Report on Sustainability in Agri-food Value Chains. Case Studies from The Mediterranean Regions and The Middle East.

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Introduction

Drawing on academic literature from environmental studies, global value chains, political ecology and international trade studies, this report presents five case studies on successful practices in agri-food value chains. This research field is very rich, and the cases do not aim to provide an extensive literature review. We selected specific examples from Mediterranean and Middle Eastern countries because their climatic conditions are comparable to, and share insights for farming crops and trees in Syria.

The idea underlying this report is to disseminate agri-food research from different disciplines, anticipating that a range of Syrian agricultural operators and policy makers may be interested in understanding opportunities that could be further developed, at this stage, in Syria, but also challenges faced by business and organisations from other countries.

The content of these case studies is linked to dimensions of the global value chain analytical framework. We undertook a systematic literature review focusing on the following topics.

1) Sustainability challenges concerning the use of the agricultural resources

It is critical to ensure efficient and sustainable resource use in global agri-food value chains, yet water scarcity and land degradation present significant challenges in agricultural systems. This case study focuses on ways in which land can be cultivated in a sustainable way. It examines a few examples, to understand the different ways in which water and soil resources are being managed in agricultural systems. We examined practices used to mitigate soil erosion in Cànyoles river watershed, Eastern Spain; reviewed studies that explored the effects of irrigation in an olive-growing region in Andalusia, Spain; and looked at water harvesting techniques, micro-catchment and mulching in pistachio plantations in Northern Jordan.

2) The role and power of agricultural producers in the value chain

Producer cooperatives and organisations can play an important role in local economic development and social cohesion. This case study examines forms of producer organisation and provides a review of the economic, environmental and social sustainability benefits and challenges associated with producer cooperatives and associations. It draws upon examples of olive oil cooperatives in Andalusia, Spain, highlights challenges in cooperatives in the Aegean region, Greece, and emphasises the role of charities and funders in promoting cooperatives for improving economic development (for example, Oxfam’s work in West Bank, Palestine).

3) The role of food standards in governing the global agri-food chains

The use of food standards in ensuring quality, safety and sustainability issues is discussed in this case study, drawing upon examples from GlobalGAP for fresh fruit and vegetables, Fair Trade Palestinian extra-virgin olive oil, and protected designation of origin (PDO) and EU–organic certification extra-virgin olive oil in Southern Italy. Different types of food standard are presented, including public, mandatory standards, public voluntary standards, legally-mandated private standards, and voluntary private standards.

4) Challenges and opportunities associated with agricultural by-products and waste

Globally, one third of food is lost or wasted from the points of production to consumption, and there is increasing awareness of the need to shift towards a resource-efficient economy (e.g. UN Sustainable Development Goal 12 on responsible consumption and production). This case study focuses on by-products and waste in global value chains, examining the examples of citrus waste in Southern Italy, pistachio waste in Greece and olive mill waste management in Mediterranean regions. These examples reveal the diverse ways in which by-products can be utilised and valorised, and the challenges and opportunities associated with current waste management practices.

5) The role of international trade and institutions in shaping and deepening global agri-food value chains

Trade agreements have important implications for how agri-food systems operate, and can constrain or enable the extent to which nation states implement food system-level actions for health and sustainability. This case study introduces the role of institutions such as the World Trade Organization (WTO), and the Food and Agriculture Organization of the United Nations (FAO), and examines trading partners and import rules, drawing upon the European Union, China, and Russia as examples. The economic, environmental and social sustainability benefits and challenges associated with international trade frameworks and institutions are discussed, including how trade frameworks align with the UN Sustainable Development Goals.

All the case studies consider the links between economic, environmental and social sustainability and the chosen topics, followed by reflections on how sustainable agricultural practices and organisations can support food security. A list of resources used and websites accessed is included in each case study.

We hope you will enjoy reading this Report and you will find it useful for further exploring these topics.

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Agricultural Resource Use

1.1. Introduction

Ensuring healthy soils and land in agricultural systems is fundamental to achieving the UN Sustainable Development Goals (SDGs) (Visser et al., 2019). A challenge underpinning the UN SDGs – including SDGs 2 (zero hunger) and 15 (life on land) – is the need to address and reverse land degradation, defined by the United Nations Convention to Combat Desertification (UNCCD, 1994) as: "*The reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or rangeland, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (1) soil erosion caused by wind and/or water; (2) deterioration of the physical, chemical and biological or economic properties of soil; and (3) long-term loss of natural vegetation".* Taking agricultural areas in the Mediterranean Basin as an example, a large proportion on which traditional citrus, olives, vineyards or almonds orchards are cultivated, are characterised by steep topography and at serious risk of degradation (Rodrigo-Comino et al., 2018). Frequent, intense rainfall interacts with steep slopes and large areas of bare soil that contribute to soil quality degradation, including aggregate stability, water retention, depleted nutrients, soil loss and loss of biodiversity (ibid.).

Developing countries face difficult challenges in meeting growing demands for food, water, and energy, further compounded by climate change (Rasul & Sharma, 2016). Climate change further exacerbates land degradation as water scarcity associated with global warming causes high vapor pressure deficit and evaporation reduces water availability for vegetation growth (Zhao & Running, 2010; Pereira et al., 2011). It is predicted that competition for water resources will become more severe as populations grow (Pereira et al., 2011). Given these important challenges, it is critical to explore solutions for ensuring efficient and sustainable resource use in global agri-food value chains. The focus in this briefing paper is on *water* and *soil/land* as agricultural resources, which affect and are affected by the use of agricultural inputs such as agrichemicals (fertilisers, pesticides), other additions to the soil, as well as seed/crop varieties. Managing land in a sustainable way requires a holistic approach that considers both bio-physical and socio-economic aspects with a long-term vision (Visser et al., 2019). Sustainable land management practices include the use of catch crops, mulches, and vegetation barriers (Giménez Morera et al., 2010). Integrated "nature-based solutions" such as the sustainable use and management of the soil-water systems are associated with healthier soil system, supporting land degradation neutrality by 2030 (Keesstra et al., 2018).

1.2. Case studies

Mitigating soil erosion in Cànyoles river watershed, Eastern Spain

Recently established drip-irrigation systems on the slopes of the Cànyoles river watershed trigger high erosion rates and soil degradation due to the lack of vegetation cover, soil compaction and low soil organic matter, which result from intensive ploughing, herbicide and fertiliser use. Soil erosion is also increasing due to new plantings of citrus orchards on slopes. A study examining straw mulching to prevent soil erosion found that it resulted in improved soil moisture, soil water infiltration, and reduced runoff. The application of straw for mulching reduced soil erosion by one order of magnitude: from 11.4 to 1.9 Mg ha^{-1} y^{-1} (Cerdà & González-Pelayo, 2018). The combined effect of the yearly use of straw and a no-tillage strategy resulted in a reduction of the sediment yield, and 11 years later soil erosion rates were two orders of magnitude lower than in the control plot (Cerda et al., 2017). However, Cerda et al. (2017) found farmers' attitudes towards straw mulching to be extremely negative due to its cost, at 1.9 times that of traditional tillage. An assessment of farmers' attitudes in the Cànyoles citrus production area also found resistance to catch crops or weeds, as they traditionally prefer weed-free farms ('clean soil') and are reluctant to take up no-till farming techniques (Cerda, 2018). However, the farmers were prepared to use of catch crops and weeds if subsidies were introduced (Cerda et al., 2018). An important constraint in moving from ploughing to no-till practices, straw mulching and the use of catch crops and weeds, is the lack of subsidies to incentivise farmers to adopt more sustainable land management practices (ibid.).

The effects of irrigation in an olive-growing region in Andalusia, Spain

Over the last 50 years, the irrigated land area in Spain has increased almost eightfold with the objective of increasing agricultural production (Rodríguez Sousa et al., 2019). Rodríguez Sousa et al. (2019) examined the effects of irrigation in Estepa, an olive-growing region of Andalusia, Spain. The results showed that although irrigation increases the productive level of the olive groves, the process of irrigation progressively alters the soil as compared with rainfed groves. Farmers may not necessarily benefit from increased production due to irrigation costs and a lower selling price associated with irrigated olive groves. Irrigation also alters the physical (soil compaction, increased humidity, lower gravel content, porosity and soil weight) and chemical (reduced organic matter and higher nitrate content) characteristics of the soil in ways that aggravate erosion. Rodríguez Sousa et al. (2019) conclude that the productive benefits of irrigation may be unsustainable in the long term, both ecologically and economically. Climate change is likely to further restrict water resources in the Mediterranean, limiting the long-term sustainability of irrigation in olive agroecosystems. Spatial planning and alternative management techniques are required that focus on soil conservation and efficient irrigation to ensure the environmental and economic sustainability of olive groves.

Water harvesting techniques, micro-catchment and mulching in pistachio plantations, Northern Jordan

Water harvesting techniques have shown promising outcomes in mitigating risks, increasing yields and delivering benefits to ecosystems (Tadros et al., 2021). Tadros et al. (2021) conducted a study in Northern Jordan to examine the effects of in-situ water-harvesting techniques, micro-catchment and mulching on soil moisture content, plant morphology, gas exchange, and midday stem water potential of young pistachio (*Pistacia vera cv. Ashori*) trees. This was examined in pistachio farms under rainfed conditions for two growing seasons. Vertical and horizontal gravel mulching (rather than straw or no mulching) and 36 m^2 micro-catchment (rather than 64 and 100 m^2 micro-catchment areas) were found to have the highest percentage increase in plant height. Vertical gravel treatment had the highest percentage increase in leaf numbers per tree. In addition, a 36 m^2 micro-catchment area was also optimal in terms of runoff efficiency. Overall, the combined water harvesting techniques, gravel mulching (vertical and horizontal) and the 36 m^2 micro-catchment hold promise for improving the morphology and physiology of young pistachio trees grown under rain-fed regime. Tadros et al. (2021) concluded that water harvesting can provide a supplementary source of water for the cultivation of pistachio, especially during drought periods. Furthermore, combined water harvesting techniques (mulching and micro-catchment) significantly improved soil water content, plant morphology and the physiology of pistachio trees.

1.3. Basic definitions for agricultural resource efficiency

Catch crops: fast-growing crops grown between successive plantings of a main crop.

No-till farming: a technique for growing crops without disturbing the soil through tillage (mechanical disturbance such as digging and stirring).

Micro-catchment areas: In-field systems of water harvesting consisting of small structures such as basins, pits, and holes. Such areas are designed to increase runoff from rain and concentrate it in a basin where it penetrates and is stored in the soil.

Mulching: A technique generally used to save water, suppress weeds and improve the soil around plants. Examples of materials use for mulching include straw, plastic, and gravel.

Riparian vegetation: The riparian zone links water and land, and vegetation planted or conserved in this zone can contribute to providing habitat connectivity, strengthening the banks of rivers and streams and preventing erosion, reducing flood risk and protecting water quality by reducing diffuse pollution.

1.4. Economic sustainability and agricultural resource use

Variations in soil management can substantially alter the quality and quantity of crops produced, such as seen in the case of olive oil production (Gómez et al., 2014; Sastre et al., 2017). The quality of the soil and its chemical and physical properties has significant consequences for economic development, particularly in regions and countries reliant on agricultural production for income and growth (Khaledian et al., 2017). It has been found that soil quality and properties can affect diets and the cost of living in the Mediterranean (Tekaya et al., 2016; Rodrigo-Comino et al., 2018). The use of vegetation cover is a cost-efficient treatment for soil erosion that is not always taken up. As found by Cerda and González-Pelayo (2018), a significant barrier to transitioning to more sustainable land management such as no-till practices, mulching and using catch crops is the lack of incentive for farmers, even if their longer-term economic sustainability is threatened by land degradation.

The increasing use of irrigation systems in regions means that farmers can produce vegetables and fruits at competitive prices, but overextraction of groundwater can result in the depletion of aquifers and reduction in water resources with associated social and economic problems. For example, in the case of the Cànyoles river watershed, water flows are insufficient to sustain the traditional spring-supplied irrigation by flooding (Cerda & González-Pelayo, 2018).

Visser et al. (2019) argue that sustainable soil management requires new knowledge to be effectively developed and synthesised, shared, organised and applied in practice. Facilitating knowledge flows between diverse stakeholders in soil management is critical. Practical measures for such knowledge exchange may include more translation of scientific papers into usable information for soil management, and translation of policy documents and stakeholder demands into scientific questions; and networks and communities of practice to facilitate knowledge flows (Visser et al., 2019).

1.5. Environmental sustainability and agricultural resource use

Well-managed soil can contribute to the SDGs. For example, soils can store carbon to mitigate climate change (SDG 13); healthy soils sustain biodiversity and terrestrial ecosystems (SDG 15), support the provision healthy food (SDGs 2 and 12) and clean water (SDG 14) (Visser et al., 2019). Keesstra et al. (2018) describe the use of nature-based solutions to contribute to sustainable system stewardship in agricultural settings. Solutions at the level of soil can include the use of cover crops and straw mulching brings many benefits. At the landscape level, nature-based solutions promote the disconnection of water and transfers across the landscape, such as vegetative buffer strips and riparian vegetation.

According to Visser et al. (2019), barriers to adoption of nature-based approaches in agricultural-land management often relate to the presence or absence of farmer

incentives. Subsidies, however, may also promote irrigation in dryland farming areas, or herbicide use with resulting land degradation. As importantly, lack of collective implementation measures across landscapes can limit the impact of individual land users. Holistic systemic approaches (e.g. at landscape or watershed level) that consider local context and culture are needed to address environmental sustainability in the use of agricultural resources. It is important that land managers have access to appropriate landscape-specific knowledge and the capacity and technologies to examine and anticipate the potential trade-offs of particular land management practices (Visser et al., 2019).

1.6. Social sustainability and agricultural resource use

In is undoubtedly critical to understand optimal management techniques for the use of sustainable agricultural resources from a biophysical point of view, but also social and cultural dimensions and the challenges associated with implementing particular management strategies. The perception of farmers can either support or impede the success of sustainable management plans. In Mediterranean landscapes, for example, there is significant social pressure to maintain clean soil, limiting the adoption of nature-based management solutions such as organic farming and the use of straw as a mulch (Visser et al., 2019).

At the same time, the impacts of climate change, land degradation and water scarcity pose significant social challenges for farmers and agri-food value chain actors more broadly. Horton et al. (2016) therefore proposed a framework for integrated solutions based on mapping agri-food systems, life cycle assessment, the free access of data to all stakeholders – all intended to encourage more democratised agri-food system, in which sustainability and resource efficiency are embedded. When policies are developed, farmers' views should be understood and taken into consideration to drive more sustainable practices that are sensitive to culture and everyday practices.

1.7. Agricultural resource use and food security

The absence of integrated decision-making across the agri-food system is arguably the single biggest obstacle to global food security (Horton et al., 2016). Climate change compounds the effects of this lack of joined-up governance; with highly differentiated impacts on food security between and within countries, increasing the vulnerability of people dependent on agriculture for their livelihoods. It is evident that effective adaptation to change requires the efficient use of land, water, energy and other vital resources, and coordinated efforts to minimise trade-offs and maximise synergies (Rasul & Sharma 2016).

Climate-smart agriculture (CSA) is an approach for transforming agricultural systems to support food security under conditions posed by climate change (Lipper et al., 2014). CSA emphasises the implementation of flexible context-specific solutions that are supported

by innovate policy and financing actions, and based on the coordinated actions of farmers, researchers, the private sector, civil society and policymakers towards climate-resilient pathways (ibid.). The CSA approach could support food security in the context of climate change, while increasing resource efficiency in agricultural production.

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1.9. Links

Climate-Smart Agriculture https://www.worldbank.org/en/topic/climate-smart-agriculture

RECARE: a multidisciplinary research project of 27 different organisations that assessed the threats to Europe's soils and identified innovative solutions to prevent further soil degradation: http://recare-hub.eu/

RECARE Case Study Experiment, Cànyoles River Basin, Spain, http://recare-hub.eu/case-studies/canyoles-river-basin-spain

United Nations Convention to Combat Desertification (UNCCD): https://www.unccd.int/

UN Sustainable Development Goals (SDGs): https://sdgs.un.org/goals

Producer Organisation: Cooperatives and Associations

2.1. Introduction

Agricultural cooperatives have substantial market shares in agri-food supply chains in western countries. For example, in 2010, cooperatives represented 40% of the agri-food sector market share in the European Union (EU) (Candemir & Duvaleix 2021). However, the market shares of cooperatives differ substantially according to sector and country. In the olive oil sector in 2010, the Spanish cooperatives' market share was 70%, while in Italy it was 5% (ibid.).

Producer cooperatives and organisations can play an important role in local economic development and social cohesion through their benefits to farmers, especially where no other economic organisations exist (Sánchez-Martínez et al. 2020). Cooperatives can also support more environmentally friendly practices (Candemir & Duvaleix 2021). Such organisations are important as individual farmers may not be able to build the value of their products or protect their products from large-scale distribution networks, and may not be able to stay up to speed with the technological change taking place in the whole food chain (Sánchez-Martínez et al. 2020).

Cultural, political and historical contexts are significant in the development and success of cooperatives. However, another important element of the institutional environment is the impact of the state in its role as regulator and supporter of cooperatives (Bijman & Iliopoulos, 2014). The first Spanish cooperatives appeared in the 1890s, but their numbers grew substantially after the 1906 Agrarian Syndicates Act was enacted, which meant that associated farmers were entitled to tax advantages. By the end of the nineteenth century, the Spanish Catholic Church began to pursue the goal of organising small farmers through cooperatives (Garrido, 2007). Garrido (2007) argues that the Church wanted to organise the small and medium farmers to keep them away from more radical social and political proposals, but took on an important business role in developing cooperatives. From a more contemporary perspective, the experience of EU countries shows that the weaker the cooperatives are the more the state is willing to support them (Ribašauskienė et al., 2019).

Due to their collective approach to bargaining, cooperatives have been an important component of socialist movements. According to Brusselaers et al. (2014), cooperatives in Eastern Europe are often associated with the communist era, which explains in part the unwillingness to develop and participate in cooperatives in Hungary, Lithuania, and Estonia. In Estonia, for example, the political and economic system relies on the principles of liberalism (due to experiences with communism), and commercial organisations that

are owned by foreign investors do not display an interest in establishing cooperatives (ibid.). As a result, the low number of cooperatives and lack of political and economic interest means that no institutional lobby exists in favour of cooperatives (Brusselaers et al., 2014). In other countries, cooperatives were developed as part of solidarity movements, and connected to international solidarity networks in response to neoliberal market regulation and the privatisation of state-run agencies (Bacon, 2013).

2.2. Case studies

Olive oil cooperatives in Andalusia, Spain

Olive oil cooperatives in Andalusia provide an interesting case study of innovative activities to support the survival of traditional practices in the region. In the context of falling average profit margins for small- and medium-sized farms in recent years, cooperatives have been seeking to improve efficiency in the management of agricultural work, in order to reduce costs. Innovations include incorporating new technologies, leading to higher quality products and improved value chain management efficiency. The success of these goals depends on training, particularly for the youngest farmers who migrate to urban areas due to perceptions of limited opportunities in rural areas (Sánchez-Martínez et al. 2020). Cooperatives create resilience in times of uncertainty and shocks, allowing small-scale producers to be better protected. In these ways, Andalusian olive oil cooperatives can contribute to making collective organisation competitive in an open market economy within global value chains.

Challenges in cooperatives in the Aegean region, Greece

In a study of cooperatives for mastiha, wine, olive oil and cheese in the Aegean region in Greece, Vakoufaris et al. (2007) found that first-degree cooperatives, which trade farm input supplies for their members, also provide other services such as handling paperwork relating to EU subsidies. Second degree cooperatives are engaged in the processing and standardisation of agricultural products, as well as in their trade and marketing. They also handle EU subsidies, and trade farm input supplies and machinery. According to Dodopoulos (2006), (cited in Vakoufaris et al. 2007), the overall debt of Greek cooperatives reached €840,000,000. Papadimoulis (2006, cited in Vakoufaris et al. [2007]) claims that this debt is partly due to the fact that in Greece, cooperatives are formed from above (by the Greek State), rather than bottom up, which would constitute an organised agricultural movement.

Cooperatives such as UVCL (Union of Vinicultural Cooperatives of Limnos) and the UACL (Union of Agricultural Cooperatives of Lesvos), are characterised by the inflexibilities of cooperatives: non-specialist employees, the inability to make quick decisions and respond to a changing market, inability to produce manufactured products and to effectively market and differentiate manufactured products and achieve good prices. The UVCS is characterised by a strong social cohesiveness, a high cooperative spirit, but also low

institutional support. In the case of olive oil, the workers of cooperative mills in the Aegean region have even claimed that they deliberately grade the quality of their farmers' olive oil as lower, in order to pay them less. By selling the olive oil at its true quality to other actors, they make an extra profit (Vakoufaris et al. 2007).

Oxfam's promotion of olive farmer cooperatives in West Bank, Palestine

Cooperatives are promoted by agencies and charities as an important pathway or condition for economic development, offering multiple advantages for smallholders such as collective action and the aggregation of resources, including joint storage, pressing and marketing. Oxfam's program "From Grove To Market: Supporting olive farmers in the West Bank" (Ismail, 2015) explicitly emphasised the need to strengthen and expand producer groups, and support for individual cooperatives to join together to create regional federations, thus supporting access to productive assets, product certification and markets otherwise closed to individual farmers. The programme aims to enhance the capacities of cooperatives and federations through coaching and organisational development support and by strengthening their capacity to manage various environmental, market, production and business risks.

2.3. Forms of producer organisation

Producer groups and associations jointly adapt the production and output of producer groups to market requirements; they consist of individual producers or individual producers and organisations (Vakoufaris et al. 2007).

Producer associations consist of recognised producer groups and pursue those groups' objectives on a larger scale. Producer groups may be defined as spontaneous collective actions of producers seeking to bypass the limitations of cooperatives (such as inflexibility and power struggles), to work with existing cooperatives, or to provide a joint solution to a problem experienced by producers in a particular area (Vakoufaris et al. 2007).

A cooperative is a voluntary group of individuals who derive mutual benefit from the coordination of production decisions, shared access to inputs, including seed, enhanced market power and more effective lobbying capacity (Di Falco et al. 2008). Their principles include democratic decision-making, equality and solidarity, differentiating them from different types of enterprise (Candemir & Duvaleix 2021). Fundamental features, distinguishing cooperatives from other economic organisations, are (i) the superiority of members' access to capital (Holmén, 1990; Birchall, 2003), and (ii) that collective rights prevail over individual rights (Marcis et al., 2019). In order to adapt to challenges posed by globalisation, cooperatives must be well-positioned to meet the requirements of international competition. Cooperatives have played a role in searching for technical solutions to lowering costs and boosting harvests, and incorporate qualification and diversification processes (Sánchez-Martínez et al. 2020).

- **first-degree cooperatives** trade farm input supplies for their members (Vakoufaris et al. 2007);
- **second degree cooperatives** engage in the processing and standardisation of agricultural products, as well as in their trade and marketing, as well as handling EU subsidies and trade farm input supplies and machinery (Vakoufaris et al. 2007).

How cooperatives' profits are spent is democratically decided by their members, or distributed to their members (Saarelainen & Sievers, 2011).

2.4. Economic benefits and challenges of cooperatives

Mainly concentrating on developing country contexts, many empirical studies have looked at the impact of farmers' cooperative membership on the productivity of farms, or on the incomes of farmers. The impact of cooperative membership has been shown to be dependent on farm size. Some studies (e.g. Hoken and Su 2018; Kumar et al. 2018) show that the relative impact of cooperative membership on farm income is larger for small-scale farms. This may be explained due to small-scale farmers' lack of bargaining power. Large-scale farms can derive benefits from cooperative membership due to economies of scale in processing and marketing activities.

In developed country contexts, research finds wider economic impacts of cooperatives such as impacts for non-members (through 'yardstick effects', whereby the presence of cooperatives in the market forces higher procurement prices for farmers' products) and mixed effects on quality requirements. Agricultural cooperatives generally pay more than the marginal values of the product, and can provide farmers with access to larger national and international high-quality markets, choosing different ways to signal the product quality to consumers and create product differentiation for them.

Despite these benefits, cooperatives have been criticised due to their poor economic performance (Candemir & Duvaleix 2021). As agricultural cooperatives have limited powers to restrict quantities supplied by farmers, who tend to oversupply because they do not bear the full marginal profit loss, which is shared at the level of the cooperative. Crucially, overproduction may occur when the cooperative is responsible for setting the final market price. As outputs are pooled in the case of cooperatives, low quality producers may benefit from average quality levels.

2.5. Environmental benefits and challenges of cooperatives

Several studies examine the role of cooperative membership in technology adoption and in the adoption of more environmentally friendly practices. Cooperative membership has been found to increase the probability of investing in organic amendment, and the adoption of green-control techniques including ecological regulation, significant biological and physical control and the **scientific** use of chemical pesticides.

By providing technical assistance and reducing transaction costs, agricultural cooperatives can help farmers to improve their productivity and their profits, reduce the

cost of production or adapt to specific quality requirements. Cooperatives, especially those in developing countries, may help farmers adopt innovations that decrease production costs or increase farm-level productivity. Such innovations may, in practice, have unintended adverse environmental impacts as a result of the intensification of agriculture through increased use of chemical fertilisers and pesticides.

2.6. Social benefits and challenges of cooperatives

Research suggests that being a member of a cooperative has a positive social impact, as 'non-price' factors provide greater incentives to stay in a cooperative than simply prices. Such factors include securing market access, providing information about the cooperative management and supporting farmers to meet market requirements.

Cooperative membership has been found to support on-farm employment. The resilience of cooperatives and their positive contribution to employment in times of crisis is well established (Brandano et al. 2019). Studies have found that cooperative membership allows female smallholders to improve their economic outcomes, develop skills and access decision-making. Figueiredo and Franco (2018) find that agricultural cooperatives in Portugal provide training and technical support and promote local development. Cooperatives can also contribute to public infrastructure and provide services to communities.

In order to benefit from cooperatives, members must demonstrate a willingness to participate. For example, in Greece, many farmers are members of a cooperative, but members are rarely consulted by the boards of these cooperatives. This may be due to a lack of awareness, amongst members, of the potential benefits of cooperatives, free-rider behaviour by members, and/or a lack of a willingness by board members to change. As a consequence, farmers do not fully participate in the cooperatives (Brusselaers et al., 2014).

2.7. Producer organisations and food security

According to Bacon (2015), state-led agrarian reforms and cooperatives had positive effects on food sovereignty[1], as increased access to land, markets, water, forests and pasture have reduced (but not eliminated) seasonal hunger in a study in Nicaragua. Cooperatives helped to create an institutional environment for Fair Trade certification.

Baiphethi and Jacobs (2009) argue that there is a need to significantly increase the productivity of subsistence/smallholder agriculture in order to ensure long-term food security. They argue that farmers will require a dramatic increase in the use of fertilisers, organic inputs and conservation investments, combined with well-functioning input and

[1] Food sovereignty being related to a political movement to secure "the right of peoples to democratically control or determine the shape of their food systems, and to produce sufficient and healthy food in culturally appropriate and ecological ways in and near their territory", and food security being the condition of access to adequate food. These terms are not conflicting but can be complementary (Bacon, 2015).

output markets to help farmers acquire and use improved inputs, market their (surplus) output and reduce transaction costs and risks (ibid). Other research, points to small-scale, agro-ecological farming in a cooperative environment as the most promising way to increase productivity on a sustainable basis, whilst simultaneously meeting local demands and empowering actors in value chains (Schultz, 2012).

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International Fund for Agricultural Development (IFAD). IFAD is an international financial institution and specialized United Nations agency based in Rome, the UN's food and agriculture hub: https://www.ifad.org/en/producer-organizations

International Cooperative Alliance. The International Cooperative Alliance aims to unite, represent and serve cooperatives worldwide. Founded in 1895, it is one of the oldest non-governmental organisations and represents 1 billion cooperative members: https://www.ica.coop/en

International Labour Organization. Inclusive Markets & Value Chains: The Inclusive Markets and Value Chains team supports ILO's work in achieving more systemic impact by applying the Market System Development approach to a wide diversity of sectors. https://www.ilo.org/empent/areas/value-chain-development-vcd/lang--en/index.htm

Oxfam GB Programme "From Grove To Market: Supporting olive farmers in the West Bank" https://policy-practice.oxfam.org/resources/from-grove-to-market-supporting-olive-farmers-in-the-west-bank-562212/

Food Standards

3.1. Introduction

The increasing globalisation of food production and consumption has posed significant challenges for national governments in the task of overseeing entire value chains, and identifying quality, safety and sustainability issues across borders (Garcia Martinez & Poole, 2004). As a result, global agri-food trade is governed by a range of standards and regulations that operate at different scales (Herzfeld et al., 2011). One group of food standards is developed by countries imposing regulations on imports, which are subject to the Agreements on Sanitary and Phytosanitary barriers (SPS) and Technical Barriers to Trade (TBT). Another group of food standards has emerged from action taken by retailers and other private global value chain actors. Such standards set requirements related to quality, safety and sustainability with which retailers, wholesalers and food service companies must comply (Herzfeld et al., 2011).

Over the last 20 to 30 years, private standards have emerged as important modes of market governance (Jaffee & Henson, 2004). They are considered as substitutes for inadequate public regulation, or responding to increasingly stringent regulation, or as a way of 'going beyond' public regulations to differentiate products in a credible way (Henson & Humphrey 2010). At the same time, standards related to certain forms of food production such as organic agriculture, fair trade, origin-based and quality can be considered as alternatives to productivist, industrial systems, and a way of bringing to mainstream markets social, economic and ecological relations that are fair and just (Pugliese et al., 2013; Hatanaka, 2010). Producers may adopt standards as they imagine opportunities to add value to their products and improve rural development livelihoods; while citizens rely on standards to address their concerns for food safety and quality, ecological sustainability, social justice, and cultural heritage (Pugliese et al 2013).

Food standards for governing agri-food systems are increasingly widespread and established and, given their power in global value chains and their governance, they raise important questions about the role of public and private institutions in ensuring food safety, food quality and the economic, environmental, social sustainability of the agri-food system (Henson & Humphrey 2010).

3.2. Case studies

GlobalGAP for fresh fruits and vegetables

GlobalGAP is a private standard that promotes good agricultural practices (GAP) on imports of fresh fruits and vegetables. It was established by the European Retail Working Group, originally an association of German, Dutch and British retailers. Since then, over

40 retailers, from 15 mainly Western European countries, require their suppliers to be GlobalGAP certified. Although the standard was originally established by European retailers, it developed a membership and governance structure that included significant producer representation (from within Europe and beyond) on both its technical committees and main board (Henson & Humphrey, 2010). The countries with the highest number of GlobalGAP certificates are Spain and Italy, both with more than 12,000, and Greece with more than 8,000 certified farms (Herzfeld et al. 2011). GlobalGAP is an "in-chain standard" that is not intended to be communicated to the consumer via product labels (Herzfeld et al. 2011). Monteiro and Caswell (2009) examined the GlobalGAP adoption behaviour of Portuguese pear growers and found that producers' orientation towards exporting and their involvement in producer organisations increased the probability of GlobalGAP certification. Across countries, GDP per capita is shown to be positively correlated with the number of GlobalGAP certificates that have been issued. Smaller countries are less likely to have any certified farms. Certification is highly influenced by previous trade relations, and farmers' participation in organisational innovation has been found to be negatively affected by poor quality national institutions (for example in the case of poor rule of law) (Herzfeld et al. 2011). The environmental benefits from GAP have been considered rather modest (Fuchs et al., 2009).

Fair Trade Palestinian Extra-Virgin Olive Oil

"Fairtrade means fairer pay and more power in the hands of farmers, so that they can create change for us all, from investing in climate friendly farming techniques and clean water for their community, to nurturing women leaders and making sure children get an education" (Fairtrade UK, 2021). Even if Palestinian olive oil meets international chemical and organoleptic tests for export, it is difficult for this oil to flow into foreign markets without fair trade accreditation. Through fair trade accreditation, consumers abroad are made aware of the harsh conditions faced by Palestinian farmers and how these are being tackled through fair trade (Meneley, 2014). In response to this challenge, there have been numerous initiatives to support farmers. Standards have been used to grow and add value to the Palestinian olive oil industry and make new distinctions for olive oil, organoleptic tasting practices, organic certifications, Denomination of Protected Origin (DOP) and ethical consumerism through fair trade strategies that seek to connect producer and consumer (Meneley, 2014). Meneley (2014) finds that these practices are aimed at an international audience and consumers who are encouraged to engage in the "taste of solidarity" with Palestinian farmers. Palestine's biggest agricultural NGO, **Palestinian Agricultural Relief Committee (PARC),** founded in 1983 and **Canaan Fair Trade LLC,** founded in 2004, have made significant investments in supporting farmers to attain fair trade certification from international accreditation bodies (Fairtrade Labelling Organization (FLO)) and from local bodies (such as the Palestinian Fair Trade Association (PFTA)) (Meneley, 2014). It has been important to connect the Palestinian farmers with fair trade networks internationally – for example, PARC is a member of IFAT (The International Fair Trade Association) and has partnerships with fair trade organisations and solidarity

movements in Europe, the United States, Canada, and Japan. Another company, **Zaytoun,** connects Palestinian farmers with UK consumers through fair trade certification (achieved in 2009). It is a “Community Interest Company” whose profits are reinvested into its mission of supporting Palestinian farmers through fair trade.

Central-southern Italy: Consumers of protected designation of origin (PDO) and EU–organic certification

Organic farming aims to produce food using natural substances and processes, encouraging the responsible use of energy and natural resources, biodiversity maintenance, enhancing soil fertility, maintaining water quality and preserving regional ecological balances (European Commission, 2021a). The EU sets out rules and regulations governing the production, distribution and marketing of organic products in the EU (ibid.). For trade of organic products with countries outside the EU, there are specific requirements depending on the countries of origin. Key principles in organic farming include the prohibited use of Genetically Modified Organisms (GMOs) and ionising radiation, and limited use of artificial fertilisers, herbicides and pesticides. According to EU rules, organic food and feed products must be processed separately from non-organic products, a minimum organic content of 95% of organic agricultural ingredients is required (with strict conditions for the remaining 5%), clear rules on labelling and on which products can use the EU organic logo, and specific limits to the substances, additives and processing aids for product processing (European Commission, 2021b).

Spognardi et al. (2020) investigated the behaviour and the habits of the consumers from central-southern Italy in relation to extra olive oil consumption, focusing on the impact of protected designation of origin (PDO) and EU-organic certification on purchase intention and quality perception. Through a comparison of three Italian samples: (1) an extra-virgin olive oil without certification, (2) an organic extra-virgin olive oil and (3) a PDO extra-virgin olive oil, the study found that people interviewed prefer local olive oils and are positively influenced by PDO/organic certification. Price was not a decisive factor for purchasing choices. The implications of this study are that information campaigns could help consumers to distinguish products, correctly identify food attributes and overcome skepticism towards the quality of organic products (Spognardi et al., 2020).

3.3. Types of food standards

In many agri-food value chains, public regulations and private standards operate simultaneously (Henson & Humphrey 2010). For example, private standards may include criteria for producers and other value chain actors to demonstrate legal compliance, and public regulations may include requirements based on private standards and certification (for example the EU Timber Regulations refer to Forest Stewardship Council certification). This interaction between public and private standards can be beneficial, as industry and firms are highly knowledgeable regarding product quality, and public regulation can generate reputation-based incentives to monitor quality (Garcia Martinez & Poole 2004).

Henson and Humphrey (2010) distinguish between the following types of public and private standard that, in practice, interact in global value chains:

1. Public mandatory standards: More accurately (and commonly) referred to as 'regulations'. These can be enforced through criminal and/or administrative action by regulatory authorities.

2. Public voluntary standards: Standards created by public bodies but whose adoption is voluntary, or 'optional laws' (Brunsson & Jacobsson 2000). An example of this is the French Government's 'Label Rouge' food (and unprocessed agricultural product) quality assurance standard.

3. Legally-mandated private standards: Standards developed by the private sector which are then made mandatory by public bodies.

4. Voluntary private standards: Standards developed and adopted by private bodies. These may be enforced by third party certification to demonstrate independence and credibility (Hatanaka et al. 2005). Such voluntary private standards may include:

- **Individual firm standards** such as 'From Field to Fork' by UK retailer Marks & Spencer, and 'Shared Planet' by Starbucks.
- **Collective National Standards** such as Assured Food Standards (Red Tractor) and RSPCA Assured UK in the UK, and the German QS Qualität und Sicherheit assurance standards for food safety and quality.
- **Collective International Standards such as** GlobalGAP, British Retail Consortium, Marine Stewardship Council, Rainforest Alliance, IFOAM for organic products, and SA 8000 (the international certification standard for social accountability covering companies, factories, and farms).

Private adopters of standards, such as supermarket chains, can compel compliance with standards by encouraging other private entities to implement these standards, such as food processors and agricultural producers they are sourcing from. Through the market power of the initial adopters, standards can become *de facto* mandatory for producers and processors to access important markets (Henson & Humphrey 2010). Coordinated supply chains require members not only to belong to industry-led assurance schemes but also to meet the additional costs of complying with proprietary specifications, safety and quality requirements (Garcia Martinez & Poole, 2004).

Not all standards are 'top down' and driven by government or powerful retailers: producer groups and organisations develop standards 'from below' to differentiate products based on particular production systems (e.g. organic production, high animal welfare), or produced in particular regions (Henson & Humphrey 2010).

3.4. Economic benefits and challenges of food standards

The positive opportunities from the adoption of private agri-food standards are associated with product differentiation and added value to products, as firms can communicate product attributes to customers that set them apart from their competitors (Henson & Humphrey, 2010). Such product differentiation can be seen in the trend towards quality-based competition in agri-food markets (Busch & Bain, 2004), particularly evident in the case of coffee (Ponte, 2004). Another important benefit of food standards is the prevention of safety risks in value chains in response to food crises such as salmonella, dioxins and BSE (Bovine Spongiform Encephalopathy). Standards have emerged that improve the traceability of global value chains, which is critical for identifying the sources of food safety risks, developing appropriate responses and securing consumer trust (Fuchs et al., 2009).

For poorer countries, integration into global markets is considered to offer the potential for more rapid growth and poverty reduction (Garcia Martinez & Poole, 2004). Private standards may act as catalysts of processes of upgrading in developing countries and/or competitive positioning in international markets (Jaffee and Henson, 2004). Studies have also found positive evidence of smallholder market integration through third-party certification in African countries, e.g. Maertens and Swinnen (2009) and Minten et al. (2009).

However, there are concerns that retailer driven standards increase the inequality within countries, between farmers that are able to comply and those that are not (Herzfeld et al. 2011). Although food standards have been promoted to secure market access, they may in fact create a new trade barrier for agricultural producers in developing and transition countries, excluding small farmers and/or farmers in developing countries from European and North American export markets who are unable to comply with standards (Ponte, 2008). This may be particularly pronounced for countries without current trade relations (Herzfeld et al., 2011).

Garcia Martinez and Poole (2004) found that the lack of a harmonised approach to food safety and quality among European retailers may result in a ‘compliance gap’ for developing Mediterranean exporting countries, depending on the nature of destination markets and the supply chain chosen to deliver their products. More critical perspectives consider that Western company-led standards are reproducing colonial food relations (Campbell 2005).

3.5. Environmental benefits and challenges of food standards

Most retail standards aim to ensure whole-chain food quality and safety, and many standards also cover environmental and social sustainability requirements (Fuchs et al., 2009). Environmental requirements include pollution prevention, use of energy, water and other natural resources, recycling and reuse of material, and emissions (ibid.). For environmental and social standards, process standards are more important than product standards as it is the process of production or operations that have the associated

environmental and/or social impacts. Requirements of organic production standards, for example, include the prohibited use of conventional pesticides, artificial fertilisers, ionising radiation and food additives, or antibiotics and growth hormones for animals (Fuchs et al., 2009). Some studies argue that the organic sector is moving away from its original 'bottom up' alternative food movement positioning (Buck et al., 1997), with strong corporate actors attempting to dilute standards (Jaffee & Howard, 2010).

International standards such as GlobalGAP pay some attention to environmental and social issues, but compliance with environmental and social requirements in the GlobalGAP is voluntary or recommended, so in practice non-compliance does not constitute a threat to the supplier (Fuchs et al., 2009). According to Van der Grip et. al. (2005), GlobalGAP's emphasis on various sustainability issues within the initiative has gradually decreased since its establishment, turning into a programme primarily focused on food safety.

3.6. Social benefits and challenges of food standards

Standards cover multifaceted social sustainability issues such as workers' rights, migration, rural livelihoods, gender issues and food security (Fuchs et al., 2009). Social requirements, such as worker welfare, gender non-discrimination and rules against sexual harassment, are included in mainstream standards (e.g. Ethical Trading Initiative) and in companies' codes of conduct (e.g. Chiquita Code of Conduct). However, it has been argued that their scope is limited as they apply only to the regular employment force, rather than adequately covering "flexible" seasonal work or "informal" work (Fuchs et al., 2009).

Small farmers face high costs of implementing new private standards, especially documentation and certification costs (Hatanaka et al. 2005). While some workers may benefit from new management practices that give increased responsibility to an elite group of workers, an increasing share of the population may be disadvantaged (Van der Grip et al. 2005). Although some social benefits are observed from private standards, Fuchs et al. (2009) argue that opportunities tend to exist only for a small subset of suppliers, receiving capacity-building support from NGOs, development or multilateral agencies.

3.7. Food standards and food security

Few studies have explicitly examined the links between food security, certification and standards. Schleifer and Sun (2020) explore the impact of sustainability certification on food security in developing countries, identifying three main causal mechanisms to guide their analysis – economic, land use and land rights, and gender effects – that link certification to local food security. Schleifer and Sun found that existing research points to a positive (but weak and very context-dependent) relationship between certification, farmers' income, and food security. If certification increases farmers' productivity, it can make more food available for consumption and, if environmental conditions are improved

on farms, food may be available in the longer term. However, Schleifer and Sun (2020) emphasise that certification standards do not necessarily lead to higher yields or better conditions and may have negative outcomes in some contexts (de Fries, 2017). Certification may impact on individual or household access to food by changing their income or land rights and, as a result, their access to food. Sustainability certification may also affect food security by changing food quality and safety. Unfavourable weather conditions, political instability, or economic factors such as unemployment and rising food prices, can all be a source of food instability. Sustainability certification can bring uncertainty to producers' income if price premiums are not ensured, but sustainability standards may increase climate resilience of agricultural production and improve food stability in the longer term (Schleifer & Sun, 2020).

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3.9. Links

Fairtrade International (product-oriented multistakeholder group aimed at promoting the lives of farmers and workers through trade. Fairtrade's work is guided by a global strategy) https://www.fairtrade.net/

Fair Trade Organisation UK https://www.fairtrade.org.uk/

GlobalGAP https://www.globalgap.org/

ISEAL Alliance (global membership organisation for credible sustainability standards) https://www.isealalliance.org/

IFOAM -Organics International https://www.ifoam.bio/

United Nations Forum on Sustainability Standards https://unfss.org/

Zaytoun, Community Interest Company founded to support Palestinian farmers https://zaytoun.uk/about/

By-Products and Waste Management

4.1. Introduction

Agricultural waste can be considered unwanted waste produced during agricultural activities (e.g. manure, oil, silage plastics, fertiliser, pesticides and herbicides) (Ramírez-García et al., 2019). Fruit and food waste are also generated during agricultural production and agro-industrial processing, transportation and storage (Torres-Leon et al., 2018). Fruit by-products, such as bagasse (fibrous material following crushing), peels, trimmings, stems, shells, bran and seeds, account for more than 50% of fresh fruit (Ayala-Zavala et al., 2011). The generation of by-products and waste has important environmental, economic, and social sustainability impacts, contributing to greenhouse gas emissions and, when sent to landfill, waste can result in environmental problems due to microbial decomposition and leachate production and, in turn, lead to health impacts (Torres-Leon et al., 2018). Management of agricultural waste is costly, so realising ways to reduce and effectively manage existing waste streams presents a significant economic opportunity for the agricultural sector. For example, Boudi et al. (2016) identify the possibility of reviving the processing industry and recycling industrial waste in the olive oil sector in Algeria as an important opportunity for supporting sustainable development.

Increasing awareness of the need to shift towards a resource-efficient economy – embedded in UN Sustainable Development Goal 12 on responsible consumption and production – is stimulating the development of bioeconomy strategies (Raimondo et al., 2018). Bioeconomy refers to economic, environmental, and social activities combined with the production, yield, transport, pre-processing, conversion and use of biomass to produce bioenergy, bioproducts, and biofuels (ibid.). The notion of a bioeconomy is promoted on the basis of opportunities to support environmental and economic sustainability by championing job creation and reducing dependence on fossil fuels (Raimondo et al., 2018). In this context, the transformation of agricultural waste and by-products into value-added products, for participants throughout the supply chain, is part of a bioeconomy strategy and generates new market and non-market values (ibid.).

4.2. Case studies

Citrus waste management in southern Italy

Although citrus waste management is a major issue for rural development, Raimondo et al. (2018) argue that citrus waste represents a potentially unexploited resource for sustainable development in rural areas. By examining the preconditions for developing an innovative and sustainable citrus by-product supply chain, these authors examined (i) current citrus waste-management practices in Southern Italy, (ii) determinants and barriers affecting decisions in citrus-waste management, and (iii) preferences of citrus processors with participation contracts in a co-investment scheme. Raimondo et al. (2018)

focused on the management of *pastazzo* (citrus waste) that makes up 50-60% of citrus production volume. *Pastazzo* is mainly composed of water (75–85%), mono- and disaccharides (6–8%), and some limited amounts of oils in peel waste. *Pastazzo* management presents a major issue for citrus processors due to the high costs incurred for pre-treatments before its disposal - the essential oils pose environmental risks if not treated. Globally, a small percentage of this waste is recycled to obtain essential oils that can be used in the cosmetic, food and pharmaceutical industries (Torres-Leon et al., 2018). Technological innovations that aim to convert potential environmental hazards into a valuable resource, have been developed to valorise *pastazzo*, including pectin extraction, dietary fibre extraction, biogas production, ruminant feed and essential oil extraction (Raimondo et al., 2018).

The results indicated that one of the main criteria for choosing alternative valorisation pathways is the distance between the citrus processors and the citrus by-products plant. A multifunctional plant should be as close as possible to the companies to enhance entrepreneurs' willingness to valorise *pastazzo* at an industrial level. The return from each alternative, such as cattle feed pellets, essential oils and biofuels production, may influence the propensity to invest in multifunctional plant. Guaranteed capital, a short-term contract and reduced risk, are characteristics that improve entrepreneurs' willingness to co-invest in the development of a multifunctional citrus waste plant (Raimondo et al., 2018).

Pistachio waste in Greece

Harvested pistachio nuts are covered with organic outer pericarps (hulls) and endocarps (shells) which are removed during the processes of de-hulling and shelling (Bartzas & Komnitsas, 2017). In Greece, 7000 tons of pistachio waste are disposed of annually (Komnitsas et al., 2015). The dominant waste management option currently used for hulls and shells is on-farm dumping/uncontrolled disposal, even though this is considered illegal under the Waste Framework Directive 2008/98/EC (Bartzas & Komnitsas, 2017). Bartzas and Komnitsas (2017) argue that pistachio farmers have traditionally adopted this inappropriate approach due to the high cost of transport, lack of adequate farm waste treatment facilities, convenience and lack of scientific knowledge and guidance.

Such disposal causes serious environmental problems and the development of alternative and more sustainable waste management practices is an important concern in the pistachio production sector, which has led to considerable attention being given to the production of compost and biochar from pistachio waste (Bartzas & Komnitsas, 2017). The production of compost and biochar has been considered a possible strategy for improving soil quality and productivity, sequestering soil carbon and mitigating greenhouse gas emissions (Mohammadi et al., 2016). In a study examining the use of pistachio by-products and waste in Greece, Bartzas and Komnitsas (2017) concluded that application of compost and biochar (rather than the use of chemical fertilisers) offers

significant environmental benefits. Beyond these environmental benefits, the reuse and recycling of agricultural residues can also provide additional income to farmers due to the achievement of higher yields (Bartzas et al., 2015).

Olive mill waste management

Olive mill waste is a significant environmental problem in Mediterranean regions (Berbel & Posadillo, 2018), as such waste is generated in vast quantities over short periods of time (Roig et al., 2006). Olive mill wastewater has been considered the most polluting and problematic form of waste produced by olive mills in all Mediterranean countries, as high phenol, lipid and organic acid concentrations make waste phytotoxic (ibid.). However, this waste contains a large proportion of organic matter and a wide range of nutrients that could be recycled and constitute a valuable resource (Roig et al., 2006). A range of methods exist for the valorisation of olive mill waste, including second oil extraction, combustion, gasification, anaerobic digestion, composting and solid fermentation (Roig et al., 2006). According to Tamborrino et al. (2020), stone recovery in the olive oil extraction process can provide an opportunity to increase both incomes and environmental sustainability, by improving the quality of extra virgin olive oil and by providing a higher quality stone to be used as a biomass fuel. Berbel and Posadillo (2018), also examining olive oil by-products, classified waste management alternatives according to a 'bioeconomy value pyramid' where they prioritised higher value uses with lower volumes (such as use in pharmaceuticals, food and feed) over the current energy and compost valorisation. Despite these noted benefits, Roig et al. (2006) found that the most suitable valorisation strategy depended on the social, agricultural or industrial environment of a particular olive mill.

4.3. Basic definitions related to by-products and waste

Anaerobic digestion: a process – in the absence of oxygen – by which organic matter (e.g. animal or food waste) is broken down to produce biogas and biofertiliser.

Biochar: a carbon rich product with a porous structure that can be produced through pyrolysis of biomass from a variety of agricultural waste and residues (Komnitsas et al., 2015).

Bioeconomy: economic, environmental, and social activities combined with the production, yield, transport, pre-processing, conversion, and use of biomass to produce bioenergy, bioproducts, and biofuels (Raimondo et al., 2018).

Lifecycle assessment (LCA): a methodology used to identify, quantify and evaluate the potential environmental, human health and resource scarcity impacts of any product or process over its entire life cycle, from raw material acquisition to production, use, end-of-life treatment, recycling and/or ultimate disposal (Bartzas and Komnitsas, 2017).

Phytotoxicity: a delay of seed germination, inhibition of plant growth or any adverse effect on plants caused by specific substances (phytotoxins) or growing conditions (Blok et al., 2019).

4.4. By-products and waste: economic sustainability benefits and challenges

A significant adverse economic impact of by-product and waste production relates to the costs of handling solid waste in landfills (Torres-Leon et al., 2018). Innovative and resource-efficient uses of food waste and by-products – either as raw materials or food additives – could contribute important gains for industry and deliver nutritional and health benefits, and address these negative economic impacts.

Boudi et al. (2016) propose that an important opportunity for the olive oil industry is the use of by-products for: pomace oil (human consumption or industrial use); cattle feed (leaves and twigs, pomace, water residue, unicellular proteins, etc.); biofuel/energy (burning prunings, hulls, pomace); particle board (hulls, chipboard); fertilisers (water residues, pomace); and the production of furfuraldehyde, phenols and polyphenols for the pharmaceutical industry and cosmetics. Exploring these options could help provide added value to olive oil production, increasing processing industry margins (Leonetti et al., 2009). The suitability of the use of particular by-products, however, depends on the agricultural products in question, as well as environmental conditions (i.e. not all by-products will be suitable for use as fertilisers or biofuels). Therefore, further research, innovation and training are needed to support optimal use of by-products in ways that generate value for agricultural producers.

There are barriers to providing the technologies and infrastructure to process waste and by-products in a sustainable way and, in some cases, even traditional waste management facilities (e.g. landfill) are limited. In the case of pistachio waste management, Bartzas and Komnnitas (2017) found that no landfill sites or mechanical-biological-treatment facilities existed in the study region, so solid waste needed to be transported via 18 miles of sea transport and 24 km of road transport using heavy-duty trucks, resulting in significant economic costs.

4.5. By-products and waste: environmental sustainability benefits and challenges

The food sector faces important challenges: the depletion of renewable resources, reduction in land for cultivation, continuous population growth, and waste production (Torres-Leon et al., 2018). Therefore, the use of waste and by-products in agri-food value chains provides an important resource-efficiency opportunity contributing to the UN Sustainable Development Goals.

In the case of olive oil production, substantial quantities of waste are produced with high levels of phytotoxicity, with negative consequences on soil microbial populations on land (Paredes et al., 1987), aquatic environments (DellaGreca et al., 2001) and air quality (Rana et al., 2003). Boudi et al. (2016) found that olive oil mills in Algeria dispose of liquid

extracts directly into sanitation systems, ending up in Wadi flows (seasonal streams). Pomace are thrown away after a period of storage on the Wadi beds and then burned. Although there have been some measures and taxes imposed by agricultural services to reduce these practices, the impacts of such interventions have to date been insufficient and inconsistent. There is a critical need for guidelines to manage this waste through technologies that minimise their environmental impact and support sustainable resource use.

One useful methodology for understanding – and seeking to improve – the environmental profiles of food products, is lifecycle assessment (LCA), which is used to identify, quantify and evaluate the potential environmental, human health and resource scarcity impacts of any product or process over its entire life cycle, from raw material acquisition to production, use, end-of-life treatment, recycling and/or ultimate disposal (Bartzas & Komnitsas, 2017). LCA can support the identification of opportunities for improvement, or the comparison of alternative farm management options at the farm or wider landscape level (Bartzas et al., 2015; Kendall et al., 2015).

4.6. By-products and waste: social sustainability benefits and challenges

Social impacts related to by-product generation and waste management include environmental impacts that influence human health and wellbeing. Furthermore, food waste poses an ethical dilemma given the problem of global food security. Torres-Leon et al. (2018) argue that the use of residues and by-products in the formulation of novel foods has direct positive impacts on local communities by improving nutrition and health (see section 7). Valorisation of waste streams can reduce waste accumulation, as well as provide new economic opportunities for farming communities (Torres-Leon et al., 2018), thus supporting social wellbeing.

The use of technologies to optimise by-product and waste reuse, and valorisation, may provide opportunities and challenges for local producers and value chain actors. On the one hand, there may be job opportunities in operating sustainable waste management facilities, but on the other hand, labour may be scarce in certain contexts, and changes to livelihoods and working patterns may have unforeseen social and environmental impacts.

4.7. By-products, waste and food security

Torres-Leon et al. (2018) found that although high levels of waste and by-products causes negative environmental impact and high economic costs, such biomaterials (including proteins, lipids, starch, micronutrients, bioactive compounds, and dietary fibres) have strong potential for generating food additives that can minimise malnutrition and hunger in countries of production. Globally, around nearly 690 million people are hungry and close to 750 million are exposed to severe levels of food insecurity (FAO, IFAD, UNICEF, WFP & WHO, 2020), so more composite nutritional sources are needed (Torres-Leon et al. 2018).

Biomaterial use could support food security by improving resource efficiency and ensuring the sustainable use of natural resources. However, it is important to note that food security is a broader issue of equitable distribution that in certain geopolitical contexts is partially addressed through urgent humanitarian aid, rather than being an issue of adequate by-product use and production inefficiency improvements. Efficiency improvements can certainly contribute to reducing environmental impacts, increasing value for producers and reducing waste disposal costs, but broader structural conditions and institutional support need to be considered for securing long-term food security and resilience across agri-food value chains.

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4.9. Links

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International Trade Frameworks and Institutions

5.1. Introduction

As noted by Saha et al. (2020), there is a need to better understand how political processes and institutions affect trade policy, and the potential for policies to support sustainable development, including resilient livelihoods and food security. Despite economists' commitment to free trade, certain forms of trade protection such as tariffs, subsidies, quotas and regulations are common (Saha et al., 2020). There is increasing recognition of the need for inclusive and progressive trade policies linked to transparent trade negotiations, frameworks, institutions and governance, as well as trade support mechanisms. Inclusive innovation in trade requires meaningful interactions across states, markets and society, to ensure ownership and transparency in trade agreements, and to better protect consumers, workers, and regions that are frequently marginalised in current trade discussions (ibid.).

Trade agreements have important implications for how agri-food systems operate and can constrain or enable the extent to which nation states can implement food system-level actions for health and sustainability (Friel et al., 2020). Furthermore, trade can have complex and indirect impacts when goals are different and competing (Amos & Lydgate, 2019). Currently, international agreements to liberalise trade are binding, but efforts to address malnutrition and climate change are non-binding, so there are risks that trade may hinder progress towards addressing these challenges (Friel et al., 2020).

5.2. Trade frameworks and institutions: definitions

Regional trade agreement (RTA) is a treaty between two or more governments that define the rules of trade for all signatories. Examples include North American Free Trade Agreement (NAFTA), and the European Union (EU).

World Trade Organization (WTO) is a global international organisation dealing with the rules of trade between nations. Develops WTO agreements that are negotiated and signed by the world's trading nations and ratified in their parliaments. The WTO replaced the General Agreement on Tariffs and Trade (GATT) in 1995, which was the first worldwide multilateral free trade agreement designed to remove tariffs and increase international trade.

Food and Agriculture Organization of the United Nations (FAO) is a specialised agency that leads international efforts to defeat hunger.

UNCTAD is a permanent intergovernmental body that is part of the UN Secretariat. It supports developing countries to access the benefits of a globalised economy more fairly and effectively, and aims to equip them to deal with the potential drawbacks of greater

economic integration. UNCTAD provides analysis, facilitates consensus-building, and offers technical assistance.

Sanitary and phytosanitary (SPS) agreement covers the domain of food safety, animal health and plant pests and diseases. Signatories must have SPS regulations for imported products that are the same as for domestically produced goods.

Technical barriers to trade (TBT) agreement is designed to discourage the creation of nontariff trade barriers and covers specific technical requirements (e.g. labelling, packaging) that could risk reducing global trade. As with the SPS agreement, there should be consistency between products for the internal market and imported products. The TBT agreement is intended to discourage delays at ports of entry by harmonising technical requirements.

Agreement on trade-related intellectual property (TRIPs) is designed to harmonise intellectual property rules globally. There was a scandal relating to the granting of a patent for turmeric, a spice used in India for centuries, that illustrated the problems associated with TRIPs (Marshall & Bagla, 1997). Although the patent was overturned, the agreement has been associated with providing a considerable advantage to firms in industrialised nations.

Dispute settlement process (DSP) allows all nations to bring complaints, but as this is an expensive process, the DSP has been criticised for being biased against poorer nations.

5.3. Case studies: Trading partners and import rules

European Union

The top five countries from which European Union imported goods in 2018 were China (US$ 465,022 million), the United States (US$ 313,541 million), the Russian Federation (US$ 179,625 million), Switzerland (US$ 128,625 million), and Turkey (US$ 89,613 million) (WITS, 2018a). According to the European Commission (2021), the EU: (1) has import taxes that are among the lowest in the world, (2) is the most open to developing countries (excluding fuels) it imports more from developing countries than the US, Canada, Japan and China combined, granting developing countries many duty exemptions under a variety of agreements (Bureau & Swinnen, 2018). Both exports and, increasingly, imports are critical to economic growth and job creation, as raw materials and intermediate goods are needed for production processes (European Commission, 2021).

The EU has a range of policies related to UN Sustainable Development Goal 12 on ‘Responsible Consumption and Production’, including: the Investment Plan for Europe, Circular Economy Agenda, food waste, biodiversity policies and private sector development, including sustainable and responsible supply chains, promoting transition

to a greener economy in partner countries, implementation of multilateral environmental agreements by developing countries, and rules to combat illegal, unreported and unregulated fishing (Amos & Lydgate, 2019).

The EU helped to create a rules-based international trade regime under the WTO (Bureau & Swinnen, 2018). Although the EU was reluctant to contemplate the elimination of export subsidies, it has played a more constructive role in recent years in their removal (ibid.).

China

China's top five import partners are Korea (US $204,566 million), Japan (US$ 180,401 million), 'other' Asian countries (US$ 177,346 million), United States (US$ 156,004 million) and Germany (US$ 106,257 million) (WITS, 2018b). Since China joined the WTO in December 2001, companies seeking to engage in import trade only need to register with the Ministry of Commerce or its authorised local offices. All companies (both Chinese and foreign) have the right to import most products, but a limited number of goods are reserved for import through state trading enterprises (China Briefing, 2019).

Complex inspection and certification requirements apply for trade, including requirements for certain goods to be inspected on arrival and/or to be accompanied by formal certification recognised by the Chinese government (China Briefing, 2019). Labelling and packaging requirements are particularly important for consumer goods. Between January and July 2019, 727 batches of foreign food and beverage items needed to be "returned or destroyed due to a lack of compliance in food quality, certificates, label, and package, excessive or limited use of food additives, presence of micro-organisms, no access for inspection and quarantine, non-compliant ingredients, and other reasons" (China Briefing, 2019). In some cases, import trading companies' licenses may be revoked, and investors barred from continuing trade with China (ibid.).

In relation to China's strategic approach to addressing SDG 12, its role in global production and consumption is emphasised, as well as its environmental impacts with reference to 'green' national legislation and policy (Amos & Lydgate, 2019).

Russia

Russia's top five import partners are China (US$ 52,217 million), Germany (US$ 25,510 million), United States (US$ 12,690 million), Belarus (US$ 12,906 million) and Italy (US$ 10,580 million) (WITS, 2018c). Russia is a member of the Eurasian Economic Union, which allows goods imported into any member nation (Armenia, Belarus, Kazakhstan, Kyrgyzstan, and Russia) to be freely transported across these countries (Russia Briefing, 2019).

Customs declarations can be made by assigned managers of Russian-registered companies (including foreign companies established under Russian law) (Russia Briefing, 2019). All imports must present freight declarations accompanied by contracts;

commercial invoices and packing lists, transport documents, import licenses, certificates of conformity, and - if applicable - certificates of origin and sanitary certificates (ibid.). The rates displayed in the customs tariff are applied to countries which benefit from the 'Most Favoured Nation' clause (MFN) (which requires a country to provide any concessions, privileges, or immunities granted to one nation in a trade agreement to all other WTO member countries), and include a majority of developing countries, as well as those of the European Union (subject to EU sanctions, which may make certain products ineligible) (Russia Briefing, 2019).

Examining implementation strategies for SDG 12 in Russia, Amos and Lydgate (2019) found that there is no specific consideration, although a sustainable development strategy is in progress. There was recognition by Russia of its role as 'global contributor' of energy and natural resources (Amos & Lydgate, 2019).

5.4. Trade frameworks and institutions: economic sustainability benefits and challenges

Transforming food systems for greater sustainability requires examining trade agreements. Potential interventions could include the removal of market barriers for agricultural commodities, the protection of regulatory policy space, and the revision of subsidies (Friel et al., 2020). The UN Sustainable Development Goals contain several targets aimed at supporting free trade, particularly for developing countries, including:

- **SDG target 2.b:** Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with an equivalent effect, in accordance with the mandate of the Doha Development Round.
- **SDG target 10.a:** Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with WTO agreements.
- **SDG target 17.10:** Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the WTO, including through the conclusion of negotiations under its Doha Development Agenda.
- **SDG target 17.11**: Significantly increase the exports of developing countries, in particular with a view to doubling least developed countries' share of global exports by 2020.
- **SDG target 17.12:** Realise timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with WTO decisions. This includes by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access.

Busch and Bain (2004) argue that although considerable research has examined the role of the WTO on food trade, changes to the agri-food system that have been made possible

by the WTO are of greatest significance. Specifically, the WTO has brought in numerous international organisations to regulate trade, has made a number of voluntary standards *de facto* mandatory, and promoted private regulation of agri-food value chains through standards and agreements (Busch & Bain, 2004). Understanding agri-food trade – and associated sustainability concerns – must therefore pay careful attention to the role of food standards.

5.5. Trade frameworks and institutions: environmental sustainability benefits and challenges

Examining the SDGs, the WTO, the Committee on World Food Security (CFS) and the Group of Twenty (G20), Clapp (2017) argues that agricultural trade liberalisation is seen as essential for food system sustainability. This logic is based on liberal economic theory that emphasises the role of trade in generating economic efficiency gains that can be used to promote sustainable food systems (Clapp, 2017). Academic and policy documents that support the idea that trade is linked with sustainability refer to the economic concept of 'comparative advantage' (Baldos & Hertel, 2015; Lamy, 2011) whereby all countries specialise in the goods for which they have the least opportunity costs and then engage in trade. This results in efficiency gains on a global scale, thus minimising the overall use of natural resources, with production shifted to the countries best suited to producing specific crops (Lamy, 2011). The theory of comparative advantage perceives international trade to be a static and harmonious phenomenon (Schumacher, 2013) but is increasingly contestable in the context of a global economy that faces inequality and systemic risks.

Trade has been promoted as supporting more sustainable agricultural production climate change adaptation through technological solutions such as the access to, and use of, drought-tolerant seeds and the adoption of strategies for sustainable intensification (Clapp, 2017). According to the Organisation for Economic Cooperation and Development (OECD): "*Trade will be essential in order for supply increases to be achieved sustainably. Trade enables production to locate in areas where natural resources, notably land and water, are relatively abundant, and where systems are more resilient to the effects of climate change"* (OECD, 2013: 18). However, innovation and access to technology and resources plays a considerable role in improving the use of natural resource and facilitates the concentration of high value-added activities in developed economies.

Supporters of agricultural trade liberalisation do acknowledge the environmental challenges in the global food system (Hertel et al., 2014), but treat them as separate from trade (Clapp, 2017). They are viewed as arising from externalities from domestic policy failures that can be addressed through appropriate pricing mechanisms at domestic levels rather than through trade policy (ibid.). In recent decades, a range of economic tools have been developed with the aim of internalising costs in the agricultural sector such as

'payments for ecosystem services' (PES), certification and standards, tax and subsidy schemes. while keeping within WTO rules to stop the restriction of trade (Clapp, 2017).

5.6. Trade frameworks and institutions: social sustainability benefits and challenges

There are long-standing concerns that increased expansion of export agriculture as a result of trade policies (e.g. the EU trade policies), has had detrimental effects on self-sufficiency and food security, due to large-scale land acquisitions leading to the dispossession of small farmers and community access to land, in particular in countries with weak institutions (Bureau & Swinnen, 2018). The EU has also been described as "fortress Europe", preventing developing countries from export productions (e.g. agricultural products) in which they had a comparative advantage. Non-governmental organisations and researchers have claimed that this development has been detrimental to subsistence agriculture, which allowed the poorest people to feed themselves (ibid.). Conversely, some studies show how export agriculture has increased revenues and access to inputs and technology, stimulating household food production and reducing capital and technology constraints (Riera & Swinnen, 2015).

Large-scale land acquisition projects for export trade, may not always promise jobs as frequently promoted in 'agriculture for development' discussions (Spann, 2017), as in practice, trade deals may lead to capital intensive agriculture with a low labour/land ratio (Li, 2011).

5.7. Trade frameworks, institutions and food security

In recent decades, trade and markets have been seen as either a threat or an opportunity to attaining food security, with calls for trade openness highlighting market efficiencies, increased domestic food security and increased productivity and competitiveness of the agricultural sector (Borsellino et al., 2020). According to the FAO and WHO (2017: 11), *"Trade is inextricably linked to food security, nutrition and food safety. Trade affects a wide number of economic and social variables, including market structures, the productivity and composition of agricultural output, the variety, quality and safety of food products, and the composition of diets*."

Numerous studies demonstrate that participation in markets has positive impacts on farmers' food security (e.g. Montalbano et al., 2018; Haggblade et al., 2017). Here, food security relies on the free market to improve efficiency and enhance food production, supporting in turn economic growth, employment and incomes – both in agriculture and, through a spillover effect, to other sectors (Borsellino et al., 2020). The role of public policies in this framing is confined to correcting market failures such as externalising environmental costs (ibid.).

On the other hand, there are critics of 'trade as an opportunity' who reject the notion of higher integration in agri-food markets supporting food security (Borsellino et al., 2020).

Hao et al. (2017) suggest that countries more dependent on food imports and food aid are at greater risk of being affected by price shocks. Future swings in food prices may jeopardise food security in poor countries (Bekkers et al., 2017). Those who consider 'trade as a threat' generally call for increased involvement of local and regional governments, consumers and farmers in agri-food system governance, supporting a vision of the multifunctionality of agriculture and highlighting the importance of local biodiverse farming systems, self-sufficiency and domestic production for food sovereignty (Borsellino et al., 2020).

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5.9. Links

Committee on World Food Security (CFS): The Committee on World Food Security (CFS) was established in 1974 and reformed in 2009 as the foremost inclusive international and intergovernmental platform for all stakeholders to work together to ensure food security and nutrition for all. http://www.fao.org/cfs/en/

International Trade Centre (ITC): the joint agency of the United Nations and the WTO, ITC is the only multilateral agency fully dedicated to supporting the internationalisation of small and medium-sized enterprises. Its joint mandate combines a focus on expanding trade opportunities with the aim of fostering sustainable development. https://www.intracen.org/

Sustainable Development Goals (SDGs): The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet. At its heart are the 17 Sustainable Development Goals (SDGs): an urgent call for action by all countries - developed and developing - in a global partnership. The SDGs include goals and targets to end poverty, improve health and education, reduce economic inequality, all while tackling climate change and conserving ecosystems. https://sdgs.un.org/goals.

World Integrated Trade Solution (WITS): a joint product of the World Bank and UNCTAD, in consultation with other organisations. It gives users access to detailed information on trade and tariffs https://wits.worldbank.org/.