CHARM-EU BAIX LLOBREGAT PARK

- CIRCULAR AGRI-PLASTICS -

SOLUTION PACKAGE

POLICY BRIEF - BOOKLET - RECOMMENDATIONS

INTRODUCTION

This comprehensive solution package includes recommendations on how to approach the issue of the agricultural plastic waste issue within the Baix Llobregat Park. The solution package is established on extensive research conducted in 2023 in the region of Catalunya and addressed to three main stakeholders; Policymakers at European and national levels, the park management, the park farmers and technicians. In order to create solutions implementable at every level, this solution package includes three main elements:

- Recommendations for the Park management: This set of recommendations to the Park management includes concrete interventions that can be implemented to decrease the amount of agricultural plastic waste.
- Policy brief for policymakers: The policy brief includes a set of principles and solutions that can be implemented on the European or national level with regard to agricultural plastic waste.
- A booklet for farmers and technicians: The booklet includes specific recommendations for sustainable practices to reduce agricultural plastic waste.

RECOMMENDATIONS

INTERVENTION: IMPROVE ACCESSIBILITY BY CREATING A NEW WASTE COLLECTION POINT

Creating a new local waste collection point in Can Comas, San Boi or Viladecans would provide a convenient solution for farmers that could improve their accessibility to proper recycling options and willingness to dispose of their agricultural plastics. Large collection points as the Punto Limpio at the Mercabarna contain access barriers due to the low profits the farmers receive when they sell their crops to the wholesale market. Instead of the large collection points, a locally managed collection point without access barriers is proposed.

Farmers interviewed suggested Can Comas as a potential location for this collection point since farmers are already familiar with this place (Farmer 3, personal communication, November 6, 2023). Furthermore, Viladecans and San Boi could be suitable locations due to their large space. A future collection point focusing on materials with potential for mechanical recycling presents the most opportunity for a more circular economy within the park in terms of plastic usage; therefore, collection and management should move toward more mechanical recycling alternatives. In order to boost the usage of the new collection point, implementing weight-based collection fees can motivate farmers to dispose of their waste at the collection site. Establishing a local collection point in combination with financial incentives has great potential to increase the recycling of agricultural plastic waste. Several EU funds such as EAGF (European Agricultural Guarantee Fund) and the European Agricultural Fund for Rural Development can be applied in order to realise these collection fees.

RECOMMENDATIONS

INTERVENTION: CREATING A COMMUNICATION, AWARENESS OR EDUCATION CAMPAIGN

PABLL farmers noted the lack of available educational material (Farmer 1, Farmer 3, Farmer 4, personal communication, 2023). A targeted campaign would provide clear and accessible information to farmers about the location of recycling plants, the importance of removing agricultural plastic mulch from soil before it is degraded by sun and contaminants, existing initiatives like ECOPAP, and other actions or education related to APW disposal as well as plastic input reduction.

Pertinent European examples of farmer communication and awareness initiatives include France's interactive encyclopaedia for farmers regarding plastic usage, including end-of-life best practices (James et al., 2021, p. 19) and agri-influencers producing content about better plastic management in Poland. Similar methods may be successful at PABLL to encourage behavioural change, especially among young farmers.

Providing accessible education through training addresses multiple barriers such as knowledge and skill gaps while promoting future (generational) knowledge transfer. Additionally, valuable awareness can be achieved on the balance between the long-term negative costs of the conventional usage of agri-plastics and the investments in implementing circular economy principles. For the success of this training, cultural biases are very important to consider but could be overcome by providing clear information on circular practices. Previously mentioned EU funds could support the realisation of this education and awareness campaign.

RECOMMENDATIONS

POLICY PROPOSAL: BUILDING PARTNERSHIPS AND NETWORKS WITH LOCAL STAKEHOLDERS

Partnerships and networks between farmers, established initiatives, companies, and research institutes can further knowledge transfer, development, and innovative solutions. Potential collaboration could include farmer-farmer cooperation to facilitate crop-livestock rotations. Partnership or collaboration suggestions for the park management and farmers (such as individual farmers, the farmers union [Unio de Pagesos Catalunya], and farm technicians) include:

Governmental stakeholders:

- Spanish Ministery for Ecological Transition and Demographic Challenge
- SIGFITO
- AEVAE

Two similar schemes are already active in Spain —SIGFITO and AEVAE — focusing on AP *packaging* waste, where EPR is already mandatory. However, there is currently no contact between the three APR schemes and PABLL management. The research team aims to facilitate relationships that could positively impact current APW management practices in the PABLL.

Public sector:

- Waste Agencies/Catalan Waste Agency

- Punto Limpo: Emphasise the separation of types of plastic and reform the sorting system
- Recycle plastic cooperatives
- UCAN: collaborating with local recycler companies concerning innovations converting the APW stream into valuable products, such as outdoor furniture

Private sector:

- Plastic supplier San Boi
- ECOPAP
- REINWASTE
- Plastic Energy
- Gravity Wave: An innovative solution could involve exploring the usage of APW in open-loop recycling partnerships that create similar purchasable, unique decor items like those produced by Gravity Wave. If a relationship is established in which farmers can sell their difficult-to-recycle APW such as mulch films to a company like Gravity Wave, it would make the removal of films and the recycling more lucrative for PABLL stakeholders. This solution, however, requires a willing partnership and much coordination, but it presents an intriguing point for solution-based brainstorming. Exploring connections with private recycling companies such as Gravity Wave may lead to establishing open-loop recycling solutions for agricultural plastic films.
- Equipment rental company
- Recycled Polymers Europe: The director of Recycled Polymers Europe S.L.U. expressed interest in exploring a potential connection with the park to address drip irrigation pipes, which he said can be recycled with less concern about contamination than plastic films; per the discussion, one contribution to the capstone product will be the facilitation of an introduction between park management and Recycled Polymers Europe, via the researchers.

Set up a meeting with Recycled Polymers Europe S.L.U to discuss a potential partnership, particularly with the recycling of drip irrigation pipes.

Research sector:

- CIRAD: This French research institute could potentially collaborate with the park as a ‘living lab’ by implementing agroecological solutions such as direct-seeding mulch-based cropping systems

POLICY BRIEF

FROM FARM TO POLICY: WORKING ON A GREENER TOMORROW WITH AN EU-WIDE EPR SCHEME

EXECUTIVE SUMMARY

The increasing use of plastics in agriculture poses challenges from a health and environmental perspective. This document raises awareness about the issue of unregulated non-packaging agricultural plastic waste (APW) flow in particular. The paper presents an achievable and practical solution: the introduction of an EU-wide extended producer responsibility (EPR) scheme. Such a regulatory tool would help Europe overcome the growing APW challenge.

INTRODUCTION

A prevalent and successful method in making waste management sustainable is cost internalisation in line with welfare economics, particularly the producer-pays principle (OECD, 2001, p. 292). The United Nations and several academic researchers argue that the most effective way to implement such an approach in the case of agricultural plastic waste (APW) would be with an EU-wide extended producer responsibility (EPR) scheme (FAO, 2021; Hann et al., 2021). Its successful implementation would ensure that agricultural plastic producers take responsibility for the appropriate end-of-life management of their products. While EPR is theoretically the responsibility of each individual company, producers can handle plastic waste through producer responsibility organizations (PRO) (Pazienza & De Lucia, 2020, p. 6). These entities would manage the collection, disposal, and recycling of non-packaging APW in cooperation with the relevant public bodies and funded by the plastic producer corporations.

POLICY CONTEXT AND RATIONALE

The European Union has already introduced EPR schemes for several waste categories, including electrical and electronic equipment, vehicles, packaging, and tires. The 2018 EU Plastic Strategy and the revised Waste Framework Directive (WFD) mention EPR schemes as the potential solution to improve APW recycling, but no concrete steps have been taken since. Moreover, some Member States have already set up voluntary or mandatory EPR schemes for non-packaging AWP. Still, in today's globalised world, where many agricultural plastic producers operate in several EU Member States, creating the regulatory framework would be the most beneficial at the European level.

Therefore, the EU is advised to adopt a Directive on APW management to create an EPR framework in a way that leaves room for Member States, or even smaller NUTS units, to determine the specific measures based on the local agricultural characteristics to achieve the targets. As Muise (2016) concludes, the most efficient and successful strategy for managing an APW program shifts the responsibility to a regional organisation, under public control but funded by the plastics producers, dealers, or importers.

Potential issues that should be considered are the local feasibility and the peril that the plastic producers and distributors will pass the burden of the additional finances to the farmers with a price increase (Brog & Camilleri Fenech, 2023, p. 23).

IMPLEMENTATION PLAN

I: STAKEHOLDER ENGAGEMENT, RESEARCH & DATA COMPILATION: 4 MONTHS

The research team has already conducted a pilot study, including data compilation and stakeholder engagement in the park. Nonetheless, similar work is needed in other Member States, including ones with already established and successful APW EPR schemes, such as Ireland, and Member States where the legislators have not developed any similar strategies, such as Hungary.

The proposed time framework for a Europe-wide data compilation and stakeholder engagement is four months. During this time, the research team can identify and engage with key stakeholders, such as public bodies on various levels, environmental organisations, agricultural associations, plastic producer corporations, and other relevant industry actors.

Additionally, the research team can continue to work on the comprehensive analysis of the environmental impact of non-packaging APW in Europe, involving new case studies. Moreover, the key stakeholders of the existing successful national EPR APW schemes (Norway, Iceland, and Ireland) should be contacted to gain information on the implementation and outcome of such structures.

II: DETAILED POLICY PROPOSAL DEVELOPMENT: 1 MONTH

The research team would develop the concrete details of the new policy based on the data collected Europe-wide, aligning it with existing EU environmental goals and policies.

III: DEVELOPING A COMMUNICATION STRATEGY: 1 MONTH

A targeted communication strategy will be developed to raise awareness among all key stakeholders, including national and regional public bodies, agriculture and plastic industry actors, and individual farmers. Traditional and digital media channels will be utilised to disseminate key messages, emphasising the economic, environmental, and social benefits of the proposed EPR framework.

In addition, concise, persuasive, and clear factsheets will be produced to help the stakeholders understand the relevance of the APW challenges and the proposed regulatory framework.

MONITORING AND EVALUATION

The policy, research, and communication teams' work will be continuously monitored.

Moreover, during the first year following the establishment of the EU-wide EPR scheme, a comprehensive monitoring and evaluation framework should be implemented to assess the scheme's effectiveness. Key elements of the evaluation will include a thorough analysis of waste reduction metrics, recycling rates, the actual implementation by relevant actors, and the overall environmental impact. Stakeholder engagement will be closely tracked to gauge industry cooperation and public awareness of the EPR scheme. Financial aspects will be scrutinised, such as the producers' costs and the agricultural sector's economic implications.

Regular feedback opportunities will be offered to the involved parties, including producers, recyclers, and governmental bodies, providing insights into operational challenges and potential areas for improvement. The assessment will be complemented by a transparent reporting mechanism, ensuring accountability and facilitating evidence-based decision-making. The combination of these monitoring and evaluation steps will not only measure the success of the EPR scheme but will also inform iterative refinements to optimise its impact on sustainable waste management practices across Europe.

CONCLUSION

In conclusion, this policy brief underscores the escalating challenges posed by the unchecked flow of non-packaging APW and advocates for an EU-wide extended producer responsibility (EPR) framework. Recognising the success of existing EPR schemes in various waste categories, the proposed policy introduces the producer-pays principle in the field to ensure better end-of-life management of agricultural plastic products. The data compilation, spanning stakeholder engagement, comprehensive implementation plan, detailed policy proposal development, and communication strategy, offers a roadmap for effective execution. With the collaboration of key stakeholders and commitment to the proposed plan, the implementation of an EU-wide EPR scheme stands poised to address the environmental and health concerns associated with non-packaging agricultural plastic waste.

BOOKLET FOR FARMERS & TECHNICIANS

The surge in agricultural plastics has transformed agricultural practices but is accompanied by a significant environmental toll. The global consumption of plastic in agriculture skyrocketed from 2 to over 10 million tons annually between the 1980s and 2019. These plastics, ranging from expanded polystyrene to polyethylene, pose a substantial threat as they reach the end of their lifespan. Complex polymer blends impede efficient sorting and recycling, and their synthetic nature leads to delayed degradation. Inadequate recycling infrastructure and increasing global demand contribute to environmental leakage, with plastics harming individual organisms and entire ecosystems as they disintegrate. As concern over plastic pollution grows, an examination of alternative practices becomes imperative for the sustainability of agriculture as well as human and environmental health.

This booklet is aimed at both farmers in Parc Agrari del Baix Llobregat (PABLL) and the Agrupacions de Defensa Vegetal (ADV), private non-profit entities that group farmers together and hire technicians to implement the principles of Integrated Pest Management (IPM) in Catalonia.

A group of five master's students of Universitat de Barcelona conducted a project on agricultural plastics in PABLL. Searches across several online databases revealed the following articles (available through the links) detailing practices that could reduce plastic usage in the park. Interviews with some farmers and technicians working in the Park identified some practices already in place. It is hoped that this information might provide a point of departure for future research and practice in the Park as a 'living lab', described by the European Commission as follows:
'Living labs are initiatives in which experimentation is conducted on real farms, in specific territorial and community contexts, with farmers and other actors involved from the beginning as equal partners in proposing ideas, testing them, improving them and promoting them further'.

In the pursuit of sustainable agricultural practices, both alternative materials and techniques as substitutes for plastics are suggested. A thorough examination of various alternative materials is presented, considering factors like environmental impact, costs, yield implications, and soil moisture properties. While alternative materials may in some cases closely align with the functions of plastics, practical challenges such as high costs, limited availability or accessibility, as well as negative environmental impacts, have led to the exploration of techniques that eliminates the need for any material. This dual focus provides a nuanced understanding, offering flexibility in adopting sustainable practices based on specific needs and challenges in agriculture.

Plastic type	Alternative technique or material	Alternative at farmer level	Comments and resources
Greenhouse and Tunnel covers	Alternative technique	Paint the plastic with lime	Uncertainty was expressed as to whether greenhouses are necessary in the PABLL but the FAO (2021) recognises their continued role in climate adaptation. They are used in the park to extend the crop season. There is a need to improve their durability and in the park, greenhouses are sometimes painted white with lime to protect them from the sun. This can have the effect of enhancing crop productivity (Aboamera et al., 2018) and potentially remove the need for using plastic nets for shade (Puglisi et al., 2021). A technician confirms that this practice extends their lifespan while also improving climatic conditions in the greenhouse.
	Alternative material	Rigid polycarbonate (more durable than conventional plastics used such as LDPE or other flexible polymers)	A farmer as well as a technician in PABLL suggested the use of durable plastics for applications like greenhouses, aligning with FAO (2021)'s recommendation to consider rigid polycarbonate for greenhouses when no alternatives are viable. While more durable plastics may incur higher costs, it is essential to note the dual role of costs in waste management. Affordable products may be easily discarded, while pricier options may encourage responsible handling and recycling. However, a technician expressed that a different greenhouse structure is needed for the usage of rigid polycarbonate than conventional plastics which are flexible. Thus, this material would only be an option to be considered for new greenhouses.
Mulch	Alternative technique	No mulch	Some farmers in PABLL do not use any mulch, claiming that it's not necessary and that manual weeding is sufficient. It is clear that different farming philosophies impact the willingness of farmers to apply certain techniques. The potential costs from increased fertilisation and increased drought conditions suggest that complete 'no mulch' may not necessarily be possible for farmers in PABLL. Although one farmer suggested it is only necessary to mulch early crops, it is not usually done because it still is important for temperature and reduces evaporation. Not many people use mulch, but those who do use it leave it on the soil, creating huge contamination opportunities. Organic crop production can be found to generate up to 100% less plastic waste in durum wheat production (Bux et al., 2022). One technique is that alternative weeds are sometimes planted in the Park to prevent more harmful ones growing. A technician has suggested that this is not a 100% alternative technique to mulching, however. It is possible to farm without plastic mulch and improve greenhouse gas emissions resulting from plastic production as well as to decrease microplastic from residues. To prevent the yield from decreasing and costs from rising too much, however, it could be necessary to improve irrigation and fertilisation techniques, increase plant density as well as matching required accumulated temperatures to environmental temperatures based on plant variety (G. Zhang et al., 2023). Wang et al. (2023) also conducted a study where mulch was avoided and irrigation was increased. They found that the economic benefit of doing this was far lower and this would majorly deter farmers from switching techniques

Plastic type	Alternative technique or material	Alternative at farmer level	Comments and resources
Mulch	Alternative technique	Reuse mulch	When plastic mulch is used together with conventional tillage, its disintegration and residual amount is increased. "No tillage" is a technique that hardly destroys the structure of the plough layer (Hu et al., 2023). Hu et al., (2023) found in their study that reusing conventional plastic mulch from previous years for two years, when paired with no tillage, is optimal. It increased the net revenue as well as the sustainability index of maize. With many crops, reusing plastic mulch results in similar levels of productivity (X.-L. Zhang et al., 2022) (Lu et al., 2020) (W. Yin et al., 2021). Chen et al., (2021) found that the 'one film for two years' system decreases the carbon footprint per unit area and maize grain yield. Ren et al. (2023)'s study saw that reusing mulch for two years further increased the partial mulching technique. The age of the reused plastic can have an effect on its threat to the environment, however (Bao et al., 2023). Furthermore, although plastic mulch can be reused with positive effects, such as boosting N productivity, in just its second year its coverage can reduce to 70% (Tan et al., 2022). The reuse period of conventional polyethylene mulch is therefore quite short. Yan et al., (2015) suggest the concept of a crop safety period for plastic film mulching whereby the effectiveness of the film is assumed to decrease based on the length of time it is used. If certain types of film are chosen for particular crops under specific conditions for a specified period of time, the author's assumption is that it would decrease the amount of plastic residues in soil. Reuse of mulching is done in the park up to three times. Given research suggesting safety periods surrounding the reuse of mulch, farmers should properly consider the impact of this practice not only on costs, but also on the environment. Quilting sheets are a more durable type of mulch mostly used in gardening for up to 10 years. They are also used in agriculture but due to cost and installation procedures they are not widely used. In fruit growing, they are used more frequently to cover the area of the cultivation line.
		Intercropping and no tillage	Zhao et al. (2019) found that intercropping maize and peas along with a no-tillage technique reduced plastic as it doesn't involve replacing the plastic each year the field is cultivated.
		Cover crops	Sumiahadi et al. (2023) found that Arachis pintoi benefited soil health as a cover crop but competed with maize growth when left to grow with it. They recommended future research, however, given the competing results of other studies. Lee et al. (2011) found that hairy vetch produced a similar yield of soybeans to plastic mulch and a greater yield than crimson clover and rye mulch. Alfalfa or vetch mulch is used in the park as cover crops, but there is a lack of tradition. There is potential for this situation to improve, however, if machinery that properly fits the field is made available and with technical and learning support.

Plastic type	Alternative technique or material	Alternative at farmer level	Comments and resources
Mulch	Alternative technique	Ridge-shaped or partial mulching	Ren et al., (2023)found that although plastic mulching led to the best water use efficiency, it caused the most white pollution and the overconsumption of deep soil water, accelerating the consumption of soil organic carbon. Partial plastic mulching of ridge furrows, leading to 75% plastic reduction paired with no-tillage enhanced rainwater infiltration and helped optimise the soil microenvironment. El-Beltagi et al. (2022) also found that this type of mulching could "improve soil water supplies, root density, energy and water conservation, plant dry weight, and maize productivity".
		Crop-livestock rotations	Concenço et al. (2011) found that soils with crop-livestock integration and livestock only "may strongly reduce weed infestation at the area when grain crops are periodically or sporadically grow," potentially decreasing the need for weeding tools such as mulching or herbicides. Horticulture is the primary farming activity in PABLL and has been the main concern of the articles discovered. Sheep and chickens are also farmed in the park, however. Mutually beneficial agreements could be made between farmers to establish some crop-livestock rotations in the park. There are only 23 livestock farms in the park. However, estimates of animal farming plastic sales in Europe suggest that they generate more tonnes of plastic than horticultural farming (APE Europe, n.d.). The role of these farms in plastic reduction and agroecological development should be considered in future PABLL developments.
		Crop alternatives	Some articles suggested native and alternative plants, without plastic mulching, as a method of climate adaptation where soil is being eroded as a way of maintaining farm income. Huang et al., (2012) looked at the impact of cropping pattern modifications on the peri-urban area outside Beijing on water use. Although land use was constricted, farming intensity increased and gave way to increased water use, largely caused by an increase in grain to vegetable farming.
		Tree shelterbelts	Trees can also have protective functions for other crops. One study analysed the influence of tree shelterbelts on water consumption by crops and the trees themselves (Thevs et al., 2017). Their use contributed to a reduction in water use in fields of 25ha. This study did not compare it to the use of mulch, however.

Plastic type	Alternative technique or material	Alternative at farmer level	Comments and resources
Mulch	Alternative materials	Bioplastic/Biodegradable plastics: *PLA* (polylactic acid) *PBAT* Poly(butyleneadipate-co-terephthalate) *PHA* (Polyhydroxyalkanoate) *PHBV* (Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) *PHB* (polyhydroxybutyrate) *Starch-based*	Biodegradable films in agriculture, while comparable to traditional plastic in moisture retention, face challenges due to a 5.8% higher input cost than PE mulch (Jia et al., 2020). Despite this, they offer cost-effective alternatives, reducing labour costs. Adoption depends on factors like initial prices, labour costs, and farmer preferences. Consumer willingness to pay more for products with biodegradable mulches presents opportunities, but challenges include higher initial prices and farmer prioritisation of cost savings (Madrid et al., 2022). Integrating organic waste into bioplastic production could cut costs by substituting expensive polymers with commonly disposed materials (Pudełko et al., 2021). However, concerns about metal accumulation in soils from bioplastics exist. Reports discuss elevated element concentrations in bioplastic-covered soils. This increased metal availability, linked to bioplastic crystallisation, raises environmental worries during biodegradation (Santini et al., 2022 & Maraveas et al., 2023). Furthermore, a technician argued that cost overruns, decreased lifespan, and limited access to these materials due to lack of suppliers, are limiting issues connected to the use of these materials.
		Woodchip mulch	A study demonstrated that woodchip mulch effectively curbed the drastic decline in water content during rainless periods, showcasing their ability to reduce watering costs (Hofmann et al., 2023). A technician commented that in order to be able to use this type of mulch a guaranteed supply in quantity is essential.
		Hydromulch	Hydromulch, a water-lignocellulosic material mix, was studied as an organic alternative to agricultural plastics. Three variants, blending paper pulp and cardboard with wheat straw, rice hulls, and mushroom cultivation substrate, demonstrated artichoke yields similar to polythene (López-Marín et al., 2021). A technician expressed high interest in implementing this material.
		Textile mulch mats	A study examining two textile waste nonwovens as eco-friendly alternatives to plastic mulch films, found that, after three months of accelerated weathering, the mulching mats demonstrated efficient soil moisture retention and excellent soil warming properties (Abidi et al., 2021).
		Paper mulch	A technician in PABLL discussed that paper mulch may be a suitable alternative to plastic but it can be more expensive, requiring a specialised team for application. Paper's shorter lifespan means more frequent distribution. The economic viability of sustainable alternatives is hindered as they are perceived as less cost-effective by farmers.
		Cardboard	A farmer in PABLL highlighted that organic alternatives like cardboard can outperform (bio)plastics in terms of weed control. The effectiveness of cardboard regarding weed control has also been confirmed by Tamer & Menderes (2011) who analysed that cardboard (as well as black PE cover and sand applications) are the most effective mulch methods and when compared to these methods, herbicide application is less effective. However, according to a technician, a disadvantage of cardboard is that it is not adaptable to large surfaces.

Plastic type	Alternative technique or material	Alternative at farmer level	Comments and resources
Irrigation pipes/tape	Alternative techniques (integrated approaches)	Direct seeding mulch-based cropping systems (DMCs)	The French agricultural research centre, CIRAD, proposes this no mulch, no tillage technique. They published a report in 2009 that proposed using this technique for maize and sweet potato and soy in Yunnan province and Chongming Island and the Shanghai Region. It involves "no tillage, permanent plant cover and relevant crop sequences or rotations associated with cover crops" (Séguy, 2009). Crops are sown directly into permanent biomass cover (residues of previous crops or fresh mulch). According to Séguy (2009), it can be promoted and adapted under most socio-economic and agro climatic conditions. Collaboration with agroecological research groups such as CIRAD could have great potential in the park. Although DMCs have thus far only been used in low and middle income countries, it incorporates elements of agroecology that are already being used in the park, e.g. through the use of bio-mulch materials and could aid further establishing the park as a 'living lab', an agroecological principal discussed below.
	Alternative material	Reusable plastic irrigation pipe - Rigid polycarbonate (more durable than conventional plastics used such as LDPE or other flexible polymers)	A farmer as well as a technician in PABLL suggested the use of durable plastics for applications like irrigation pipes, aligning with the FAO's recommendation to consider rigid polycarbonate for greenhouses when no alternatives are viable (FAO, 2021). While more durable plastics may incur higher costs, it is essential to note the dual role of costs in waste management. Affordable products may be easily discarded, while pricier options may encourage responsible handling and recycling.
Polymer-coated fertilisers	Alternative technique	Organic fertiliser e.g. Vermicompost	Controlled-release fertilisers and those with technical additives such as anti-caking both contain polymers (Fertilizers Europe, n.d.) that result in the presence of microplastics in the soil. The EU fertilising products regulation has set out a timeline to make them illegal by 2026. Farmers and technicians are potentially unaware of the type of fertilisers used on the farm and their potential plastic contamination. Given that EU regulations will insist on polymer-containing fertilisers being made illegal by 2026, it is important that farmers begin to make this transition, such as testing the use of vermicompost on the farm. Such types of organic fertiliser can still achieve a significant yield improvement (Zare et al., 2016). Vermicompost is "one of the most important bio-fertilisers in the world" and involves composting organic waste using earthworms (Zare et al., 2016). (Ahooi et al., 2020) also advise the addition of trichoderma fungus to enhance vermicompost effects.
	Alternative material	Biodegradable coated fertiliser	The FAO (2021) suggests using biodegradable materials as fertiliser coatings such as natural materials (e.g. cellulose) or a biodegradable plastic (polylactic acid, starch-polyvinyl alcohol and others) More specifically, a new type of slow-release fertiliser was successfully developed by coating solid calcium ammonium nitrate with a biobased raw material—hemp oil. The resulting product demonstrated promising controlled-release properties and environmental friendliness. The tested material exhibits significant potential as a key component in a two-layer coated fertiliser, making it particularly valuable for agricultural and horticultural applications (Boberski et al., 2022).

Plastic type	Alternative technique or material	Alternative at farmer level	Comments and resources
Agrochemical containers (for pesticides & herbicides)	Alternative technique	Alternative pesticide containers (such as aerosols)	Lucchi et al., (2018) suggest that the use of aerosols as phytosanitary containers can cover more hectares per device. The potential of different types of containers that may impact the number used, not only for pest management, depends on design developments and ultimately local availability.
		Sprayer service	"Sprayer service providers can avoid the need for each farmer to apply pesticides. In a community of small-scale farmers, one farmer can be trained and equipped to provide a pesticide spraying service to neighbours. Such services avoid the need for each farmer to have stocks of pesticides and application equipment. It avoids the need for unsafe small-dose packs or repacking into inappropriate receptacles. However, reliance on such services could exacerbate the use of pesticides rather than using more sustainable and potentially less costly pest management practices" FAO (2021).
		Mechanical pest removal	Khedhr et al. (2005) also discuss mechanical pest removal, where traps with wet sacks and molasses were used to trap snails. The success of this technique in terms of plastic management lies in reducing the need for mulch or phytosanitary containers for pest management but depends on what material the trap is made of.
Crates	Alternative technique	Removal of farm plastic litter	Braun et al. (2023) discuss how plastic litter can have a significant impact on microplastic content. After mulch and greenhouses, the most obvious visible presence of plastic in PABLL were plastic crates. Although these may be disregarded in plastic reduction as they can be reused, these crates were broken and left to degrade at the edge of fields. One technician also identified plastic bottle litter as being one of the main sources of plastic on the farm.
Nursery plastic/seedling pots	Alternative technique	Reuse	One technician noted how both reusable and single-use trays are used for young plants. He says that it is necessary to use this plastic in plant nurseries and that alternative materials are not common. Single-use trays could, however, be easily phased out in the park.
Tree plastic covers	Alternative technique	No cover with anticipated pruning	Ferreira et al., (2004) found that the use of a plastic cover over grapevines did not increase the speed of the vegetative cycle and reduced production in Southern Minas Gerais, Brazil. Those subjected to anticipated pruning, however, produced a higher number of bunches with no extra costs.
Plant clips (stem and arch support clips)	Alternative material	Bioplast GS2189 as a base biopolymer and wood-derived biochar as a filler	While some biodegradable plastics, like foils, persist in water, a study on biochar-added stem and arch support clips found they fully degraded in industrial composting at 58°C. However, degradation during composting may vary based on size, weight, and thickness. Expenses for single-use biodegradable materials in greenhouse tomato cultivation, including support clips, were found to be similar to conventional plastics. The overall cost, considering purchase, on-farm handling, waste management, and disposal, suggests conventional plastic clips may be comparable to biodegradable alternatives for tomato cultivation (Malińska et al., 2022).

REFERENCES

Please note that these references are regarding the recommendations and policy brief. The references for the booklet are linked in text to make relevant literature more accessible for the farmers and technicians.

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