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8th Sino-German Agricultural Week: conference report

"Approaches to Domestic and Global Food Security"

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Note

This conference report summarizes the contributions made by speakers and participants at the **8th Sino-German Agricultural Week** held in Beijing and online from 21-25 November 2022 and organized by the Sino-German Agricultural Centre (DCZ). Its aim is to synthesize the challenges and opportunities for Sino-German collaboration in creating the sustainable and resilient food systems needed for providing sufficient, adequate, and nutritious food to everyone on the planet. Under the guiding theme "Approaches to Domestic and Global Food Security", the conference assessed the potential of digitalization, seed development, and initiatives aimed at reducing food loss and waste in achieving this goal.

For the full conference program, pre-recorded video addresses, list of speakers and presentation slides for individual contributions with further references, as well as the recorded livestream of the event, please refer to the DCZ website.

21st November: Digital solutions to food security

Both countries considered digital technologies (DT) and smart agriculture holding great potential to contribute to domestic and international food security. Government representatives and experts shared what the challenges were for which DT could contribute solutions, highlighting resource conserving and climate resilient production, quantitative and qualitative optimization along the entire agri-food value chain, compensation for lack of labor force in an aging rural (farming) population, and attractiveness of the agricultural sector and rural areas for younger generations. It was understood that digitalization in agriculture could not be considered in isolation but had to be understood as embedded in broader rural development as well as integrated into the entire agri-food value chain. A key concern on both sides was the question of effective research, development and dissemination of DT that addressed practitioners' actual needs. Discussed problems included demand-oriented research and development of DT, hurdles and concerns around DT adoption, synergy between DT with experience-based forms of agricultural knowledge, and distribution of costs and benefits of DT adoption. Sino-German exchange and collaboration in this field could build on existing efforts that have been seriously impeded by Covid-19 restrictions over the last three years.

Perspectives on challenges and opportunities

China: The Chinese government integrated digitalization and smart agriculture into their broader strategies to address the Three Rural Issues.[1] Since 2012, various policies on national- and sub-national level have provided strong support for pilot projects. E-commerce for agricultural products via social media and online platforms is wide-spread and demonstrated benefits for both farmers and consumers. However, adoption of DT at the level of production is still very limited and faces many challenges: lack of funding and high costs, small scale of farming in most of China, low educational levels and limited familiarity of farmers with modern technology, limited availability of some DT on domestic market, questions around data (regulations, quality, quantity), amongst others.

Representatives from Suzhou illustrated the approach taken within their national-level pilot for smart agricultural reform since February 2020. It developed standards for smart village development with the aim to scale up to 200 villages by 2025. A village-level example showcased

a smart village governance platform run on WeChat that was coupled with an "Offline Village Livingroom" that extended online services into the offline space to foster broader engagement, especially of older villagers. These centers provided access to public services, digital medical services, smart education, digital culture, e-commerce, financial services, internet services.

Experts showcased empirical research that evaluated the adoption and performance of DT in practice. All provinces have pilot projects and zones dedicated to rural digitalization and smart agriculture, though they are longest-standing and most numerous in the more affluent regions of Eastern China. Similarly, private company initiatives such as the Taobao Villages[ii] are most prevalent in coastal areas. However, even on the advanced side of this geographical digital divide, farm-level DT adoption is limited (examples: automatic and smart greenhouse ventilation, drones for pesticide application, tracing of agricultural products for quality control) and further exploration of supportive financial models is needed (examples: mortgages, insurances). E-commerce via direct marketing on social media benefitted farmers with higher prices for their products. Questions around finding effective and inclusive development pathways that could bring benefits of DT to farmers were raised, and the need emphasized to further test, evaluate and improve different modes of engaging public and private actors.

Experts demonstrated the technical capabilities being developed in DT research projects. Work on smart orchards showed latest progress but also exemplified technical as well as broader practical challenges of DT in Chinese agriculture. Lack of data still limited accurate guidance for production, though it could support broader management of the orchards. The integrated data collection and analysis at farm-level down to the individual tree and fruit via satellites, sensors, robots, mapping and analysis supported precision irrigation and pesticide application, robotic weeding and fruit-handling assistance. The potential to address quantity and quality of yields, conserve environmental resources, and address lack of available labor was demonstrated.

Germany: The new German government showcased its strategy for digitalization in rural areas, which encompassed the following dimensions: digital infrastructure, work/education, regional value chain, landscape and environmental protection, medical care, mobility, local engagement/participation, settlement development. The digital divide in Germany continues to challenge digitalization in rural areas, including agricultural production, where internet coverage

is not ensured yet. Key challenges for rural development include an aging population and a drain of skilled workers to the urban centers, including the phenomenon of emptied out villages ("donut villages"),[iii] but the strength of strong rural communities and participation was also highlighted. Rural development emphasizes climate protection, energy policy and fostering primary production in pursuit of building attractive and sustainable rural areas.

The government supports various research and pilot projects, of which, for example Smart Rural Areas are ongoing and Future Farms recently started in September 2022, which encompasses the exploration of DT for on-farm applications and in regional value chains for agricultural products. DT in focus include autonomous driving of farm machinery, plant protection products and fertilizers, organic production aided by mechanical weed control, but also precision livestock farming with sensor-based monitoring of virality, animal health and location that reduces costs and facilitates automation. It is highlighted that agricultural production crucially needs to consider social challenges in weighing technological solutions, such as rural livelihoods, animal welfare in livestock sectors, resource efficiency and emission reduction, variety of products and biodiversity especially in times of climate change, as well as the transparency of platforms and DT's economic efficiency.

Experts showcased latest DTs for livestock management, food storage, agrivoltaics and seed breeding. The examples for livestock management encompassed various elements along the value chain exemplified for cows, from harvesting of feed optimized for nutrition to grazing and feeding robots to sensor monitoring of cow health and behavior. For the case of pigs, where sensor technology on the animal is less feasible, applications for evaluating maturity for slaughter via optical systems or acoustic sensors inside piglet barns showed adjusted DTs. Further DTs, such as stall technology for automated, smart soiling in pigsties, cleaning robots and smart ventilation to prevent heat stress in barns complemented on-farm application examples. Demand-driven production through on-farm milk processing facilities, data sharing with slaughterhouse before delivery of livestock and smart management of grain storage complemented potential for optimizing regional supply chains beyond primary production.

Experts further highlighted the challenges of mitigating and adapting to climate change in the agricultural sector. The example of agrivoltaics showcased how renewable energy could be

produced where DT creates new energy demands. Next to reducing emissions from other energy sources, agrivoltaics could address various challenges in the food-energy-water nexus. Examples showcased various designs of agrivoltaic modules and how they can be integrated into different production settings, such as in greenhouses or above and amongst crops. Integrated with other smart technologies, they can be adjusted to benefit plant growth or optimize for energy production in line with changing on-farm needs (e.g., provide shade, break wind, protect from hail, etc.) to regulate soil humidity, temperature and increase yields via tracking systems.

22nd November: High-level forum: Sino-German cooperation on food security

The 8th consecutive Sino-German Agricultural Week took stock of Olaf Scholz' recent visit to China and his meeting with Xi Jinping and 50 years of diplomatic relations between Germany and China. Both sides emphasized the DCZ as a maturing institutional platform for urgent bilateral collaboration to address the global food crisis. Global food security[v] is in the midst of short- and long-term crises, ranging from international conflict and war (such as the Russian war on Ukraine) and impacts of the Covid-19 pandemic to accelerating climate change, eroding soil quality and biodiversity loss. Progress towards the UN Sustainable Development Goal (SDG) of Zero Hunger by 2030 is eroding[vi] and population growth as well as dietary transition in many places of the world have not peaked. In this context, ensuring domestic food security while contributing to a food secure global future faces many challenges that urgently call for concerted bilateral as well as international engaged efforts by Germany and China. Government representatives and experts discussed potential for bilateral policy dialogues around international trade, joint efforts to shape global food security governance and explore synergies in working with vulnerable third countries.

Perspectives on challenges and opportunities

China: Chinese government representatives stressed the achievements made in ensuring domestic food security through grain self-sufficiency and continued yield growth. The recent political term "agricultural power 农业强国" was elaborated in relation to food as aiming to strengthen domestic food production capacity by technological progress, improving the environment, and strengthen trade. It includes securing agricultural inputs, such as fertilizer and machinery, but also mastering technologies in the areas of breeding, mechanization, and digital solutions. The current approach to food security was described as taking a "greater food view 大食物观"[vii] that stressed not only production capacity of grain but takes the whole food value chain across food groups into view. It also expands thinking about land use beyond agricultural production and acknowledges the importance of the broader ecosystem, including grassland, forests and the sea. It was emphasized that China's experiences could benefit developing

countries, who could learn from China's poverty reduction and agricultural policies, and ongoing exchange with Venezuela around policy strategies for the agricultural sector were mentioned.

China's food security is the result of domestic production and international trade. It faces many challenges, such as land and freshwater resource constraints, natural disasters and rising production costs (labor, material and services, land). This puts technological progress under pressure as the key enabling factor for continued yield growth. Also, it moves reliability of international trade into focus. The relationship between advocacy of self-reliance and open international markets was elaborated upon. It was stated that the relationship had been subject to much debate internally as well as subject to international criticism as well, be it for supporting domestic agriculture instead of engaging in trade or for importing large amounts of international resources to meet domestic demand. The current domestic consensus was explained as self-reliance for basic food security (eating enough), while relying on international trade for eating well. While China has to ensure its own food security, it is also invested into ensuring stable global food markets.

In regard to trade, it was stressed that volatile international food prices in response to Russia's war in Ukraine, other trade conflicts and interruptions due to Covid-19 created concerns that reliance on international trade might hold unwanted risks. At the same time, it was strongly emphasized that China was a strong supporter of open, rule-based international trade and highly interested in contributing to bilateral policy dialogue and international efforts in that direction. This included a call for more coordinated strategies within the Word Trade Organization (WTO) to make unilateral restrictions on trade more difficult or forbidden. It was criticized that the WTO had "no teeth" to address current developments and was not giving countries stronger confidence in international trade as a reliable partner for food security. It was stated that the domestic support system for trade was under review and active participation in future trade negotiations was anticipated, including multilateral trade negotiations within the WTO and free trade agreements. The goal is to diversify imports from different trading partners and across different food categories.

Germany: The German government representatives emphasized the vision of a sustainable agri-food system that ensured future climate, air, water, biodiversity, and consumption of a sustainable

diet. At the global level, they emphasized the goal to fight hunger and aspire to agroecology as the leading image. Demand-side challenges to global food security were mentioned, such as conflicting land and resource use for energy, meat and food production. Protectionist trends on international food markets were seen critically and support expressed to foster open, rule-based international trade.

Experts commented that in order to balance short- and long-term crises and goals, a transition to sustainable agrifood systems needed to be advanced while addressing immediate crises at the same time. An example for this was the flexibility afforded within the EU policy framework, which encouraged environmentally friendly practices on farms on voluntary basis but allowed for a switch to intensified food production to quickly meet short-term needs. It was pointed out that it was crucial to create commitment around a common goal at all levels of the food supply chain in order to achieve the transition to sustainable agrifood systems despite short-term crises. This needs to take into account the unequal power distribution at different parts along the food value chain, which was described as strongest at distributer level and weakest on the level of farmers and other producers.

Experts addressing global food security across borders:

It was encouraged to understand food security as a global problem which required adequate responses with increasing urgency. Experts across both countries explained the various challenges to global food security in the short- and long-term. Most prominently, these included disruption of food value chains due to Covid-19, the impact of war and conflict on trade, food price inflation, high prices for energy and raw materials (fertilizer), accumulated debts, destruction of nature, and climate change. The lack of emission reduction in the agricultural sector was highlighted, while also pointing out great potential for climate change mitigation.[viii] Furthermore, concrete examples for the most cost-effective investments to reduce global hunger were introduced.[ix]

Experts made various concrete suggestions for both bilateral Sino-German action and coordinated international efforts to address both immanent crises (trade of food, supply of food, social protection and nutrition) and continue pursuing the long-term goal of transitioning to sustainable agriculture.[x] These included the reprioritization of agricultural support policies that

foster research and development for the production of nutrition-rich and low-emission food that benefits small scale farmers. But going beyond food prices, a broader policy approach and international coordination was pointed out as crucial. Policy dialogue around the core concepts of bioeconomy, bilateral and international trade, and a broader redesign of global food system governance was suggested.

23rd November: "Microchips of agriculture" – seeds as a foundation of food security

Public and private organizations shared their perspective on the German seed sector within the EU context and latest developments in the Chinese context. Seed breeding was discussed as a key ingredient to continue yield growth in the future. In light of limited environmental and human resources, as well as other challenges to food security such as population growth and dietary transition, new seed varieties promise yield growth that can no longer be achieved by land expansion or increase in agrichemical inputs. Especially new breeding technologies, most notably gene editing, was highlighted as an important contributor to fast and precise breeding of new varieties with desired characteristics. While industry representatives expressed their concern that restrictive regulations in Germany around gene editing might hinder its benefits being taken to market, the newly enabling research and policy environment in China for both research and marketization of new products was noted favorably. The need to communicate about new technologies and new products to both countries' publics as well as other stakeholders along the food value chain was noted. There was a keen interest on both sides to understand regulatory approaches to new breeding technologies and new products as well as conditions for market access and intellectual property protection in both countries.

Perspectives on challenges and opportunities

China: The Chinese government has put high political emphasis on developing the seed industry and biological technologies for seed breeding. It was strongly emphasized that the Ministry of Agriculture and Rural Affairs (MARA) made protection of new varieties a priority and that China was a member of the International Union for the Protection of New Varieties of Plants (UPOV). The newly amended Seed Law strengthened the protection of intellectual property rights in new plant varieties (PVR), which also includes essentially derived varieties (EDV) stipulations. The Supreme People's Court has further elaborated on the rights' interpretation and its relationship to farmers rights. Farmers will be allowed to use seeds on their own land for their own household consumption. Foreign companies' applications for PVR in China are noted favorably and said to be encouraged through increased breeder rights' protection as part of a wider enabling policy environment for the seed industry overall.

Many measures were initiated in support of its domestic seed industry. These efforts were underpinned by a national survey of germplasm resources, establishing gene banks and putting in place germplasm protection and utilization systems. Experts demonstrated the high technical sophistication in seed breeding with the examples of maize and wheat. However, the R&D investment of companies was still lacking behind leading international companies and greater synergies with public research institutions is encouraged. Improved protection of PVR, new administrative measures for the safety assessment of genetically modified organisms and support for biotechnology encouraged market vitality. MARA streamlined the application and approval for import and export of seeds through an online administrative platform, which aims to simplify and speed up the process. Furthermore, MARA exempted some seeds listed in the national catalogue from value added tax to encourage imports. Chinese seed companies are encouraged to aspire for international competitiveness and to go global.

Despite the strong emphasis on strengthening domestic seed breeders, it was also noted that no country could provide all seed varieties it needed to itself. Global collaboration via UPOV is important. For seeds in the national catalogue, foreign companies can apply for a seed production certificate and enjoy the tax relief. Great complementarity between Germany and China's seed industries was noted, highlighting the leading role of Bayer, BASF and KWS in biotechnology. While looking to diversity trading partners to avoid dependency, imports for especially rape seed and sunflower seed were earmarked as welcome. General support for promoting circulation of seeds across the world was expressed.

Germany: The Federal Plant Variety Office explained its role within German and EU-level testing and listing of new varieties. It works closely with UPOV and is engaged in bilateral exchanges with EU countries and internationally. Germany has about 60 domestic breeding companies, primarily for agricultural crops, but also for ornamental plants, fruits and vegetables. German breeders marketing their varieties abroad and foreign breeders marketing their seeds within Germany and the EU requires an efficient system for variety testing. On the technical level, this international cooperation is based on the UPOV system, which provides technical and administrative guidance, allows for the harmonized performance of tests and ensures the stability of the system. In this system, Germany provides results to more than 60 countries worldwide. The results are used to

protect plant breeders' rights in other countries or used in procedures for national listing. The UPOV statistics show that German applicants have applied for plant breeder rights for over 100 varieties in 2021. A national listing in one EU member state is the precondition for access to the European market. This is a system open for any breeder, though breeders from outside the EU need a representative in Europe. The requirement for new varieties to gain national listing is that they are distinct, uniform and stable, which is tested in stress tests in multi local trial in up to 15-30 locations in Germany. After the trials, the variety committee will decide about national listing. A new variety has to demonstrate an improved performance compared to existing varieties already on the market. The Federal Plant Variety Office then provides the official data of variety testing, which is a very important tool for breeder to place their variety on the market.

Further institutional representatives spoke about institutional settings for seed breeders in Germany and the wider EU context, while also emphasizing their integration into the wider UPOV system. The Wheat Initiative provided an example of an institution initiated to pool resources, support strategic research and foster communication between research communities, funders and global policy makers. It was founded in 2011 by an endorsement of Chief Agricultural Scientists of the G20 group of countries. China and Germany are both member countries, international research centers and private companies also involved. Representatives from the European Seed Association and the Federal Association of German Plant Breeders both elaborated on the contribution of established and new breeding technologies to yield growth, environmental sustainability and resilience in agricultural production. They stress the high level of investment into R&D across the variously sized breeding companies and their high speed of bringing new varieties to market. It was elaborated that Germany organized its seed breeding along a clear separation between state institution and breeding companies: basic research and method development in state institutions and universities, varieties being bred in private companies. They voiced concern that Germany's strict regulations around genetically modified organisms extends to genome editing. They advocated for a differentiated approach to facilitate global collaboration in R&D and trade. Also, Germany's specification of breeder's privileged and farmer's privilege as it related to the protection of intellectual property in line with UPOV was explained further.

24th November: Food security and food loss & waste

The reduction of food loss and waste[xi] is an important feature of food security policies in both China and Germany. China is focused on reducing food loss, especially at the harvest and post-harvest end of agri-food supply chains, while Germany's main challenge is to reduce food waste at the consumer end. However, both countries take a holistic view in assessing the potential for improvement that contribute to food security by reducing the pressure on yield growth through technological solutions, improved management and public outreach.

Perspectives on challenges and opportunities

China: The Chinese government has highlighted the reduction of food loss and waste since its action plan in 2012. It conceptualizes five stages for action: production and harvesting, storage, food transport, food processing, restaurant and consumption. The room for improvement is ample, with measures ranging from awareness building and education, to technical support and innovation, technical demonstrations and training, improved regulation and international sharing of experiences. China faces similar issues as other developing countries, who face highest losses in harvest, storage and processing. Harvest-level losses are highlighted as a particular concern in China and subject to a range of measures, such as switching out old machines, professionalizing machine operators and emphasis of quality over speed in harvesting practices. Especially the actual loss in corn harvests falls short of standards for machine loss. Storage is another major issue, where improved management of stocks, separation, classification and processing shows potential to reduce resource intensity and food loss across grains, fruit and vegetables. In particular cold chains and highly perishable goods such as meats and vegetables are of concern. However, food waste at the demand-side is also a topic in China. The government addresses this by public outreach and educational campaigns to raise awareness. It is noted that solutions found in the complex context of China's small scale agricultural production can benefit other countries through technological transfer and sharing of experiences.

Germany: The German government addresses food waste and loss in the context of EU frameworks. It defines the scope of the issue differently to China by not including losses before or during harvest and slaughter. Similar to other developed countries, Germany's main issue is food waste on the consumer end, especially in private households. But engagement of businesses

along the whole food value chain is practiced trying to include all relevant stakeholders. A joint body of the federal government aims to bring all stakeholders together to discuss the issue and refine the agenda. This is complemented by sector-specific dialogues across the food value chain that draw up specific measures together with businesses and civil society. These are used to follow up in practice by measuring and tracking, for example, in businesses that commit to take action and join a shared platform that benchmarks their progress. The benefit of avoiding loss as a business case is highlighted, since it can reduce company costs and improve their operations. Public outreach includes the campaign “Too good for the bin”, which aims to foster greater appreciation of food within households.

Experts share detailed examples of how assessment and improvement at the company level can be conducted in practice. Life-cycle assessment within companies demonstrate potential in monitoring sources of food waste and provide sustainability assessments for reduction measures. The goal is to reduce waste at low cost while providing ecological and social benefits, which are assessed quantitatively and qualitatively in close communication with specific companies. Smart agriculture, specifically precision horticulture, can employ sensor networks to provide farmers with information that contribute to reducing food loss by optimizing farm operations. New challenges of climate change impacts are highlighted that have practitioners face unfamiliar situations, such as changing requirements for irrigation or risk of sunburn on fruit in regions previously not affected by similar extreme weather events. Analysis of risks and ad hoc mitigation on the farm can reduce loss of quantity and quality of harvest, as well as help assessing produce characteristics to suggest suitable processing for different quality grades. The potential of publicly funded research to support low-cost, ready-to-use technological solutions for practitioners was highlighted. The example was the development of open-access models that, once developed, could be integrated into low-cost or free smart phone applications. Edge computing further allowed any collected data to stay on the farm.

25th November: Sino-German crop production and agrotechnology demonstration park project closing ceremony & Sino-German agribusiness conference

The week of bilateral exchanges between decisionmakers and experts concluded with the closing ceremony of the Sino-German Crop Production and Agrotechnology Demonstration Park Project. Project partners and representatives of Chinese and German agribusinesses exchanged experiences from past collaborative efforts and aspirations moving forward.

References

[i] The term "Three Rural Issues" (三农问题) refers to policy issues around agriculture, rural areas and farmers. For an introduction to the term and its usage in policy documents, see DCZ's terminology paper: https://www.dcz-china.org/2021/11/11/terminology-san-nong-wenti/

[ii] Taobao Villages refer to a cluster of users that engage in e-commerce via the platform Taobao, which is run by the company Alibaba. For an introduction to Taobao Villages in the context of rural e-commerce, see the brief report by Friedrich Ebert Stiftung https://indonesia.fes.de/e/en-taobao-villages-the-emergence-of-a-new-pattern-of-rural-ecommerce-in-china-and-its-social-implications

[iii] The term "Donut Village" (Donut-Dörfer) is used to refer to the phenomenon of villages with abandoned centers that continue being expanded with new construction at the edge. A similar term, "hollow villages" (空心村) is used for empty villages in China, though here the expansion at the edge is not included. Both phenomena are strongly linked to an aging rural population.

[iv] DCZ developed the website *Smart Agriculture*, which showcases "virtual study visits" that introduce 14 different research projects under the "Digital Experimental Fields" initiative launched in 2019 by the German Federal Ministry of Food and Agriculture (BMEL): https://smart-agriculture.org (available in English, German and Chinese).

[v] The definition for "food security" used most commonly at the international level was formulated at the 1996 World Food Summit. It encompasses four main dimensions that must all be met simultaneously, namely physical availability of food, economic and physical access to food, food utilization, as well as the stability of the other three dimensions over time. For a basic introduction to the term as used by the FAO, see https://www.fao.org/3/al936e/al936e00.pdf

[vi] Undernourishment and hunger rose again in 2020 and 2021, concluded the latest report Food Security and Nutrition in the World 2022 by the FAO. Projections estimate about 9 percent of the global population still facing hunger in 2030. For the full report, see https://www.fao.org/3/cc0639en/online/cc0639en.html

[vii] For a comprehensive introduction to the concept of "greater food view" (大食物观), see the recent DCZ terminology paper: https://www.dcz-china.org/2022/11/16/terminology-paper-da-shiwuguan-greater-food-view/

[viii] Food systems account for one third of all greenhouse gas emissions, but have great potential to mitigate emissions through reform, concluded the Emission Gap Report 2022 by UNEP. For the full report, see https://www.unep.org/resources/emissions-gap-report-2022

[ix] Research suggests that the global cost of drastically reducing world hunger by 2030 is about 50 billion dollars per year and calculated the expected reduction according to targeted investment into different areas. See the relevant publication: Chichaibelu et al. (2021) "The global cost of reaching a world without hunger: Investment costs and policy action opportunities", *Food Policy* 104: 102151. URL: https://www.sciencedirect.com/science/article/pii/S0306919221001299

[x] The notion of sustainability in food systems was variously elaborated upon, including the common reference to the UN Sustainable Development Goals (SDGs) and related normative definitions of food system transformation and the concept of strong sustainability. See for example: Braun et al. (2021) "Food system concepts and definitions for science and political action", *Nature Food* 2: 748-750. URL: https://www.nature.com/articles/s43016-021-00361-2 ; Neumayer (2011) "Sustainability and Inequality in Human Development" UNDP Human Development Reports, Research Paper 2011/04. URL: https://hdr.undp.org/content/sustainability-and-inequality-human-development

[xi] The FAO defines food loss as losses occurring on farms, during transport, in storage and during processing. For details on the FAO's Food Loss Index, see https://www.fao.org/platform-food-loss-

waste/food-loss/food-loss-measurement/en. The UNEP defines food waste as any substance intended for human consumption that is removed from the human food supply chain in retail, food service or households.. For the latest UNEP Food Waste Index Report 2021, see https://www.unep.org/resources/report/unep-food-waste-index-report-2021