, some evidence[6] that higher yields can lead to lower environmental outcomes, primarily due to efficiency of inputs and lower land-use change required for the same output, but this is not always true. And while larger farms tend to be more efficient than smaller farms in the developed world, there is an ongoing debate around studies that show smallholder agriculture in Africa has higher yields per area than larger farms.[7] The quantification in this paper is therefore based on a large number of assumptions, often conflicting evidence, and multiple issues of definition and measurement.

Implications for *Codex Planetarius*

The numbers in this paper, particularly in terms of the producers, production, and trade impacts of *Codex* are speculative given the large number of underlying assumptions required. These assumptions are detailed throughout as a starting point for discussion. The quantification of the bottom quartile or decile of producers by environmental performance, their production, and the related trade implications are particularly problematic given gaps in data, often contradictory studies, and the large number of variables detailed above.

2. Environmental models

Three models illustrate the possible trade implications of *Codex*. The first is environmental protection legislation, in which a large body of historical evidence, dating from the 1970s, shows the impact on investment and trade of environmental regulation, mainly in the manufacturing sector. The second is Voluntary Sustainability Standards (VSS), particularly those such as RTRS and Forest Stewardship Council (FSC) that incorporate environmental measures for application to large-scale commodity agriculture. Finally, it looks at the impact of Non-Tariff Measures (NTMs) for environmental standards such as for Maximum Residue Levels.

2.1 Environmental Protection Legislation

From the 1970s environmental regulation became part of a wave of social legislation driven by the increased willingness of governments to intervene in business. This was reflected by the establishment of multiple national and multilateral environmental agencies, including the US Environmental Protection Agency in 1970, the UN Environment Programme in 1972, and the EEC's Environmental Action Programme in 1973. Reactions then were similar to those prompted by recent EU environmental regulation of agriculture, with opponents arguing that it imposed huge costs, lowered productivity in competitive markets, and transferred investment to other jurisdictions.[8] This last "pollution haven" hypothesis is relevant because it is based on trade theory and assumes that differences in regulation between geographies will simply increase costs and transfer environmental impacts to lower cost regions. This is particularly important when looking at carbon emissions which have an indirect (global), rather than direct (local), impact. The alternative theory of this sort of legislation is the "Porter" hypothesis which suggests that more stringent environmental regulation has a net positive effect on firm-level competitiveness because it promotes efficiency improvements that offset regulatory costs and fosters innovation.[9]

Legislative impact on costs and investment

There is good evidence that environmental regulation increases direct production costs. The European Emissions Trading System (EU ETS), which regulates carbon emissions across 12,000 EU facilities, is estimated to have increased average material costs by 5-8%[5]. The type and severity of regulation can also be shown to lead to significant differences in capital expenditure on environmental measures ranging from 1% in Taiwan to 5% in Canada. However, these increases in costs do not necessarily have a direct relationship with production and trade because companies react by reducing costs, innovating, and creating competitive advantage through new processes and markets. Abatement practices and costs themselves are also relatively minor compared to inputs and raw materials, labor availability, transport, and fixed costs. Pollution Abatement and Control Expenditures (PACE) studies from the US, EU, and Asia since the 1990s show that, when relative PACE increases, it can lead to small increases in imports but that this is not significant in capital-intensive industries.

Similarly, there is limited evidence that EU carbon pricing has had any impact on imports of cement or steel into the region. This implies that regulation has a trade effect, but it tends to be small, concentrated in a few sectors, and overwhelmed by larger factors. The impact of environmental legislation on inward and outward Foreign Direct Investment (FDI) flows, production location, and employment are inconclusive with limited evidence that it has a significant effect except for the most polluting sectors, such as industrial chemicals. In the agricultural sector, climate change is likely to force shifts in crop production and regulation that, while not the most important factor, may incentivise choice of location.

Legislative impact on productivity and Innovation

In theory, regulation imposes costs and therefore a productivity penalty on producers. The largest study in the US incorporating 1.2 million plant observations showed that productivity declined by 4.8% for plants in counties with higher regulation but that this was almost entirely restricted to the first year, suggesting that the impact is short term in nature. Similarly, a study of US oil refineries from 1979 to 1992 showed that a small reduction in productivity was reversed over the medium term with higher productivity from those facilities that had to meet more stringent air quality regulations. This is supported by an Organisation for Economic Co-operation and Development (OECD) study which showed that increased regulation actually improved productivity on average with the most efficient companies showing high productivity growth while the least efficient showed a reduction.[10] More widely, there is good evidence that the costs of meeting environmental objectives are typically much smaller than originally anticipated due to induced innovation (e.g., innovation driven by regulation)[5] but that this doesn't necessarily makes firms any more competitive overall. What is clear is that innovation and efficiency gains almost entirely correct for the increased costs of environmental regulation and can drive longer-term competitive advantage in areas that are technology driven.

Implications for *Codex Planetarius*

While there are clear differences between the industrial and agricultural sectors, there are also similarities that allow us to read across some of the evidence above. Both are increasingly automated and dominated by large-scale, capital-intensive operations with relatively high fixed costs. In both, small producers are typically less efficient, much more labor intensive, and lack the resources necessary to invest in compliance. This is important for the implementation of *Codex* because, while the medium-term costs of its standards are likely to be minimal on average, the smaller, less efficient farms that are the primary target of *Codex* will need support to cover the up-front investment required. The evidence suggests that this will unlock the innovation and efficiency required to allow them to recover these costs in the medium term and help transform agriculture globally.

2.2 Voluntary Sustainability Standards

Voluntary Sustainability Standards (VSS) and certification programmes have been operating across global supply chains for over three decades. They are generally recognized as having been effective in supporting higher performing businesses in specific sectors and shifting the public debate on sustainability. They have been generally less effective in reaching the bottom 10% of producers that are the target of *Codex*.[11] Soy is the largest single traded agricultural commodity and is as a major driver of environmental degradation, directly through deforestation, and indirectly as a significant source of animal feed. The Round Table for Responsible Soy and voluntary prohibitions such as the Moratorium on Soy Deforestation provide direct evidence of the impact of VSS. Governments are gradually taking more responsibility for sustainable practices, integrating the theory and practice of VSS into regulation and trade, which aligns with the objectives of *Codex Planetarius.*

VSS and Trade

A recent study[12] looked at VSS certification across seven standards for five tropical commodities to estimate the trade effects of adoption. This confirmed that an increase in VSS coverage of 1% typically resulted in a 1.8% to 3.3% increase in export value. This had the largest impact for products sold direct to consumers with minimal secondary processing such as bananas, coffee, and tea. It had an insignificant impact on large-scale commodities incorporated into end products such as soy (oil and feed) and palm oil (multiple consumer products). The study also showed that this impact grew with both the income of the importer and the income gap between trading partners. This suggests that the standard VSS model of rewarding the best performers has limited applicability for South-South trade and for bulk commodities, such as palm oil and soy, that are used as ingredients in other products. This is reflected in certification rates which range from a high of 25% for coffee production where the US is the largest importer to 2.2% of soy production where the largest importer is China. Despite representing a tiny portion of global production, from 2020 to 2021 the amount of “verified” soy imported to the EU rose from 38% to 42% of the EU total.[13] The size of EU imports shows how important certification is to high-income end markets while it is marginalised elsewhere. China is the largest importer of soy globally but represented 0% of certified RTRS trade in 2020 and, of the 20 million tonnes of soy produced domestically in China, only 66,000 tonnes were RTRS certified. This is partly because soy imports into China are predominantly used as feed, primarily for pork production, hiding their environmental impact. This dynamic is unlikely to change until indirect carbon is quantified for consumers, customers, traders, and domestic regulators.

VSS and environmental outcomes

The evidence for the impact of VSS on key environmental measures is mixed. In a 2021 review of empirical studies,[14] 51% were found to have had a positive environmental impact, 41% made no difference, while 8% had negative outcomes. Even when examining the FSC forest standard there are a huge range of outcomes from studies that show little reduction in deforestation in Mexico and Cameroon to a 74% reduction in managed areas of the Congo.[15] More widely, the evidence for positive environmental impacts from responsible commodity production is equally mixed with 34% of cases showing a positive outcome, 58% showing no change, and 8% negative.[16] Many of these differences come down to the fact that many VSS are practice rather than performance based. This makes factors such as differing farm type, size and yields and the wider regulatory environment as important as the standards themselves. There is also the wider issue that relatively high standards and complexity of compliance for VSS exclude smaller, less efficient farms from certification with take up linked to farm size and assets. A good example of the unintended environmental consequences of voluntary initiatives is the Soy Moratorium (SoyM). This was signed in 2006 by the world’s major soy traders who agreed not to purchase soy grown on deforested lands in the Amazon. It was a success. Soy deforestation in the Amazon fell from 30% in 2006 to 1% in 2014. However, it shifted soybean encroachment to the Cerrado region and neighbouring countries.[17]

Implications for *Codex Planetarius*

Voluntary standards create quantifiable social and environmental impact and have moved the discussion of sustainability standards from a private sector niche towards wider public and regulatory domains. However, the limitations of VSS are also clear and well documented and two specific areas outlined above should be considered when designing and piloting *Codex* standards. The first is that levels and costs of compliance should be developed for the lowest common denominator of farms to reduce barriers to take up and amplify impact. This should be performance-, rather than practice-, based to allow widespread adoption and compliance across and between countries and avoid the risk of unintended shifts in production and trade flows. The second is that it is important to avoid relying on mature economy demand and end-consumer behaviour to drive producer compliance. Incorporating South-South input into standard setting and regulation and quantifying the indirect impacts of commodities primarily used as ingredients for manufacturing or livestock such as soy, palm oil, maize, and sugar will be key.

2.3 Non-Tariff Measures (NTMs)

Non-Tariff Measures (NTMs) are policy measures other than tariffs and tariff-rate quotas that impact international trade. This paper focuses on “technical measures” which include regulations, standards, testing, and certification as part of Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT). *Codex Planetarius* as currently envisaged would itself be a NTM technical measure. A second type of NTM, “non-technical” measures such as quotas or import licenses, is out of the scope of this paper.

WTO *Codex* model

The most obvious trade model for *Codex Planetarius* is the historical experience of the *Codex Alimentarius* (CA). The World Trade Organisation’s SPS agreement places restrictions on the domestic regulation that countries can use to protect human, plant and animal life, and health. Countries cannot impose standards that are more restrictive to trade than necessary, they should not create different treatment between countries, should not be applied to create hidden trade barriers and, with limited exceptions, must be based on scientific principles and maintained using scientific evidence. This is rigorous, but the SPS Agreement allows it to be completely avoided by countries that followed CA standards. The integration of the *Codex Alimentarius* into the SPS agreement changed its governing body from an organization that provided consensus guidelines and voluntary standards as a ”floor” to one which provided a “ceiling” beyond which there were much more onerous requirements. This transformed standard setting into a political exercise because any standards agreed could be the subject of future WTO dispute resolutions with a real impact on trade.[14] This is important because integrating *Codex Planetarius* into existing WTO structures would also need parallel application to SPS or its equivalent through WTO to materially influence trade flows and environmental externalities. There has been progress in this direction recently through WTO committees but integrating a new set of standards into TBT or SPS agreements would likely be a slow process.

Codex Alimentarius impact

The setting of pesticide standards through "Maximum Residue Levels" (MRLs) by the *Codex Alimentarius* Commission illustrates some of the issues involved in setting new environmental measures. In a meta-analysis of papers that quantify the impact of MRLs on trade, most studies found that their impact was negative.[18] However, the detailed data shows that this was partly driven by the Commission's capacity limitations. It can take years to set MRLs and, where no *Codex* MRL has been established, some importing countries do not set any standards and apply zero tolerances for specific pesticides. This creates differentials in domestic and export markets, represents a risk for exporters, and has a negative impact on trade. A study on MRLs in 2020 similarly showed that differentials between standards limits trade by reducing the "varieties of goods traded, the value of goods traded and observed trade flows."[19] This also creates price rises, typically driven by companies who exit the market when they cannot comply, allowing remaining firms to take advantage of reduced competition through improved pricing. In common with the findings for voluntary standards, MRLs and other Non-Tariff Measures reduce export flows from the South more than from the North. A study of five OECD countries where aflatoxin tolerance levels diverged from CA guidelines showed that South African exports were reduced by $69 million annually in the 1990s and, in the beef sector, divergence from CA standards on antibiotics had an impact of $3.2 billion on global trade flows.

NTMs impact on agricultural trade

A UNCTAD and World Bank report[20] in 2018 found that the average Ad-Valorem Equivalent (the theoretical pricing effect of an increase in trade measures) of technical NTMs in agriculture was an average of 17%, which is 4x higher than actual tariffs and much more onerous than the 3% equivalent for manufacturers. How this actually impacts global trade in agriculture is variable – with studies providing evidence for both "standards as barriers" and "standards as catalysts" viewpoints. However, there is broad agreement on several points. First, that trade effects produced by NTMs are product, sector, and country specific, particularly for SPS measures, and that they typically inhibit South-South trade and exports from LDCs to more developed markets. It is estimated that low-income countries miss out on $3 billion in agricultural exports due to the EU's SPS requirements. For importers, domestic NTMs can increase the price of consumer goods depending on the level of food import dependency. This is estimated at 4% for cereals in low-income countries. However, the consumer and producer benefits of SPS measures in terms of improved consumer health and mitigation of harvest losses by preventing pests and diseases can significantly exceed the costs involved when applied in a non-discriminatory way to both imports and exports.[21]

Implications for *Codex Planetarius*

Non-Tariff Measures can add friction and cost to the trade system. Whether this is a net positive or negative depends on a multitude of factors and particularly on their wider benefits in terms of productivity, consumer health, the environment, and mitigation of pests and diseases. A key issue across almost all NTMs is that they inhibit trade primarily where there is an imbalance in standards, compliance, or certification between importer and exporter. The experience of MRLs shows that even where there is a global system such as *Codex Alimentarius* to prevent these imbalances, significant resource and flexible structures are required to keep up with the speed of change. This has clear implications for the design of both *Codex* standards and any future *Codex* organisation which will need to be well resourced and agile in a way that many multilateral entities are not.

3. Trade implications

The implications of *Codex Planetarius* will be highly dependent on the final standards selected, the basket of commodities chosen, how it is implemented through national-level regulations, actual compliance with those regulations, supply chain reaction, the speed and impact of climate change, and both the market and the wider geo-political environment among others. However, there are some broad implications that we can outline based on the environmental models, case studies, and assumptions made in the first section of this paper. Beyond the specific impact of *Codex* to producers, traders and end customers, there are also a series of potentially much wider, climate-related impacts of not doing anything – the "Business-As-Usual" scenario. There is strong evidence that climate change has reduced the Total Factor Productivity of global agriculture by around 21% since 1961,[22] more in warmer regions such as African and Latin America, and globally, seasonal variations in weather are responsible for approximately a third of variability in crop yield. This suggests that not implementing wide-ranging environmental standards such as those proposed through *Codex* could lead to accelerating declines in yields, productivity, soil health, and, eventually, catastrophic crop and food system failures.

3.1 Production trends

A number of trends in commodity agriculture provide context for likely *Codex* impact at a farm level. The first is that Land Use Change (LUC) is accelerating. The rate of global deforestation grew by 3.6% between 2021 and 2022[23] and as much savanna as forest was lost to agriculture in regions such as the Brazilian Cerrado and the Central Asian Western Steppe. This Land Use Change makes up as much as a quarter of all GHG emissions from agriculture and an even larger portion of biodiversity loss. This is primarily driven by demand for beef and (indirectly) soy and palm oil, combined with traditional, low-yield pasture and crop systems that require ever increasing land areas. Second, declining soil health is a long-term trend that requires action if we are to improve yields and satisfy growing demand for food on less land. The Food and Agricultural Organization (FAO) estimates that up to 40% of soil is currently degraded and that, overall, soil is being lost from agricultural areas 10-40x faster than it can be replaced.[24] This is leading to increased investment in regenerative agriculture including the development of sustainable inputs such as fertilisers, but this has been limited by the short-term costs associated with it. Third, climate change is already impacting the viability of crops and their location. This will vary by geography and crop. A model produced by the International Food Policy Research Institute (IFPRI) shows that the North could see an increase in average yields of above 5% for core staples such as maize, rice, and wheat with the Global

South seeing a decline by a similar amount to 2050. Fourth, quantification and monetisation of environmental services has the potential to become an alternative revenue stream for farmers. Carbon, water, and biodiversity in particular could allow the recovery of soil health by replacing crop revenue streams in land with degraded soil and incentivize the sort of sustainable agricultural practices proposed by *Codex*. Finally, innovative approaches to plant genetics such as CRISPR represents risks but also huge opportunities to breed crops for improved yield, resilience to adverse climatic conditions, lower wastage, and a reduction in impacts to consumer health.

Codex standards and regulation

The impact of *Codex* will be highly dependent on the final standards and commodities selected, national regulation, and compliance at a farm level. However, based on the assumptions in the first section of this paper, we can highlight some potential implications for farmers. The first is the potential *Codex* impact on environmental policy at a farm level. There is limited cross-country data on environmental regulations for agriculture specifically, but the OECD does produce a more general "Environmental Policy Stringency Index," which measures the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behavior **(See Figure 3, "Environmental Policy Stringency", page 13.)**. This shows that there is a reasonable level of policy convergence (distinct from actual performance) between the three core countries identified — the US (3.03), China (3.14), and India (2.83), and key producers including the EU (3.43), Canada (3.03), and Australia (2.92). Between them, these countries account for over half of the production of the 15 key *Codex* commodities. However, four large producers, Russia, South Africa, Indonesia, and Brazil, lag the index average significantly and there will likely be higher costs related to bringing core *Codex* standards into their legislation. A proviso to this is that the accelerating impacts of climate change are likely to create pressure on farms in the near future that will force this sort of change regardless of regulation unless production becomes much more resilient.

Codex standards and compliance

At a more micro level, there is the question of how *Codex* standards that become part of national regulation will directly impact farms. Any possible change here is much more speculative. Part of the issue is illegality. Forty-nine percent of tropical deforestation between 2000 and 2012 was caused by illegal agriculture and up to half of all agricultural commodities are estimated to involve some sort of illegality either through land use change or labor abuses.[25] UN Environment published a report on the Environmental Rule of Law in 2019 that showed a 38-fold increase in environmental regulation since 1972 but a decline in enforcement.[26] This is particularly true of those countries where resources are limited. Measuring illegality is inherently difficult but the differences between policy and performance can be compared.

Figure 4 **(page 13) s**hows the difference in percent between country performance and the average for the OECD Environmental Policy index and for the Yale Environmental Performance index. There are significant issues with this sort of comparison since they measure different things for different reasons, but it does indicate that, directionally, wealthier countries' environmental performance may be better than their policy stringency would suggest while the converse may be true for developing states. This differential is most pronounced for China and India, suggesting specific issues around policy implementation there.

The question for *Codex* is therefore how much difference improved regulation would make in practice. This will depend on national enforcement but also on international trade. Trade plays an indirect enforcement role where end-customers demand compliance to standards and is likely to be more relevant to commodities such as soy where 65% is exported than beef or maize where less than a quarter is. The working assumption for this paper is that the farms that are being targeted are more likely to be involved in illegal practices and less likely to be involved in formal export arrangements. This would limit the impact of *Codex* regulation and trade on production. However, this needs more research to quantify and confirm. Specifically, this is needed to profile the worst performing 25% of farms, what type of farms they represent, their location and yields, impact, crop production, and exposure to trade.

Codex production considerations

The actual production implications of this for farm pricing and total yield are likely to be very limited due to the focus on the worst performing 25% of producers. The UK's National Food Strategy looked at taking the 9% least productive agricultural land out of farming, a similar segment to that targeted by *Codex*. **(See Figure 5, "Production impact of taking 9% of UK land out of agriculture", page 14)** It estimated that less than 1% of the UK's overall food production would be lost with minimal impact on crops, fruits and vegetables, and only projected material declines for specific livestock, including beef (-8%) and lamb (-22%).[27] It also found that this land had a high conservation value, making it ideal for either improvement (e.g., to *Codex* standards) or taking out of agriculture entirely with incomes substituted through sales of environmental services such as carbon or biodiversity. In the UK, even taking 21% of the least productive farmland out of agriculture would only mean a decline in total calories produced of 3%.

The implications of this are directionally similar to those from other studies: Due to high variability, applying minimum standards or removing marginal land from agriculture has outsized impact on environmental performance but limited impact on production. Not all the worst performing farms will be on marginal land, and it is expected that most will remain in agriculture with investment to bring them up to *Codex* standards, but it does provide a basis for estimating impact. However, UK agriculture is structurally different from much of the rest of the world and the differences in yield between and within countries can be even more significant than the variability in environmental impacts. Figure 6 **(page 14)** shows the percent of total global production and emissions produced by the lower quartiles and deciles of producers across the 15 core *Codex* commodities. Datasets typically do not integrate production and emissions data at a sufficient level to segment effectively. This analysis is therefore based on global FAO yield data and links the portion of each commodity produced globally to its GHG Emissions (IPCC), derived from Poore and Nemecek.[2, 30]

Beyond the assumptions made, there are a number of wider issues. Emissions have been used here as a comparable impact across commodities but *Codex* looks at multiple impacts and there is not always a correlation between good performance in one indicator such as emissions and others such as water take or eutrophication.[5] In addition, while marginal farms can be a reasonable proxy for the "worst producers" and are typically associated with disproportionately high impacts, this is not always true and some high-yield systems such as palm oil plantations on peat soils also create very significant environmental impacts. While these issues have been built into assumptions as far as possible, it means that both the data and the conclusions derived from them are highly directional at best, and both hypotheses and data require significant further quantification and validation. This shows that targeting 10-25% of the poorest performing producers for the top 15 commodities would be likely to impact only 2.0% to 5.4% of total production overall.

However, this masks significant variation between commodities with the highest impact likely to be on traditional crops including soy (3.8-10.2%), palm oil (4.6-11.6%), rice (4-10.4%) and sugar (4.6-11.6%). The production implications for beef would be minimal with only 0.9-2.6% of total production impacted but could reduce total emissions by almost 15%. Despite their relatively small contribution to total production, the worst performing producers are likely to create 21-43% of total agricultural emissions at a farm level. Some of this may be on marginal land and could be taken out of farming but, as above, this would be unlikely to have a large impact on production. There is evidence from the US Conservation Reserve Program, and a pilot by the UK Centre for Ecology and Hydrology, that total yields can be maintained despite removing adjacent land from production for conservation.[28]

3.2 Trade and Market Trends

Beyond the farm, the implications of *Codex* for global trade in agricultural commodities and its end markets are less clear but there are a number of trends that provide context. The first is that market volatility for agricultural commodities will increase in the face of increased geopolitical risk, unpredictable climate events, logistics cost rises, and long-term changes in yield. McKinsey[29] show that the ". . . financial results of commodity traders tend to correlate more with volatility than absolute price. This is not new. Trading has always been more profitable where there is both volatility and information asymmetry, but it will become more pronounced. The second is that yields are likely to decline with resulting price increases because of climate change. This will increase the cost of commodities overall with implications for markets, consumer pricing, and the trading environment, but, as we have seen, this will be highly variable by farm type, crop, and geography.

Thirdly, geopolitical risks such as those related to Ukraine (Black Sea) or Israel (Red Sea) have raised logistics costs and accelerated a wider COVID-related trend for onshoring and countries prioritising food security. This is likely to make trade more regional than global. Finally, environmental markets such as those for carbon and biodiversity and standards such as the EUDR or *Codex* will reduce the opacity of commodity supply chains and decrease the fungibility of commodities. This increase in transparency and traceability is unlikely to have a short-term impact but will drive medium-term change in commodity production practices and sustainability.

Codex and Trade

There are two ways in which embedding *Codex Planetarius* within WTO structures will influence world trade. The first is direct, with parallels to the *Codex Alimentarius* model where national regulation restricts exports and imports that do not meet agreed international standards. This regulation, although targeted primarily at trade, also has an indirect, and often much larger, impact on goods produced for domestic markets through the same national regulation. This approach treats individual commodities in the same way regardless of their provenance and is distinct from approaches such as the EU's Deforestation Regulation (EUDR) that segregate physically identical products based on other requirements; deforestation, in the case of the EUDR. *Codex* is likely to be applied to all farms but is directed at the bottom quartile which will limit its short-term impact on international trade.

As outlined above, the worst performing quartile of farms represent only 5.4% of total production. This requires validation for application to global markets but when applied to trade, suggests that *Codex* would impact only 1.9% of total production of the core commodities identified, $60 billion of a $2.9 trillion in global production. **(See Figure 7, "Bottom 10%/25% of farms, trade as % production", page 15)** Only the exports of beef, soy, and coffee impacted by *Codex* represent a significant portion of their total production. This is due to a combination of trade factors but primarily because soy and coffee are by far the most exported commodities at 65% and 72% of production respectively. Much higher volume products such as pork represent a tiny portion of world trade. This data is based on global averages and is therefore likely to be an overestimation given that most of the worst performing farms are likely to be outside traditional export channels. These relatively low volumes spread across geographies and products means that the impact on trade flows overall is unlikely to be material despite the outsized impact of *Codex* standards on the environment. However, the impact on coffee and soy export is likely to be significant, particularly given that these are concentrated in a small number of producer countries and should be investigated as part of the next stage of *Codex* research.

Codex and Legislation

The development of regional and national legislation for environmental standards creates opportunities for *Codex*. Regionally, the European Union Deforestation Regulation (EUDR) overlaps with five of the 15 core *Codex* commodities and will have a significant impact on its development and global trade. The EUDR marks the shift of regulation from direct towards indirect environmental impacts on supply chains. This imposes penalties of up to 4% of turnover and confiscation of goods for companies that do not comply. In its impact assessment of the regulation, the EU estimated that it would increase costs somewhere in the range of €175 million-€2.6 billion. Beyond specific EU supply chains, this is driving wider investment in the sort of supply chain transparency and environmental reporting that will be critical to creating global platforms such as *Codex*.

The potential downsides of EUDR have been widely reported, including its limitations as a unilateral demand-side measure.[30] Its effectiveness in reducing deforestation is likely to depend on how regulation develops beyond the EU. The 2010 Dodd-Frank Act, which required US companies to disclose the source of their "conflict minerals," provides context. The Act has driven awareness of, and investment in, supply chain transparency and the emergence of conflict-free certification but led some companies to simply halt sourcing from DRC and producers to create parallel markets for unregulated, potentially conflict-related minerals. This is the primary risk of EUDR. It simply creates two separate supply chains, one for deforestation-free production into the EU and one into less regulated markets. A global approach would reduce this risk. A related trend is the development of national-level standards and legislation by producing countries. This includes ARS1000 in Ghana and Cote d'Ivoire for cocoa, adopted as national standards and expected to become mandatory, and ISPO in Indonesia and MSPO in Malaysia, both of which are embedded in legislation. *Codex* provides the potential to create a common minimum baseline across multiple geographies and standards within this sort of national-level regulation. It also shows how standards are starting to be developed by producing countries that are initially trade focused but also act to mitigate domestic market and production impacts.

Codex and Pricing

Although improving the bottom 10-25% of farms is likely to have a limited impact on trade volumes due to poor productivity and practices on often marginal land, climate change will have a broader influence on pricing. This is related to projections by institutions such as IFPRI for potential yield declines and reflected in price increases due to climate change in comparison to Business as Usual (BAU). Figure 8 **(page 15)** illustrates this based on data from Agricultural Model Intercomparison and Improvement Project (AgMIP). The crops most impacted by climate will be those that are crucial to food security where demand will continue to rise due to population growth, but where yields are most vulnerable, creating a supply-demand imbalance. This is particularly concerning for maize and rice which are collectively the staple foods for 8 billion people, primarily in Africa and Asia. These projected price increases are in comparison to BAU so the actual increases would be even higher, 72% for maize and 36% for rice between 2020 and 2050.

Numerous studies have examined the impact of food price shocks for maize across Africa and concluded that a 25% increase in maize prices in Kenya would negatively affect 80% of the population, driving an increase in poverty. Without mitigation measures through standards such as *Codex*, a sustained climate-related increase in prices of this sort would have a catastrophic impact on livelihoods and food security. However, the volume impact of *Codex* itself is likely to have a minimal direct impact on either traded or consumer pricing. Using the assumptions previously outlined, implementing *Codex* would directly impact a tiny portion of international production and therefore help mitigate climate-related price increases. This represents a potential benefit from *Codex* by mitigating some of the worst excesses of climate change of between $14 billion and $40 billion annually. However, this is for a production value of over $3 trillion and is not material in terms of an impact on trade pricing.

Codex and Data

Global trading systems have developed in ways that incentivize the creation of goods that are "fungible," meaning they are interchangeable for commercial purposes and practically indistinguishable physically from each other. This has helped drive the growth of opaque supply chains that ignore environmental impacts and, "launder away negative externalities"[31] through limited traceability and transparency. This means that, whilst end products such as palm oil or soy may end up as indistinguishable commodities, the difference between the environmental impacts of the worst and best performing producers can range from 22x in the case of beef to 66x for palm oil.[32] That makes dealing with the worst performers much more important than improving the rest. The problem is that identifying them is difficult in commodity chains that are expensive to segregate and as part of a system where there is little commercial incentive to do so.

The profitability of the traders that dominate the global food system is based on selling interchangeable products at scale and retaining, not sharing, information so when market demand or pricing changes they have a competitive advantage. It's exacerbated by the fact that over 40% of key commodities including palm oil, cocoa, soy, and beef are purchased through intermediaries or third-party supply chains.[33] The impact of *Codex* as a truly international environmental standard with regulation at a national level and enforcement both directly through WTO systems and indirectly through domestic laws could be significant. This would put additional pressure on traders and end-customers to measure, report and monitor environmental standards in their supply chains at a level of detail beyond existing transparency initiatives such as TNFD, TCFD, IIRC or CDSB. However, ensuring that standards are ubiquitous, inexpensive, and actionable at scale will require significant work and financing to give governments the tools to enforce novel standards.

Codex and Consumption

There is a large body of literature that looks at the potential impact of demand-led measures to reduce the environmental impact of agriculture. These include taxes to reduce per capita consumption, product innovation such as vat-grown meat, and public education campaigns. *Codex* is designed to incentivize production rather than consumption and, due to its relatively small volume effects on both production and trade, is unlikely to have a significant impact on consumer pricing or demand. However, given that *Codex* standards are intended to be applied widely and are likely to be similar to basic agroecological measures, it is worth looking at what the potential consumer impact of these would be at a national level.

Much of the research shows that it would have a relatively small impact on retail pricing in mature markets outside some outliers such as maize. This is partly because the spread between farm gate prices and retail prices is large and has increased in recent years and partly because large retailers are able to improve efficiencies and put pressure on suppliers due to buying power. In the UK, widespread use of agroecological practices is projected to lead to price rises of between 1% (pasta, bananas, tomatoes, white bread) and 3% (potatoes, cucumbers, peas). This compares to increases for organic practice-based certification which increases the cost by up to 245%. However, agroecology would also increase the price of livestock from 5% (salmon) to 26% (chicken) and 145% (beef mince). This illustrates that climate change will have an impact on consumer pricing and end-market demand, but that it will be highly variable by product and unlikely to be excessive overall.

Implications for *Codex Planetarius*

The way that *Codex* is structured and its focus on the worst performing 10% of farms will minimise its direct impact on total production, world trade, and both market and consumer pricing. However, its indirect impact is likely to be wider in the form of creating a requirement for broad, cost-effective environmental traceability to monitor *Codex* standards and to mitigate the worst effects of climate change on the prices of staples such as maize and rice through national level regulation. However, both will require significant funding to ensure the measurement, compliance, and impact on a global scale. The data gaps identified in previous sections are particularly important to fill to ensure that the assumptions made on production, pricing, and trade here are robust and validated.

4. *Codex* Costs and Benefits

4.1 *Codex* Costs

Beyond the impact of *Codex* on production which is likely to be limited by the relatively small contribution of the farms targeted, a significant driver of change will be the availability of finance to improve farm-level standards. This will be critical to the success of *Codex*. Many of the worst performing 25% of farms are likely to be on marginal land, or land created due to Land Use Change, over-cultivation, or poor growing conditions which generates outsized environmental impacts. This type of land is often cultivated as a reaction to pressures ranging from urbanisation, habitat destruction, water table depletion, and soil degradation to consumer demand. This means that much marginal land is likely to continue to be used to provide nutrition and livelihoods due to a lack of alternatives.

Marginal land ranges from 8% of total agricultural land in South America to as much as 38% in West Asia so it does make a contribution to food and income security.[34] To ensure that this land is improved to *Codex* standards will require finance at scale and in a form that is acceptable to farmers. Calculating these costs will require more data and analysis. However, a paper in Global Food Security[35] analyses the potential costs of reconfiguring global food systems, building on more than 20 papers to provide an estimate. This is more ambitious than *Codex* in that it looks to transform the food system, not just production, and includes wider conservation costs, but with some additional assumptions it is possible to estimate the extent of climate finance required to bring up the bottom 10% of farms to *Codex* standards.

Figure 9 **(page 16)** suggests that the total investment required in agriculture within selected regions is $824 billion p.a. but only a small portion of this would be a direct *Codex* cost. Targeting the bottom 10% of producers in the 15 core commodities and countries identified in our previous assumptions and applying only a portion of relevant conservation costs would amount to $4.12 billion p.a. in total. This tallies with bodies such as Food System Economics Commission (FSEC) who estimate a total of $292 billion p.a.[36] which would give an equivalent *Codex* cost of $4.16 billion and a United Nations Forum on Sustainability Standards (UNFSS) range of $300-$400 billion which would give an equivalent *Codex* cost of $4.99 billion. For comparison, this is far below the $16.1 billion aid budget of the UK alone and a tenth of the $46 billion EU CAP budget allocated to eco-schemes from 2023. Much more analysis is needed to identify these farms' location, cost base, crop production, yield profile, social considerations and environmental impact, and mitigation actions required against *Codex* standards. However, almost by definition, the farms in the bottom 10% with poor standards and productivity will lack resources and access to finance. We have seen how changing practices to meet environmental regulation incur costs but that these can be reversed in the medium term through yield improvements, innovation, and efficiency savings. None of this will happen without the initial adaptation funding required on a global scale.

4.2 *Codex* Benefits

The benefits of introducing baseline environmental standards for agriculture are likely to very significantly exceed the relatively modest costs outlined above. These benefits will be in the form of mitigation rather than upside due to the huge potential costs of inaction across three main indicators: agricultural production, farmer incomes, and the environment.

Production: The International Food Policy Research Institute created an IMPACT model[37] that considered a baseline scenario for production assuming no climate change to 2050 and one that factored in the impact of climate change on agriculture. **(See Figure 10, "Codex impact on production", page 16)** The model projects declines relative to the baseline ranging from 1.5% for livestock to 7.6% for cereals. However, this masks significant variation between regions and the available data is not broken out for specific crops so the assumptions here are based on averages for cereals, livestock, oilseeds, and fruit and vegetables. Only those core countries listed in the first section of this paper were examined for the top 15 agricultural commodities. The results are striking, showing a loss in production relative to the baseline scenario of $177 billion annually by 2050. Even if only applied to the bottom 10% of farms which represent 1-5% of total production, this represents a production loss of $8.8 billion annually. It also disproportionately effects two key staple crops for food security – maize and rice – which make up half of all losses combined. A lower 3% yield decline has been assumed for wheat based on the HadGEM2 model used by IFPRI and a higher 24% decline applied to maize[38] but detailed analysis is required to ensure that assumptions are accurate. The benefit of implementing a baseline standard such as *Codex* could therefore be equivalent to this $8.8 billion value in mitigation. This production decline will disproportionately impact the Global South, with yields potentially increasing in the Northern Hemisphere particularly for crops such as wheat, while maize yields, particularly in Africa, face steep falls.

Incomes: These trends have the potential to exacerbate poverty and North-South income disparities without mitigation investment. Additional work is required to better identify and define the bottom 10% of farms targeted by *Codex* but there are several assumptions we can make. The first is that they are likely to be predominantly less than two hectares in common with 84% of the 570 million farms globally.[39] However, these small farms represent only 12% of global agricultural land and many smallholders are relatively efficient so some farms in the bottom 10% will be larger and located on less productive or marginal land. The second is that reduced yields, as explored above, are likely to directly impact farm incomes, particularly for smallholders who do not have the resources to switch crops or invest in resilience.

The third is that an increase in extreme weather events including drought, flooding, and pests because of climate change will disproportionately affect the agricultural sector and farm level incomes. The sort of yield declines listed above will therefore have a catastrophic impact not only on livelihoods but also on food security across much of the developing world. The link between yield and poverty is well recognized but highly variable depending on geography, farm type, population, and socio-economic develop stage. An analysis of the potential impact of climate change in Brazil at the level of municipalities calculated that the production deficit caused by climate change could increase the rural poverty rate by 3.2 percentage points overall. Again, this masks significant regional variation with the North experiencing a 6.2-point increase and the South a 0.2-point reduction in poverty.[40] A 2020 IPSOS Mori study for Syngenta[41] across the US, France, China, Brazil, India, and Africa found that 72% of farmers were concerned by the impact of climate change on their business and 87% had already experienced at least some impact. However, these averages do not reflect significant variability by country and type of farm. In the US where infrastructure, mitigation, government support, and finance mechanisms are well established 26% of farmers were not concerned at all about climate change compared to 3% in India and 2%

in Africa. Due to the impact of climate on farming, cost is by far the most important barrier to implementing more sustainable farming practices with 53% of farmers globally stating that it was not financially viable. This reflects the importance of funding the implementation of *Codex* standards as a bridge to restructuring global food systems.

Environment: The benefits of baseline environmental standards on the environment need wider research to quantify properly but we can base the impact of the *Codex* on existing analysis. The FSEC[26] have quantified the net benefits of Food Sector Transformation compared to current trends. The cost of this in terms of mitigating measures for the environment is included in the calculations in **Figure 11 (page 17)** but the benefits are enormous, partly through the "hidden" negative effects of agriculture on ecosystems and climate. FSEC estimates this at $3 trillion annually including GHG emissions, water use, biodiversity loss, and the wider environmental damage caused by excess nitrogen pollution of water and air. This is similar to the $2.86 trillion of "hidden" environmental impact calculated by FAO.[42] The mitigating measures proposed by FSEC are wider than those likely to be applied as part of *Codex* but are similar enough to be used as a benchmark. This assumes a reduction in these externalities by 45% in total: 13% from GHG emissions, 17% from habitat conservation, and 15% from lower nitrogen pollution. For the purposes of this paper, we will take the lower FAO figure to be conservative. Applied to the selected *Codex* commodities and countries, and assuming an impact reduction of 45% for the bottom 10% of farms, themselves representing approximately 50% of impacts corresponds to a potential annualized benefit of $180 billion.

Implications for *Codex Planetarius*

Without much more extensive research and modelling it impossible to estimate the potential impact of *Codex* on production more accurately. Focused, structured data analysis to fill the gaps noted in this paper should be considered as part of any next steps. However, the evidence we do have suggests that for a potential cost of around $4 billion p.a., the benefits of applying *Codex* standards to a relatively small sub-set of producers could be as high as $200 billion annually, a 50-fold return on investment. These costs and benefits will vary significantly between geographies, farm types, and crops with costs and yield declines disproportionately affecting smaller farms in the Global South. Because enforcement is often variable, implementing *Codex* will require finance at scale, provided effectively and efficiently to incentivize producers to change practices, invest in mitigation measures, and fundamentally reduce their environmental impact.

Conclusions

Codex Planetarius is likely to impose costs on the production of a core selection of commodities, but these should be short-term in nature and small in comparison to its long-term benefits. Historical evidence from environmental legislation, NTMs and VSS standards all demonstrate that these costs can be recovered through efficiency gains, innovation, and wider environmental and social benefits. Based on the assumptions in this paper, expenditure of $4 billion annually could deliver benefits of up to $200 billion p.a. through production and pricing improvements and environmental mitigation. At a macro level, the impact of climate change on agricultural production, pricing and trade could be catastrophic for food security and livelihoods. Without a baseline standard such as *Codex*, mitigation is likely to be partial, ad hoc, and almost certainly ineffective. This is important because the worst performing 10% of farms targeted by *Codex* probably generate less than 2% of production, making them uniquely fragile and resource constrained. One clear outcome from this paper is that without effective finance mechanisms, these farms will not be able to afford the mitigation actions required to deliver *Codex* benefits or, in the case of marginal land, afford to stop farming through subsidies or environmental markets.

The assumptions and conclusions in this paper are based on available case studies, climate models, meta-studies, and academic research. However, there are very significant gaps and uncertainties which require further analysis, data gathering, and review, listed below:

- **Identify and profile the worst performing 10% of farms globally:** There is evidence that 5% of the world's food calories drives 40-50% of environmental impact,[2] but identifying, profiling, and reaching the farms that produce them requires further analysis. This will need to be based on the final *Codex* countries and products selected since environmental standards vary widely by geography and commodity and focus on defining the worst performing farms by geographical location, type, ownership, size, yields, production, exports, and environmental impact. This will allow more accurate quantification of *Codex* implications and create a platform for future implementation.
- **Analyse the potential costs and benefits of Codex:** Modelling and quantification of the costs and potential bene fits of measuring to, and implementing, *Codex* standards including yield, volume, and pricing shifts for core products compared to BAU. This will need to look at both the costs of the targeted bottom 10% of farms but also the potential halo effect of *Codex*-based national regulation on wider agricultural practices.
- **Incorporate fisheries data:** This paper has not considered aquaculture or fisheries. This should be evaluated as a potential addition to the core *Codex* products listed.
- **Quantify indirect emissions as part of global trade:** Importing emissions through trade in feed such as soy is a significant issue for large importers such as China and needs focus, particularly where it is re-exported, to avoid double-counting or underreporting.
- **Identify organizational requirements to ensure Codex does not add friction to trade:** Establishing NTMs such as *Codex* can create friction and cost if there is an imbalance in standards between importers and exporters. This requires an agile organization with the resources and flexibility to keep up with the pace of dynamic change in standards.
- **Investigate financing options for Codex:** Finance of up to $4 billion p.a. may be needed to implement and ensure the long-term success of *Codex*. This funding is necessary for engagement with national bodies for legislation and compliance, with farmers for mitigation investment and practice change and with environmental markets and participants to provide alternative revenue streams for *Codex* target farms. ■

Peer Reviewers

1. **Chris Brett,** World Bank Group
2. **Jason Clay,** WWF Markets Institute
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Figures

Figure 1. Value of top 15 agricultural exports against total CO2e emissions. *Data from Poore, J et al (2018), "Reducing Foods Environmental Impacts", Science and FAOSTAT.*

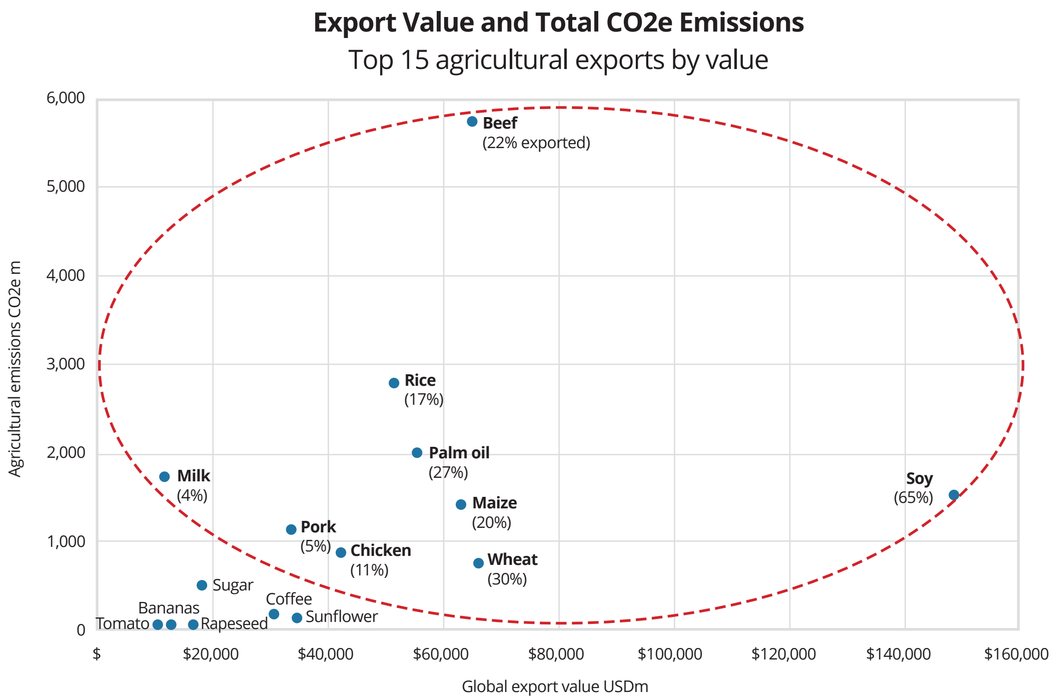

Figure 2. Agricultural exports. *FAOSTAT data (2024)*

Agricultural product	Exports USDm	% of crop exported
Soy	$ 94,010	65%
Wheat	$ 66,353	30%
Beef	$ 65,265	22%
Maize	$ 63,326	20%
Palm oil	$ 55,564	27%
Rice	$ 51,702	17%
Chicken	$ 42,506	11%
Pork	$ 33,973	5%
Milk	$ 11,432	4%

Figure 3. Environmental policy stringency. *OECD Data (2020)*

OECD Environmental Policy Stringency Index	2020
Norway	3.94
Japan	3.78
United Kingdom	3.61
EU average	3.40
Korea	3.17
China	3.14
Average	**3.08**
Canada	3.03
United States	3.03
Australia	2.92
Türkiye	2.89
India	2.83
Indonesia	1.64
Russia	1.17
South Africa	0.92
Brazil	0.89

Figure 4. Environmental policy vs performance. *OECD (2020), Yale (2022)*

Differential vs. average	OECD Policy Index	Yale Performance Index
Norway	28%	38%
Japan	23%	33%
United Kingdom	17%	81%
EU average	10%	44%
Korea	3%	9%
China	2%	-34%
Average	**0%**	**0%**
Canada	-2%	16%
United States	-2%	19%
Australia	-5%	40%
Türkiye	-6%	-39%
India	-8%	-56%
Indonesia	-47%	-34%
Russia	-62%	-13%
South Africa	-70%	-13%
Brazil	-71%	1%

Figure 5. Production impact of taking 9% of UK land out of agriculture. *The National Food Strategy (2022) – "The Evidence"*

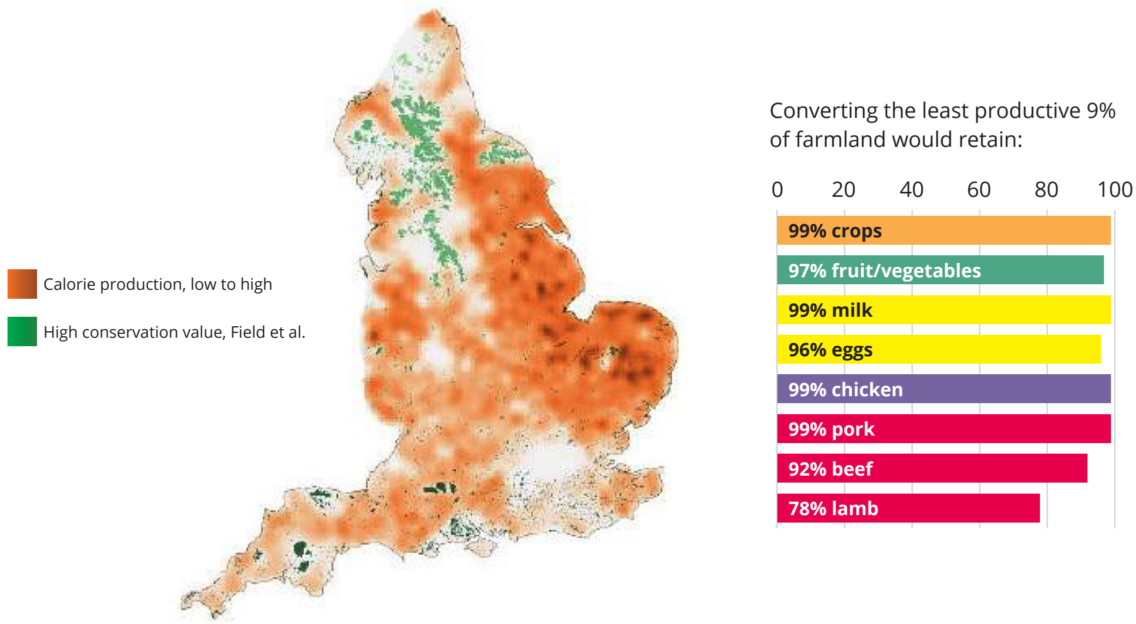

Figure 6. Impact of targeting the bottom 10% and 25% of producers. *Data from Poore & Nemecek, FAOSTAT*

15 core Codex products	Bottom 10% of producers		Bottom 25% of producers	
	% of total production	% of total emissions (CO2e)	% of total production	% of total emissions (CO2e)
Beef	0.9%	4.2%	2.6%	14.9%
Soy	3.8%	2.4%	10.2%	3.7%
Maize	1.8%	2.0%	5.6%	3.5%
Palm	4.6%	2.1%	11.6%	4.0%
Wheat	2.2%	0.8%	6.4%	1.6%
Rice	4.0%	4.8%	10.4%	6.3%
Chicken	0.7%	1.1%	2.1%	1.9%
Pork	1.3%	0.9%	3.7%	2.1%
Milk	1.5%	1.6%	4.8%	3.4%
Coffee	1.5%	0.8%	4.1%	0.5%
Sugar	4.6%	0.3%	11.6%	0.8%
Rapeseed	3.4%	0.1%	8.9%	0.3%
Bananas	1.8%	0.0%	4.9%	0.1%
Tomatoes	1.4%	0.0%	3.9%	0.1%
Sunflower	2.6%	0.1%	7.2%	0.2%
Totals	**2.0%**	**21.1%**	**5.4%**	**43.5%**

Figure 7. Bottom 10%/25% of farms, trade as % production. *Data from FAOSTAT, Nat Food Strategy*

15 core Codex products	Bottom 10%	Bottom 25%
	trade impact as % of production	trade impact as % of production
Beef	0.2%	0.7%
Soybeans	3.9%	10.3%
Maize	0.4%	1.4%
Oil palm	1.5%	3.9%
Wheat	1.0%	3.0%
Rice	0.8%	2.1%
Chicken	0.1%	0.3%
Pork	0.1%	0.2%
Milk	0.0%	0.1%
Coffee	2.3%	6.0%
Sugar	1.2%	3.0%
Rapeseed	2.0%	5.4%
Bananas	1.0%	2.6%
Tomatoes	0.2%	0.6%
Sunflower	1.5%	4.1%
Totals	**0.7%**	**1.9%**

Figure 8. Climate-related price increase vs BAU. *Data from AgMIP (IFPRI), FAOSTAT (2024)*

Core commodity	Price increase to 2050 vs BAU	Codex price impact bottom 10% USDm	Codex price impact bottom 25% USDm
Beef	54%	$ 3,783	$ 11,726
Soybeans	33%	$ 2,825	$ 7,474
Bananas	26%	$ 352	$ 955
Rice	24%	$ 3,670	$ 9,593
Wheat	18%	$ 1,433	$ 4,094
Tomatoes	12%	$ 253	$ 728
Rapeseed	11%	$ 432	$ 1,144
Sugar	8%	$ 728	$ 1,850
Poultry	6%	$ 233	$ 670
Pork	5%	$ 645	$ 1,850
Beef	3%	$ 224	$ 651
Milk	1%	$ 71	$ 221
	Total	**$ 14,649**	**$ 40,957**

Figure 9. Potential Codex costs for selected regions. *Data from Global Food Security/ UNFS/ FSEC*

USDm p.a.	Forest conservation	Peatland conservation	Seed, fertilizer, irrigation	Agricultural infrastructure	Social safety net
South Asia	$ 400	$ 27,500	$ 52,500	$ 1,500	$ 1,400
Sub-Saharan Africa	$ 96,400	$ 62,200	$ 50,400	$ 3,400	$ 500
Europe & Central Asia	$ 177,000	$ 6,400	$ 600	$ ---	$ 100
Latin America	$ 185,600	$ 24,400	$ 100	$ 100	$ 100
North America	$ 133,400	$ ---	$ ---	$ ---	$ ---
Total (selected regions)	**$ 592,800**	**$ 120,500**	**$ 103,600**	**$ 5,000**	**$ 2,100**
				Total	**$ 824,000**
Data above applied to bottom decile of farms, representing 5% of production across key Codex commodities and countries only				Codex cost p.a.	**$ 4,119**
Estimate based on FSEC report				Codex cost p.a.	**$ 4,160**
Estimate based on UNFSS report				Codex cost p.a.	**$ 4,990**

Figure 10. Codex impact on production. *FAOSTAT (2024), IFPR IMPACT model*

Commodity	2050 change in production value USDm/p.a.
Maize	$ (75,379)
Rice	$ (33,869)
Pork	$ (13,589)
Sugarcane	$ (13,297)
Chicken	$ (7,770)
Soybeans	$ (7,490)
Milk	$ (6,208)
Beef	$ (5,651)
Wheat	$ (4,883)
Tomatoes	$ (3,131)
Oil palm fruit	$ (2,709)
Sunflower seed	$ (1,740)
Bananas	$ (1,343)
Total	**$ (177,059)**
Codex bottom decile	**$ (8,853)**
Codex mitigation benefit	**$ 8,853**

Figure 11. Codex impact on environmental externalities. *Data from FAO, FSEC, FAOSTAT*

Environmental externalities		USDm	
Environmental externality cost (FAO)		$	2,860,000
Core Codex commodities	56%	$	1,601,600
Core Codex countries	50%	$	800,800
Mitigation potential (FSEC)	45%	$	360,360
Codex bottom decile impact	50%	$	180,180
Potential Codex environmental benefit		**$**	**180,180**

Footnotes / Citations

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