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FOOD SYSTEMS AT RISK

NEW TRENDS AND CHALLENGES

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CHAPTER 3.3

THE EFFECTS OF AGRICULTURE'S ENVIRONMENTAL EXTERNALITIES ON FOOD SYSTEMS

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SUMMARY

A healthy environment is essential for the proper functioning of both natural and cultivated ecosystems and, as such, plays a major role in food systems. Many different sources, including the agricultural sector itself, emit and accumulate pollutants in different environmental compartments (soil, water and air). When there are excessive pollutant levels, ecological functioning is hampered by eroded biodiversity, disrupted nutrient cycling, toxicity and depleted soil fertility, and can lead to reduced yields and contaminated food products. Many pollutants end up in water through leaching and run-off and have negative impacts on aquatic ecosystems, reducing fish and seafood stocks. Pollutants can also contaminate the food chain and cause food toxicity risks, and this is particularly true when pollutants undergo gradual biological concentration along the food chain.

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Pollutant diversity and sources

The environment is a major sink for numerous pollutants, derived mainly from human activities. All environmental compartments are concerned (soil, water and air), with specific and complex dynamics. Pollutants belong to two main categories (Edwards, 2002; OECD, 2017; FAO, 2015):

- Inorganic pollutants are mainly heavy metals (arsenic, cadmium, lead, mercury etc.). Cadmium is the most serious heavy metal likely to contaminate agricultural soils. Due to its high mobility in the soil, it can be easily absorbed and transferred to the food chain.

- Organic pollutants are highly diverse (hydrocarbons, phenolic compounds, fertilisers, pesticides, micro-plastics etc.) and their accumulation in the environment is due to the absence of any biological process to degrade them (xenobiotic molecules) or to the relative slowness of the degradation process. 'Chemicals of Emerging Concern' are new challenges, including products such as nanoparticles, pharmaceuticals, cosmetics, hormones, detergents and certain industrial chemicals whose effects are not always understood and/or measured.

Pollution may come from different sources (Thangavel, 2017); it can be a single discharge point, which means control strategies can be employed, or a more diffuse source at the landscape level via air-soil-water systems, which requires complex analyses involving these three compartments in order to tackle the pollution (IPES-Food, 2017):

- Large quantities of urban solid waste, mostly treated in landfills or incinerators, can eventually affect groundwater and the soil quality of cultivated ecosystems in the vicinity. Sewage sludge, sometimes applied on cropland, can also be highly contaminated with heavy metals and pesticides (Rodríguez-Eugenio, 2018).

- Many industrial chemicals pollute land near their production sites but can also be transported to other systems through discharges into aquatic systems or wind dispersal. These chemicals include heavy metals, inorganic gaseous emissions, and volatile organic compounds (Rojas *et al.*, 2016).

- Agriculture is a major contributor to pollution in many regions of the world through the use of synthetic inputs, such as fertilisers and pesticides, and animal waste (Lelieveld *et al.*, 2015). When applied in excess, only a fraction of fertilisers are absorbed by plants and the rest can contaminate groundwater or river systems through leaching or run-off. Phosphates generally also bring heavy metal contaminants, such as cadmium. Agrochemicals are also a major pollutant affecting soils and water. Organochlorine insecticides that can persist in the soil for decades can be bioconcentrated from the soil to final consumer along the food

chain. Antibiotics, used on a large scale in animal and fish production, are causing growing concerns for the resistance they can generate (Rodríguez-Eugenio, 2018; IPES-Food, 2017)

Effects on food systems

There are two main impact pathways on food systems: through degradation of the productive capacity of land or aquatic ecosystems and through contamination at different stages of food production. The impact of a pollutant will depend on its toxicity and its persistence. This means heavy metals have much more serious effects than relatively transient chemicals. An ecosystem's resilience to the effects of a pollutant depends in part on its biodiversity, stability and the existence of alternative processes for performing essential functions.

Agroecosystem degradation and reduction of production potential

While some degradation processes can be observed directly, soil contamination cannot, making it an insidious hazard, a 'hidden danger' (FAO, 2018). The analysis is further complicated by the diversity of contaminants (in particular persistent organic pollutants, constantly changing due to developments in agrochemistry), their random circulation, their transformation through biological activity in soils and the ability of soils to store, immobilise and degrade. However, the effects may appear suddenly after changes in land use that alter environmental conditions.

The impacts of soil pollutants are highly diverse and chemicals such as pesticides can have direct toxicity effects on surface and subsoil biota. These in turn can have major influences on soil ecology by changing the availability of organic matter that provides nutrients to other living organisms, modifying the plant rhizosphere or altering the soil pH. These changes can have an impact not only on population size but also on the functions of terrestrial ecosystems that affect production (Rodriguez-Eugenio, McLaughlin and Pennock, 2018).

Impact on aquatic ecosystems and fish resources

Acute or chronic pollution with a wide range of organic and inorganic compounds entering the aquatic ecosystem is likely to impact both wild and farmed aquatic species through direct (toxicity) or indirect effects (Ryder, Karunasagar and Ababouch., 2014). Aquaculture might allow for better control of the risk through ensuring the composition of fish feed and monitoring water quality.

Another source of pollution likely to affect ecosystem and production systems is eutrophication, which results from organic and inorganic nutrients rich in nitrogen and phosphorus being released into water bodies. Depending on its intensity, eutrophication can lead to changes in the assemblage of species (with micro- or macro-algae proliferation), reduced biodiversity, changes in trophic food webs or massive fish kills as a result of deoxygenation and the release of toxic gases by anoxic bacteria (van Beusekom, 2018).

A rapidly growing concern is plastic pollution, especially micro- and nanoplastics, as they have become ubiquitous in inland waters and oceans and are of growing significance. Evidence is still lacking on their real impact and additional research is required for nanoplastics, as their size could allow some of them to cross cell membranes and enter blood circulation (Lusher, Hollman and Mendoza-Hill, 2017).

Food system contamination

Food represents the main source of human exposure to some of these pollutants and, despite the lack of comprehensive data, food contamination is a serious threat to human health (WHO, 2015). Heavy metals are ubiquitously distributed in the environment, reach plant and animal-derived food and can cause chronic or acute toxicity and serious human pathologies (Rodríguez-Eugenio, 2017). Numerous organic pollutants can contaminate human food, even at very low concentrations, exemplified by endocrine-disrupting chemicals (EDCs). The risks can increase through the biomagnification process, where some pesticides stored in the fatty tissues of animals are gradually concentrated along the food chain until their consumption by humans.

Synergic effects

In nature, organisms are exposed not only to a single pollutant but often to many chemicals in large quantities or in trace amounts. Interactions between various chemicals (for example, antibiotics and cadmium) can increase or decrease the overall effect (Wang *et al.*, 2018). In other words, the resulting effect may be greater or lesser than the simple combined effect or be unchanged. It is also possible that a compound may not be toxic itself but may become so in the presence of another compound. Ecotoxicology struggles to address these possible complex cocktail effects.

Trends in developing countries

Asian countries experiencing rapid industrialisation are confronted with considerable contamination of their agricultural soils. For example, large quantities of mercury from the chemical industry and gold mines are released into the environment (Sari *et al.*, 2016). Arsenic is also naturally present in groundwater in many parts of Bangladesh and western India (Rahman, Dong and Naidu, 2015; Mojid *et al.*, 2016).

This poses a threat to agriculture, particularly in rice fields. Intensive pesticide and fertiliser use has also resulted in the accumulation of organic pollutants in the region's soils and eutrophication in water. In China alone, heavy metal contamination may result in a reduction of more than 10 million tonnes of food supplies each year (FAO, 2015). Many studies have shown the existence of high levels of organochlorines in vegetables and other food products (Lam, Pham and Nguyen-Viet, 2017).

In Africa, mining, the oil industry and poor urban waste management are highly significant sources of pollution. According to a study of ten Ogoni communities in southeast Nigeria, pollution from oil spills has led to concentrations of hydrocarbons and heavy metals in water, air and soil that are 900 times higher than allowable levels (UNEP, 2007). However, soil pollution through agrochemicals is of less concern than in other parts of the world because of their low level of use, with the exception of intensified peri-urban horticulture where groundwater is often contaminated (Sorensen *et al.*, 2015). There are also several examples of mismanagement, as illustrated by reported cases in Botswana and Mali, where more than 10,000 tonnes of pesticides, including very dangerous organochlorine compounds such as dichlorodiphenyltrichloroethane (DDT), aldrin and heptachlor, have leaked from damaged containers and contaminated the soil (Cachada *et al.*, 2018).

The growing threat of lead pollution, through petrol additives or battery recycling, also illustrates contexts where regulations are weak or absent (Gottesfeld *et al.*, 2018).

In the Near East and North Africa, in addition to the excessive use of chemical fertilisers and pesticides, a frequent source of soil and water pollution is the use of wastewater for irrigation and sewage sludge as a fertiliser (Mekki and Sayadi, 2017).

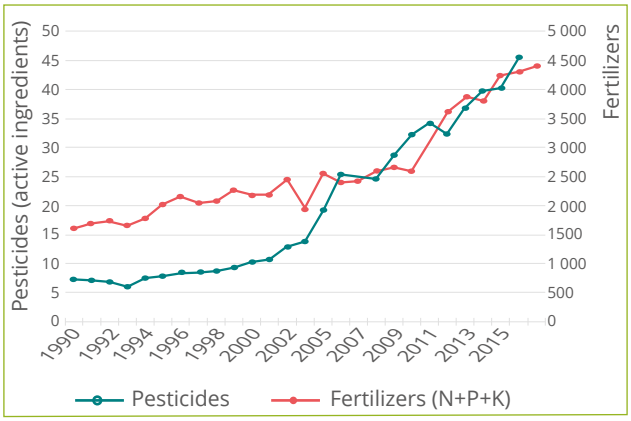

Figure 17: *Least Developed Countries: chemical inputs used in agriculture from 1990 to 2016 (1,000 tonnes).*
Source: FAOSTAT, consulted on February 15, 2019.

BOX 7

PESTICIDE USE IN HORTICULTURE IN SUB-SAHARAN AFRICA: AN INCREASING RISK FOR FOOD SYSTEMS[1]

Even though sub-Saharan African countries are the smallest users of pesticides in the world, African agriculture is far from being 'organic by default'. Since the 1970s, farmers have been using pesticides on their crops to prevent pest invasions and crop losses. Back then, the use of pesticides was mainly dedicated to export crops, such as cotton, coffee, tea, bananas and other tropical fruits. Driven by urbanisation and changes in diet as well as the growing population, the demand for fruit and vegetables in urban markets is continuously increasing. In order to meet this demand, peri-urban horticulture is increasing and the import value of pesticides in Central, East and West Africa grew by 261 percent between 2000 and 2010.

The risks associated with this growing pesticide use are being increasingly documented. First, there are risks in terms of the quality of the pesticides used. Indeed, they are often not adequate for the crop targeted. For instance, studies have shown that farmers in Benin generally spray cotton pesticides on vegetable crops in Cotonou. In addition, most of the time the products used are not good quality pesticides; sometimes they come from international out-of-date stock, which means they are no longer effective. Sometimes products used by farmers are forbidden on international markets, but still sold in African markets.

The study on market gardens in Cotonou showed that of 15 pesticides used, only two were officially allowed by the national regulations. Furthermore, the study reports inadequate farmers' practices and misuse of pesticides that are a threat to their own health and for their families and final consumers. Pesticides are often sprayed at the wrong moment and the period between spraying and sale is often not respected. This means that consumers buy vegetables on the market that should not be consumed. Additionally, farmers' lack of awareness, poor equipment and reuse of pesticide containers for other family uses, the absence of instructions (sometimes due to repackaging or illiteracy) and the difficulty for farmers in converting dosages usually prescribed for hectares for their small farms generate high risks for human and environmental health. Finally, the overuse of pesticides on certain crops can cause a high risk of pest resistance, as has been illustrated with tomato bollworm in Benin.

The increasing use of pesticides in horticulture, combined with urban sprawl, competition for land (involving the production of more food on smaller plots), as well as industrial and transport pollution, are aggravating risks for food systems seeking to comply with food security objectives and environmental integrity.

1. Based on De Bon et al., *2014*

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