Deliverable 5.1

Report of the coverage of all the plant productions and supply chains in the definition of the binding and optional rules

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Executive summary

The concept of **Integrated Pest Management (IPM)** has evolved significantly since its inception in 1959, moving from a focus on combining biological and chemical control to encompassing **all aspects of plant protection**. European policy, particularly the **EU Framework Directive 2009/128/EC on the sustainable use of pesticides**, emphasizes this shift by incorporating the notion of ecological processes in crop protection, in order to reduce use and impacts of pesticides.

In the last fifteen years, the EU Directive has mandated that all Member States support the implementation of the **eight general principles of IPM** by professional pesticide users. These principles are: Prevention and suppression (1), Monitoring (2), Decision-making (3), Non-chemical methods (4), Pesticide selection (5), Reduced pesticide use (6), Anti-resistance strategies (7), and Evaluation (8). While these principles are intended to be applied sequentially (1 to 8), current implementation often prioritizes the pesticide-based principles (5 to 8). The Agrowise project identified a **major gap between Principles 1-4 and 5-8**, noting that implementing Principles 1 and 4 often requires **redesigning cropping systems**, unlike Principles 5-7 which primarily aim to improve pesticide efficiency.

This discrepancy led to the development of **Active Prophylaxis** as the core of Principle 1.
Active Prophylaxis is defined as a series of actions, agronomic practices, and cultural combinations **intentionally implemented to reduce weed, pest, and disease pressure below a harmfulness threshold**. This threshold is dynamic, being higher if chemical pesticides are used later and lower if no pesticides are to be used. Strategies enabling low pest pressures through active prophylaxis can lead to a significant **reduction in pesticide dependency**, thus deserving public policy support.

The Agrowise project's taxonomy demonstrated the diversity and general applicability of IPM Principle 1 practices, showing their relevance across **diverse crops** (annual, vineyards, orchards, vegetables) and **various pests** (weeds, fungal diseases, insects, viruses). These practices are crucial for setting prevention and active prophylaxis.

Current pesticide-dependent crop protection is a **"locked-in situation"**, where no single stakeholder can initiate change without others. The Agrowise project involved all stakeholders—upstream and downstream sectors, society, consumers, and policymakers—to devise ambitious proposals for transition. **Financial instruments and risk management mechanisms are identified as prerequisites** for any change, requiring documentation of the real value and hidden costs of crop protection.

Key financial and market-based mechanisms discussed in Agrowise workshops include:

- **CAP funding:** Potentially offering a "top-up" for implementing active prophylaxis measures beyond general conditionalities.
- **Downstream sector involvement:** Through **long-term contracts (3-5 years)** between farmers and industries to provide visibility, and the definition of a **European IPM quality label**. This label could measure pesticide use (e.g., Pesticide Load, Total Applied Toxicity) or document implemented practices.
- **Innovation and upstream sector involvement**: Through increased availability and closer ties with advisors, extensive services and research, farmers can easily acquire the most innovative crop protection methods. This involves making biocontrol products and agricultural equipment **available in all countries where they are authorised, without limitation by market size**.
- **Premiums for farmers:** Combining contracts and quality labels with a premium for farmers applying IPM Principle 1 and active prophylactic measures.

- **Stopping unfavourable subsidies and supports:** Discontinuing subsidies for farms or cropping systems using more pesticides than regional averages to ensure financial equilibrium and incentivize IPM adoption.

The project proposes a **three-tier approach for IPM guidelines and recommendations**:
- **Tier 1: Active prophylaxis is recommended for farmers**, with Member States identifying in their national IPM guidelines the most adapted practices and supporting them thanks to targeted CAP funding and market recognition.
- **Tier 2: Strategies for groups of farmers** are defined for actions successful only when implemented collectively (e.g., sexual confusion, inoculum source removal), recognizing plant health as an increasing **common good**.
- **Tier 3: The upstream and downstream sectors are fully involved** in the transition at the supply, collecting, processing, and retailing levels.

Training is essential for all stakeholders – farmers, advisors, downstream decision-makers, and policymakers – to ensure long-term success and adapt to market constraints and climate change.

Data collection on IPM deployment can be shared among stakeholders to reduce the burden on farmers. By empowering the right players in the chain, it is possible to shift the balance and thus set fair conditions for farmers.

Active prophylaxis also generates **new research questions**:
- Better documentation of the **hidden costs of pesticide-based crop protection** and of **benefits due to economical services and synergic systems**.
- **Revision of harmfulness thresholds** to align with the absence of later interventions, impacting IPM Principles 2 (Monitoring) and 3 (Decision-making). These principles have to be extended to thresholds adapted to any kind of intervention (mechanical, biological…)
- Integration of new biodiversity components, such as **plant and soil microbiota and odorscapes (odour landscapes)**, into IPM implementation and regulations.

In conclusion, effective crop protection requires **profound, long-term changes** based on a combination of common goods (biodiversity, human health) and private goods. This necessitates a **complete redesign of cropping and agri-food systems**, supported by staged, adaptive, and sector-integrated regulations. Collaboration among research, farmer representatives, and NGOs is crucial to ensure a successful transition where some practices become compulsory and others remain optional, supported by tailored financial incentives. Working within this framework, the Agrowise project produces deliverables that are suitable for use by a wide range of stakeholders in the agricultural sector and for all situations and pest-crop combinations.

1. Introduction

IPM has come a long way since the introduction of "integrated control" defined as "applied pest control which combines and integrates biological and chemical control" (Stern et al., 1959[1]). The concept was initially developed by entomologists faced with indiscriminate broad-spectrum insecticide use and insect outbreaks caused by the elimination of natural enemies and the emergence of pesticide resistance. IPM now applies to all aspects of plant protection. It is the object of renewed focus as European policy, research, and extension efforts strive to mainstream it across the European Union. The EU Framework Directive 2009/128/EC on the sustainable use of pesticides addresses this challenge. It provides a definition of IPM largely inspired by the definition given by the Food and Agriculture Organization of the United Nations, substituting the concept of "pest control techniques" with "plant protection methods" and adding the notion of "ecological justification" to that of economic justification (Fig. 1). These modifications reflect an increasing interest in understanding and working with ecological processes.

2. Active prophylaxis as a game changer to define IPM guidelines

The EU Framework Directive requires that all EU Member States develop a National Action Plan to ensures that a set of eight general principles of IPM are implemented by all professional pesticide users starting on January 1, 2014 (European Union 2009a).

These 8 principles are:

- Principle 1—Prevention and suppression. The prevention and/or suppression of harmful organisms should be achieved or supported by other options than pesticide application
- Principle 2—Monitoring
- Principle 3—Decision-making
- Principle 4—Non-chemical methods
- Principle 5—Pesticide selection
- Principle 6—Reduced pesticide use
- Principle 7—Anti-resistance strategies
- Principle 8—Evaluation

This structure was proposed for IPM and has been discussed in many scientific papers such as Barzman et al. (2015)[2]. These analyses all underline the need to implement the principles in numerical order (1 to 8), even though, in reality, this is not the case, and only some of the principles are applied.

From the start of Agrowise, it was clearly identified that among these principles, there was a major discontinuity between Principles 1 to 4 and Principles 5 to 8. The latter group is pesticide-based and is today the most-implemented part of the IPM strategy.
The analysis of the practices and systems that are covered by all principles was carried out during the Agrowise project and was released as the taxonomy of IPM (D2.1). It showed the diversity of the various principles, and especially Principle 1 and Principle 4. This may be surprising as it is often reported by farmers and farmers organisations that there are few alternatives to pesticides.
However, the analysis of these practices also showed that

[1] Stern V.M., Smith R.F., van den Bosch R., Hagen K.S., 1959. The integrated control concept. Hilgardia 29, 81–101
[2] Barzman M. et al, 2015. Eight principles of Integrated Pest Management. Agronomy for Sustainable Development 35, 1199-1215

- The implementation of the Principles 1 and 4 is not only a search for substitution (according to the ESR scale, standing for the Efficiency/Substitution/Redesign scale, defined by Hill and McRae in 1998), but that it may generate a need for redesigning cropping systems. By contrast, the Principles 5 to 7, relying on safe use of pesticides, are only concerned with improving of Efficiency, reminding us that the present European cropping systems are pesticide-based.
- Some practices and systems of Principles 1 and 4 require long anticipation times (at least 3 to 5 years) and rely on strategic choices, while implementation of Principles 5 to 7 relies only on tactical choices.

This completely changes the structure of the IPM triangle.

During the course of Agrowise, an additional element emerged regarding the first principle. Indeed, a careful rereading of the guidelines and of the monitoring procedures for implementation at the European level (as done in Deliverable D3.1, which confirmed the 2020 EU report) revealed the same information than the EU report published in 2020[3]. Indeed, the interviews with Member State representatives and the Agrowise poll (conducted in Brussels in Septembre 2024, see D6.1) show a paradoxical situation: the implementation of this first principle is claimed to be widespread and some public policy instruments were identified as targeting this first principle (D4.1 of Agrowise). However, the implementation of the practices included in this principle seems very difficult to assess accurately. The reason for this discrepancy lies in the fact that most practices and systems that claimed to be preventative were not initially designed for this purpose. This is very obvious when analysing the objectives of crop rotations. They were initially designed for purposes of soil fertility. They only became preventative against weeds when large populations of herbicide-tolerant weeds, especially ryegrass and black grass, became prevalent, with large impacts on cereal yield and quality. It is interesting here to quote a sentence from the HDR document produced by Nicolas Munier-Jolain in 2011[4], where he quoted that the use of herbicides was set to control the weeds in the year of applications and to avoid the risks in the subsequent years. Surveys of crop rotations, in cereal-based production systems, performed in many countries showed that there is a trend to shorter and less complex rotations. This means that this lever which contributes to prophylaxis is less and less used.

This led to the idea that in the preventative approach, it was important to consider the intention as well as the action. The result is that the Agrowise project proposes to include the concept of Active Prophylaxis as the core of principle 1. A note has been written to precisely describe what this concept covers (Annex 1).

The Active Prophylaxis would be defined as a series of actions, agronomic practices and cultural combinations that are intentionally implemented in order to reduce the weeds, pests and diseases pressure, alone or after the use of chemical or non-chemical crop protection levers, below the harmfulness threshold. The Active Prophylaxis is thus leading to a 'residual pressure'. *This threshold consider long term pest dynamics and the hidden costs of plant protection. It is based on the level of pressure that the crop can withstand without affecting yield or quality*. It must not be confused with the economic threshold. Of course, the acceptable residual pressure will be higher if a chemical pesticide is later used to control the weeds, pests or diseases. This acceptable pressure will be intermediate if non-chemical methods are to be used (Principle 4), where the main action modes rely on biological regulations. And the residual pest pressure will be the lowest if no pesticide is to be used. Thus, seen from the opposite perspective, an Active Prophylaxis strategy that makes it possible to achieve low pressures, corresponding the harmfulness threshold is leads to a major reduction in

[3] STUDY SUPPORTING THE EVALUATION OF DIRECTIVE 2009/128/EC ON THE SUSTAINABLE USE OF PESTICIDES AND IMPACT ASSESSMENT OF ITS POSSIBLE REVISION, FINAL EVALUATION REPORT, EUROPEAN COMMISSION, DG SANTE

[4] Munier-Jolain N., 2011.Protection Intégrée contre la flore adventice des champs cultivés. Vers des systèmes agricoles plus durables ? Habilitation à Diriger les Recherches, Univ de Dijon.

pesticide use, and thus pesticide impacts. As a consequence, it deserves a top-up provided by public policies.

3. All crops – pests situations were considered in Agrowise

The overall strategy implemented in Agrowise made it possible to cover all situations. Indeed, the taxonomy built during the project was designed to be fully generic and may be used for all crops. This taxonomy classifies all the available levers for plant protection and links them to the IPM general principles. It is a tool to discover practical actions hidden behind the eight general principle.

If we consider the layers 1, 2 and 3 of the taxonomy for Principle 1, which was shown to be the richest, in terms of the number of options, and where all levers of Active Prophylaxis are listed, it can be seen that most practices are relevant to all groups of crops, even though there are some divergences (Table 1). These differences are related to the perennial nature of vineyards and orchards and to the difficulty of increasing the diversity within these productions, except through the introduction of perennial grass covers.

Table 2 shows how the practices identified in Principle 1 are providing options to set prevention and active prophylaxis against the various pests that are likely to affect production and quality.

Table 1: Relevance of the various practices of IPM Principle 1 for various production sectors. The practices in red are the most relevant for an Active Prophylaxis.

Level 1 (target)	**Level 2** (strategy)	**Level 3** (practice)	Annual crops	Vineyards	Orchards	Vegetables
1.1 Crop selection	1.1.1 Varietal diversity	Use tolerant cultivars	x	x	x	x
		Use resistant cultivars	x	x	x	x
	1.1.2 Crop species diversity	Crop rotation	x			x
		Intercropping	x			x
		Species mixtures	x			
	1.1.3 Site conditions	Crop selection: soil structural conditions and texture	x	x	x	x
		Crop selection: climatic region	x	x	x	x
		Crop selection: soil chemical properties	x	x	x	x
		Crop selection: infested area	x	x	x	x

		Crop selection: fallow	x			x
	1.1.4 Planting materials	Use of certified seeds	x			x
		Use of certified planting materials		x	x	
	1.1.5 Seed selection	Seed treatment	x			x
		Seed technology	x			x
1.2 Crop establishment	1.2.1 Sowing	Sowing time	x			
		Seed density	x			x
	1.2.1 Planting (cuttings/ seedlings)	Plant spatial arrangement		x	x	
1.3 Cultivation techniques	1.3.1 Soil cultivation	Reduced tillage	x			x
		Direct seed/ direct sowing	x			
		Plough	x			x
		Stale seed bed	x			x
	1.3.2 Crop cultivation	Pruning		x	x	
	1.3.4 Harvest management	Harvest timing	x	x	x	x
		Harvest technology	x	x	x	x
1.4 Amendments	1.4.1 Suppressive amendments	Mulching	x	x	x	
	1.4.2 Balanced fertilization	Organic fertilization/inorganic fertilizer	x	x	x	x
		Green manuring	x	x	x	x
	1.4.3 pH management	Liming	x	x	x	x
	1.4.4 Water management	Irrigation	x	x	x	x
		Drainage	x	x	x	x
1.6 Management of ecological infrastructure	1.6.1 Protection and enhancement of beneficial organisms	Creation or restauration of habitat outside the production area	x	x	x	x
		Creation or restoration of habitat inside the production area		x	x	
	1.6.2 Management of resources to the pest	Removal of non-crop hosts		x	x	

1.7 Hygiene measures	1.7.1 Cleaning of machinery and equipment	Cleaning of machinery and equipment	x	x		x
	1.7.2 Management of resources to the pest	Water/soil sanitation	x	x	x	x
		Removal of inoculum sources	x	x	x	x

Table 2: Relevance of the various practices of IPM Principle 1 for various pests. The practices in red are the most relevant for an Active Prophylaxis.

Level 1 (target)	**Level 2** (strategy)	**Level 3** (practice)	Weeds	Fungal diseases	Insects	Virus
1.1 Crop selection	1.1.1 Varietal diversity	Use tolerant cultivars		x	(x)	x
		Use resistant cultivars		x	x	x
	1.1.2 Crop species diversity	Crop rotation	x	x	x	x
		Intercropping	x	x	x	x
		Species mixtures	x	x	x	x
	1.1.3 Site conditions	Crop selection: soil structural conditions and texture	x	x	(x)	x
		Crop selection: climatic region	x	x	x	x
		Crop selection: soil chemical properties	x	x	(x)	x
		Crop selection: infested area	x	x	x	x
		Crop selection: fallow	x	x	x	x
	1.1.4 Planting materials	Use of certified seeds	(x)	x		x
		Use of certified planting materials		x		x
	1.1.5 Seed selection	Seed treatment		x	x	
		Seed technology		x		x
1.2 Crop establishment	1.2.1 Sowing	Sowing time	x	x	x	x
		Seed density	x	x	x	x
	1.2.1 Planting (cuttings/ seedlings)	Plant spatial arrangement	x	x	x	x
		Reduced tillage	x	x		x

1.3 Cultivation techniques	1.3.1 Soil cultivation	Direct seed/ direct sowing	x	x		x
		Plough	x	x		x
		Stale seed bed	x	x	x	x
	1.3.2 Crop cultivation	Pruning		x		x
	1.3.4 Harvest management	Harvest timing	x	x	x	
		Harvest technology	x	x	x	
1.4 Amendments	1.4.1 Suppressive amendments	Mulching	x	x	x	x
	1.4.2 Balanced fertilization	Organic fertilization/inorganic fertilizer		x		
		Green manuring	x	x		
	1.4.3 pH management	Liming		x		
	1.4.4 Water management	Irrigation	x	x		
		Drainage	x	x		
1.6 Management of ecological infrastructure	1.6.1 Protection and enhancement of beneficial organisms	Creation or restauration of habitat outside the production area		x	x	x
		Creation or restoration of habitat inside the production area		x	x	x
	1.6.2 Management of resources to the pest	Removal of non-crop hosts		x	x	x
1.7 Hygiene measures	1.7.1 Cleaning of machinery and equipment	Cleaning of machinery and equipment	x		x	
	1.7.2 Management of resources to the pest	Water/soil sanitation		x	x	
		Removal of inoculum sources	x	x	x	x

The Agrowise consortium also provided a consolidated approach to qualify the agronomic services provided (ASR) by every practice and system (see Deliverable 3.2). This approach was documented through several case studies across Europe and makes it possible to quantify the potential reduction of pesticide use once individual practices or combination of practices are implemented.

In the work carried out by the Agrowise consortium, the control is always the full pesticide coverage, in line with the objective of the SUD 2009/128, that aims at reducing the use and impact of pesticides, in comparison with the reference situation (years 2015-2017). However, the same ASR approach could be used in case where the control is the absence of pesticides as may happen when an active substance is withdrawn.

4. All stakeholders along the supply chains were involved in Agrowise

4.1. A typical locked-in situation

There is a large literature showing that the present crop protection system, mainly based on pesticides, is a typical locked-in situation, as it is initially described by Geels (2002) (Bakker et al, 2021[5];Trèves et al, 2025[6]).
It has been demonstrated that, in such locked-in situations, it is not possible for one stakeholder to change his/her behaviour and practices, if the other stakeholders are not changing accordingly. The other stakeholders in the crop protection locked-in situation are i) the upstream and downstream sectors of the agrifood system, down to processing industries and retailers, ii) society (NGOs) and consumers, and iii) policy makers.

Considering this situation, the Agrowise project sets three groups for setting the scene (with the SUD representatives for the Member States), for building propositions (with experts) and for discussing the propositions (with stakeholder representatives).

A special attention was given to cover the downstream sector, alongside representatives of farmers and farmers organizations. An active participation from International processing industries (Mondelez, Mc Cain) and local holders (Maxfrut) took place during expert and dedicated meetings.

The strong commitment of the stakeholders all along the supply chains made it possible to have rich discussions and ambitious propositions regarding the crop protection transition at the farmer level and in agreement with the whole supply chains. This made it possible to identify the financial incentives and the risk management that could be promoted, where the whole supply chains would be involved. Financial incentives and risk management, which could be ensured by both public policies and the markets, are a prerequisite before all changes. Such a change also requires to document the real value and real costs of new crop protection mainly based upon active prophylaxis. It also requires documenting the hidden costs of the pesticide-based crop protection and how much of these hidden costs could be saved thanks to prevention and active prophylaxis. Active prophylaxis would generate hidden gains (costs reduction for society as a whole such as reduction of water treatment, restoration of services provided by biodiversity, reduction of human health issues). These data, i.e. the crop protection costs saved thanks to prophylaxis plus the reduction of hidden costs documents the financial resources that could become available.

4.2. Financial instruments

Among the financial instruments which were discussed and that are in line with Deliverable 4.1, the CAP funding and the conditionalities are first. However, the CAP and the National Strategic Plans have not been explicitly linking measures toprecise IPM practices implementation. Moreover, a better

[5] Bakker L., et al, 2021. Kicking the Habit: What Makes and Breaks Farmers' Intentions to Reduce Pesticide Use? Ecological Economics 180, 106868. DOI 10.1016/j.ecolecon.2020.106868

[6] Trèves V., Hannachi M., Meynard J.M., 2025. Enhancing capacities for sustainability transition policy design: Lessons from French pesticide reduction plans. Agricultural Systems 223, 104175, DOI 10.1016/j.agsy.2024.104175

coherence between the CAP national strategic plans and the SUD national action plans should be ensured, as many discrepancies were quoted. Greater support for IPM would already be possible under this CAP period if Member States chose to include this as a priority in their national CAP SPs. Thus, this offers a major possibility for real promotion of IPM, and especially active prophylaxis, in the post-2027 CAP period. Beyond conditionality, Member States could increase IPM support, e.g. with a top-up when active prophylaxis measures are implemented. For every cropping system and country, one core measure could be identified, reflecting the importance farmers would give to active prophylaxis.

4.3 Role of the downstream sector

The discussions in the group of experts clearly underlined the role of the downstream sector, i.e. from food processing to retailing.
Several possibilities were explored, based upon quality assurance approaches, where farmers and downstream sectors would be partners. Three possible formats were discussed.

- Long-term contracts (3-5 years long) could be set, between farmers and downstream industries to ensure visibility to the farmers.
- An IPM quality label could be defined across Europe, in order to ensure the absence of discrepancies between neighbouring countries. However, the gap with the Organic Farming label should be discussed. One option could be to include use and impact of pesticide used by farmers. Such a metric could be provided by the Pesticide Load or by the Total Applied Toxicity. The alternative could be to document the practices that were actually implemented. This can either be done for a given group of crops or per farm. In such a case, the rating of farms regarding IPM implementation must be simple and on a voluntary basis to avoid administrative burdens.
- Contracts and Quality Label could be combined with a premium paid to farmers implementing the IPM Principle 1 and especially a short list of Active Prophylactic measures.

Higher prices must fit with the willingness to pay (WTP) of the consumers. Such a WTP must be based upon accessible information, easy to understand and coherent with the practices implemented by farmers. This could be acknowledged by a Pesti-score (load of pesticides), or an IPM score. This is to be implemented in coherence with the IPM labelling mentioned above.

For a sake of coherence but also for a financial equilibrium, it would be necessary to stop subsidizing unfavourable actions or policy instruments (such as a reduced tax on pesticides).

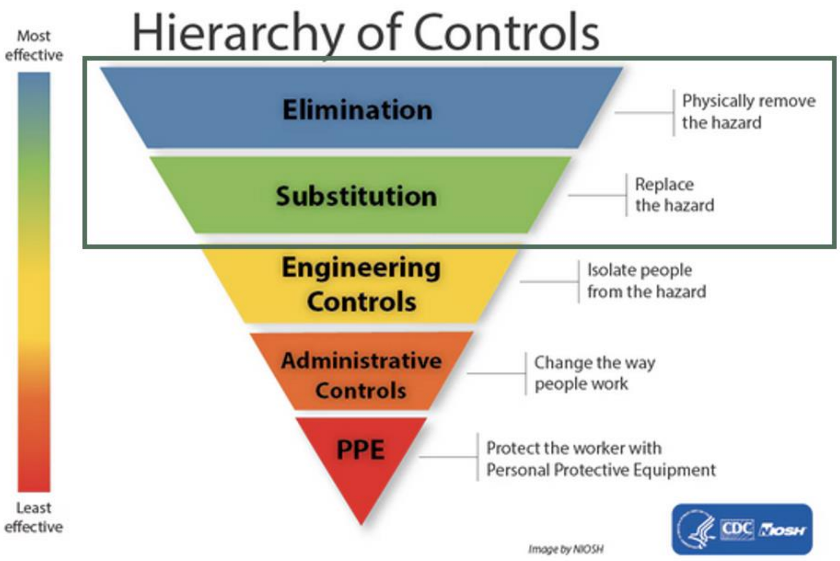
5. How to include these elements in the guidelines?

The definition of **active prophylaxis** sets a new paradigm for IPM guidelines (see the document dedicated to Terminology: Annex 1). It may indeed be described and implemented in all cropping systems and all contexts. Indeed, the intention to reduce pest pressure below a predetermined harmfulness threshold through an adapted strategy may be achieved through agroecology and restoration of ecosystem services. Thus, **active prophylaxis** is coherent with restoration of biodiversity and the actual sustainability of the cropping systems.

5.1. Hierarchy of controls

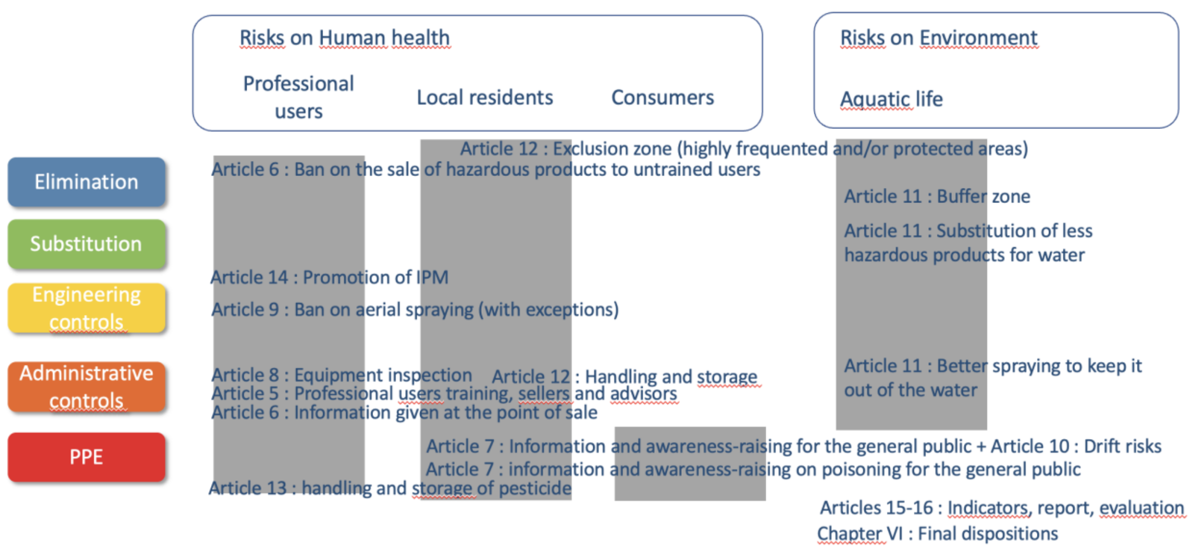
Cropping systems and sustainable use of pesticides imply a sound management of risks, as implied by the 2009/128 directive. Risk management may be analysed through the hierarchy of controls as defined in the industry (Figure 1). The most effective measure is the elimination of risks. In the case of crop protection, the elimination of risk is the suppression of pesticides, i.e. when the crop protection is ensured by other measures and especially when the active prophylaxis makes it possible to take the pest pressure below the harmfulness threshold.

Figure 1: Hierarchy of controls



The SUD may be analysed according to the hierarchy of controls (Figure 2), which shows where the various articles refer to.

Figure 2: Analysis of risk management in SUD directive according to the hierarchy of control.



This Figure 2 shows that the SUD is poor in terms of elimination of risks, if a satisfactory crop protection is to be ensured. Indeed, the only articles addressing elimination of risks are

- Article 6: Ban on the sale of hazardous pesticides to untrained users. All Member States implemented a system where all users have to be trained, such as Certiphyto in France. But the content of these trainings includes a limited number of elements supporting a thorough

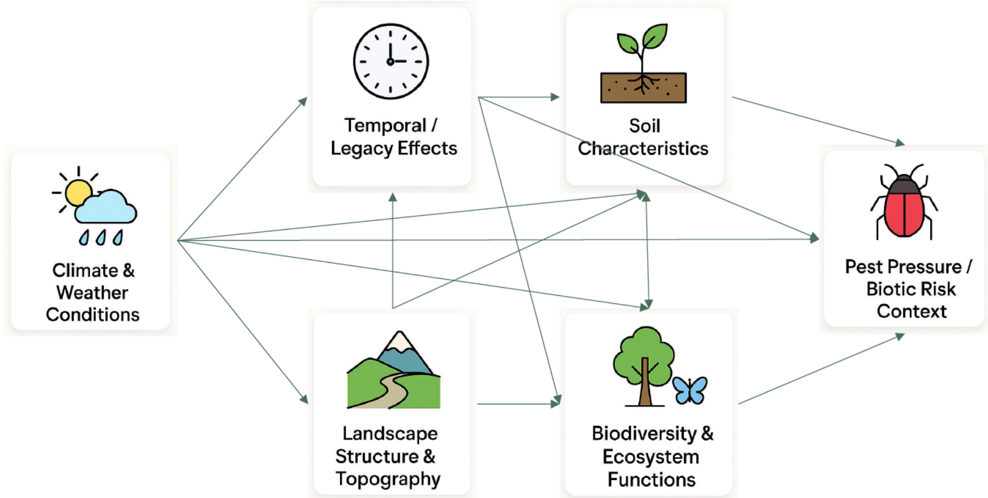
change in practices and a really short time for training users. Most items of the training target a better use of the chemicals. Thus, the dominant crop protection paradigm is not modified
- Article 12: Exclusion zone. It reduces the area under chemical crop protection, but again does not modify the dominant paradigm.

5.2 A 3-tier proposition

Thus, this could be enriched by three propositions (three tiers)

- **Tier 1: The active prophylaxis is recommended to farmers through IPM guidelines and incentives**. During IPM guidelines and National action plan updates, on the basis of the taxonomy defined in Agrowise, every member state may identify the most adapted groups of practices and systems contributing to such an active prophylaxis. The context dependency of the IPM practices effectiveness and of active prophylaxis was assessed as part of the Agrowise project. We identified cascade effects among the elements of context (Figure 3) showing that actions of farmers (temporal/legacy effects) can influence key parameters (soil parameters/landscape and ecosystemic functions) over the long term and continuous actions. These practices and systems may be acknowledged by a top-up in the CAP financial support, adapted to the context of each member state, and may be further recognized by the markets.

Figure 3: Interdependency among elements of context and cascade effect



- **Tier 2: IPM and Active prophylaxis become a strategy for groups of farmers through collective actions.** This makes it possible to recognize actions carried out in groups, in order to protect the environment and restore ecosystem services, and for actions that are only successful if all farmers in a site implement the same actions. This situation is known for example when farmers have to implement sexual confusion against codling moth in apple orchards or against grapevine moths (*Eudemis* and *Cochylis*). Similarly, in order to remove inoculum sources, such as potato mildew or sugar beet viruses, success is achieved only if all farmers in a region implement a very strict control of sources. Plant health appears increasingly as a common good and should be handled as such. This may require planning at the local level, requiring solidarity among all, including sometimes beyond the professional farmers. For instance, the management of the inoculum of *Drosophila suzukii* will require all residual fruits from red fruit trees (cherry, berries) in the gardens around the professional orchards to be collected and destroyed.
- **Tier 3: IPM including Active prophylaxis is highlighted by Member States as an asset to involve the upstream and downstream sectors in the transition**, at the level of supplying,

collecting, processing and retailing. The diversity of stakeholders is fully committed to achieve a successful transition. Member States can incentivize the stakeholders through instruments of the National Action Plan.

5.3 Training is essential, for all stakeholders

Beyond this 3-tier approach, the public policies must be adapted. One of the key policies for the long-term success is the training. It was already a key element back in 2009 in the SUD, and its importance is growing among buyers, sellers and advisors as well. The training must of course focus on farmers and advisors. But it is critical that the decision-makers of the downstream sector are also fully trained about the stakes and the actions to be implemented. Similarly, a proper training of the policy makers is key, as they have to articulate the decisions for the short-term adaptation of the farming systems to the immediate constraints of the markets and of the biotic conditions of the growing season, with the long-term transition of agriculture where a sustainable crop protection will have to be combined with the adaptation and resilience to climate change.

6. Active prophylaxis generates new questions for research

The active prophylaxis was identified as a game changer in integrated pest management. In order to get a full benefit from this new paradigm, emerging questions need to be investigated. This means that a research policy must be adopted alongside with the implementation of the reinforced guidelines for the SUD directive.

Among the research questions to be investigated, we identified the following ones as critical to foster large adoption of active prophylaxis:

- **The hidden costs of crop protection**. The hidden costs are the pesticides costs occurring beyond the farm's gate. They are poorly documented, and should be better known. It is anticipated that a better implementation of IPM should reduce them and the active prophylaxis should further reduce those costs. This has to be further documented.
- **Updated harmfulness thresholds are critical**. Today, they are used as an element in the decision support systems that lead to pesticide applications. These thresholds have to be revised if more alternative biological and physical techniques are being used (IPM Principle 4). Furthermore, with the search for new practices for active prophylaxis, lower pest pressures may be reached, and it will be important to know whether they would be compatible with an absence of later interventions. So, this research will lead to a modification of IPM Principle 3 (Decision-making) and will likely influence how the IPM Principle 2 (Monitoring) is implemented.
- When IPM was first defined, there were large components of the biodiversity that were ignored or not taken into account. This is particularly the case for the plant and soil microbiota which play key role in plant protection and in plant nutrition. It is also the case for the odorscapes which determine the insect behaviour, with consequences both on the damages of the herbivorous ones on the crops and on the biological regulations provided by the auxiliaries and the parasitoids. It is important to include these new areas in the implementation of IPM but also in the regulatory issues (SUD, 1107/2009).

These research questions are cross-cutting and must be applied at the farm or landscape level. They therefore involve all farming systems and all stakeholders.

7. Conclusions

To be able to propose meaningful recommendations, Agrowise project organised collaboration with various stakeholders and covering a large scale of agricultural situations. Its analysis of the IPM, enriched with the concept of active prophylaxis, considering the need to adapt it to all supply chains and all contexts and discussed with many stakeholders and group of experts led to the definition of guidelines and to several recommendations to the member states and to the European Commission.

We clearly showed that crop protection is a major issue for agriculture, as it has to be efficient and economically viable, with less and less pesticides, because of their withdrawal and the continuous emergence of resistance. So, thorough changes are necessary. They require long-term vision based upon a combination of common goods (biodiversity and human health) and private goods, which can only be reached thanks to a full redesign of the cropping systems and the agri-food systems. So, no possibility of quick fit! However, as visible from the list of efficient levers for active prophylaxis, there are a lot of possibilities for a gradual progress with an increasing implementation of active prophylaxis and more sustainable crop protection. The steps when chemicals are withdrawn or when resistances emerge create contexts for more thorough and rapid changes. Those will be developed in the final deliverables of the projects (D6.1 and D6.2)

This must lead to staged, adaptive, and sector-integrated regulations. This must be discussed with i) research to benefit from the most recent knowledge, ii) farmers representatives to consider the difficulties for adoption and for designing strategies to support adoption and iii) NGOs representing human health and biodiversity as the transition will be done with all, and not through an opposition between today and tomorrow.

From the perspective of the Agrowise project, a phased approach is necessary as, in order to cover all crops and all stakeholders, the practices must be ambitious. Active prophylaxis is therefore a means of prioritising practices that will initially be supported and useful in enhancing the resilience of systems. It may subsequently be made mandatory on a case-by-case basis to ensure that they are progressively implemented by all.