Hort4EUGreen

Strategic Partnership No. 2020-1-RO01-KA203-080398

SUSTAINABLE USE OF PESTICIDES AND THEIR RESIDUES MONITORING

EU directives on sustainable use of pesticides

Volume 1

University of Agronomic Sciences and Veterinary Medicine of Bucharest

ЛЕСОТЕХНИЧЕСКИ УНИВЕРСИТЕТ

MATE

Editura Ex Terra Aurum U.S.A.M.V. Bucureşti

Erasmus+

Bucharest, 2025

Hort4EUGreen

Strategic Partnership No. 2020-1-RO01-KA203-080398

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ISBN 978-606-072-468-1
ISBN 978-606-072-469-8

Bucharest, 2025

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"Enhancing practical skills of horticulture specialists to better address the demands of the European Green Deal"

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SUSTAINABLE USE OF PESTICIDES AND THEIR RESIDUES MONITORING

Introduction

Agriculture plays an essential role in any society, being the primary source of both our food and the raw materials needed for food production. It is closely intertwined with the food industry, forming integral parts of the agribusiness sector. Their combined productivity must be assessed together.

Modern agriculture blends historical practices with modern technological advancements. Unlike most industrial processes, it is characterized by its openness, operating in direct interaction with its surrounding environment. Agriculture not only yields biomass from this environment but also discharges waste and by-products back into it. Some of these emissions include environmental contaminants (substances that may naturally occur but are present in higher concentrations) and xenobiotics (substances typically absent in the environment). Thus, agricultural practices can contribute to pollution. Ensuring food safety, therefore, is inextricably linked to maintaining environmental safety.

Several factors inherent in agricultural technologies may jeopardize environmental safety. Among these, chemical contaminants stand out as substances released into the ecosystem that can be toxic. Agricultural technologies can lead to the release of various chemicals, primarily pesticide residues and mycotoxins. Additionally, biological contamination poses another environmental risk. This includes the proliferation of various organisms, especially microorganisms, due to agricultural practices.

Notably, mycotoxins, as microbiologicals, can be classified as both chemical and biological contaminants. Another critical category is genetic contaminants, which are part of molecular biological processes and may overlap with chemical and biological contaminants. Examples include transgenic products like proteins, transgenes, or genetically modified organisms.

As previously highlighted, it's crucial to consider food safety and environmental safety together. Environmental pollution can hinder the production of safe food, while agriculture and food production can contribute to environmental contamination. This is why environmental and food safety go hand in hand, and this is what is reflected in the “from field to fork” concept of the European Union.

Pesticides

Pesticides, also known as **Plant Protection Products (PPPs)**, play a vital role in preventing crop damage caused by pests, phytopathogenic fungi, or weeds by either eliminating or repelling them. In monoculture agriculture, which is more prone to pest damage compared to biodiverse systems (refer to Section 1.1.1), the use of pesticides has long been deemed essential. However, this increasing reliance on PPPs has led to widespread contamination of agricultural soils with pesticide residues and their subsequent leaching into surface waters, affecting not just farmlands waters but also those in natural parks and protected areas. These residues can have harmful ecotoxicological impacts and may also contaminate our food supply. Recognizing the critical role of ecosystems in human survival and the importance of biodiversity in sustaining these ecosystems, the focus has shifted towards the sustainable use of pesticides. This means endorsing only those practices that ensure the viability of using the same methods in the future. Consequently, it has become clear that the use of PPPs and the management of their residues require strict regulation to safeguard human and environmental health, requiring routine monitoring of these residues.

The negative impact of chemical PPPs

The detrimental effects of PPPs are primarily associated with the toxicity of these substances and their residues on the environment, wildlife, and humans. Non-target effects of PPPs emerge either from systemic (related to their mode of action) or from “random” reasons (unrelated to their mode of action). Thus, negative impacts of pesticides include toxicity on non-target organisms (e.g., insecticide toxicity to beneficial insects e.g., bees and other pollinating insects) as well as the widespread emergence of pesticide resistance. Approaches to reduce these negative impacts have been the quest for PPPs with increased efficacy on their target pests so that lower dosages can be applied; the search for PPPs more and more specific to their target pests; and the reduction of the application rate of pesticides particularly of those with higher environmental toxicity.

Reasoning of pesticide use despite their impact

Efforts to address the challenges posed by PPPs have emerged from various approaches. Integrated Pest Management (IPM) seeks to control pests through a hierarchical application of biological, cultural, physical, and chemical strategies, aiming to minimize economic, health, and environmental risks. Ecological Pest Management (EPM) views agriculture as an ecological system and focuses on fully ecological solutions to its challenges.

Organic farming, also known as ecological or biofarming, prohibits the use of synthetic pesticides, favoring biological and physical/mechanical pest control methods instead.

However, the use of pesticides is still deemed acceptable in agrochemical-intensive agriculture and, to some extent, in IPM. In certain highly intensive agricultural practices, pesticide use is still considered indispensable. Under the European Green Deal program, the European Union has set goals to reduce pesticide usage by 50% and to increase organic farming by 25% by 2030. While pesticides are essential in protecting crops and ensuring high yields, their overuse and misuse pose serious threats to the environment, human health, and non-target organisms. Therefore, sustainable use of pesticides and effective monitoring of their residues are imperative.

Sustainable Pesticide Use

The European Commission has put forward a new Regulation proposal on the Sustainable Use of Plant Protection Products. This includes ambitious EU-wide objectives to reduce the use and risk of chemical pesticides by 50% by 2030, aligning with the EU's Farm to Fork and Biodiversity strategies. Adopted on June 22, 2022, this proposal is a component of a broader initiative aimed at diminishing the environmental impact of the EU's food system and addressing the economic damages already being incurred due to climate change and the loss of biodiversity (EC Food Security 2023)

Monitoring pesticide residues

Monitoring pesticide residues is integral to ensuring the safety of food and the environment, maintaining public and consumer trust, and supporting sustainable agricultural practices.

Monitoring of pesticide residues is crucial for several important reasons, as public health protection, food safety compliance, environmental health, consumer confidence, agricultural practices improvement, global trade, early warning and risk assessment, resistance management, etc.

Volume 1. EU directive on sustainable use of pesticides (SUP)

Summary

Module 1 is intended to provide an insight on EU directive on sustainable use of pesticides. As already known, since June 22, 2022, the European Commission ratified a new proposed regulation for the Sustainable Use of Pesticides, where it sets forth bold targets across the EU, to cut down both the usage and hazards of chemical pesticides by half by 2030, in accordance with the EU's Farm to Fork and Biodiversity strategies. The module also presents the process of pesticide authorization in the European Union (EU), which is one of the most rigorous and comprehensive processes, designed to ensure that all pesticides used within its member states meet strict safety and environmental standards.

Learning outcome descriptors

By the end of the Module, the trainee should be able to:

- understand the EU Key Directives,
- describe the main provisions and objectives of key EU directives on SUP as Regulation (EC) No 1107/2009, Regulation (EU) 2021/2115 and the Sustainable Use Directive 2009/128/EC.
- understand the EU's regulatory framework for pesticide authorization, including the process of approval for active substances and the role of the European Food Safety Authority (EFSA).
- assess the environmental and health impacts of pesticide use as stipulated in EU directives, including understanding the concepts of maximum residue levels (MRLs) and risk assessment methodologies.
- understand the principles and practices of IPM as promoted by EU legislation, including the role of IPM in reducing reliance on chemical pesticides.
- develop the ability to critically analyze EU pesticide policies, including their effectiveness, implementation challenges, and impact on agricultural practices and environmental sustainability.
- evaluate case studies of EU member states' compliance with pesticide directives, identifying best practices and areas for improvement.
- understand the legal responsibilities and consequences for non-compliance with EU pesticide regulations for stakeholders, including farmers, distributors, and authorities.
- be aware about current debates and developments in the field of sustainable pesticide use within the EU, including emerging challenges and potential future amendments to the directives.

Learning outcome descriptors

- effectively communicate the complexities of EU directives on sustainable pesticide use to diverse audiences, including policymakers, agricultural professionals, and the general public;

General and transferable skills

1	The ability to critically evaluate policies, regulations, and their impacts, which involves analyzing complex information to assess the effectiveness and implications of EU pesticide directives.
2	Problem-Solving skills, as the ability to identify problems, consider various solutions, and predict potential outcomes in the context of pesticide regulation and sustainable agriculture.
3	Proficiency in conducting thorough research, including gathering, evaluating, and synthesizing information from diverse sources on EU directive on SUP
4	Effective verbal and written communication skills, especially in conveying complex regulatory information in a clear and accessible manner to various audiences, including non-experts.

5	The ability to understand and interpret legislation and policy documents, and apply this understanding in various contexts, such as legal compliance, policy development, and advisory roles.
6	Gaining insights from multiple disciplines such as law, environmental science, agriculture, and public health, fostering a holistic understanding of the subject.
7	Working effectively in groups, often with people from diverse backgrounds and disciplines, enhancing collaborative skills and the ability to work in a team-oriented environment.
8	Skills in planning, organizing, and managing tasks and projects, which are particularly relevant for implementing and complying with complex regulatory frameworks.

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Learning outcome descriptors

Knowledge, understanding and professional skills

1	Assess the environmental and health impacts of pesticide use as stipulated in EU directives, including understanding the concepts of maximum residue levels (MRLs) and risk assessment methodologies.
2	Gain comprehensive knowledge of the EU's legal framework governing pesticides authorization and use;
3	Gain knowledge in the objectives of the European Green Deal related to pesticides;
4	Understand the concept of risk and pesticide authorization in the European Union.

Unit 1.1 Pesticide use reduction in EU

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In recent years, the European Union (EU) has increasingly focused its efforts on reducing the use of pesticides in agriculture. This shift is driven by growing concerns about the environmental and health impacts of pesticides. As part of a broader commitment to sustainable agriculture and environmental protection, the EU has implemented various strategies and regulations aimed at reducing pesticide use and mitigating its negative effects.

Pesticide use in agriculture has long been a topic of concern due to its potential impacts on human health, biodiversity, and the environment. Pesticides can contaminate soil, water, and air, and affect non-target organisms, including beneficial insects and wildlife. Moreover, there is growing awareness of the potential human health risks associated with exposure to certain pesticides, including carcinogenicity and endocrine disruption.

The cornerstone of the EU's approach to pesticide reduction is a robust regulatory framework. Key regulations include Regulation (EC) No 1107/2009, governing the approval of active substances, the Sustainable Use Directive 2009/128/EC, focusing on reducing the risks and impacts of pesticide use and COM(2022) 305 final 2022/0196 (COD), on the sustainable use of plant protection products and amending the Regulation (EU) 2021/2115.

All the national authorities within EU have implemented national programs for monitoring and surveillance of pesticides residues, both for imported and national produced goods. The data are reported by different EU institutions, as European Food Safety Authority (EFSA) Reports (as The 2021 European Union report on pesticide residues in food (10.2903/j.efsa.2023.7939), EU Pesticides Database (https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en), National summary reports on pesticide residue analysis performed in 2021 (doi:10.2903/sp.efsa.2023.EN-7901 and https://multimedia.efsa.europa.eu/pesticides-report-2021/chapter-two/) and, Rapid Alert System for Food and Feed (RASFF) (https://webgate.ec.europa.eu/rasff-window/screen/search).

Regular monitoring of pesticide residues in food, soil, and water ensures compliance with safety standards and helps in adjusting policies as needed.

The EU Pesticides Database gives information on active substances and the maximum residue levels allowed within its boundaries, as well as details on emergency authorisations granted by Member States.

The maximum residues limits can be found here: https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/mrls/download

Despite these efforts, controversies are still happening, as the multi discussed issue of glyphosate in 2023. One significant challenge is balancing the need to reduce pesticide use with ensuring agricultural productivity and food security and granting farmers the necessary inputs to fight against pests and diseases. There is also some controversy over the banning of certain pesticides, with arguments from the agricultural sector about the lack of viable alternatives and potential impacts on crop yields.

Until now, the EU's pesticide reduction strategies have led to tangible progress. There has been a decrease in the use of the most hazardous pesticides, and a growing adoption of IPM and organic farming practices. Furthermore, these efforts have raised public awareness about the importance of sustainable agriculture and the potential risks associated with pesticide use. The EU efforts and commitment to reducing pesticide use aligns with its broader environmental and public health goals, including the **European Green Deal** and the **Farm to Fork Strategy**. Future efforts will likely focus on further developing and implementing alternative pest control methods, enhancing regulatory mechanisms, and continuing to support research and innovation in sustainable agriculture.

The EU's approach to reducing pesticide use represents a significant step towards more sustainable and environmentally responsible agriculture. By continuing to balance regulatory measures with support for innovation and farmer education, the EU can lead the way in demonstrating how modern agriculture can thrive while minimizing its environmental footprint. The success of these efforts will have important implications not just for the EU, but for global agricultural practices and policies.

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1.1.1 Sustainable use of pesticides

The high nutrient content of fruits and vegetables is attractive not only for us humans, but also for other herbivores, with whom we need to share our produce. This is particularly true for intensive agricultural technologies where crops, to achieve highest possible mechanization and automation, crops are cultivated in large monocultures (Balogh 2021).

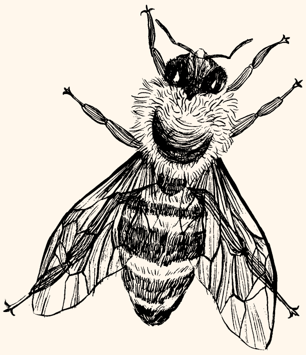
It is quite obvious, in an ecological sense, that such monocultures serve as a "set table" for herbivore species generalists or ones specialized to the given crop. We term these animals (mostly insects) as "pests" as they are attracted to the crop as a "plague", destroying our food (García-Lara și Saldivar 2016). In regular ecosystems, the population of each participant in the food chain is more or less controlled by natural enemies (e.g., predators or parasitoids), but when the food supply is as broadly shifted as in monocultures, such ecological balance also becomes off-centered. Thus, the technology itself creates an ecological condition that allows an increased rate of damage compared to more balanced circumstances.

To counteract this unbalanced situation certain technological measures, have to be set that limit the pest populations. There are a range of possibilities for such pest population control, physical, mechanical, biological barriers or limiting elements (see Handbook 2), but as for technological feasibility, agrochemicals are the "easiest" solution, given that pest populations can be controlled by properly scheduled treatments with administered chemical compounds, pesticides that exert toxicity, hopefully as specifically as possible, on the target pest population. Such treatments substitute human labor and are easily automated, therefore appear as economically feasible solutions.

However, as agricultural production intensity increased under the pressure of the human population growth and the corresponding rising food demand, the rate of pesticide, in other words plant protection product (PPP) applications and the resultant chemical load on the environment also increased and led to extended contamination of soils and surface waters with pesticide residues. In addition, the pest specificity of these agrochemicals remains imperfect: even though the target specificity of newer pesticide active ingredients surpassed by far that of their predecessors, non-target effects remain to emerge either from systemic or from "random" reasons. The former option, systemic non-target effects, is directly related to the mode of action of the given pesticide. In the case of insecticides, for example, even if modern active ingredients show directed specificity towards the phylogenic class of insects or even their orders, such specificity will not spare beneficial insects within the same class, subclass or order.

A long-standing problem has been the protection of bees against insecticides, mostly managed by physical methods or cautious timing. The latter option, “random” non-target effects, is regarded as unsystematic because the emergent non-target affects are not related to the mode of action of the compound but are attributed to a not intended or not foreseen interaction of the pesticide with a biochemical target completely unrelated from the physiological process or the phylogenic status of the organism targeted.

These ecological controversies of pesticide usage have led to the recognition that ecosystems can be critically jeopardized by one-sided, exceedingly technology-focused pest management; that ecosystem services are vital for our survival and such functions operate only under maintained biodiversity conditions; and that any technological element (including pesticides) can be applied only in a sustainable way, meaning that the technology applied today cannot exert consequences that would make the use of the same technology impossible tomorrow.



The toolset for pest control includes biocultural (crop selection, habitat features), physical-mechanical, biological (including microbiological) and chemical implements; and crop protection strategies can be classified according to the biological, chemical or combined (mixed) crop protection methods allowed in them (Figure 1.1). Agrochemicals based technologies provide mass food products. Ecological (organic) farming provides commodities produced under inspected and certified processes without the use of synthetic pesticides or GMOs, recognized by a certain layer of consumers. Integrated farming (integrated pest management, IPM) utilizes biological crop protection, but also allows chemical pest control. The choice of chemical crop protection means is not transparently defined, therefore, the technology remained unrecognized and therefore not typically supported by the average consumer.

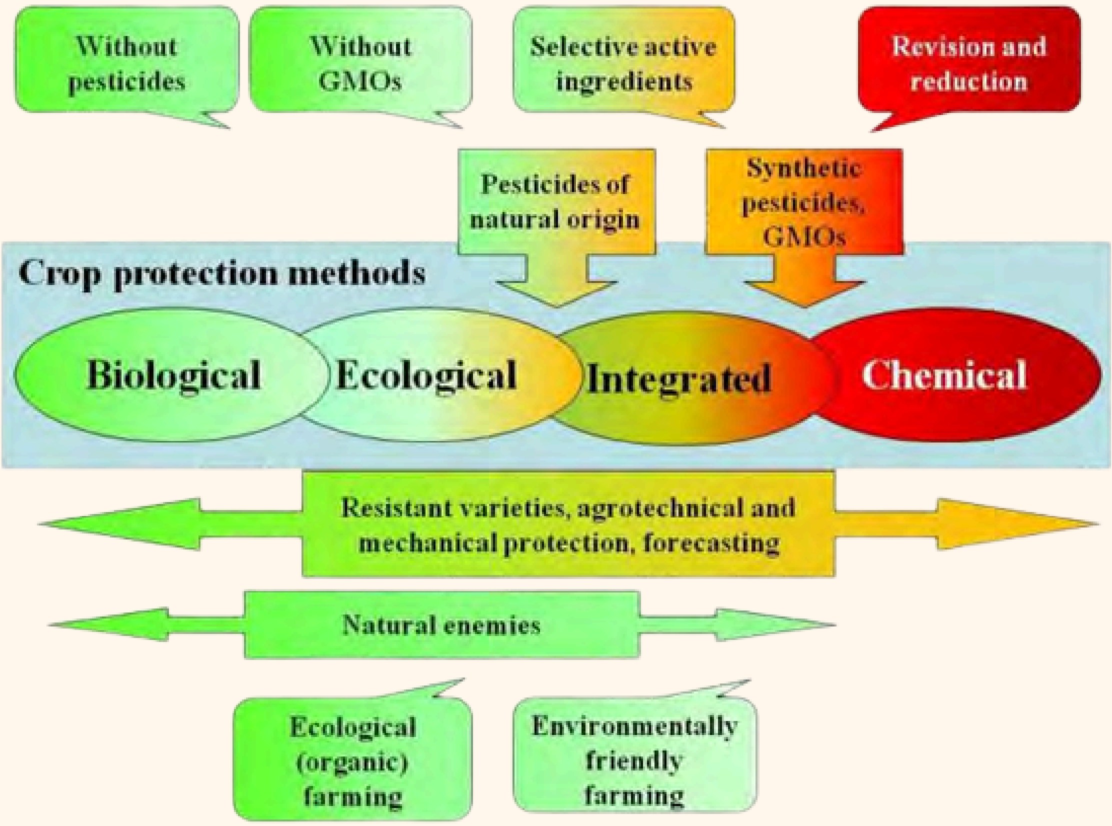


Figure 1.1. Crop protection strategies classified according to pest control methods allowed in them [Székács and Darvas, 2022].

The sustainable use of pesticides refers to practices and strategies that aim to reduce the risks and impacts of pesticide use on human health and the environment, while ensuring the effective control of pests and diseases in agricultural and non-agricultural settings. This concept is an integral part of sustainable agriculture and integrated pest management (IPM) approaches. Key aspects and strategies of sustainable pesticide use include:

Risk Reduction

Implementing measures to minimize the risks associated with pesticide use, including the selection of less hazardous pesticides, proper storage and handling, and the use of appropriate personal protective equipment during application.

Integrated Pest Management (IPM)

IPM is a holistic approach that combines biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. IPM emphasizes the use of non-chemical methods as the first line of defense against pests, resorting to chemical pesticides only when necessary and in a targeted manner.

Precision Application

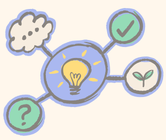
Utilizing advanced technologies such as GPS, drones, and sensors to apply pesticides more precisely, thereby reducing the amount of chemicals used and limiting exposure to non-target areas and organisms.

Pesticide Resistance Management

Implementing strategies to prevent or slow down the development of resistance in pest populations. This can include rotating pesticides with different modes of action, using pesticides only when needed, and combining chemical control with other methods.

Regulatory Frameworks and Compliance

Adhering to national and international regulations regarding pesticide registration, use, and residue limits. This includes following label instructions and observing pre-harvest intervals and maximum residue limits (MRLs).



Education and Training

Providing education and training to farmers, applicators, and other stakeholders about safe and effective pesticide use, potential risks, and alternative pest control methods.

Monitoring and Surveillance

Regular monitoring of pest populations, pesticide residues, and environmental impacts to inform pest management decisions and ensure compliance with safety standards.

Promotion of Alternatives

Encouraging the development and use of alternative pest control methods, such as biological control agents, pheromones, biopesticides, and agroecological practices that are less harmful to the environment and human health.

Public Awareness and Stakeholder Engagement

Raising awareness among consumers and stakeholders about the importance of sustainable pesticide use and the benefits of purchasing products produced with minimal pesticide inputs.

Pesticide Waste Management

Ensuring the proper disposal of pesticide containers and waste, and implementing measures to prevent environmental contamination.

The most famous ecology-based approach to agricultural crop protection strategies is the integrated pest management (IPM) (Deguine et al. 2021). It attempts to integrate chemical crop protection from intensive agriculture into the toolset of pest control alternatives. The initial definition for IPM in 1959 described IPM as a method of "applied pest control which combines and integrates biological and chemical control" (Zhang et al. 2018). Thus, the initial emphasis has been focused on the reduction of use of pesticides by proper timing of pesticide applications according to pest population levels and predefined economic thresholds; avoidance of the environmentally detrimental (e.g., harmful to human or environmental health, persistent) pesticide applications; and replacement/combination of agrochemicals with biological methods of protection. In fact, the EU Framework Directive 2009/128/EC on the sustainable use of pesticides and the Food and Agriculture Organization (FAO) of the United Nations to date defines integrated pest management as “the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human and animal health and the environment” **(FAO 2023)**. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms”.

Over time, the toolkit for IPM broadened, and the main characteristics of IPM have been categorized along with eight principles:

1. prevention and suppression
2. monitoring
3. decision based on monitoring and thresholds
4. non-chemical methods of control
5. pesticide selection
6. reduced pesticide use
7. anti-resistance strategies
8. evaluation

The concept of IPM tactics (Figure 1.2) indicates a hierarchy of practices, among which pesticides are listed only in case the alternative methods are insufficient. Indeed, a clear distinction among pesticides of natural origin (biopesticides, botanicals), biorational pesticides and the rest of synthetic pesticides is often made within IPM strategies. Initially classification within pesticides based on their IPM compatibility used to exits dividing authorized pesticide active ingredients into categories of allowed, questionable and restricted substances. With the increasing rigor of pesticide registration, however, this practice has faded.

Pesticide use remains to be a controversial issue regarding their compatibility with IPM in several application types e.g., in the use of seed coatings or in genetically modified (GM) crops. Both examples are related to the requirement of pest control measures initiated only after the pest population exceeded the threshold level: neither preventive (prophylactic) pesticide use seed coating, nor the production of plant-expressed transgenic insecticidal endotoxins can be timed for the population dynamics of the pest(s) to be controlled. The active ingredient is released after planting the given cultivar in both application types throughout the vegetation period, regardless of the emergence of the pest. Moreover, as seen in Figure 1.2, preventive application of chemical pest control is excluded in IPM

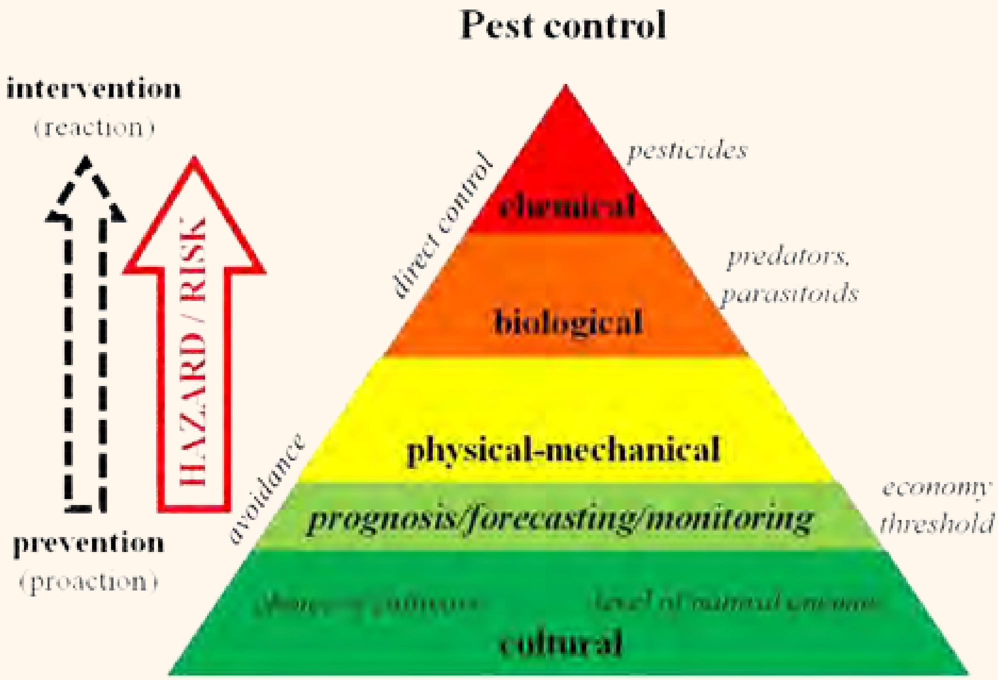


Figure 1.2. Pest control tactics in integrated pest management. The approach attempts to manage pests by applying a hierarchic set of biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks [Székács and Darvas, 2022].

As seen from the above, IPM does not exclude chemical plant protection from its toolkit, only advises it as a low priority protection measure.

On the other hand, **Ecological Pest Management (EPM)** defines strict environmental restrictions for any agrochemicals applicable with high emphasis on their soil and water contamination potential, to conserve soil and irrigation water quality, as well as to replenish soil organic matter. Ecological considerations regarding crop protection methods started to emerge as early as the late fifties, but reached observable degrees in agricultural technologies during the seventies (Deguine et al. 2021). In Ecological Pest Management (EPM), the approach to pest control views agriculture as an ecological system. Within this perspective, the occurrence of pests is seen as an ecological problem, necessitating solutions that are entirely ecological in nature. EPM emphasizes understanding and manipulating ecological processes and relationships to reduce the reliance on chemical pesticides and aims to create a more balanced and sustainable system for managing pests. Key aspects of EPM include:

Understanding Pest Ecology

EPM requires a deep understanding of the life cycles, behaviors, and interactions of pests within their ecosystems. This includes knowledge about the pests' natural predators, their relationships with other organisms, and their roles within the broader ecological system.

Emphasizing Prevention

EPM focuses on preventing pest problems before they become significant. This can involve cultural practices such as crop rotation, selecting pest-resistant plant varieties, and maintaining healthy soil ecosystems to support plant health.

Utilizing Biological Control

Biological control is a central element of EPM, involving the use of natural enemies (predators, parasites, pathogens) to control pest populations. This can be achieved through conservation of existing natural enemies or the introduction of beneficial organisms.

Habitat Manipulation

Modifying the environment to make it less conducive to pests and more favorable for their natural enemies is a key strategy in EPM. This can include creating or preserving habitats that support beneficial insects, or altering planting patterns to disrupt pest life cycles.

Minimal Use of Chemicals

While EPM does not completely rule out the use of chemical pesticides, it promotes their minimal and judicious use. When chemicals are used, they are applied in a way that minimizes non-target impacts and the development of pest resistance.

Monitoring and Decision Making

Regular monitoring of pest populations and environmental conditions is crucial in EPM. Decisions about pest management interventions are made based on thorough monitoring and an understanding of ecological thresholds.

Integrated Approach

EPM is often a component of Integrated Pest Management (IPM) systems, integrating various strategies and practices to manage pests in a more environmentally friendly manner.

Farmer and Community Participation

EPM involves the participation of farmers and local communities in monitoring, decision-making, and implementing pest management strategies. Education and extension services play a key role in disseminating knowledge and practices related to EPM.

Sustainability and Resilience

The ultimate goal of EPM is to create agricultural systems that are both sustainable and resilient to pest pressures, reducing dependency on external inputs and promoting ecological balance.

EPM is increasingly recognized as a vital component of sustainable agriculture, as it aligns with the goals of environmental conservation, biodiversity preservation, and sustainable food production.

The sustainable use of pesticides is essential for protecting ecosystems, maintaining biodiversity, ensuring the health and safety of communities, and promoting the long-term productivity and sustainability of agricultural systems. It requires a coordinated effort among farmers, industry, policymakers, researchers, and the public to implement practices that balance pest control needs with environmental and health considerations. As a consequence, EC focused since decades to improve the sustainable use of pesticides (EC Food Security 2023).

Recently, EC has proposed a new **Regulation for the Sustainable Use of Plant Protection Products**, aiming for a 50% reduction in the use and risk of chemical pesticides by 2030, as also targeted by the Green deal. This initiative aligns with the EU's Farm to Fork and Biodiversity strategies and was adopted on June 22, 2022.

The main key elements of this proposal include:

Mandatory EU-wide Targets

Establishing legally binding EU-level targets to cut the use and risk of chemical pesticides, including more hazardous ones, by half by 2030. Member States will develop national targets to ensure compliance with these EU-wide objectives.

Promotion of Integrated Pest Management (IPM)

Mandating all farmers and professional pesticide users to adopt IPM, a system emphasizing pest prevention and alternative control methods, with chemicals as a last resort.

Restriction in Sensitive Areas

Prohibiting pesticide use in sensitive zones like urban green spaces, parks, playgrounds, and ecologically sensitive areas crucial for pollinators.

Encouragement of Non-Chemical Methods

Requiring Member States to set goals to augment the use of non-chemical pest control and obligating professional users to seek independent advice on these methods.

This regulation, which updates the existing Directive 2009/128/EC, will be directly binding and uniformly applicable across all Member States. It represents a major step in the **EU Green Deal**, seeking to minimize the environmental and climate impacts of the agricultural sector. The proposal requires approval by the Council and the European Parliament through the normal legislative process.

1.1.2. Other measures on sustainable use of pesticides

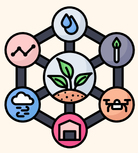
As seen, the concept of IPM introduced pronounced ecological considerations into crop protection strategies, yet it remained strongly technology-focused regarding the strong emphasis on the economy of pest control (economic injury level, economic threshold). The above FAO definition of IPM relies on the economic justification of pesticide use, and not pronouncedly on sustainability. The EU Framework Directive 2009/128/EC outlines several strict legal measures to achieve sustainable use of pesticides (above all the requirement of national action plans on pesticide use and the protection of the Natura 2000 biogeographical region sites), but otherwise formulated only intentions and not specific pesticide restrictions for IPM. In other words, the range of pesticides applicable under IPM remains the same that is governed by pesticide registration regulations for intensive agriculture, as the stringent regulatory requirements in pesticide registration are considered as a proper assurance for the sustainable use of the improved current pesticide products.

Other measures for the sustainable use of pesticides, complementing the primary strategies such as IPM and reduced chemical usage, include:

Education and Training

Providing comprehensive education and training programs for farmers, agronomists, and pesticide applicators. This includes teaching about the safe use of pesticides, understanding the risks, and training in alternative pest control methods.

Precision Agriculture Technologies



Utilizing advanced technologies like drones, GPS, and sensor-based systems for precise application of pesticides, which helps in reducing the overall usage and minimizes exposure to non-target areas and organisms.

Enhanced Regulatory Frameworks

Strengthening regulations regarding the registration, use, and disposal of pesticides. This includes enforcing stringent safety standards, regular review of pesticide impacts, and encouraging the development and registration of safer, more sustainable pesticides.

Promotion of Organic and Biopesticides

Encouraging the use of organic pesticides and biopesticides, which are derived from natural materials and are generally considered to be more environmentally friendly than synthetic chemical pesticides.

Pesticide Use Reporting and Monitoring

Implementing systems for comprehensive reporting and monitoring of pesticide use. This helps in tracking the quantities used, understanding usage patterns, and identifying areas for reduction.

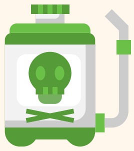
Buffer Zones and Protective Measures

Establishing buffer zones around sensitive areas such as water bodies, schools, and residential areas to protect them from pesticide drift. Implementing protective measures like cover crops and windbreaks can also help in minimizing off-target movement of pesticides.

Soil Health Management

Maintaining and enhancing soil health through practices such as organic matter addition, cover cropping, and crop rotation. Healthy soils can enhance the resilience of plants to pests and reduce the need for pesticide use.

Pesticide Resistance Management



Implementing strategies to prevent or manage pesticide resistance in pest populations. This can include rotating pesticides with different modes of action and integrating non-chemical control methods.

Public Awareness Campaigns

Conducting public awareness campaigns to educate consumers and the public about the impacts of pesticides and the importance of sustainable use. This can also include promoting the demand for produce grown with minimal pesticide use.

Fostering collaborations between governments, research institutions, industry, and farmers to develop and disseminate sustainable pest management practices and the implementation of the above-mentioned measures collectively contribute to a more sustainable and environmentally responsible approach to pest management, aiming to balance the need for effective pest control with the protection of human health and the environment.

Sustainability is defined at the cross-section of economy with the society and the environment (Figure 1.3). Key overlaps between these segments are defined as major characteristics of the feasibility of the balance between each pair of these sectors: equitability (economy and society), viability (economy and environment) and livability (environment and society), and sustainability if the lays in the very center, at the overlap of all these segments.

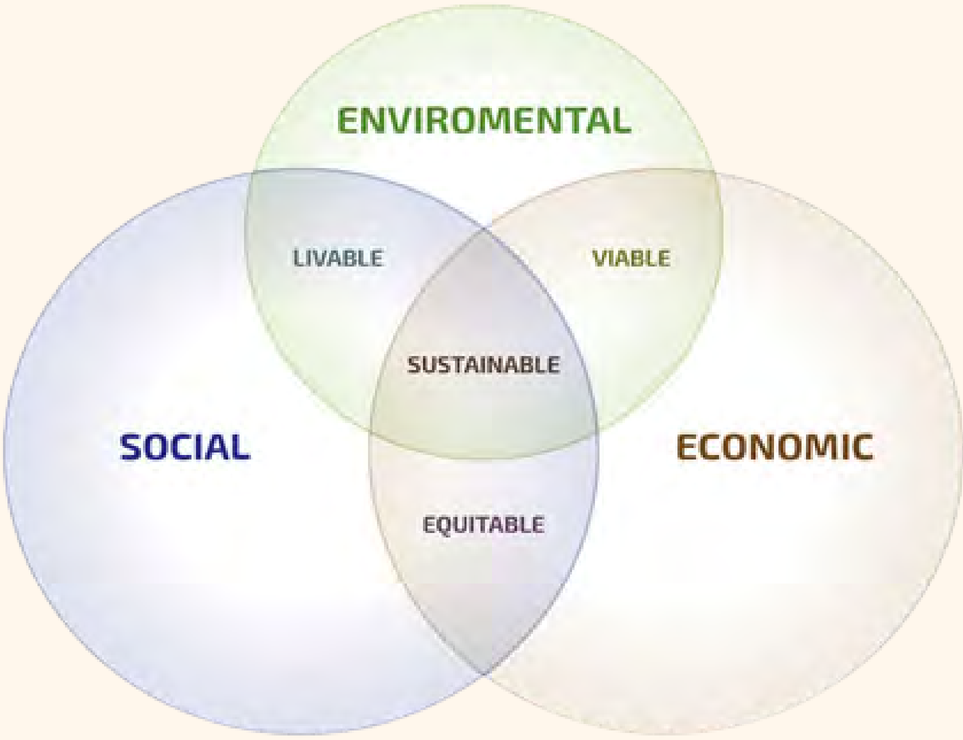


Figure 1.3. The concept of sustainability as a combination of social, economic and environmental components.

In societal terms, sustainability is about achieving equilibrium between economic growth and environmental stewardship, guided by Environmental and Social Governance (ESG). ESG, also known as socially responsible or green financing, enables investors and market participants to evaluate agricultural activities (or broadly speaking, the operations of businesses or nations) to prioritize long-term, ethical, and eco-friendly profitability over short-term gains. This approach challenges the traditional focus on relentless economic expansion, advocating for sustainable growth that accounts for environmental and social impacts. The ESG approach evaluates three core areas: (1) the environmental impact of agricultural and economic actors; (2) social concerns related to and beyond a company's operations; and (3) the governance practices and decision-making processes of senior management. Adhering to these principles ensures that businesses prioritize sustainable operations over unsustainable expansion, which is reflected in their "green rating." However, it's crucial that these achievements are genuine and not just superficial "greenwashing."

Regarding the Precision Agriculture Technologies, many companies are offering today integrations at different levels, as GeoPard Germany https://geopard.tech/why-geopard/

1.1.3. The European Green Deal

Grasping the essence of sustainability, the European Union has significantly advanced this concept within its contemporary economic growth plan. Under the European Commission's Biodiversity Strategy for 2030, the European Green Deal (EGD) ambitiously aims for Europe to lead as the first climate-neutral continent by the year 2050 (EC 2021) (Figure 1.4).

To realize this vision, the EU has outlined several economic benchmarks to be met by 2030, with a significant number pertaining to agriculture, such as:

- Halving pesticide use and cutting fertilizer use by 20%,
- Reducing nutrient surpluses in farming soil by 50%,
- Increasing organic farming to cover 25% of agricultural land,
- Boosting landscape features by 10%,Elevating the proportion of land under protection to 30%.

Additionally, goals indirectly connected to agriculture include achieving a 65% recycling rate, phasing out waste disposal by 2035, and targeting a 50-55% cut in greenhouse gas emissions by 2030 to progress towards climate neutrality by 2050.

Figure 1.4. The European Commission (2019) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal. Brussels, 11.12.2019 COM (2019) 640 final. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

The aim to reduce pesticide usage by 50% is a major challenge for the European agriculture, and questions have been raised about its practical viability.

The use of insecticides is the sector that is receiving the highest public attention, and steps have been made to strictness insecticide use (e.g., the EU ban on neonicotinoid insecticides), yet insecticides represent a low ratio (approximately 15%) of pesticide use in the EU. Alternative methods e.g., mechanical weeding and other agronomic practices, as well as microbial bioherbicides (a field of biological control of weeds emerging worldwide lately) are available to substitute herbicides or at least to reduce their usage.

Therefore, there is hope to progress towards the goals of the European Green Deal in weed control as well. Yet alternative solutions to replace or complement fungicide use are missing, particularly because the spread of plant pathogenic fungi is on the rise, partly due to the globalization of trade facilitating the transport of plant pathogens, as well as due to global warming as a Northward shift of pathogens from the Mediterranean region is observed with climate conditions becoming more tolerable for thermophilic microorganisms also at formerly colder regions. In turn, fungicides represent the largest ratio (approximately 40%) of the overall pesticide use in the EU. Concerns have been voiced regarding the anticipated rise in fungal infection incidence when the 50% reduction target was achieved. Nonetheless, a circumspect cutback on pesticide usage envisioned by the Farm to Fork Strategy supported by decision support systems is not a utopia.

There have emerged substantial voices of criticism from certain member states and societal stakeholders regarding the objectives of the European Green Deal both in general and as regarding the pesticide reduction goal. These circles are related to economy actors operating in the agribusiness sectors or participants that dispute regarding or claim to argue on behalf of the feasibility of intensive agriculture. In contrast, other societal groups embrace the aims of the European Green Deal strategy. These actors include companies and organizations geared towards circular economy, establishments focusing on ecological concerns, and obviously non-governmental organizations for environmental protection and the green movement. Argument involve the need of providing the growing human population with food, undisturbed economic development, and unfeasibility of the sudden accomplishment of the goals set on the one hand; and unsustainability of the current business model, need for immediate mitigation of the damages in the environmental equilibrium laying behind the climate change symptoms, and the need for setting ambitious goals into that direction showing an example for the world, on the other hand. Particular criticism has been voiced regarding the 50% pesticide reduction goal, including, in addition to technological unfeasibility, lack of geographic or agrotechnological fairness, and poor definition of the objectives. Claims include that such an undifferentiated setting of the reduction rate is unfair to countries with already low pesticide consumption or high proportion of agriculture. One way of pesticide use reduction is to spread ecological agriculture (organic farming) or supporting agroecology. The ban on synthetic pesticides on organic farming also decreases pesticide usage. Therefore, the expansion of organic farming in EU member states to be practiced at 25% of agricultural lands harmonizes with the aim of pesticide se reduction.

The overall aim of zero pollution and climate neutrality to be reached by 2050 is quite ambitious. One might doubt it whether it is feasible, but it is already an achievement that such an aim has been set in the EU. Other goals include to achieve affordable secure energy, smarter transport and high quality food.

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Unit 1.2 Pesticide authorization in the European Union

András Székács

The European Union (EU) has established a comprehensive system for the regulation of pesticides in order to ensure their safe use and minimize the potential negative impact on human health and the environment. As the use of pesticides may result in such impacts, it is of utmost importance to regulate their use to ensure that they are used in a safe and responsible manner.

The primary piece of legislation governing the regulation of pesticides is EU Pesticides Regulation 1107/2009, the “Pesticide Act”, establishing the criteria for the authorization and approval of plant protection products (PPPs), including pesticides. PPPs are subject to authorization at the EU level, and must undergo a comprehensive risk assessment prior to being authorized for use. The risk assessment process evaluates the intended usages, the properties of the active substance(s), and the potential exposure of humans and the environment to these substances. The assessment includes an evaluation of the potential for toxicity, as well as an evaluation of the potential for environmental impacts such as the risk of groundwater contamination or the potential harm to non-target species. In addition to strict and periodical registration for use, authorized PPPs are subject to ongoing monitoring, and if a PPP is found to pose a risk after it has been authorized, the EU may revoke its authorization and prohibit its use.

In addition to the EU Pesticides Regulation, the EU has several other pieces of legislation relevant to the regulation of pesticides. For example, the EU Water Framework Directive sets standards for water quality, while the EU Habitats Directive aims to conserve biodiversity. These pieces of legislation must be taken into account when evaluating the potential impact of pesticides on the environment. The EU also implements a number of other measures to regulate the use of pesticides, including restrictions on their use in certain areas and restrictions on the use of certain active substances.

The European Food Safety Authority (EFSA) and the European Chemicals Agency (ECHA) are responsible for implementing the EU's pesticides regulation. These agencies provide guidance on the risk assessment process and work with member states and stakeholders to ensure the consistent implementation of the EU's pesticides regulation across the EU. The ECHA is also responsible for managing the EU's database of authorized PPPs, which provides information on the active substances used in PPPs and their authorized uses.

1.2.1. Authorization of active ingredients

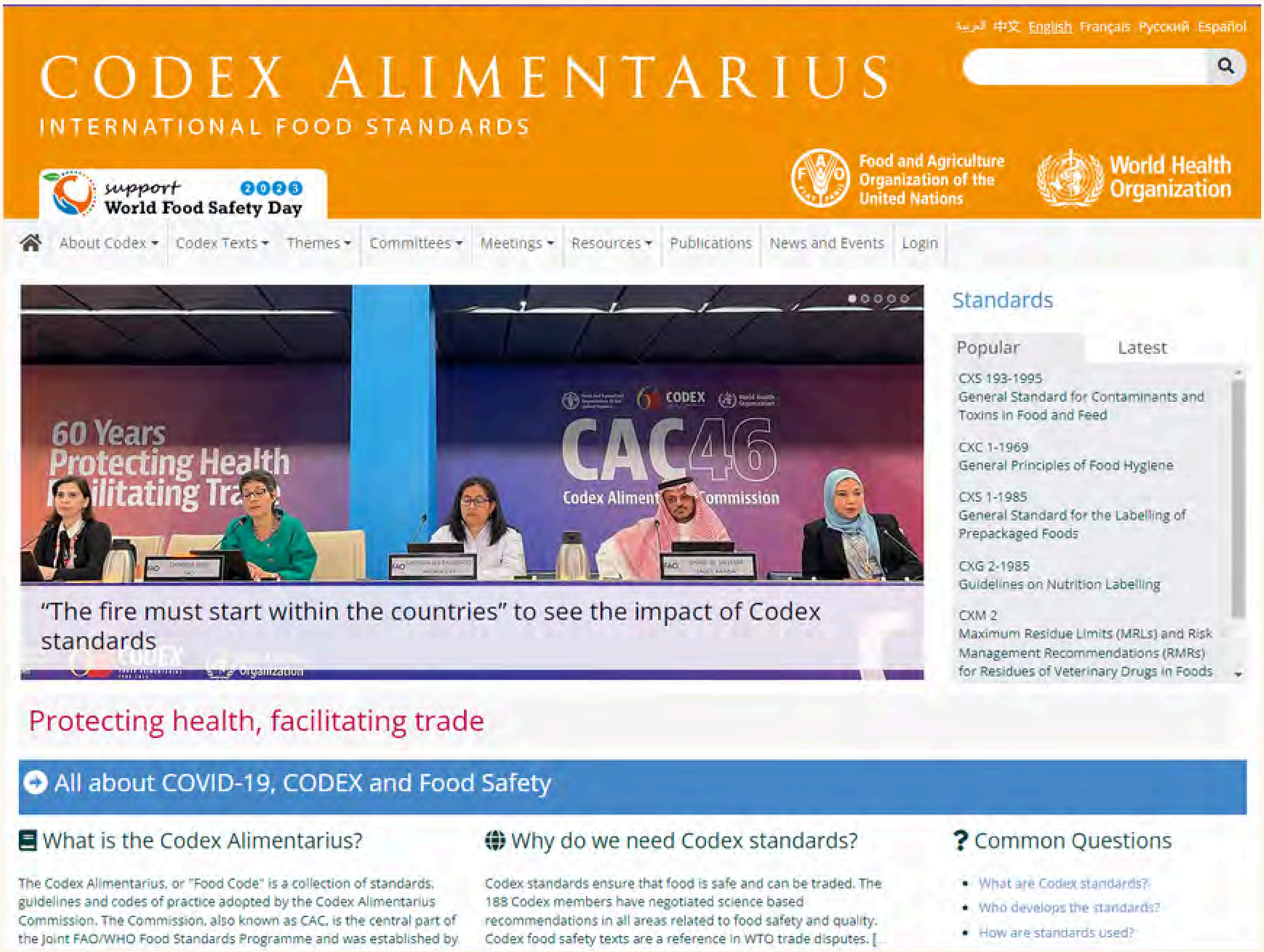
Grasping the essence of sustainability, the European Union has significantly advanced this concept within its contemporary economic growth plan. Under the European Commission's Biodiversity Strategy for 2030, the European Green Deal (EGD) ambitiously aims for Europe to lead as the first climate-neutral continent by the year 2050 (EC 2021) (Figure 1.4).

The active ingredients must be approved for use by the European Commission (EC) to be considered for being marketed in any form of pesticide formulations. In the process of authorization, these substances are evaluated in scientific evidence-based risk assessment by the EFSA, established in 2002. Risk assessment statements issued by EFSA, debated, and commented by the Member States are the basis of the subsequent EC decisions regarding authorization. Active ingredients classified as carcinogenic, mutagenic, teratogenic, endocrine disruptor, persistent, and bioaccumulative substances cannot be approved. Pesticide active ingredients regularly undergo detailed reassessment, and during a major re-registration process completed in 2010 the number of the registered active ingredients was substantially reduced from 959 to approximately 480 compounds authorized as pesticide active ingredients in PPPs, and this number has further decreased since

To avoid over-excessive human exposure to pesticide residues through foodstuff and the drinking water, MRLs have been established for these compounds in different commodities throughout the world, including the EU, and the levels of pesticide residues are required to be regularly monitored. MRL values are set by the EC for all food and animal feed categories on the basis of a complete risk assessment by EFSA.

https://www.efsa.europa.eu/en

If the levels of residues in case of approved pesticides exceed the determined MRLs in the food and animal feed products, measures have to be taken to prevent the use of the contaminated products/crops. In contrast, previously permitted, but later withdrawn or banned active ingredients of pesticides or their metabolites cannot be present in the food or animal feed at any concentration. These contaminants are usually originated from inappropriate technology or earlier environmental contamination. The official MRLs of pesticide residues are specified in *Codex Alimentarius* and other declarations for various commodities.



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1.2.2 Authorization of formulated pesticide products (co-formulants)

In contrast to pesticide active ingredients, formulated PPPs are authorized by the Member States (MS) on their territory, in accordance with the corresponding EU rules and regulations. Moreover, the enabled use of the pesticide formulations in various crop cultures is determined at MS level, as well. Pesticide formulants, also known as adjuvants, are substances added to pesticide formulations to enhance their effectiveness, stability, and handling. Pesticide formulants are also regulated the EU under Pesticides Regulation 1107/2009.

As mentioned earlier, PPPs as pesticide formulations are subject to dual approval: registration of their active ingredients at EU level and authorization of the formulated product at Member State level. Both levels rely on the determination of physicochemical, toxicological, and ecotoxicological properties of the substances (the active ingredient or its mixture with its adjuvants), and data determined are used in scientific evidence-based environmental risk assessment on the basis of both the Pesticide Act and Regulation 1907/2006 (EC), the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) Act, supervised by the ECHA, established in 2006.

A controversy in authorization, however, was that certain toxicity tests required to register PPPs were occasionally performed with the active ingredient alone, not with the pesticide formulation itself. Moreover, ingredients inert in the main effect of the preparation are generally not even indicated on product labels and are often claimed to be confidential business information. This is an improper practice, as "inert" ingredients can significantly affect toxicity endpoints, including developmental neurotoxicity, genotoxicity and disruption of neuroendocrine functions. This phenomenon remains to be a major contradiction in the scope of the legal regulations of pesticides and other biologically active substances (biocides).

1.2.3 Risk analysis

The terms "risk" and "hazard" are often used interchangeably in discussions about potential environmental or health impacts, but they have different meanings.

A hazard is a potential source of harm. It refers to a situation or substance that has the potential to cause harm to human health or the environment if not properly managed or controlled. Hazards are often characterized by their intrinsic properties, such as toxicity or flammability, and they can be physical, chemical, biological, or radiological in nature. Risk, on the other hand, refers to the likelihood and severity of harm resulting from exposure to a hazard. It is a measure of the potential harm that a hazard poses to human health or the environment. In other words, risk is a function of both the hazard and the exposure to that hazard.

To put it more simply, a hazard is a potential source of harm, while risk is the likelihood that that harm will occur. For example, a chemical used in pesticide formulation may be considered a hazard because of its toxic properties. However, the risk posed by the chemical is determined by both its toxicity and the likelihood and extent of exposure to it. If the chemical is used in a manner that minimizes exposure, the risk associated with its use may be considered low, despite the hazardous properties of the chemical. In other words, risk can be defined as a product of hazard (the potential of the substance do exert harm) with exposure (the likelihood that an individual meets that substance or becomes subject to its hazards). This can be captures in a simple equation:

$$Risk = Hazard \times Exposure$$

More expanded models related to disaster risk management also consider the elements of *Vulnerability* and *Lack of Coping Capacity* as additional dimensions in the equation, but for risk assessment of regulated products deliberately released into the environment considering the *Hazard x Exposure* dimension is sufficient. In conclusion, the distinction between hazard and risk is important in understanding the potential impacts of substances and situations on human health and the environment, and in developing effective risk management strategies to minimize these impacts.

Safety assessment of agrochemicals is an issue of emphasized importance worldwide. The establishment of the food and feed control system at EU level started in 2002 with Regulation (EC) 178/2002 laying down the general principles and requirements of food law, establishing EFSA and laying down procedures in matters of food safety. This was followed by a set of regulations on hygiene, and then Regulation (EC) 882/2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules.

The former separated units, independent authorities, and institutes adopted the food production, trade, and consumption chain approach covering the entire food chain from the farm to the table and enhancing follow-up and prevention. These regulations—to assure high level health and consumer protection—established a new, prevention approach in the food/feed policy. The aim of both the legislative and the advisory systems was utilization of an integrated, "from farm to fork" approach, covering the overall food chain including feed production, primary food production, processing, storage, transport, and trade.

Risk analysis is commonly divided into three distinct activity categories: risk assessment, risk management and risk communication. Risk assessment is a scientific evidence-based evaluation; risk management is a policy-based decision-making process on the basis of the outcome of risk assessment; and risk communication is an information exchange activity with society and the stakeholders on results or developments in the former two categories. Another classification considers risk management as a broadest category, containing risk assessment (further divided into risk analysis and risk evaluation) and risk control as main components. Yet, in management of environmental and food safety of regulated products the former tri-fold approach is used (Figure 1.5) with a strict separation between risk assessment and risk management (as a source of potential conflict of interests).

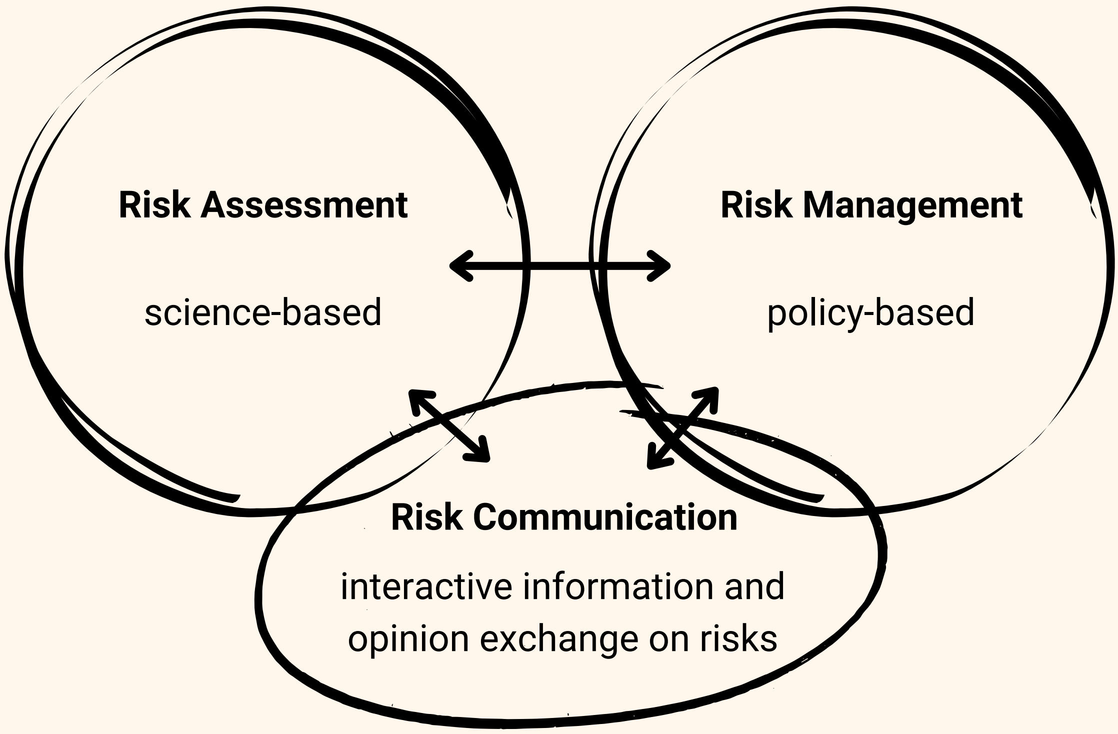

Figure 1.5. The embedded model of the interrelationships of Risk Assessment, Risk Management and Risk Communication.

The risk assessment process is performed by government agencies in the European Union, such as EFSA and ECHA, or by regulatory authorities in the Member States. The risk assessment and management process of pesticides is a comprehensive and multi-step evaluation generally consisting of the following steps:

(1) **Hazard identification:** This step involves gathering and evaluating data on the properties and characteristics of the pesticide, including its toxicity, persistence in the environment, and potential to bioaccumulate. This information is used to

identify any potential hazards associated with the pesticide.

(2) **Exposure assessment:** This step involves estimating the likelihood and extent of exposure to the pesticide, including exposure to workers, consumers, and the general population, as well as the exposure of non-target species and the environment.

(3) **Risk characterization:** This step involves combining the information from the hazard identification and exposure assessment to determine the overall risk posed by the pesticide. This step also considers factors such as the duration and frequency of exposure and the toxicity of the pesticide.

(4) **Risk management**: This step involves the development and implementation of measures to manage the risks posed by the pesticide, including restrictions on its use, mitigation measures, and labeling requirements.

(5) **Re-evaluation**: This step involves ongoing monitoring and re-evaluation of the pesticide to ensure its continued safety and effectiveness. If new information emerges indicating that a pesticide poses an unacceptable risk, its authorization may be revoked and its use prohibited.

The European Food Safety Authority (EFSA) plays a crucial role in the risk assessment of pesticides within the European Union. Established in 2002, EFSA's mandate is to provide independent scientific advice and communication on risks associated with the food chain.

EFSA's primary function in pesticide risk assessment is to evaluate the safety of active substances used in pesticides. This process involves the scientific assessment, by which EFSA assesses the hazard and risk of pesticides, considering their potential impact on human health, animals, and the environment, based on toxicological data, residue levels, and the risk to non-target species, the data analysis, by reviewing studies and data submitted by pesticide manufacturers and and development of guidance and protocols, that provide a framework for consistent and thorough evaluation processes.

More than 3000 articles and report are shown when searched with the key words ~pesticide risk assessment~

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ISBN 978-606-072-468-1
ISBN 978-606-072-469-8