Discarded food and resource depletion

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Food systems are permeated by perverse incentives which often lead to food being discarded before entering the market and to the depletion of natural resources. Tomato production in the water scarce province of Almería, in Spain, illustrates the problem and highlights the urgent need for policies that ensure ethical and environmental sustainability standards.

Over one third of the food produced globally is not consumed¹, of which approximately 14% corresponds to post-harvest loss². In most high-income countries, the primary reason for this is to control prices that, due to excess of produce in the market, may fall below production costs³. Furthermore, food being discarded is often produced unsustainably and contributes to the depletion of natural resources. Yet, some countries and supranational administrative units like the European Union (EU) offer subsidies to compensate farmers for losses associated with price fluctuations, often strengthening already extremely competitive sectors⁴.

The province of Almería in Andalusia, Spain illustrates these problems well. One of the main vegetable production centers in the world, its agricultural model became known as the “Almeriense economic miracle”⁵. Despite poor quality soils⁶ and one of the lowest per capita incomes in Spain in the 1950s⁷, the arrival of greenhouse agriculture in the 1960s made it the core of the province’s demographic and socio-economic development in recent decades, supporting most of Andalusia's international agri-food trade⁸.

The rise of horticulture

The 1960s saw successful tests to grow vegetables on sand mulch (or “enarenado”) replacing calcareous crust saline soils in the coastal area of Almería. Technological improvements have helped overcome the limitations imposed by poor soils, strong and persistent winds and low rainfall (250 mm/year on average)⁹. Lack of water was solved by exploiting the groundwater, adapting to its high salt content, and establishing efficient irrigation systems which are now used in 99.9% of the greenhouse surface area¹⁰. Old rudimentary greenhouses, with a perforated plastic cover to allow rainwater collection, have been turned into state-of-the-art greenhouses with sophisticated climate control methods. Pumping equipment draws from depths of more than 400 m¹¹, and an entire and booming agricultural research industry pivots around one of Europe's so-called ‘market garden’¹². In 2018/19, production grew by 6.4% relative to 2017/18, reaching 3.7 million t of fresh produce grown on more than 58,600 ha¹³.

Almería’s greenhouses now concentrate 75% of the production of tomato for fresh consumption in Andalusia and correspond to half of Spain's production (Spain is the main producer in the EU, with 30% of the total¹⁴). Local farmers and politicians claim efficient and sustainable use of water resources, often stating that “every drop of water is used” – an expression from Spain’s 1920s hydraulic policy based on the use of dams, aquifers and inter-

basin water transfer to compensate for the natural water imbalances of the country and help its modernization¹⁵. Yet, since the first experimental plots back in the 1960s, total water consumption has increased substantially as a result of agricultural expansion.

Economic indicators have generally shown a favorable trend, including higher production value, larger cultivation area (Fig. 1a) and greater exports, especially to Germany, France and Poland (Fig. 1d). However, the latest available data (2018/19) have shown a drop in tomato production, one of the most representative crops in Almeria (7.3% in area and 10.5% in volume), due to the poor results of the previous season. The fall in prices (17.2%) and exports (4.5% in volume and 9.4% in value) coincided with an increase in EU imports (10.1%). Farmers in Almeria see their dominant position threatened as the European market share of countries such as Morocco increases (10.7% increase in EU imports from this country). In the prevailing agro-industrial model, based on economies of scale and stability of prices and sales¹³, the prospect of recurrent falls in economic indicators makes it necessary to increase technological efforts towards greater efficiency and access to new water resources.

Fig. 1. Recent trends in Almeria's tomato production. (a) Cultivating area and production volume¹⁶. (b) Productivity and average price^{13,16}. (c) Selected import-export figures¹⁷. (d) Production and export value¹³.

Food loss and water depletion

The effects of reduced agricultural prices on farmers' incomes have often been alleviated by the partial destruction of the crop. To achieve national food security and support agricultural incomes, key aims of the European Common Agricultural Policy (CAP) are to safeguard farmers to make a reasonable living and deal with difficult market situations¹⁸. One of the instruments for achieving this is the withdrawal of up to 5% of the crop from the market⁴, which is paid by the EU at a maximum price of 339.6 EUR/t plus 18.2 - 108.3 EUR/t per transport (with a surcharge of 8.5 EUR/t if the transport is refrigerated) when it is for free distribution, and 254.8 EUR/t for any other destination (composting at best or destruction of the crop)¹⁹. Although part of the withdrawn harvest was diverted to food banks (49.1%) or animal feed

(7.4%) in 2019, a considerable part (43.5%) was destroyed²⁰, particularly during November-March when demand is highest.

Discarding food produced with so much effort, as producers claim, and in a territory with very limited water resources, maybe justifiable under exceptional circumstances (such as the Russia ban on imports of fresh fruit and vegetables from the EU in 2014³). Yet it is an ethically and environmentally reprehensible practice when it becomes commonplace. Only in 2019, more than 300,000 m³ of groundwater and 136.5 t of fertilizers have been wasted, and more than 7,500 t of CO₂-eq have been emitted to the atmosphere through this practice in Andalusia – which extends to other vegetables, like peppers, zucchinis and cucumbers (Fig. 2). It is noteworthy that the majority of these withdrawals correspond to Almeria, where 90% of the greenhouses in Andalusia are located¹³.

Poor management of water resources and overproduction in an increasingly saturated market are the main handicaps faced by farmers in Almería. The massive extraction of groundwater carried out in the last decades has deteriorated the aquifers both quantitatively and qualitatively²¹. In Campo de Dalías, where most vegetable production is concentrated, the deterioration of the upper aquifer has forced the construction of wells of more than 150 m to reach the deep aquifer¹¹. Seawater intrusion has elevated electrical conductivity above 6 dS/m in coastal areas²², which makes agriculture impossible for most crops (e.g. tomato and cucumber decrease their yield from 2 dS/m)²³. Additionally, the discharge of leachate ranges from 20 to 50% of the initial supply of 2,000-3,400 kg/ha of N-P-K fertilizers²⁴, making these areas highly vulnerable to nitrate pollution. In terms of market saturation, Almería's farmers face competition from both within and outside the EU. On the one hand, the crop yield in the Netherlands (55 kg/m²) is five times that of the area's greenhouses (10 kg/m²). On the other hand, farmers claim that increased EU imports (8,4% in 2019)¹⁷ from countries like Morocco or Senegal – considered unfair competitors because of their lax environmental standards and lower labor and production costs – reduce prices and exports (Fig. 1c).

Fig. 2. Environmental impact associated with vegetables discarded in Andalusia in 2018 and 2019.

Discarded vegetables²⁰ (a) include the loss of water²⁵ (b), the loss fertilizers^{26,27} (c) and the emission of greenhouse gases²⁸ (d) that could be avoided. Most of the Andalusian production of the analyzed crops is located in Almería (100% of pepper, zucchini and eggplant; 75% tomato; 65% cucumber).

Efforts aimed at alleviating negative effects of price shocks will not solve the multiple issues that are undermining the competitiveness of the agricultural sector in Almería and jeopardizing its future, such as the deterioration of water resources, the lack of local flagship products not available elsewhere²⁹, or the opening of the EU to other markets. The reality is that a fundamental resource, water, is being depleted at an alarming rate in an already dry area where the effects of climate change are expected to be significant³⁰. Signs of water scarcity should not be overlooked. Farmer decisions should not be based exclusively on the price of the product, which nowadays does not reflect water scarcity in the study area nor the carbon footprint of shipping the vegetables from Almería to elsewhere in Europe. Basic water indicators should also be considered, such as the exploitation rate (pumping vs. natural recharge ratio), the fall in piezometric levels or the increase of water salinity. Only with a proper management of available water resources can the sustainability of the agricultural sector be ensured.

Moving forward

The case of Almería is not unique. In Spain alone, more than 114 kt of fresh vegetables and fruits were discarded in 2019, although most of them (68.5%) were distributed for free²⁰. Fortunately, successive reforms of the CAP have contributed to food loss reduction (the volume discarded reached 2,018 kt yr⁻¹ during the 1989 and 1996 period²); still, it must be reduced further if we aim to achieve the United Nations Sustainable Development Goals (SDGs) – particularly SDG 2 (‘Zero hunger’) and target 12.3 (‘Halve per capita global food waste at the retail and levels and reduce food losses’) – while fostering a more sustainable, secure and equitable food production system³¹.

From an environmental sustainability perspective, measures to reduce the depletion of water resources are paramount along the entire food supply chain. On the production side, efforts must be made towards the internalization of externalities as well as farmers’ full compliance with the legislation, such as the EU Water Framework, Nitrates and Biodiversity Directives. The few examples where groundwater-dependent agricultural systems are sustainable are those where, such as in the Clain Basin (France)³², a strict regulation is followed. This includes restricting the drilling of new wells, closing down illegal ones, regulating water extraction during the irrigation season, installing water meters on greenhouses, and conducting hydrogeological studies to refine the calculation of safe yield, i.e. the amount of water that can be withdrawn annually without affecting the quantity or quality of the groundwater. Although many of these measures were already foreseen in the Spanish Water Law of 1999 and have been ratified by the EU Water Framework, problems like the proliferation of illegal wells have persisted in major Spanish agricultural areas (e.g. Eastern La Mancha aquifer system, Campo de Cartagena, surroundings of the Doñana National Park)³³. It is key that farmers become aware of these sustainability issues, so that regulations are not interpreted as a punitive

instrument but rather as a tool to better manage water resources and to ensure the sustainability of their activity.

On the consumption side, environmental awareness campaigns must continue, so that consumers can appreciate and decide whether to pay more for products that respect the environment (as many of them already do for organic products). Food labelling schemes related to nutrition, environmental and social responsibility are increasingly used³⁴ and should also be considered; in the EU only, there are 174 initiatives related to environmental management and 182 to organic farming³⁵. However, the current overload of labels and information may create confusion and make environmentally and socially conscious choices difficult. Although environmental and social responsibility labels are often considered less impactful than other product information and do not play a major role in food choice³⁶, there is a growing interest in sustainability in the food sector. Specifically regarding water, there are labelling schemes that certify the efficiency of water use³⁷ but not a quality label certifying that groundwater bodies are not being overexploited. This can be counterproductive if environmental sustainability continues to be seen through a productivist lens, concerned with profit maximization through resource efficiency gains as with drip irrigation technology²⁹. In that sense, it seems more logical to opt for certifications that integrate various product attributes into a single label, including environmental (e.g., carbon and water footprint, impacts on biodiversity, use of organic farming) and social (e.g., fair trade and working conditions) factors.

From an economic perspective, a critical measure that could help reduce food waste – and which has been demanded by the primary sector for years – is to shorten the gap between the prices perceived by farmers and those paid by consumers³⁸. In Spain, the increase between supermarkets and farm gate prices range from 642% for zucchini to 349% for cucumbers and 482% for tomatoes³⁹. If part of the profit accrued by large distributors buying directly from farmer cooperatives or other intermediaries would be transferred to farmers, these may have enough margins to cover production costs without the need to produce as much as possible. Finally, we must not forget that integrating all aspects involved in agricultural production requires careful territorial planning to correctly allocate land uses and the implementation of effective policies protecting essential resources like water. The use of integrated models that simultaneously consider the evolution of groundwater and the socio-economic dynamics of the area⁴⁰ can certainly help with this task. Governments should coordinate their actions on water, agriculture, climate change and land-use planning to address the environment-food production-health trilemma faced by societies in the 21st century, which is critical to ensure the sustainable development of our planet.

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Data availability

Data are available at: <https://doi.org/10.6084/m9.figshare.12053685>.

Ethics declaration

Conflict of interest

The authors declare no competing interests.

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