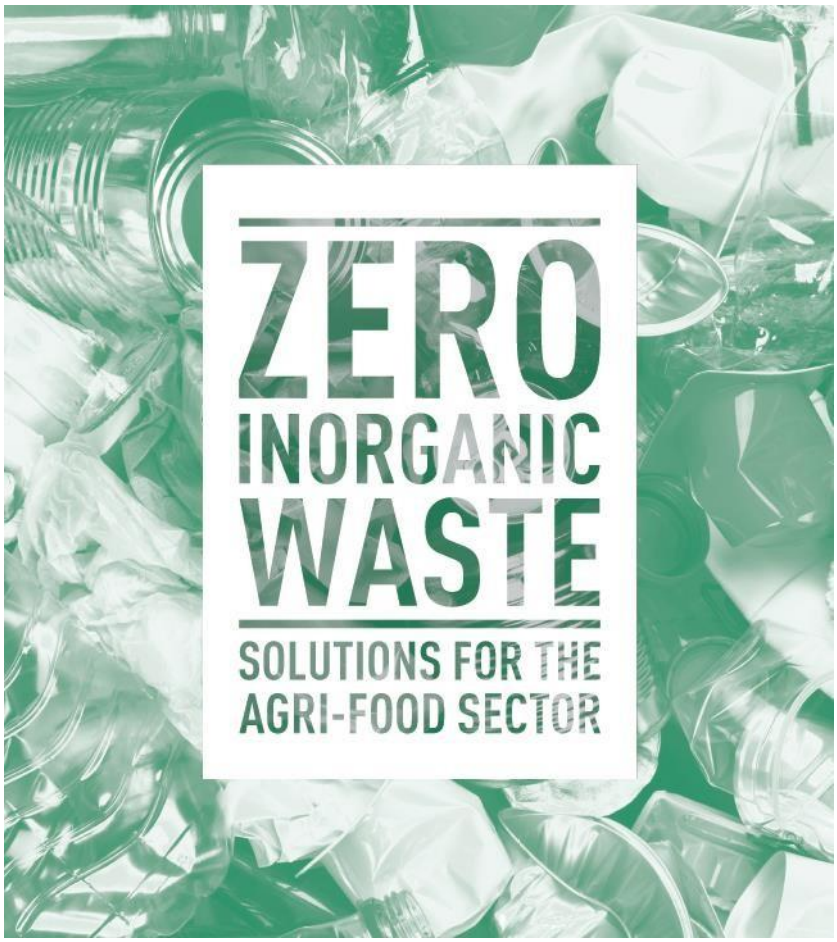
Project co-financed by the European Regional Development Fund

REINWASTE PROJECT



Deliverable: 3.6.1 Sustainability analysis: socio-economic and environmental survey

WP (*Name of the work package): WP3 Testing*

Coordinator: *(Organization and author): IFAPA*

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REINWASTE: REmanufacture the food supply chain by testing INNovative solutions for zero inorganic WASTE

DELIVERABLE 3.6.1

Sustainability analysis: Final report

Objective

The objective of the sustainability analysis is to evaluate the impacts associated with the innovative solutions compared with the traditional ones for the 3 value chain (horticulture, meat and dairy) and the 2 chain stages (agriculture and food industry) by quantifying and integrating indicators at the 3 dimensions of sustainability (economic dimension, social and environmental) and at the global level by integrating these 3 dimensions.

This document will develop the results obtained from this evaluation, using the AHP (Analytical Hierarchy Process) methodology and the evaluation through a survey of experts in the sector (explained in the Deliverable 3.6.1.1. Sustainability analysis: Survey to experts).

1. Horticulture production (Spain)

Evaluation

9 experts in horticulture production in Spain were surveyed. The indicators evaluated by the experts in all the pilots/practices analysed are:

• Economic dimension/indicators: They refer to the economic aspects of sustainability, relative to farmers/industries economic (market) benefits and costs. They are:

- Overall profitability for farmers/industries: It refers to incomes minus variable costs. Income and costs are the totals of the economic activity developed by the farmer/industry, not just those associated with the technique being tested. It measures how the practices implemented can affect the overall profitability obtained.
- Strategic positioning and competitiveness in the market: It refers to the fact that early adoption of innovations can improve the company's position in the medium and long term.
- Intrinsic product quality: Refers to the quality attributes found within the products obtained by the farmer/industry. It refers to sensory and organoleptic issues, etc.
- Diversification of economic activities related to waste management in the region: This refers to the presence in the region under study of diversified economic activities related to waste management.

• Social dimension/indicators: They refer to the social aspects of sustainability. They are social (non-market) benefits and costs. They are:

- Direct and indirect employment: Jobs generated in the farm/industry and in parallel sectors.
- Intergenerational continuity of agrifood activities: Level of guarantee of continuity of economic activity over time due to the continuation of human capital.
- Health of consumers and public health: Guarantee of good hygienic and health conditions of the products obtained by the farmers/industry.
- Health conditions of workers: Guarantee of good hygienic and health conditions for the farmers/workers.

• Environmental dimension/indicators: They refer to the environmental aspects of sustainability. They are environmental (non-market) benefits and costs. They are:

- Biodiversity of flora and fauna: Amount and variety of presence of different living beings present in the environment.
- Quality of groundwater and surface water: Low contamination of groundwater and surface water mainly due to the application of inputs in the production process.
- Soil fertility/quality and control of soil erosion: It is important that the soil is not lost and that its agronomic quality is the best possible.
- Climate change abatement: Contribution to the fight against climate change as they are processes that emit less CO2.
- Landscape quality: It refers to aesthetic quality of the landscape in the region.

PILOT 1. ALTERNATIVES TO THE CONVENTIONAL USE OF PLASTIC STAKES

Description

The horticultural remains coming mainly from greenhouses, present some difficulties due to problems associated with the presence of plastic material that is not separated at source. The plastics used in agriculture in general are neither biodegradable nor compostable, and if they are not managed properly, they become a risk for the soils, the waters, the flora, the fauna and the habitability of the place due to the degradation of the territory that they produce. Therefore, it is important to advance in the study of the processes of removal of raffia present in vegetable remains, as well as in alternative materials to polypropylene raffia, such as biodegradable and compostable raffia, so as to facilitate the subsequent management of plant remains and increase the quality of the products obtained from their valorisation.

Alternatives

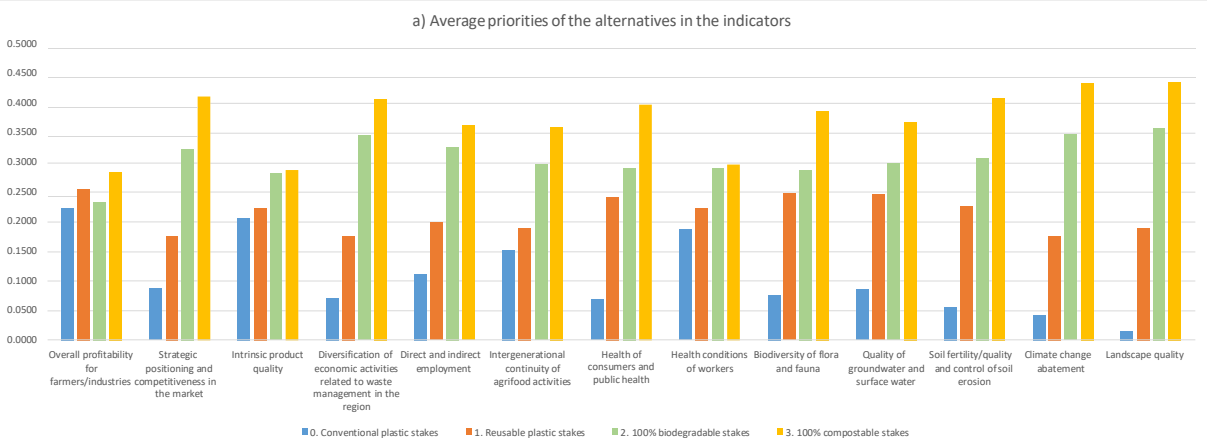
The alternatives analysed are:

- Alternative 0. Conventional plastic stakes: Use of plastic staking elements, made of polypropylene, which at the end of use, are removed together with plant waste, to follow a line of recovery.
- Alternative 1. Reusable plastic stakes: Use of plastic staking elements, made of polypropylene, which at the end of use, are separated from vegetable waste, to follow different lines of recovery.
- Alternative 2. 100% biodegradable stakes: Use of non-plastic staking elements, manufactured from biopolymers, which at the end of use, are removed together with the vegetable waste, to follow a recovery line.
- Alternative 3. 100% compostable stakes: Use of non-plastic supporting elements, made from natural fibres, which at the end of use, are removed together with the vegetable waste, to follow a recovery line.

Priorities of the alternatives in the indicators

The alternative 3 '100% compostable stakes' stands out as the best alternative in all the analysed criteria (Figure 1.a). The alternative 2 '100% biodegradable stakes' is on general the second-best option. Also, the alternative 0 'Conventional plastic stakes' is the worst option in all the indicators. The biggest differences are in 'Landscape quality' and all environmental indicators. The lowest differences are in 'Overall profitability for farmers/industries', where the alternative 0 'Conventional plastic stakes' performs a little worse than the rest, probably because experts are thinking in the medium to long term, as asked in the survey.

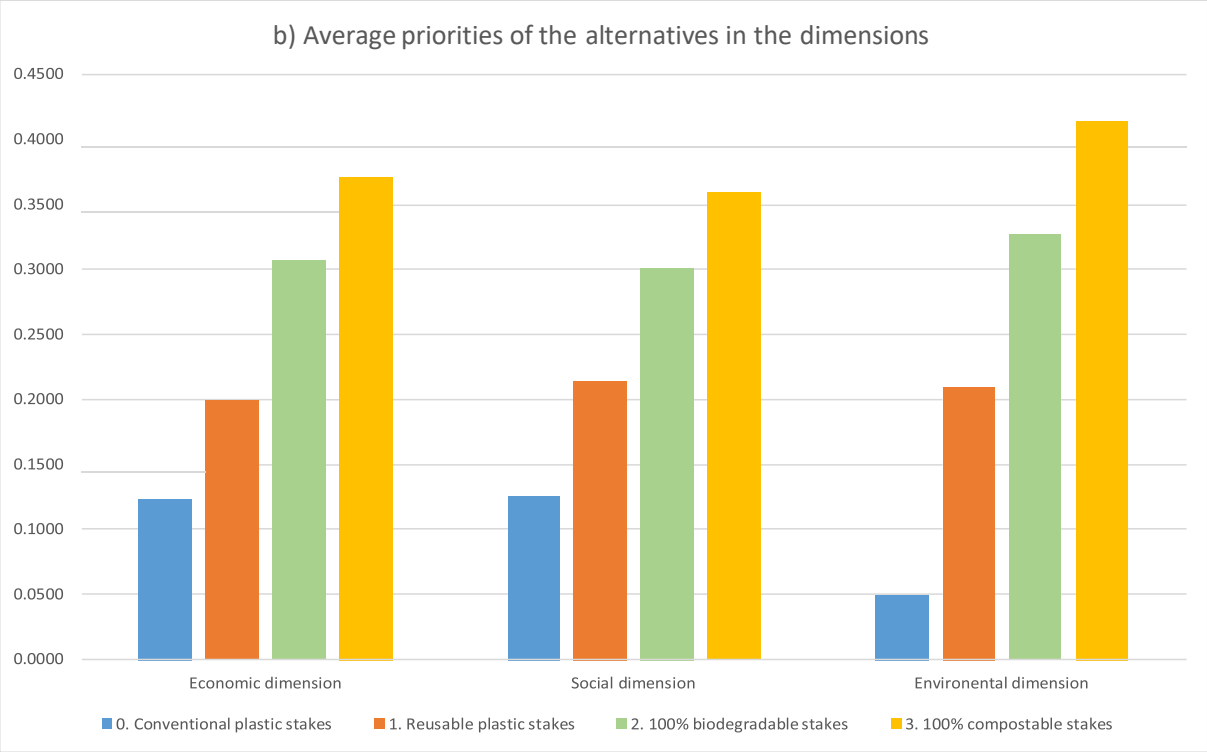
Figure 1.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

These results are corroborated by the weighted addition of the importance of the alternatives at the level of the three dimensions of sustainability (Figure 1.b). Thus, the order of priority in the three dimensions is: alternative 3 '100% compostable stakes', alternative 2 '100% biodegradable stakes', alternative 1 'Reusable plastic stakes', and alternative 0 'Conventional plastic stakes'. The environmental dimension is where the differences are greatest.

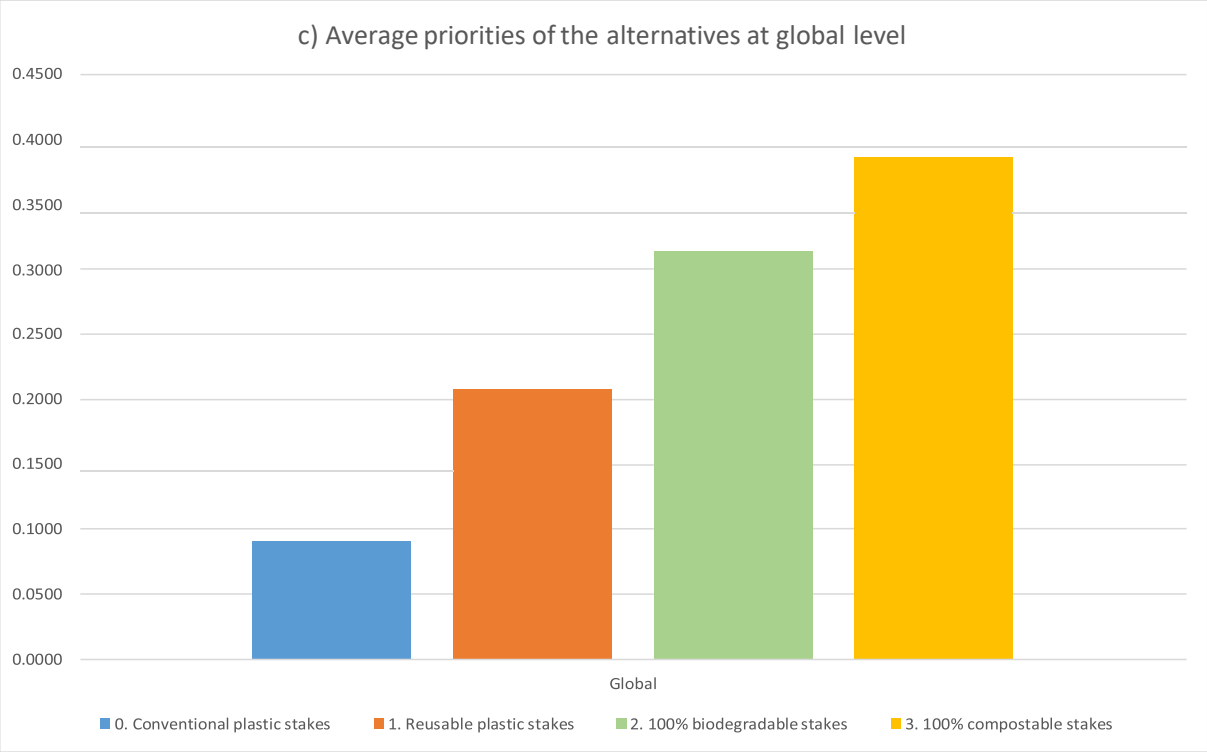
Figure 1.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

Weighing up the priorities of the alternatives in the three dimensions of sustainability, we obtain that at a global level the order of importance of the alternatives studied is again: alternative 3 '100% compostable stakes', alternative 2 '100% biodegradable stakes', alternative 1 'Reusable plastic stakes', and alternative 0 'Conventional plastic stakes' (Figure 1.c). It should be noted that the performance of alternative 3 '100% compostable stakes' is about four times better than that of alternative 0 'Conventional plastic stakes', when economic, social and environmental criteria are taken into account together.

Figure 1.c. Average priorities of the alternatives at global level



PILOT 2. DOCUMENTARY TRACEABILITY SYSTEMS

Description

It is necessary to increase inspection and control by the competent administrations on the management of inorganic waste, with the aim of preventing its abandonment and controlling its proper collection and management, to ensure the protection of human health and the environment.

Alternatives

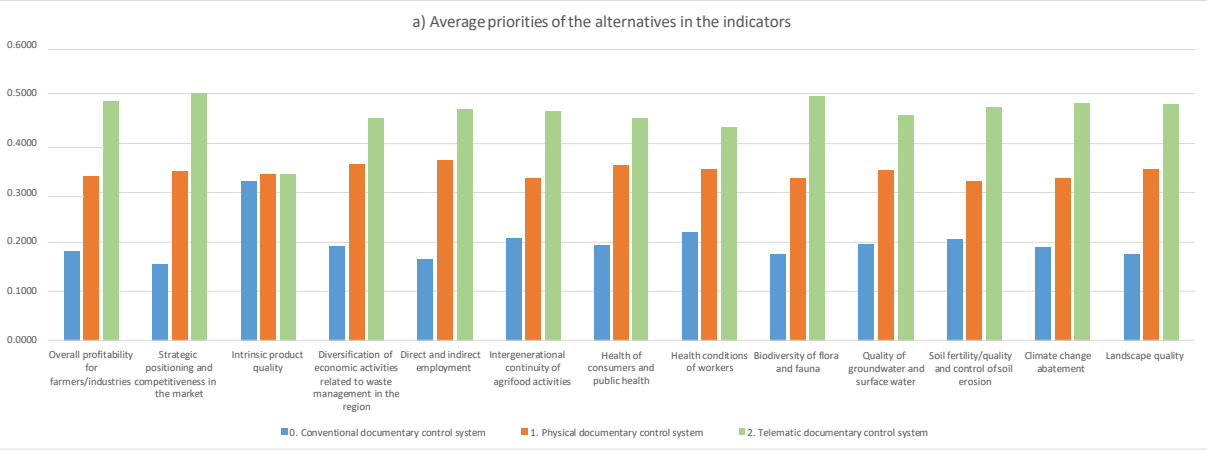
The alternatives analysed are:

- Alternative 0. Conventional documentary control system: To comply with the obligation established in article 3 of Royal Decree 180/2015, of 13 March, to have a treatment contract with the minimum contents established in article 5 prior to any waste shipment. This contract must stipulate, as a minimum, the estimated quantity of waste to be transferred, its identification by means of LER coding, the estimated periodicity of the shipments, the treatment to which the waste is to be subjected, any other information that is relevant for the adequate treatment of the waste and the legal consequences of the non-conformity of the shipment with that established in the treatment contract itself.
- Alternative 1. Physical documentary control system: To comply with the obligation established in article 6 of Royal Decree 180/2015, of 13 March, to dispose, prior to the start of any waste shipment, of the identification document completed by the operator, which will be delivered to the transporter for the identification of the waste during the shipment. The identification documents shall be consistent with the provisions of the treatment contract.
- Alternative 2. Telematic documentary control system: To achieve optimum organisation of inorganic waste management circuits. Control all the usual processes of waste management with a single tool, reducing the time spent on generating and transmitting the necessary documentation, controlling management and logistics costs and sharing information in real time with producers, transporters and final managers.

Priorities of the alternatives in the indicators

Alternative 2 ‘Telematic documentary control system’ stands out as the best option in almost all indicators (Figure 2.a). The exception is in 'Intrinsic quality production' where all three alternatives behave almost equally. In almost all indicators alternative 1 ‘Physical documentary control system’ performs halfway between 2 ‘Telematic documentary control system’ and 0 ‘Conventional documentary control system’.

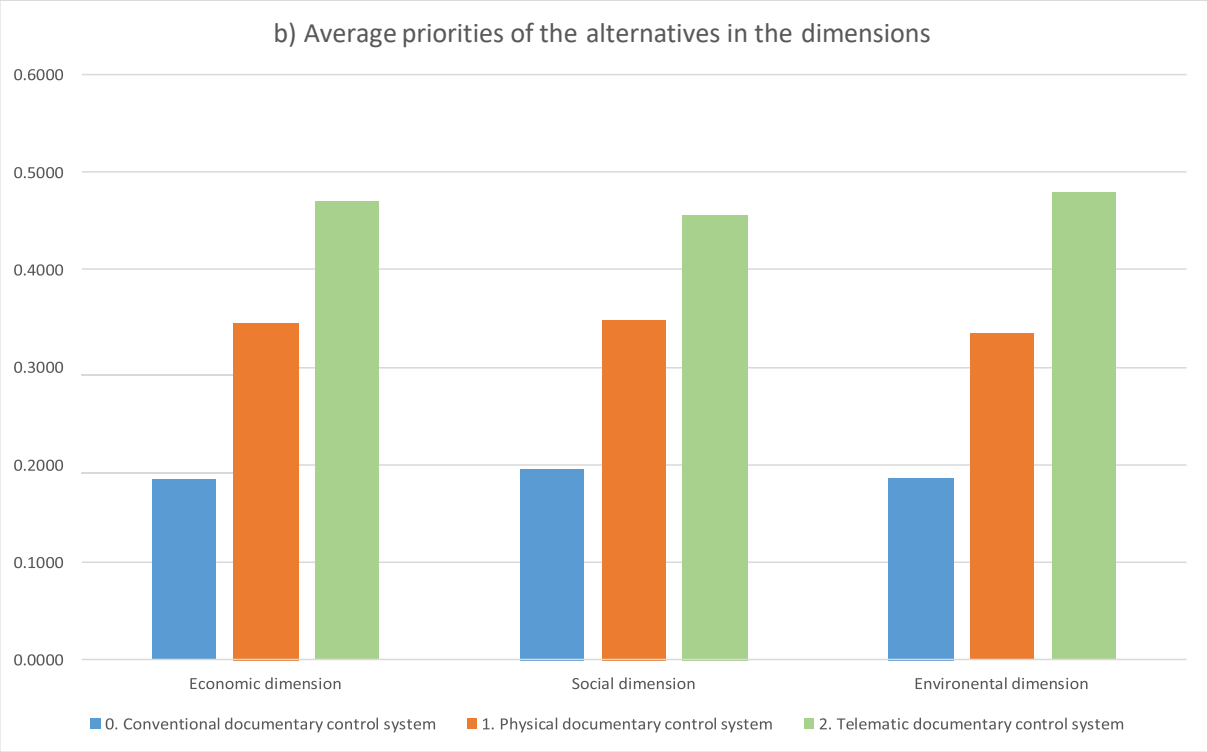
Figure 2.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

In the three dimensions of sustainability the pattern of performance of the three alternatives is very similar, standing out the alternative 2 ‘Telematic documentary control system’ (Figure 2.b). Alternative 1 ‘Physical documentary control system’ performs halfway between 2 ‘Telematic documentary control system’ and 0 ‘Conventional documentary control system’.

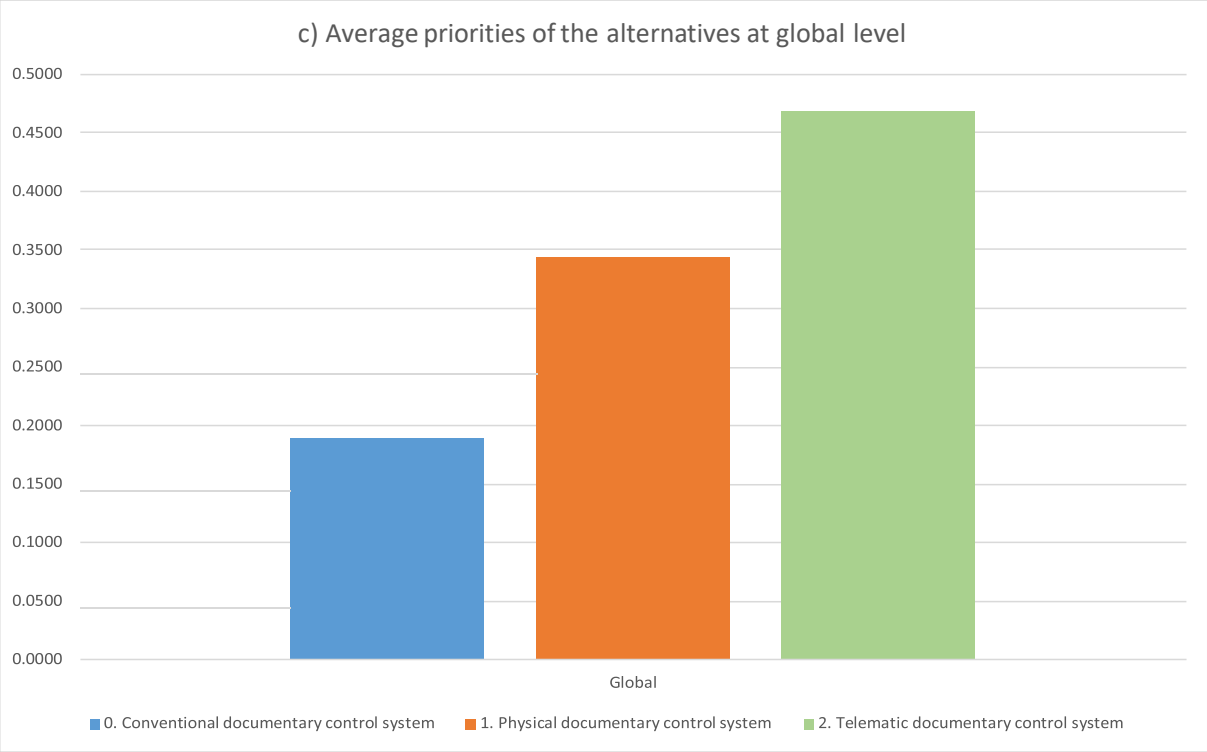
Figure 2.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

The pattern is repeated by adding the priorities at the global level (Figure 2.c). Thus, the order of performance is alternative 2 ‘Telematic documentary control system’, alternative 1 ‘Physical documentary control system’, and 0 ‘Conventional documentary control system’. Alternative 2 'Telematic documentary control system' performs more than twice as well as alternative 0 'Conventional documentary control system'.

Figure 2.c. Average priorities of the alternatives at global level



PILOT 3. THIN PLASTIC FILMS FOR SOIL MULCHING

Description

It is usual to cover he soil with thin thickness plastic film to control weeds, increase soil temperature, decrease water evaporation, avoid contact between fruits and soil.

Alternatives

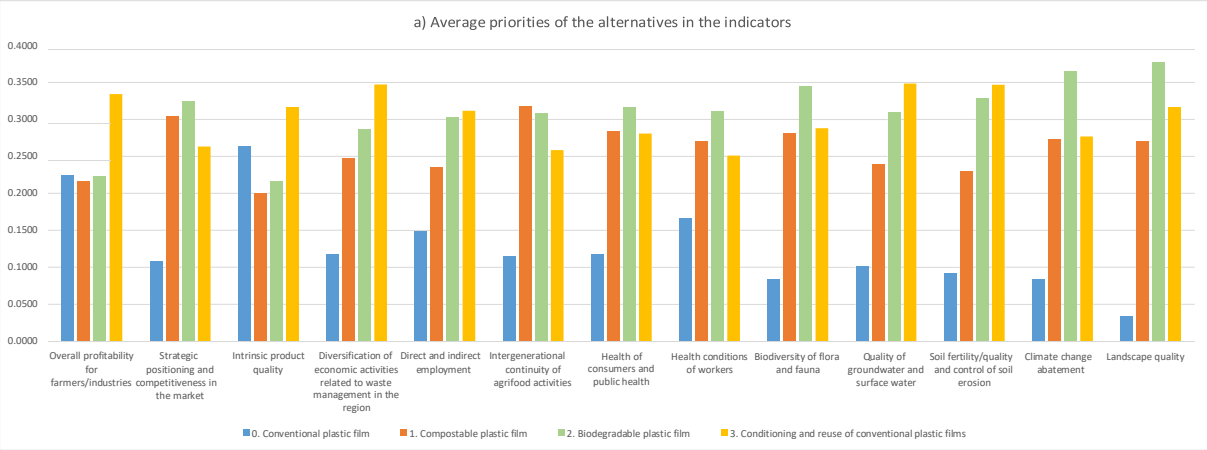
The alternatives analysed are:

- Alternative 0. Conventional plastic film: Use of thin-thickness plastic film, usually opaque low-density polyethylene and linear low-density polyethylene.
- Alternative 1. Compostable plastic film. Use of compostable plastic mulch film (Ecovio-BASF) currently being used for short cycle and outdoor crops. It is degraded by the sunshine itself under normal conditions of use, remaining in the soil 3-4 months outdoors. It is not currently being used in greenhouse crops.
- Alternative 2. Biodegradable plastic film: Use of biologically based mulching material (Biomulch) which, in contact with certain micro-organisms, decomposes and degrades once its useful life is over. This material would be able to biodegrade in less than 3 months, being necessary to have been subjected to a treatment of microorganisms by pulverization and subsequent burial. It has currently been tested in strawberry cultivation in Huelva, but it has not been tested in greenhouse conditions in southeastern Spain and is not yet a commercial product.
- Alternative 3. Conditioning and reuse of conventional plastic films: Use of innovative techniques for conditioning and reuse of conventional plastic mulching films for their correct valorisation in waste management plants.

Priorities of the alternatives in the indicators

In this case, the performances are more varied. Thus, alternative 3 'Packaging conventional plastic film' is the best option in the economic indicators such as 'Overall profitability for farmers/industries', 'Intrinsic product quality' and 'Diversification of economic activities related to waste management in the region' (Figure 3.a). In the rest of indicators, alternative 2 'Biodegradable plastic film' performs a little bit better. In any case, alternative 0 'Conventional plastic film' behaves in almost all indicators much worse than the other alternatives, with the exception of 'Overall profitability for farmers/industries' and 'Intrinsic product quality'.

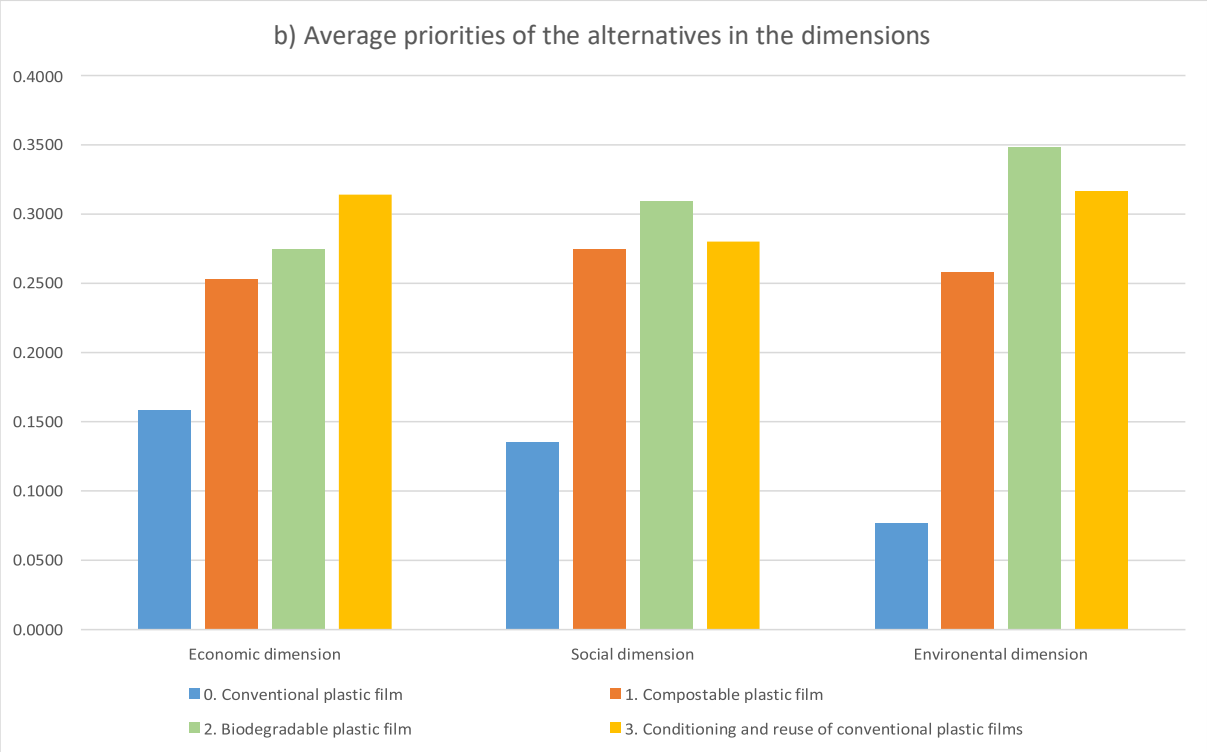
Figure 3.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

At the level of the sustainability dimensions, the pattern of performance of the alternatives is different. Thus, alternative 3 'Conditioning and reuse of conventional plastic films' has the best performance in the economic dimension while alternative 2 'Biodegradable plastic film' is the best option in the social and environmental dimensions (Figure 3.b). In any case, the performance of these alternatives and alternative 1 'Compostable plastic film' is not excessively different. It is more the case with alternative 0 'Conventional plastic film', which is the worst option in all three dimensions.

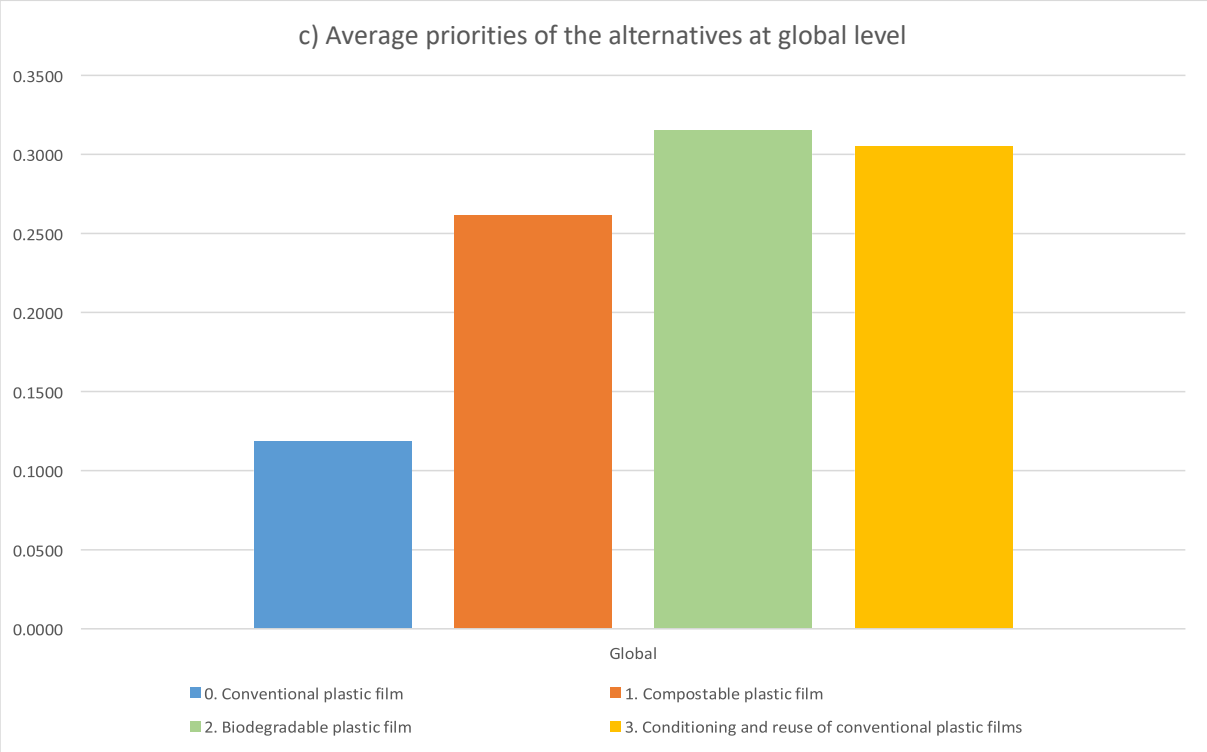
Figure 3.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

At a global level, integrating the performance at the three dimensions of sustainability, alternatives 2 'Biodegradable plastic film' and 3 'Conditioning and reuse of conventional plastic films' stand out and have a very similar performance (Figure 3.c). Alternative 1 'Compostable plastic film' follows not far behind. Alternative 0 'Conventional plastic film' is clearly the worst performing alternative.

Figure 3.c. Average priorities of the alternatives at global level



PILOT 4. ENERGY VALORISATION OF DIFFICULT-TO-MANAGE WASTE

Description

In the horticultural sector it is necessary to search for options for the recovery of different wastes that are difficult to manage due mainly to their low value and/or incorrect conditioning, such as thin plastic films, plastic raffia, non-returnable packages, plastic bags, beehives, poly-fibril floor coverings, among others.

Alternatives

The alternatives analysed are:

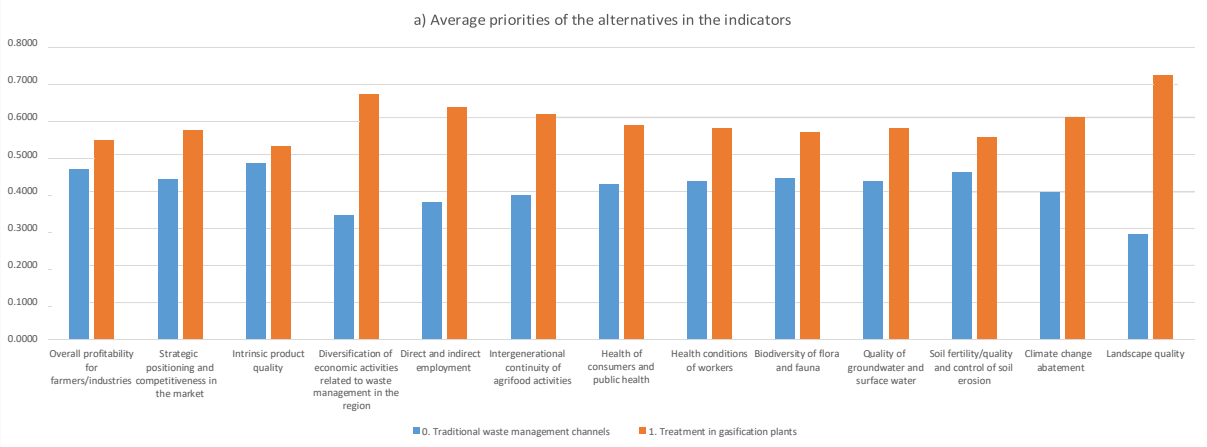
- Alternative 0. Traditional waste management channels: Use of traditional waste management channels that are difficult to manage. The traditional managers, often in the production area of protected horticultural Almeria, have not been able to give a correct response to the accumulation of waste.
- Alternative 1. Treatment in gasification plants: Currently, close to the production area, there is a non-hazardous waste valorisation manager that specializes in urban solid waste, which will allow the treatment of this waste. The treatment would make it possible to obtain fuel for possible use in the agricultural sector, contributing to a circular economy. The waste to be managed and the necessary conditioning will be evaluated (by means of performance tests), the necessary logistics (collection, preparation and transport), the capacity of the pyrolysis plant, management fees, and the uses of the hydrocarbons generated.

Priorities of the alternatives in the indicators

Alternative 1 ‘Treatment in gasification plants’ performs better than alternative 0 ‘Traditional waste management channels’ in all the indicators evaluated, especially in ‘Landscape quality', ‘Diversification of economic activities related to waste management in

the region', 'Direct and indirect employment' and 'Intergenerational continuity of agrifood activities' (Figure 4.a).

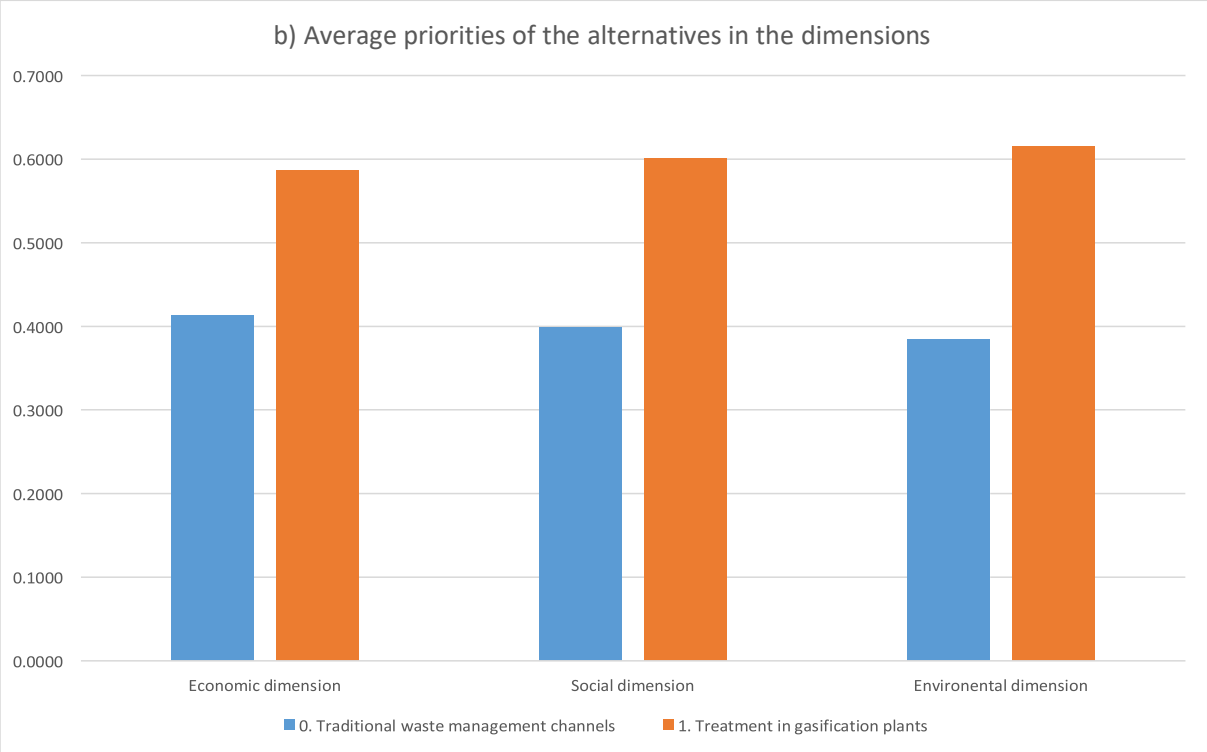
Figure 4.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

At the level of sustainability dimensions, the performance pattern of the two alternatives studied is very similar, with the performance of alternative 1 'Treatment in gasification plants' being around 50% better than the alternative 0 'Traditional waste management channels' in all dimensions (Figure 4.b).

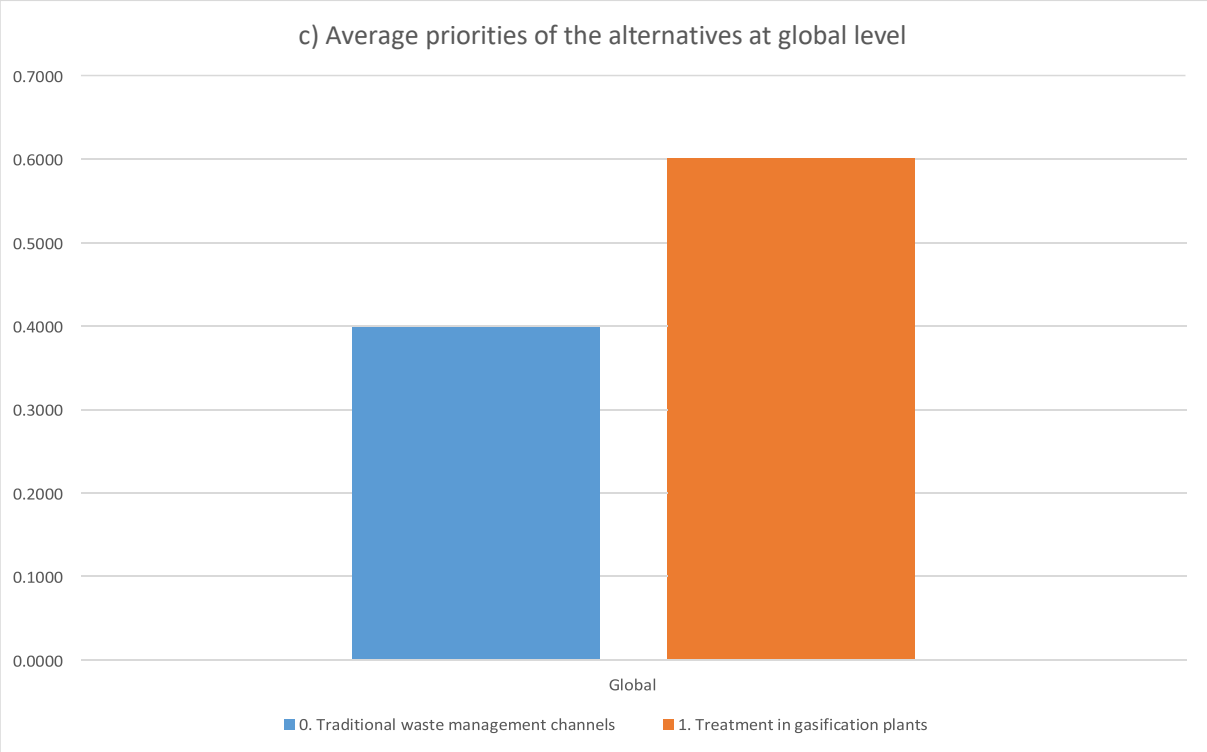
Figure 4.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

As a consequence of the performance of the alternatives in the three dimensions of sustainability, the performance of alternative 1 'Treatment in gasification plants' at a global level is better than that of alternative 0 'Traditional waste management channels', by about 50% (Figure 4.c).

Figure 4.c. Average priorities of the alternatives at global level



PILOT 5. ESTABLISHMENT OF A WASTE MANAGEMENT MODEL AT ASSOCIATIVE LEVEL

Description

Some cooperatives currently have no waste management organisation. Each farmer manages his waste at the lowest possible cost. The highest organisational level with regard to waste is based on agreements with managers (price and materials to be managed). To facilitate the development of this associative model, a classification of the organization of the management systems of the cooperatives in several levels (alternatives) is proposed.

Alternatives

The alternatives analysed are:

- Alternative 0. Cooperative not involved in waste management: The cooperative is not engaged in waste management of its members.
- Alternative 1. Cooperative agreements with transport company: The cooperative establishes agreements with an authorised transport company that is responsible for the collection on the farm, transport and delivery to the management plant (which will be selected by the transport company on the basis of a series of agreed criteria) of the waste generated by each producer. Presence of SIGFITO point (agrochemical packaging management system). Complemented with the management of non-returnable containers (hazardous waste managers).
- Alternative 2. Cooperative agreements with management plants: The cooperative establishes agreements with management plants: The farmers can deposit inorganic waste at the facilities of these companies (or at agreed point. Presence of SIGFITO point (agrochemical packaging management system). Complemented with the management of non-returnable containers (hazardous waste managers).
- Alternative 3. Collaboration between cooperative and managers: Implementation of a system coordinated by cooperative and executed by manager or managers with prior agreement. The cooperative must organise the collection in order to facilitate management and reduce costs (look for a manager for all the waste), register the waste

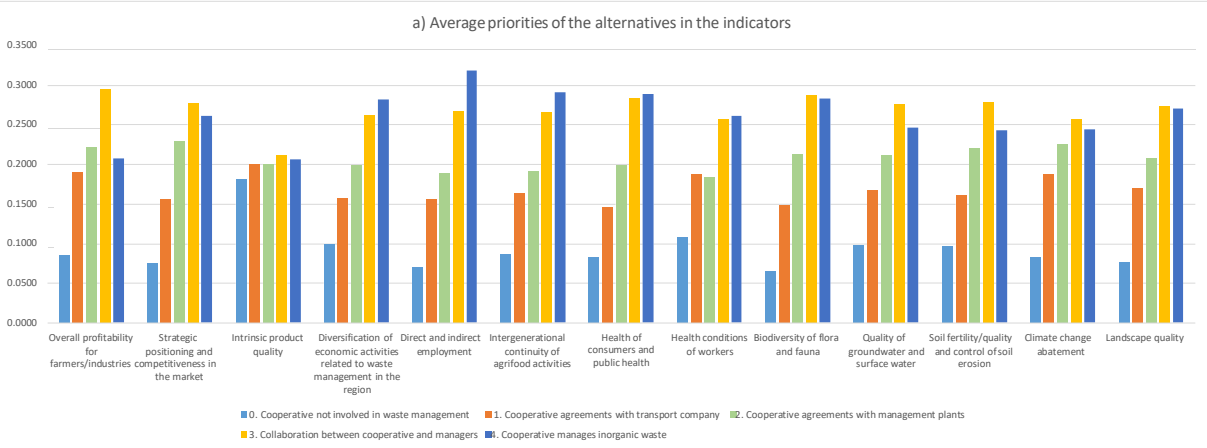
managed and carry out control and ensure the correct management of the waste and comply with the regulations in force. Currently not implemented in any cooperative.

- Alternative 4. Cooperative manages inorganic waste: The cooperative becomes an inorganic waste manager. Currently not implemented in any cooperative.

Priorities of the alternatives in the indicators

The performance pattern of the different alternatives analysed is varied (Figure 5.a). Thus, in some indicators alternative 3 'Collaboration between cooperative and managers' stands out, such as some economic ones ('Overall profitability for farmers/industries' and 'Strategic positioning and competitiveness in the market') and some environmental ones ('Quality of groundwater and surface water', 'Soil fertility/quality and control of soil erosion' and 'Climate change abatement'). In other indicators, especially the social ones, alternative 4 'Cooperative manages inorganic waste' stands out, such as 'Direct and indirect employment' and 'Intergenerational continuity of agrifood activities'.

Figure 5.a. Average priorities of the alternatives in the indicators

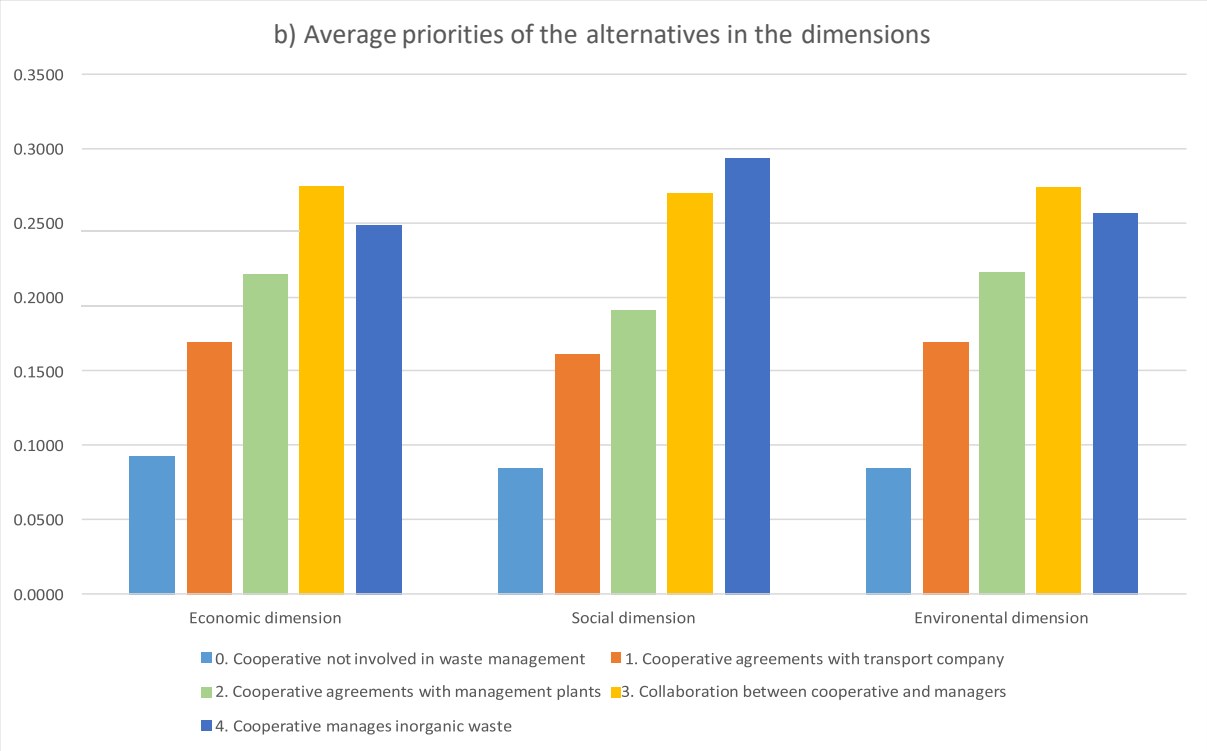


Priorities of the alternatives in the dimensions of sustainability

Adding the behaviour of the alternatives in the different indicators according to the three dimensions of sustainability, it is obtained that alternative 3 'Collaboration between cooperative and managers' stands out in the economic and environmental dimension, while alternative 4 'Cooperative manages inorganic waste' stands out in the social dimension (Figure

5.b). In any case, the performance differences between these two alternatives are not very great. The rest of the alternatives always fall behind, their order being the same in the three dimensions of sustainability: alternative 2 'Cooperative agreements with management plants', alternative 1 'Cooperative agreements with transport company' and alternative 0 'Cooperative not involved in waste management'.

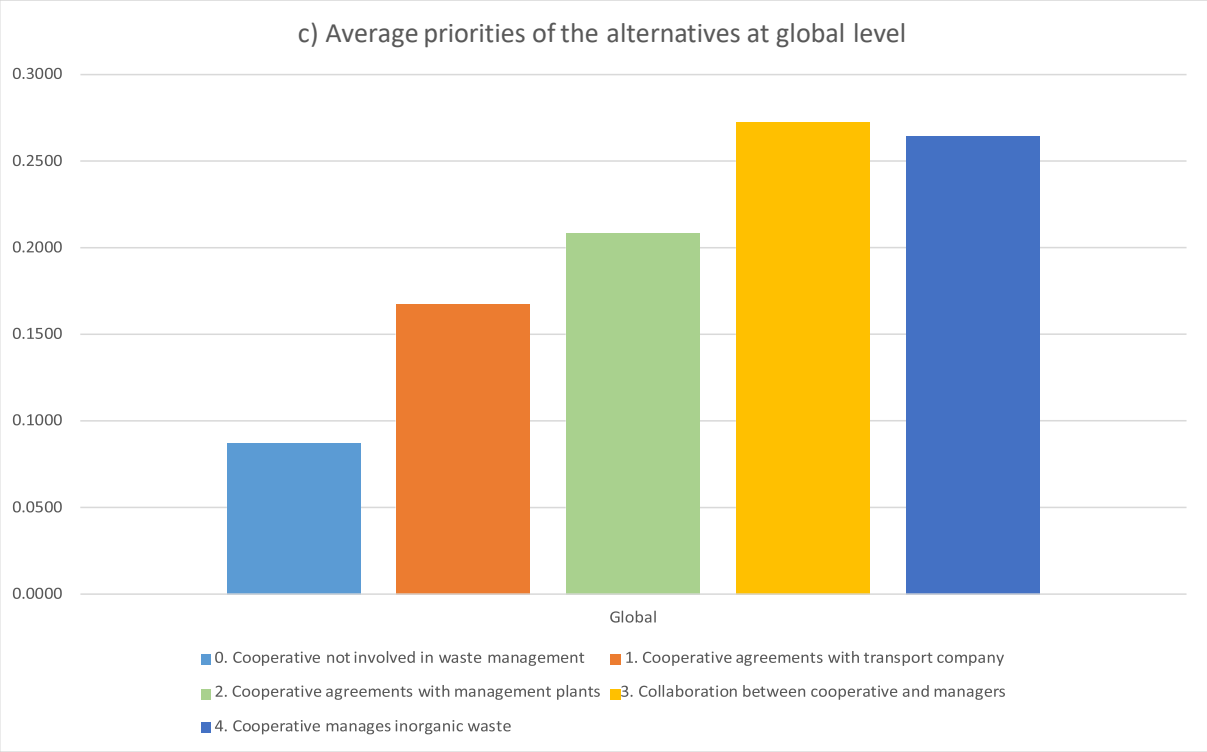
Figure 5.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

On a global level, the performance of alternatives 3 'Collaboration between cooperative and managers' and 4 'Cooperative manages inorganic waste' is very similar, being slightly higher than that of 3, and is superior to that of the rest of the alternatives (Figure 5.c). In particular, the worst overall performance of alternative 0 'Cooperative not involved in waste management' is evident.

Figure 5.c. Average priorities of the alternatives at global level



Conclusions for Horticulture production (Spain)

The results obtained show that for all the pilots studied there are alternatives that perform better from an economic, social and environmental point of view, and therefore at a global level, than the alternatives currently used in a conventional way. For all pilots, the conventional alternative is the worst globally.

The following Table summarises for each pilot the best overall alternative to conventional practice:

Table 1. Conventional versus best global alternatives for each pilot

Pilot	Conventional alternative	Best alternative
Alternatives to the conventional use of plastic stakes	Conventional plastic stakes	100% compostable stakes
Documentary traceability systems	Conventional documentary control system	Telematic documentary control system
Thin plastic films for soil mulching	Conventional plastic film	Biodegradable plastic film
Energy valorisation of difficult-to-manage waste	Traditional waste management channels	Treatment in gasification plants
Establishment of a waste management model at associative level	Cooperative not involved in waste management	Collaboration between cooperative and managers

2. Horticulture industry (Spain)

Evaluation

3 experts in horticulture industry in Spain were surveyed. The indicators evaluated by the experts in all the pilots/practices analysed are:

• Economic dimension/indicators: They refer to the economic aspects of sustainability, relative to farmers/industries economic (market) benefits and costs. They are:

- Overall profitability for farmers/industries: It refers to incomes minus variable costs. Income and costs are the totals of the economic activity developed by the farmer/industry, not just those associated with the technique being tested. It measures how the practices implemented can affect the overall profitability obtained.
- Strategic positioning and competitiveness in the market: It refers to the fact that early adoption of innovations can improve the company's position in the medium and long term.
- Intrinsic product quality: Refers to the quality attributes found within the products obtained by the farmer/industry. It refers to sensory and organoleptic issues, etc.
- Diversification of economic activities related to waste management in the region: This refers to the presence in the region under study of diversified economic activities related to waste management.

• Social dimension/indicators: They refer to the social aspects of sustainability. They are social (non-market) benefits and costs. They are:

- Direct and indirect employment: Jobs generated in the farm/industry and in parallel sectors.
- Intergenerational continuity of agrifood activities: Level of guarantee of continuity of economic activity over time due to the continuation of human capital.
- Health of consumers and public health: Guarantee of good hygienic and health conditions of the products obtained by the farmers/industry.
- Health conditions of workers: Guarantee of good hygienic and health conditions for the farmers/workers.

• Environmental dimension/indicators: They refer to the environmental aspects of sustainability. They are environmental (non-market) benefits and costs. They are:

- Biodiversity of flora and fauna: Amount and variety of presence of different living beings present in the environment.
- Quality of groundwater and surface water: Low contamination of groundwater and surface water mainly due to the application of inputs in the production process.
- Soil fertility/quality and control of soil erosion: It is important that the soil is not lost and that its agronomic quality is the best possible.
- Climate change abatement: Contribution to the fight against climate change as they are processes that emit less CO2.
- Landscape quality: It refers to aesthetic quality of the landscape in the region.

PILOT 1. ALTERNATIVES TO THE CONVENTIONAL USE OF PLASTIC TRAYS

Description

Packaging is required to protect and preserve food products (primary packaging), and also is used for grouping, transportation and as a marketing tool. Nowadays, the most common packaging used are conventional plastic trays. In this first pilot, a PET tray is used as primary packaging, using a PE flowpack as closure. These trays revert in a great amount of plastic waste, both coming from the PET tray and from the PE flowpack, that in many cases is lost and cannot be recovered. Therefore, it is important to advance in the study of packaging alternatives that possesses less environmental impact, trying to advance towards zero inorganic residue.

Alternatives

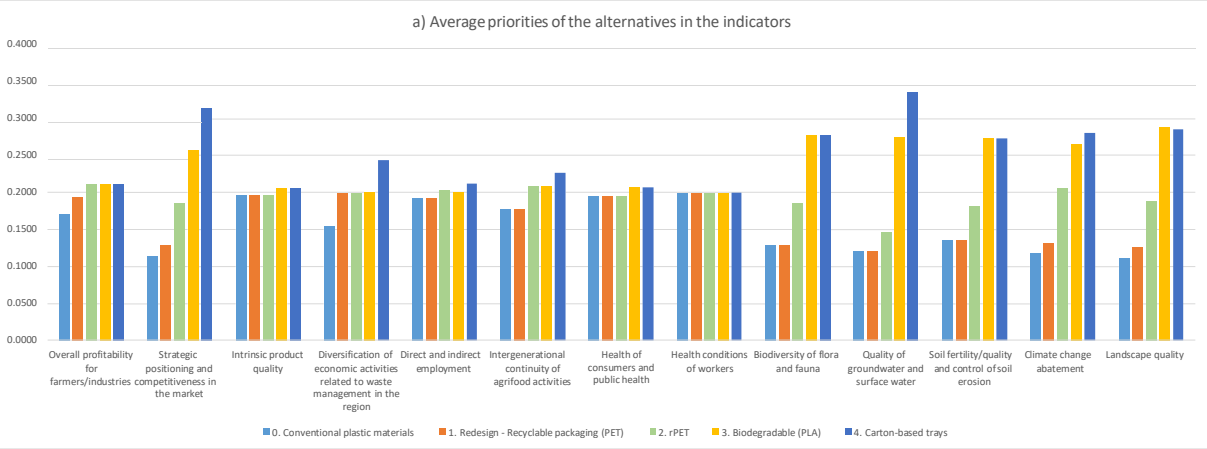
The alternatives analysed are:

- Alternative 0. Conventional plastic tray (PET) and flowpack (PE) made with conventional plastic materials.
- Alternative 1. Redesign of packaging to advance towards a more recyclable packaging (i.e. an all-in-one rigid plastic PET tray and closure).
- Alternative 2. 85-100% rPET: Incorporate recycled material (recycled PET) in the packaging, while putting into the market a 100% recyclable PET package.
- Alternative 3. 100% biodegradable packaging, by using biodegradable plastics such as PLA.
- Alternative 4. Carton trays.

Priorities of the alternatives in the indicators

The alternative 4 ‘Carton trays’ have the best performance in almost all the indicators, especially in ‘Strategic positioning and competitiveness in the market’, ‘Diversification of economic activities related to waste management in the region’, and ‘Quality of groundwater and surface water’. On the contrary, the alternative 0 ‘Conventional plastic materials’ is the worst option especially in the first two indicators mentioned (‘Strategic positioning and competitiveness in the market’, ‘Diversification of economic activities related to waste management in the region’), an in all the environmental indicators (from ‘Biodiversity of flora and fauna’ to ‘Landscape quality’). In fact, it is in the environmental issues where the differences are greatest among all the alternatives.

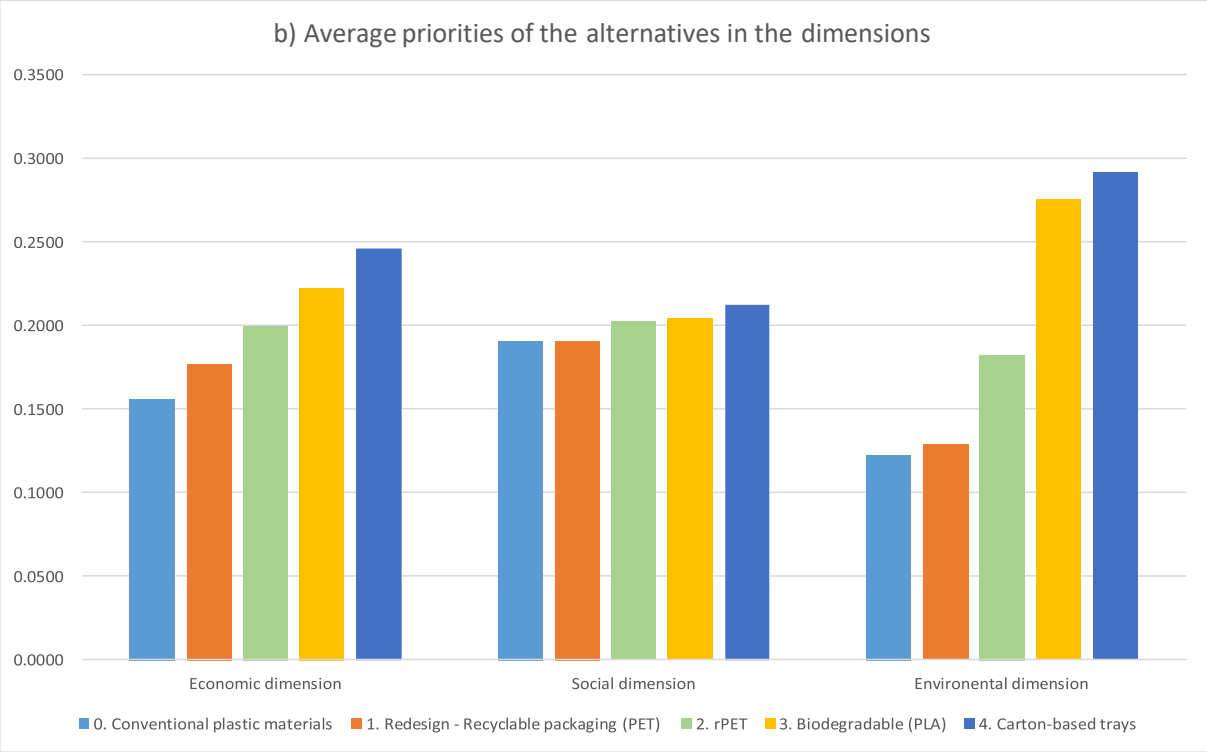
Figure 1.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

If these performances are aggregated at the level of dimensions, the wide range of performance in the environmental dimension of the five analysed alternatives is confirmed. Moreover, it is now also evident in the economic dimension. In the social dimension the variation in performance of the alternatives is not so great. In any case, for all dimensions the order of the alternatives from best to worst performance is: 4 ‘Carton-based trays’, 3 ‘Biodegradable (PLA), 2 ‘rPET’, 1 ‘Redesign - Recyclable packaging (PET)’, and 0 ‘Conventional plastic materials’.

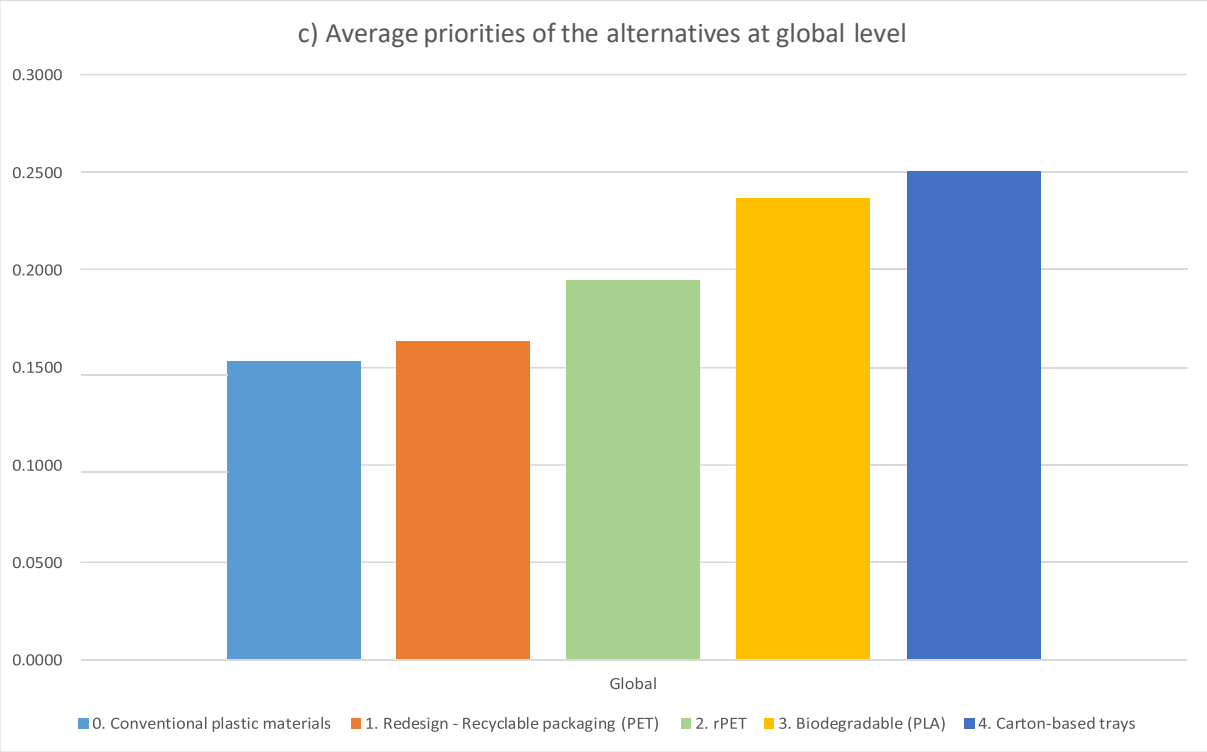
Figure 1.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

As a consequence of the data already shown, and the priorities given by the experts to the three dimensions of sustainability, the performances at the global level of the alternatives analysed are quite different. Firstly, alternative 4 ‘Carton-based trays’ stands out, followed closely by 3 ‘Biodegradable (PLA). A little further away is alternative 2 ‘rPET’. And further away, alternative 1 ‘Redesign - Recyclable packaging (PET)’, and 0 ‘Conventional plastic materials’.

Figure 1.c. Average priorities of the alternatives at global level



PILOT 2. LOGISTICS OPTIMIZATION

Description

Primary packaging consisting in a plastic tray does not adapt to the carton boxes uses for transportation (secondary packaging). Consequently, the amount of carton that is being used for the transportation of the trays is rather too much. It is necessary to rethink the whole packaging, so everything is fit together and a lower environmental impact is produced.

Alternatives

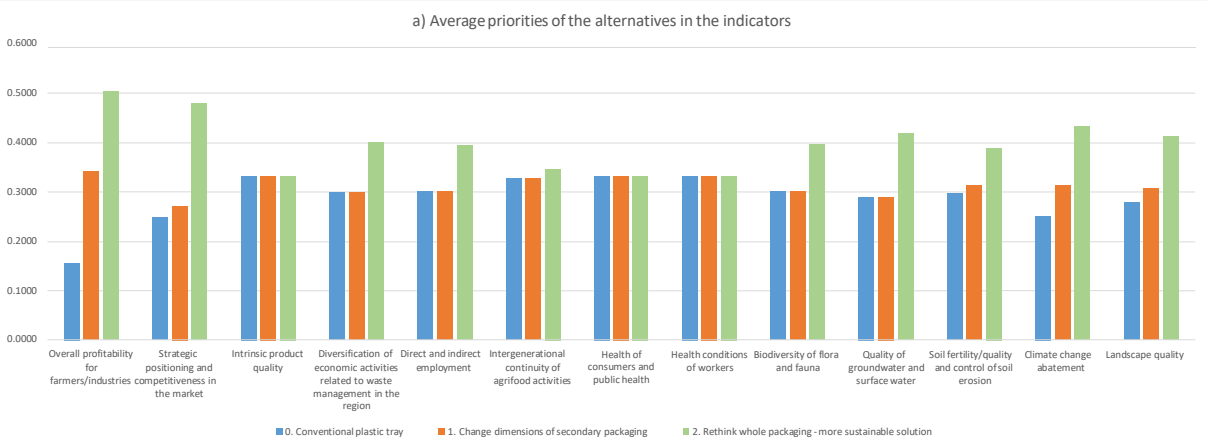
The alternatives analysed are:

- Alternative 0. Conventional plastic tray and card-board secondary package. The two elements are not well fitted and, therefore, unnecessary residues coming from the card-board box are generated.
- Alternative 1. Change dimensions of the card-board box to better fit the dimensions of the plastic trays.
- Alternative 2. Rethink the whole packaging so it results in a more sustainable packaging tray that fits into a secondary packaging that should be adapted to the new tray.

Priorities of the alternatives in the indicators

Alternative 2 'Rethink whole packaging - more sustainable solution' performs best on almost all indicators, especially on 'Overall profitability for farmers/industries', 'Strategic positioning and competitiveness in the market', 'Diversification of economic activities related to waste management in the region', 'Direct and indirect employment', and all the environmental indicators (from 'Biodiversity of flora and fauna' to Landscape quality'). The other two alternatives are not very different between them, although alternative 0 'Conventional plastic tray' is somewhat worse, especially in 'Overall profitability for farmers/industries'.

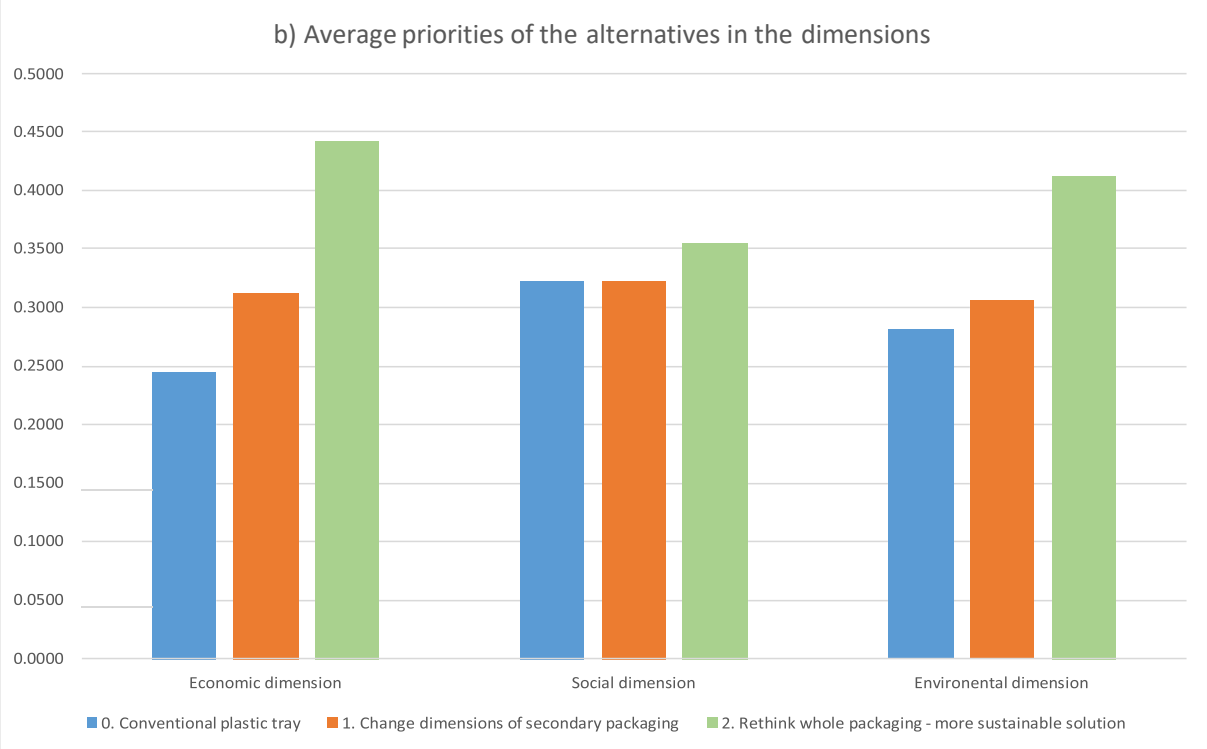
Figure 2.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

The differences between the alternatives are evident in the economic and environmental dimensions, while in the social dimension they are minor. In any case, alternative 2 'Rethink whole packaging - more sustainable solution' stands out as the best option in all the dimensions, followed by alternative 1 'Change dimensions of secondary packaging'.

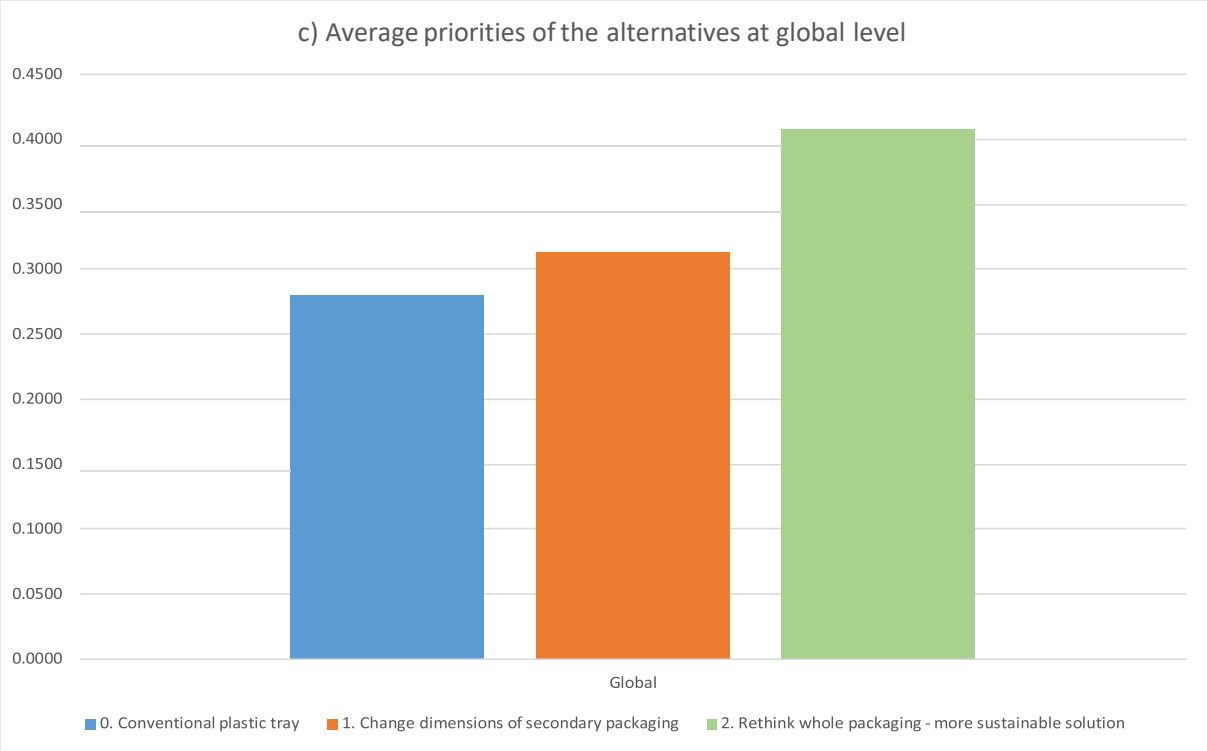
Figure 2.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

Alternative 2 ‘Rethink whole packaging - more sustainable solution’ stands out as the best option globally. It is followed at some distance by alternative 1 ‘Change dimensions of secondary packaging’, which is slightly better than alternative 0 ‘Conventional plastic tray’.

Figure 2.c. Average priorities of the alternatives at global level



PILOT 3. RETHINKING PACKAGING TOWARDS ZERO INORGANIC WASTE

Description

Cucumbers are packaged in a cardboard tray with a flowpack (conventional plastic). It is a good starting point towards zero waste, but action is required to achieve improvements from an environmental point of view.

Alternatives

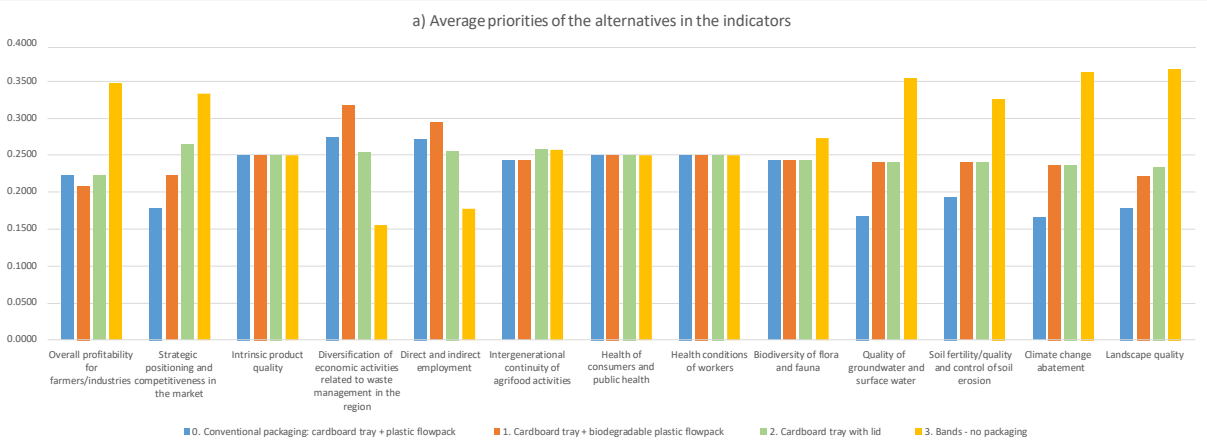
The alternatives analysed are:

- Alternative 0. Carton tray and conventional plastic flowpack.
- Alternative 1. Compostable plastic flowpack, to have a whole biodegradable packaging solution.
- Alternative 2. Cardboard tray with lid, to get rid of the plastic flowpack.
- Alternative 3. Bands to substitute the whole package, so an almost zero waste solution is achieved.

Priorities of the alternatives in the indicators

Alternative 3 'Bands – no packaging' stands out especially in many environmental indicators (from 'Quality of groundwater and surface water' to 'Landscape quality'), and some economic ones, such as 'Overall profitability for farmers/industries' and 'Strategic positioning and competitiveness in the market'. However, it performs poorly on 'Diversification of economic activities related to waste management in the region' and 'Direct and indirect employment'. Alternative 1 'Cardboard tray + biodegradable plastic flowpack' is the best option in the indicators 'Diversification of economic activities related to waste management in the region' and 'Direct and indirect employment'.

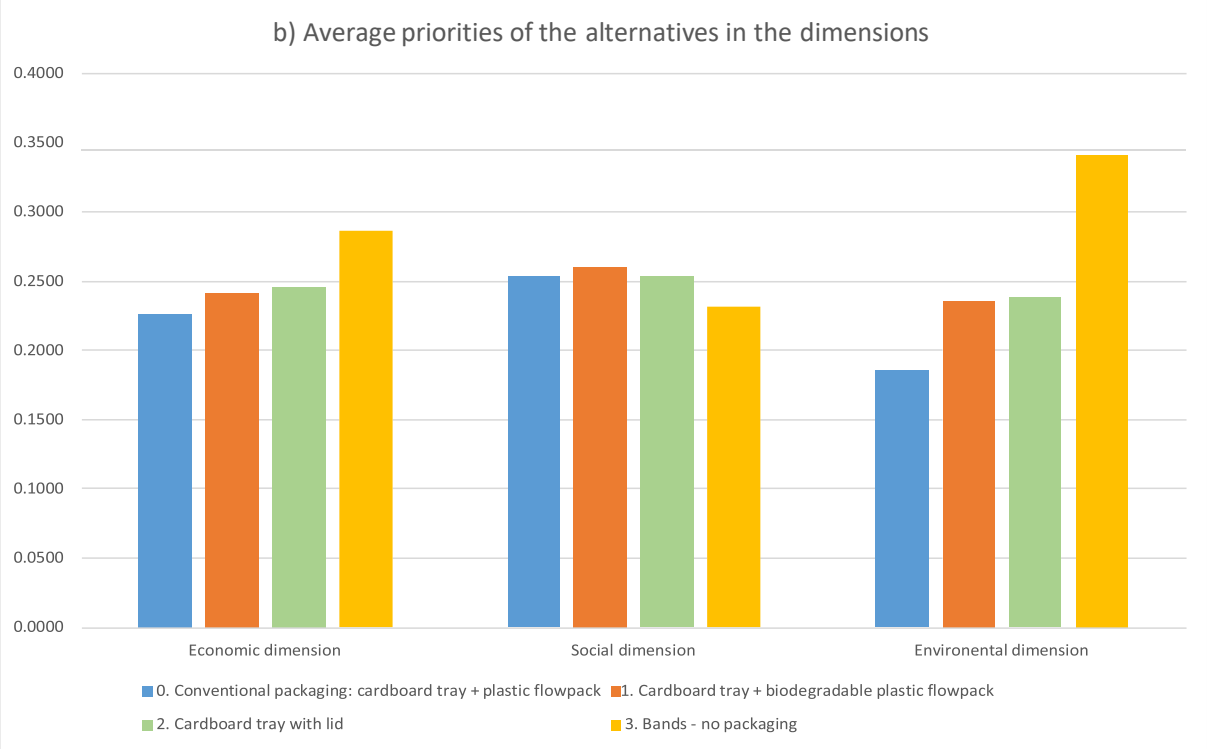
Figure 3.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

This varied performance of the alternatives is reflected at the level of the dimensions. Thus, alternative 3 'Bands – no packaging' stands out from the rest in the economic and, above all, the environmental dimension. However, it is the worst alternative in the social dimension, in which alternative 1 'Cardboard tray + biodegradable plastic flowpack' outstands.

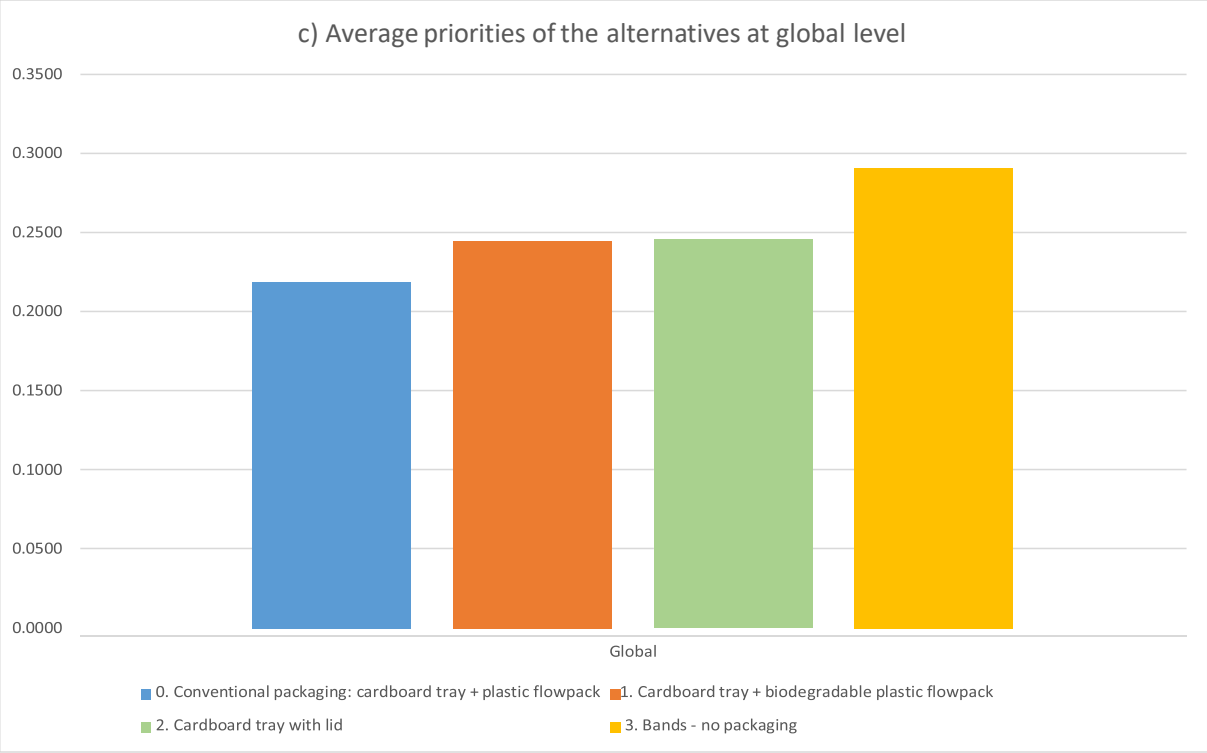
Figure 3.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

On a global level, the differences between the alternatives are not too great, in general. However, alternative 3 ‘Bands – no packaging’ stands out as the best option. The other two alternatives (2 ‘Cardboard tray with lid’ and ‘Cardboard tray + biodegradable plastic flowpack’) have a very similar behaviour and are between the optimal option and the alternative 0 ‘Conventional packaging: cardboard tray + plastic flowpack’.

Figure 3.c. Average priorities of the alternatives at global level



PILOT 4. SUSTAINABLE PACKAGING FOR GOURMET PRODUCTS

Description

A very fancy plastic pot made from conventional PET plastic material (fossil resources) is used for the packaging of gourmet products. This format requires the use of great amount of plastic, much coming from the lid, and also needs a very specific card-board box (secondary packaging) to fit them for transportation, which leads to great amounts of cardboard residues.

Alternatives

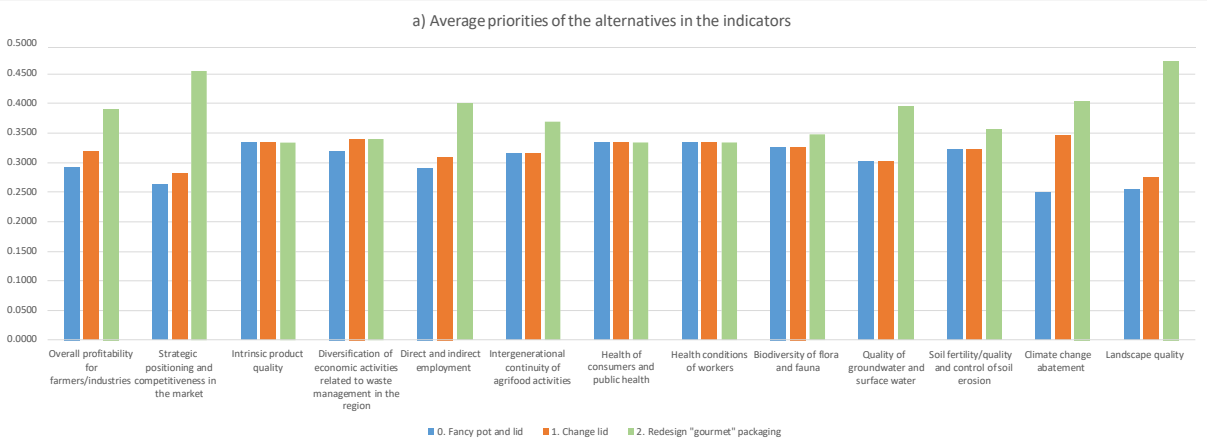
The alternatives analysed are:

- Alternative 0. Fancy PET pot that requires a lot of plastic for the lid and a special cardboard box for transportation.
- Alternative 1. Change the lid so less amount of plastic is used for its fabrication.
- Alternative 2. Redesign the packaging so it fit the “gourmet” concept but required less plastic material for its fabrication, while is better adapted to normal cardboard boxes.

Priorities of the alternatives in the indicators

Alternative 2 ‘Redesign gourmet packaging’ is the best option in almost all indicators, especially in some economic ones, such as ‘Strategic positioning and competitiveness in the market’ and ‘Overall profitability for farmers/industries’, social ones, such as ‘Direct and indirect employment’, and most environmental ones, such as ‘Landscape quality’, ‘Quality of groundwater and surface water’ and ‘Climate change abatement’. Alternative 0 ‘Fancy pot and lid’ is the worst option in almost all indicators, especially in those where alternative 2 ‘Redesign gourmet packaging’ stands out. Alternative 1 ‘Change lid’ has in general an intermediate performance between the other two alternatives.

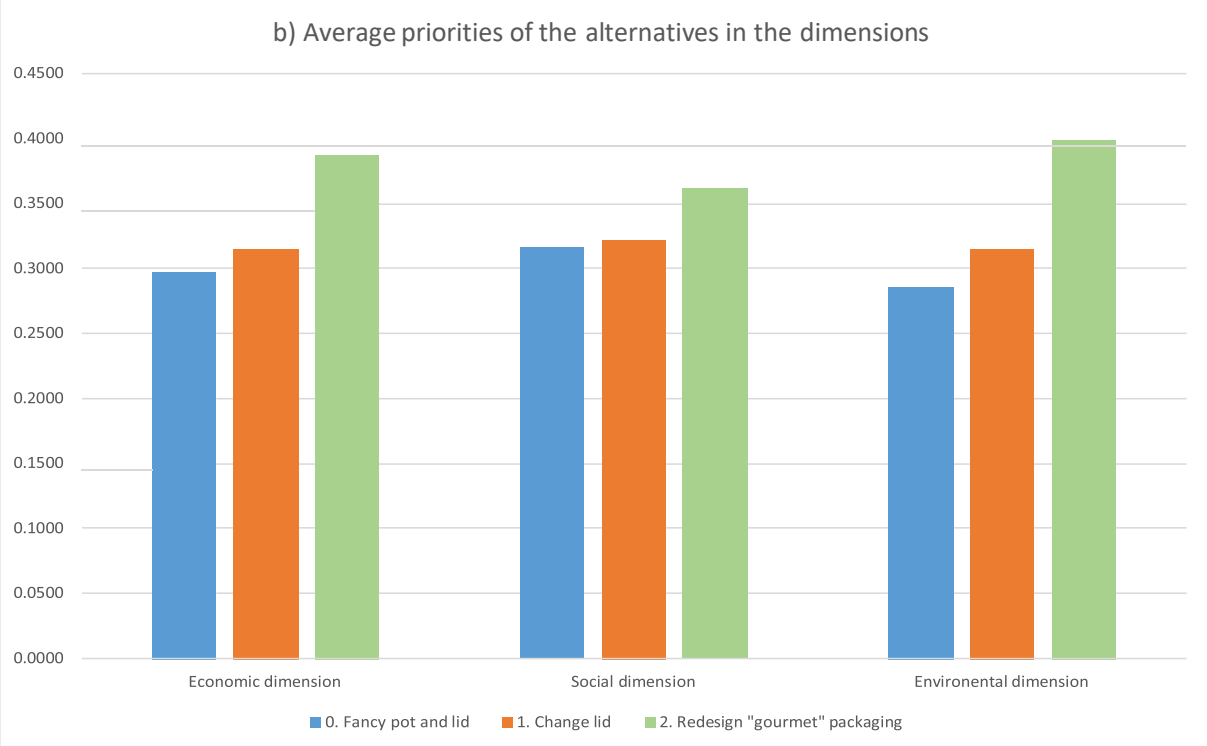
Figure 4.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

Alternative 2 'Redesign gourmet packaging' stand outs in the three dimensions of sustainability, but especially in the environmental and economic ones. The other two alternatives (alternative 0 'Fancy pot and lid' and alternative 1 'Change lid') perform not too differently, although alternative 1 'Change lid' is slightly better in all dimensions.

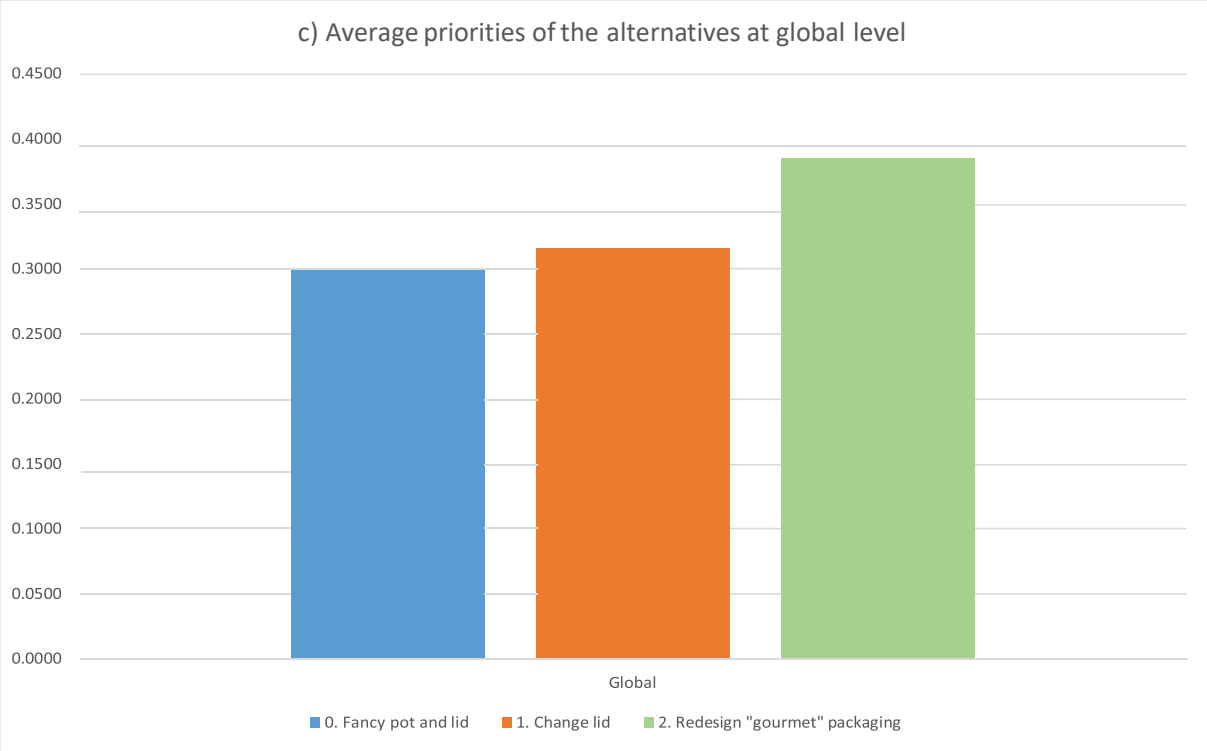
Figure 4.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

In line with the above data, alternative 2 ‘Redesign gourmet packaging’ is the best option globally. Alternative 1 ‘Change lid’ follows behind and alternative 0 ‘Fancy pot and lid’ is the worst option, but not much different from alternative 1

Figure 4.c. Average priorities of the alternatives at global level



PILOT 5. REDESIGN AND CHANGE OF MATERIALS

Description

Polypropylene (PP) is used as packaging material. The packaging is fabricated by injection, resulting in a very robust pot which is consuming a lot of PP plastic for its fabrication. Moreover, PP is not very well recycled nowadays.

Alternatives

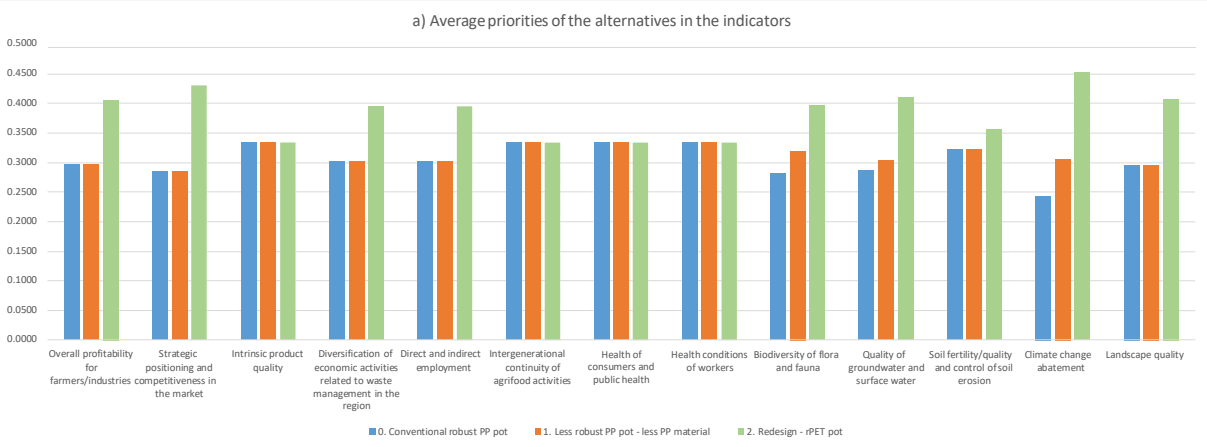
The alternatives analysed are:

- Alternative 0. Robust PP pot fabricated following an injection process.
- Alternative 1. Ecodesign the package so a PP pot can still use but employing less amount of PP for its fabrication.
- Alternative 2. Redesign packaging so it can be fabricated by a thermoforming process and with rPET as materials, which is recycled material and it is a more recyclable material.

Priorities of the alternatives in the indicators

Regarding indicators, alternative 2 'Redesign - rPET pot' has a better performance in general, and especially in some economic ones, such as 'Strategic positioning and competitiveness in the market', 'Overall profitability for farmers/industries' and 'Diversification of economic activities related to waste management in the region', some social ones, such as 'Direct and indirect employment', and all environmental ones, especially 'Climate change abatement', 'Quality of groundwater and surface water' and landscape quality'.

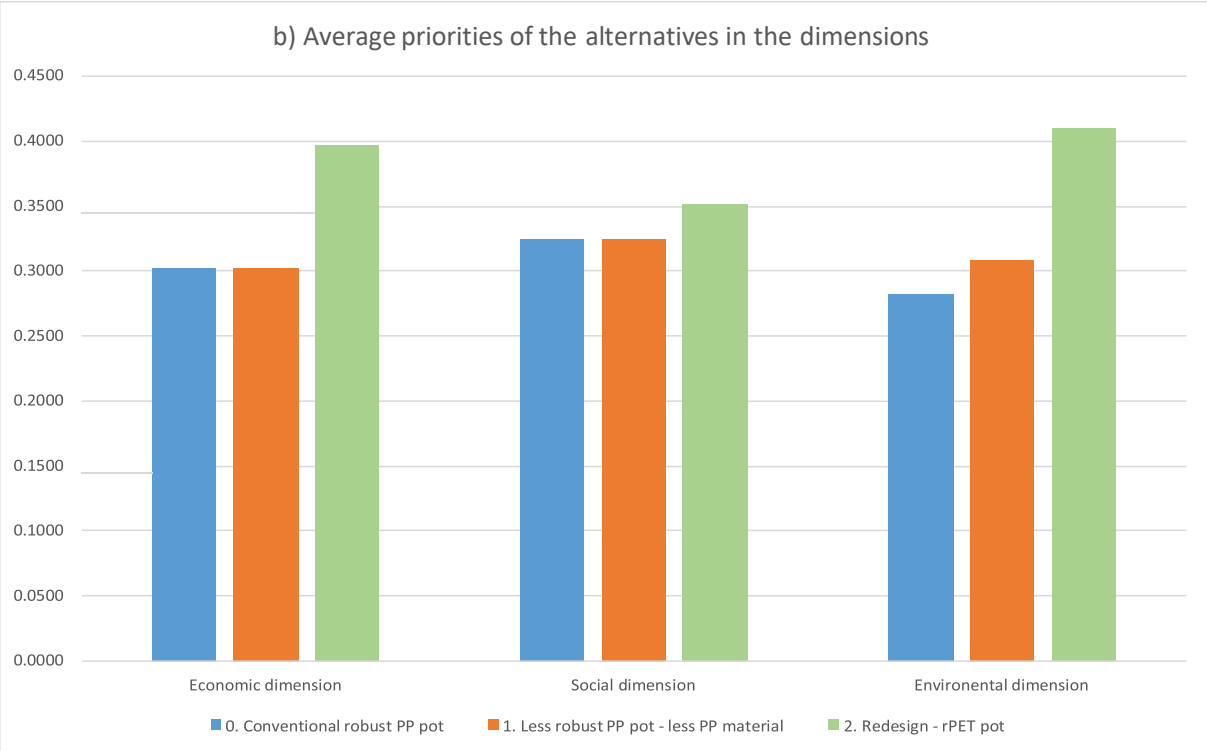
Figure 5.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

Alternative 2 'Redesign - rPET pot' excels in the three dimensions of sustainability, especially the environmental and economic ones. The other two alternatives (alternative 0 'Conventional robust PP pot' and alternative 1 'Less robust PP pot - less PP material') have a worse performance and not much different, although alternative 0 'Conventional robust PP pot' is slightly worse.

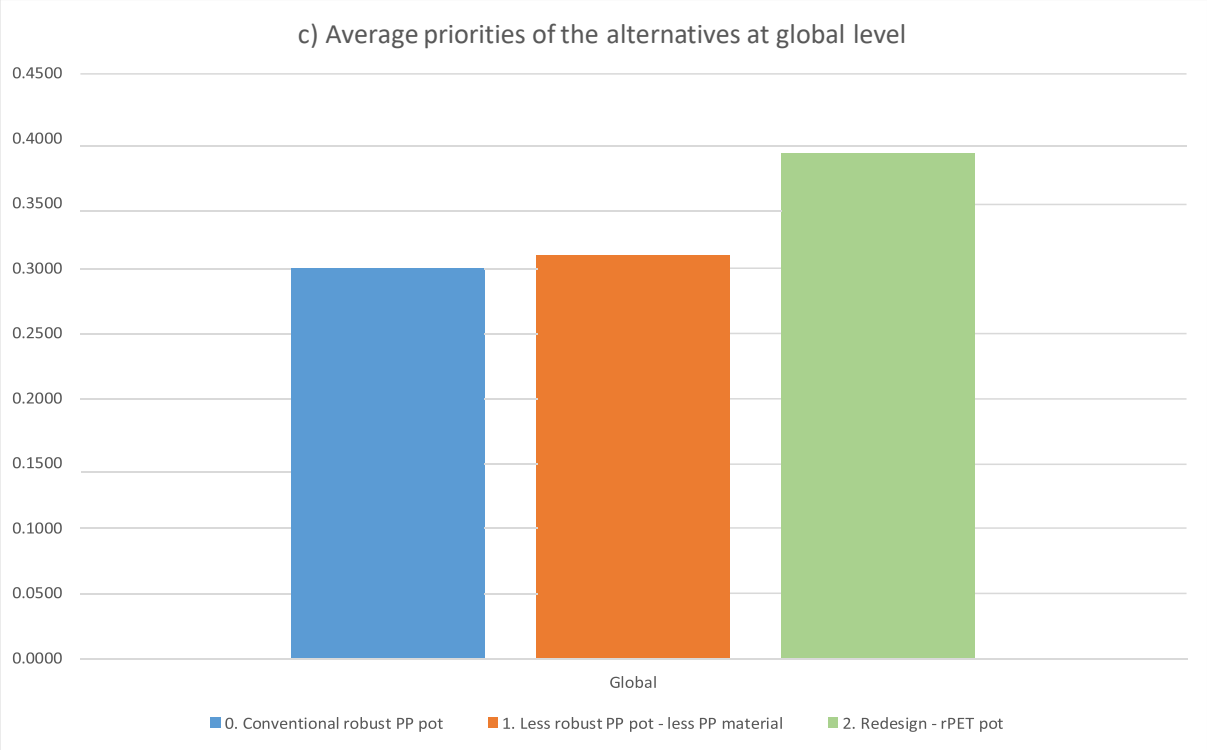
Figure 5.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

At a global level, alternative 2 ‘Redesign - rPET pot’ stands out. Alternative 1 ‘Less robust PP pot - less PP material’ and alternative 0 ‘Conventional robust PP pot’, whose performances are not very different from each other, are at a certain distance.

Figure 5.c. Average priorities of the alternatives at global level



Conclusions for Horticulture industry (Spain)

The results obtained show that for all the pilots studied there are alternatives that perform better globally than the alternatives currently used in a conventional way. For all pilots, the conventional alternative is the worst globally. Differences are especially evident in the environmental and economic dimensions.

The following Table summarises for each pilot the best overall alternative to conventional practice:

Table 1. Conventional versus best global alternatives for each pilot

Pilot	Conventional alternative	Best alternative
Alternatives to the conventional use of plastic trays	Conventional plastic materials	Carton-based trays
Logistics optimization	Conventional plastic tray	Rethink whole packaging - more sustainable solution
Rethinking packaging towards zero inorganic waste	Conventional packaging: cardboard tray + plastic flowpack	Bands – no packaging
Sustainable packaging for gourmet products	Fancy pot and lid	Redesign gourmet packaging
Redesign and change of materials	Conventional robust PP pot	Redesign - rPET pot

3. Meat industry (France)

Evaluation

4 experts in meat industry in France were surveyed. The indicators evaluated by the experts in all the pilots/practices analysed are:

• Economic dimensions/indicators: These refer to the economic aspects of sustainability in relation to the economic (market) benefits and costs of farmers/industries. They are:

- Overall profitability for farmers/industries: This is income minus variable costs. Incomes and costs are the totals of the economic activity developed by the farmer/industry, not just those associated with the technique being tested. The indicator measures how the practices implemented can affect the overall profitability obtained.
- Strategic positioning and competitiveness in the market: they refer to the fact that early adoption of innovations can improve the position of the company in the medium and long term.
- Intrinsic quality of the product : Refers to the quality attributes found in products obtained by the farmer or industry. It refers to sensory and organoleptic issues, etc.
- Diversification of economic activities related to waste management in the region: This refers to the presence of diversified economic activities related to waste management in the study area.

• Social dimension/indicators: These refer to the social aspects of sustainability. These are social (non-market) benefits and costs. They are:

- Direct and indirect employment: Employment generated in agriculture/industry and parallel sectors.
- Intergenerational continuity of agri-food activities: Level of guarantee of continuity of economic activity over time through the maintenance of human capital.
- Consumer and public health: Guarantee of good hygienic and sanitary conditions of the products obtained by farmers/industries.
- Health conditions of workers: Guarantee of good hygiene and health conditions for farmers/workers.

• Environmental dimensions/indicators: These refer to the environmental aspects of sustainability. They refer to environmental (non-market) benefits and costs. They are:

- Biodiversity of fauna and flora: Quantity and variety of different living beings present in the environment.
- Ground and surface water quality: Low contamination of groundwater and surface water mainly due to the application of inputs in the production process.
- Soil fertility/quality and soil erosion control: It is important that the soil is not lost and that its agronomic quality is the best possible.
- Fight against climate change: Contributes to the fight against climate change because they are processes that emit less CO2.
- Landscape quality: It refers to the aesthetic quality of the landscape of the region.

PILOT 1. TRACKS TO DECREASE INCOMING PACKAGING (Raw materials)

Description

The receipt of raw materials raises several waste-related issues. Indeed, the primary material used for packaging consists of bags, vacuum bags, buckets and drums. The secondary material is mainly corrugated cardboard. They have several disadvantages: they are not recyclable and are therefore treated as non-hazardous industrial waste, and they are automatically contaminated with blood, grease and other components. It is therefore necessary to think about alternatives to these two materials.

Alternatives

The alternatives analysed are:

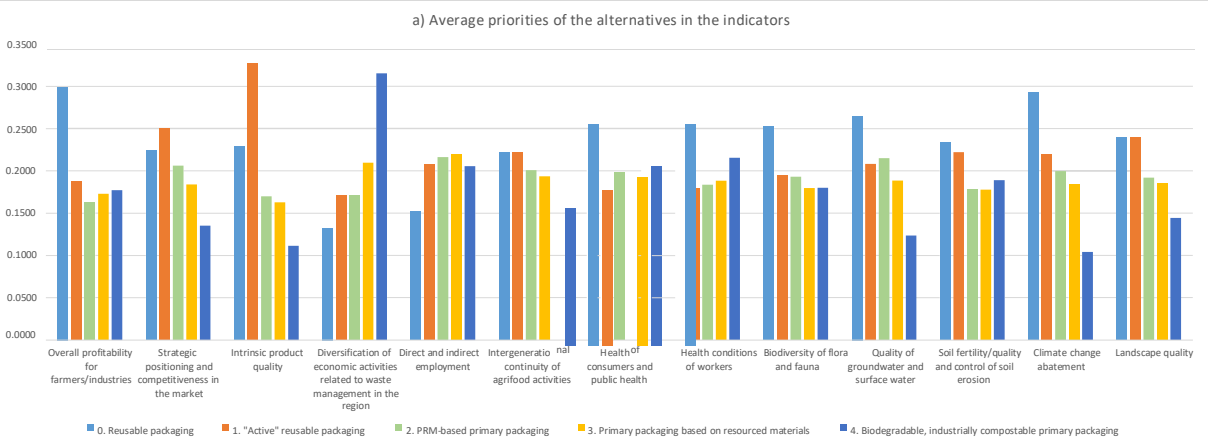
- Alternative 0. Reusable packaging (containers, crates...)
- Alternative 1. "Active" reusable packaging that eliminates the primary packaging (vacuum)
- Alternative 2. PRM-based primary packaging (films, bags, other)
- Alternative 3. Primary packaging (film, bags, other) made from bio-based materials.
- Alternative 4. Biodegradable, industrially compostable primary packaging (films, bags, etc.)

Priorities of the alternatives in the indicators

The performance of the alternatives is very varied in the different indicators. Within the economic indicators, in the 'Overall profitability for farmers/industries' the alternative 0 'Reusable packaging' stands out, in the 'Diversification of economic activities related to waste management in the region' the alternative 4 'Biodegradable, industrially compostable primary packaging', and in the two remaining ones the alternative 1 '"Active" reusable packaging'. In the social indicators, such as 'Health of consumers and public health' and 'Health conditions

of workers', the alternative 0 'Reusable packaging' stands out. This alterative also stands out in environmental criteria, especially in 'Climate change abatement', 'Quality of groundwater and surface water' and 'Biodiversity of flora and fauna'.

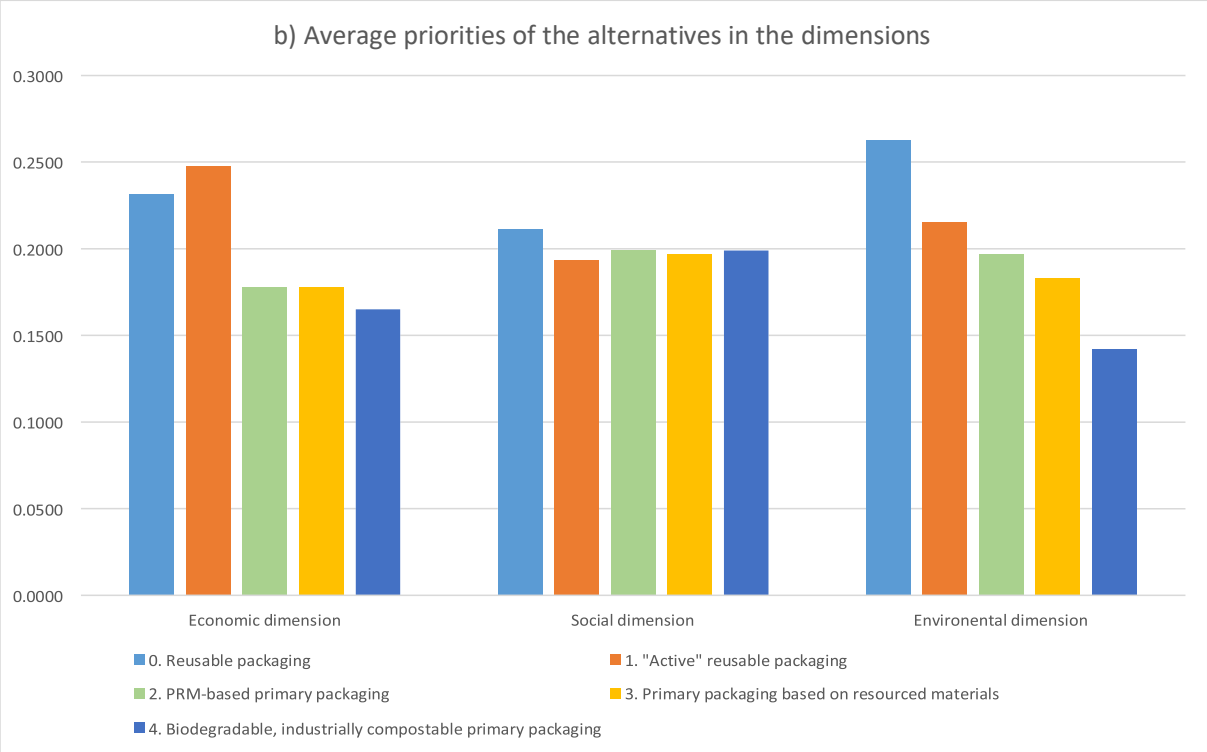
Figure 1.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

In the economic dimension, alternative 1 '"Active" reusable packaging' stands out, although it is closely followed by alternative 0 'Reusable packaging'. In the social dimension, all the alternatives perform in a very similar way, although alternative 0 'Reusable packaging' stands out slightly. In the environmental dimension, there are more differences between the different alternatives, with the alternative 0 'Reusable packaging' standing out.

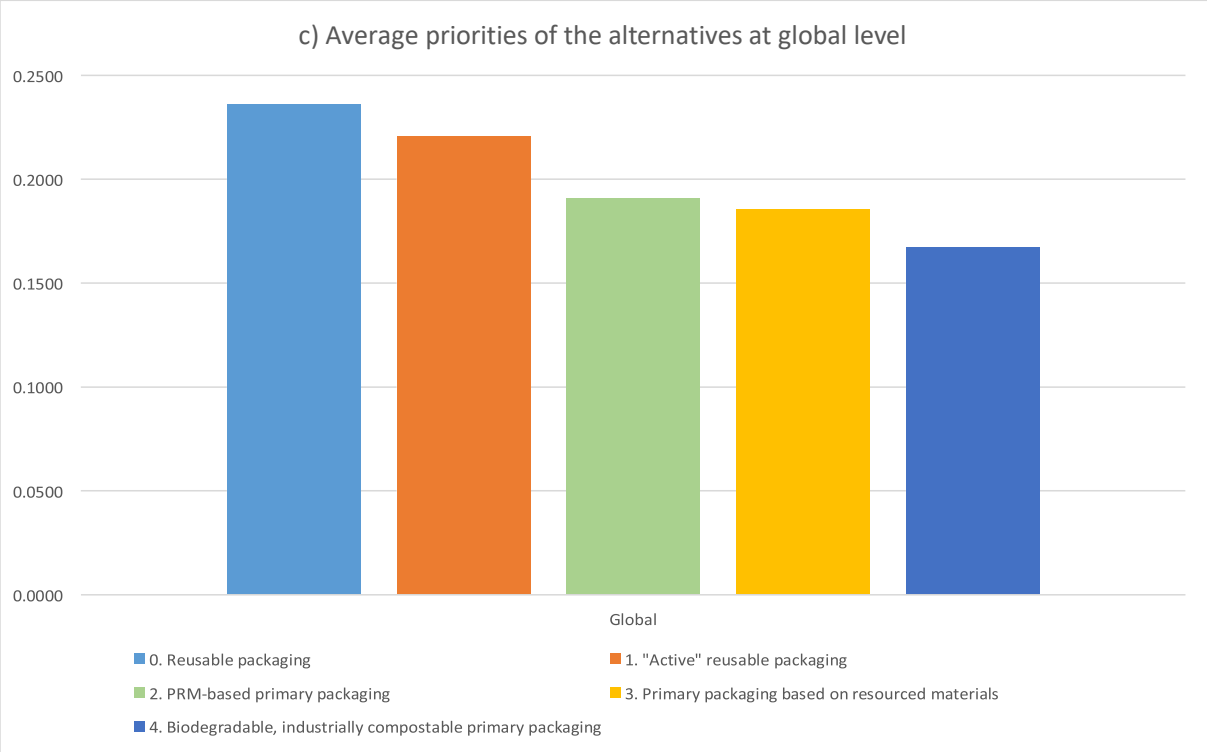
Figure 1.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

On a global level, alternative 0 ‘Reusable packaging’ stands out, although it is closely followed by alternative 1 ‘"Active" reusable packaging’. The worst alternative is 4 ‘Biodegradable, industrially compostable primary packaging’.

Figure 1.c. Average priorities of the alternatives at global level



PILOT 2. REDUCE PROCESS PACKAGING

Description

Among the processes commonly used in meat processing is the cooking of products in the packaging, as in the case of ham, for example. The materials used, either in the form of bags or in the form of thermoformed-capped, are complex PA-PE bases that allow good shrinkage on the product and thus facilitate cooking. After cooking, the products are deconditioned to be re-packaged, which generates a large tonnage of non-recoverable soiled packaging waste that goes into OIW.

Alternatives

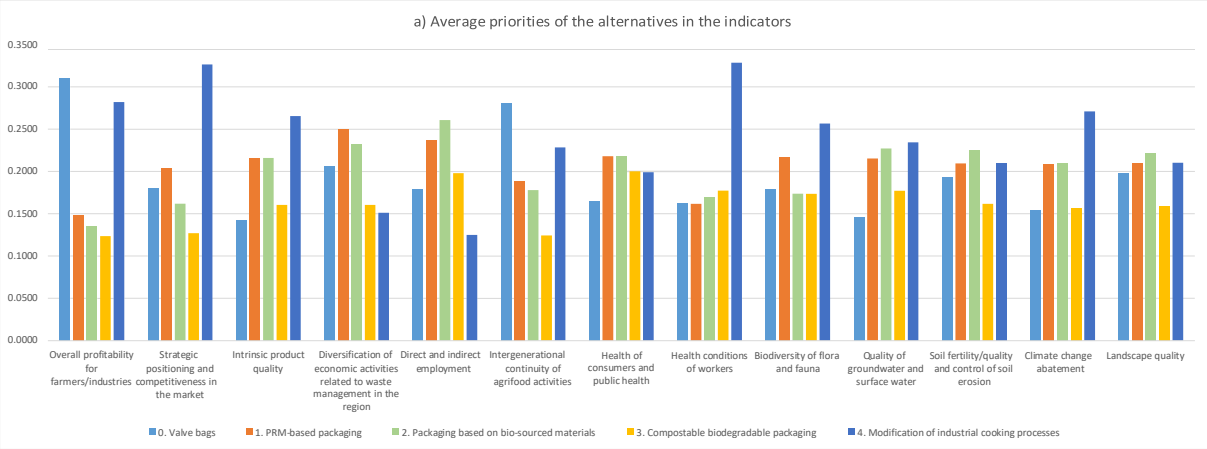
The alternatives analysed are:

- Alternative 0. Valve bags to drain the cooking juices and thus avoid deconditioning - reconditioning
- Alternative 1. PRM-based packaging
- Alternative 2. Packaging based on bio-based materials
- Alternative 3. Industrially compostable biodegradable packaging
- Alternative 4. Modify the "unpackaged" industrial cooking processes

Priorities of the alternatives in the indicators

Alternative 4 ‘Modification of industrial cooking processes’ stands out in many indicators, especially the economic ones, such as ‘Strategic positioning and competitiveness in the market’ and ‘Intrinsic product quality’, the social ones, such as ‘Health conditions of workers’, and the environmental ones, such as ‘Climate change abatement’. Alternative 0 ‘Valve bags’ also stands out in ‘Overall profitability for farmers/industries’, which is an economic indicator, and ‘Intergenerational continuity of agrifood activities’, which is social.

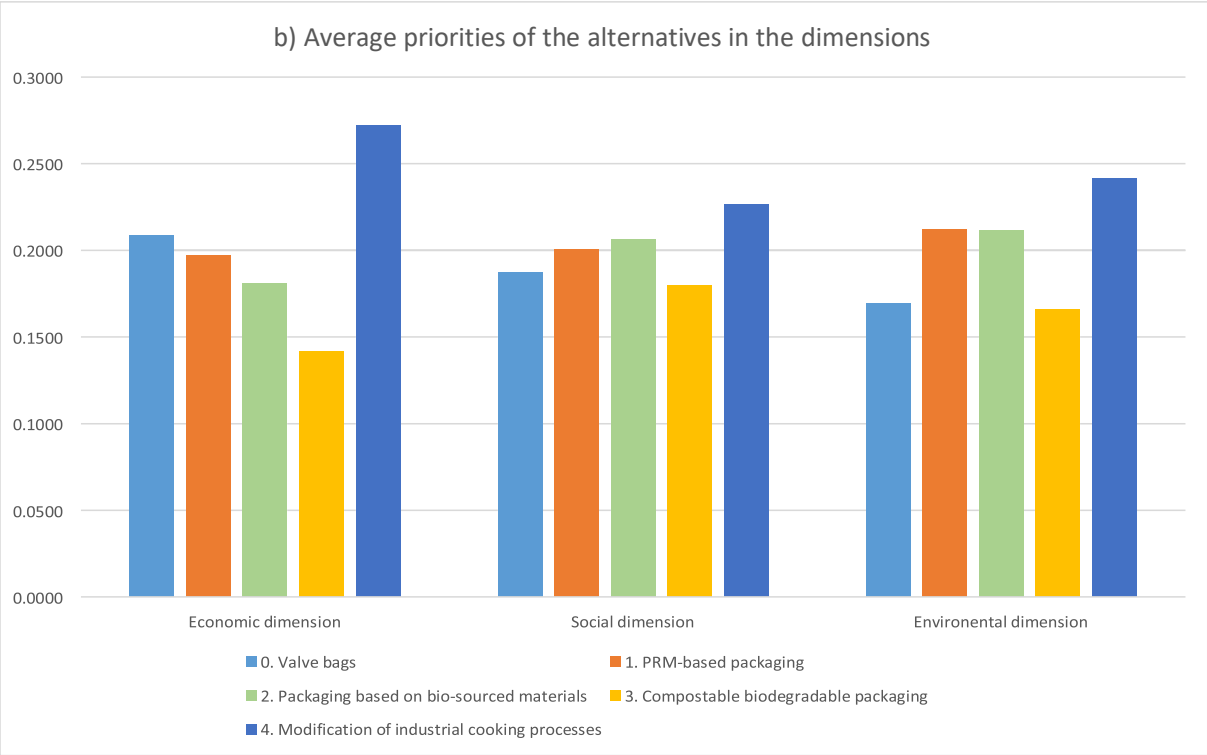
Figure 2.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

Aggregating the performances in the indicators, Alternative 4 'Modification of industrial cooking processes' stands out in all three dimensions of sustainability, especially the economic one. The order of the other alternatives is different in each dimension, although Alternative 3 'Compostable biodegradable packaging' is always the worst.

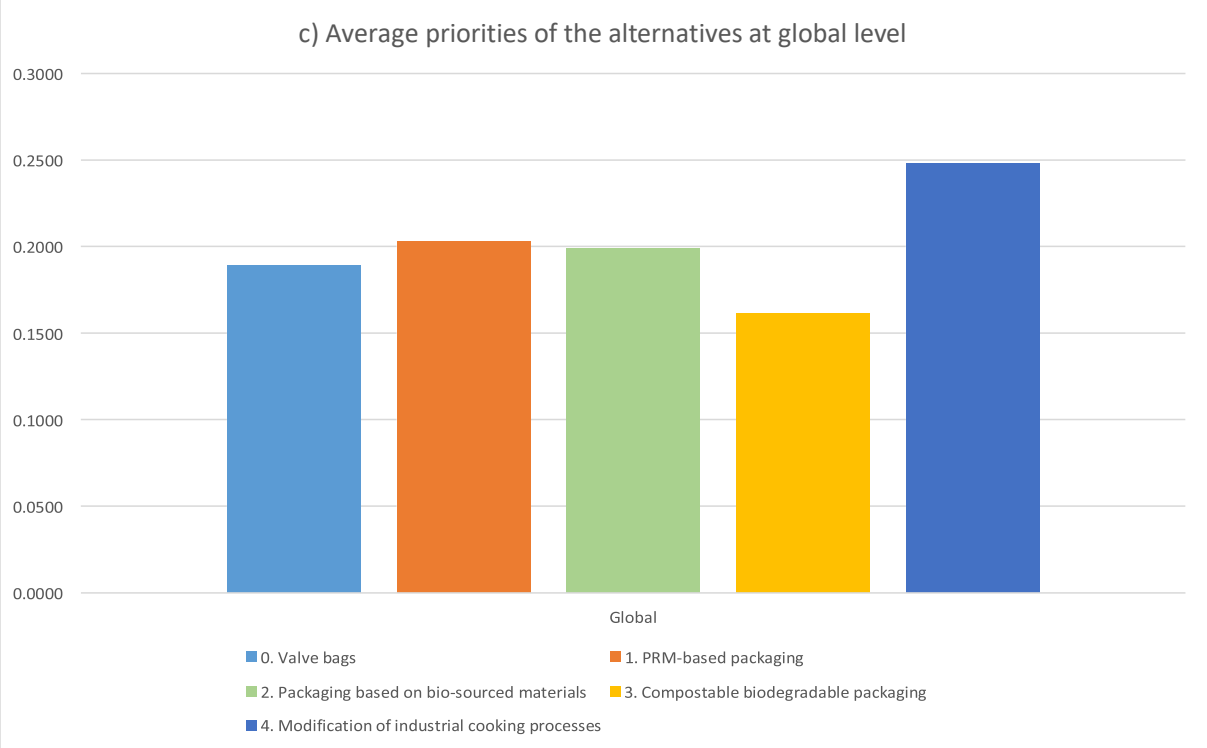
Figure 2.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

As a consequence of all the above and taking into account the weight of each of the dimensions of sustainability assessed by the experts, at a global level Alternative 4 'Modification of industrial cooking processes' stands out, with a certain advantage over the rest. Next would be alternatives 1 'PRM-based packaging', 2 'Packaging based on bio-sourced materials' and 0 'Valve bags', without many differences between them. Alternative 3 'Compostable biodegradable packaging' would be the least sustainable option.

Figure 2.c. Average priorities of the alternatives at global level



PILOT 3. REDUCE PACKAGING WASTE FROM THE PACKAGING PROCESS

Description

Finished products are usually packaged in a package consisting of a carrier (tray) and a film (lid). The trays can either be already thermoformed at the supplier's premises or thermoformed on site. In this second case, depending on the design of the packaging, a "skeleton" can be generated corresponding to the offcuts and the offcuts from the edges of the width. These technologies also generate a lot of polluted waste at the start or resumption of production.

Alternatives

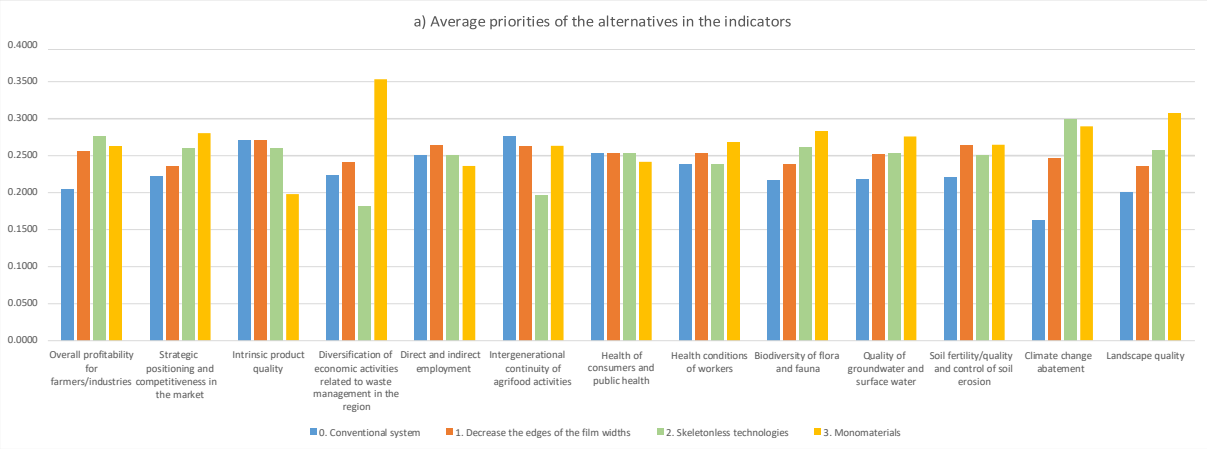
The alternatives analysed are:

- Alternative 0. Conventional packaging system
- Alternative 1. Reduce the edges of the film widths to the acceptable minimum
- Alternative 2. Moving to "skeletonless" technologies (Mondini type)
- Alternative 3. Favouring monomaterials for recyclability

Priorities of the alternatives in the indicators

At the indicator level, the different alternatives are not very different. The best performance of alternative 3 ‘Monomaterials’ should be highlighted in ‘Diversification of economic activities related to waste management in the region’, which is an economic issue, and in several environmental indicators, such as ‘Landscape quality’, ‘Biodiversity’ and ‘Quality of groundwater and surface water’.

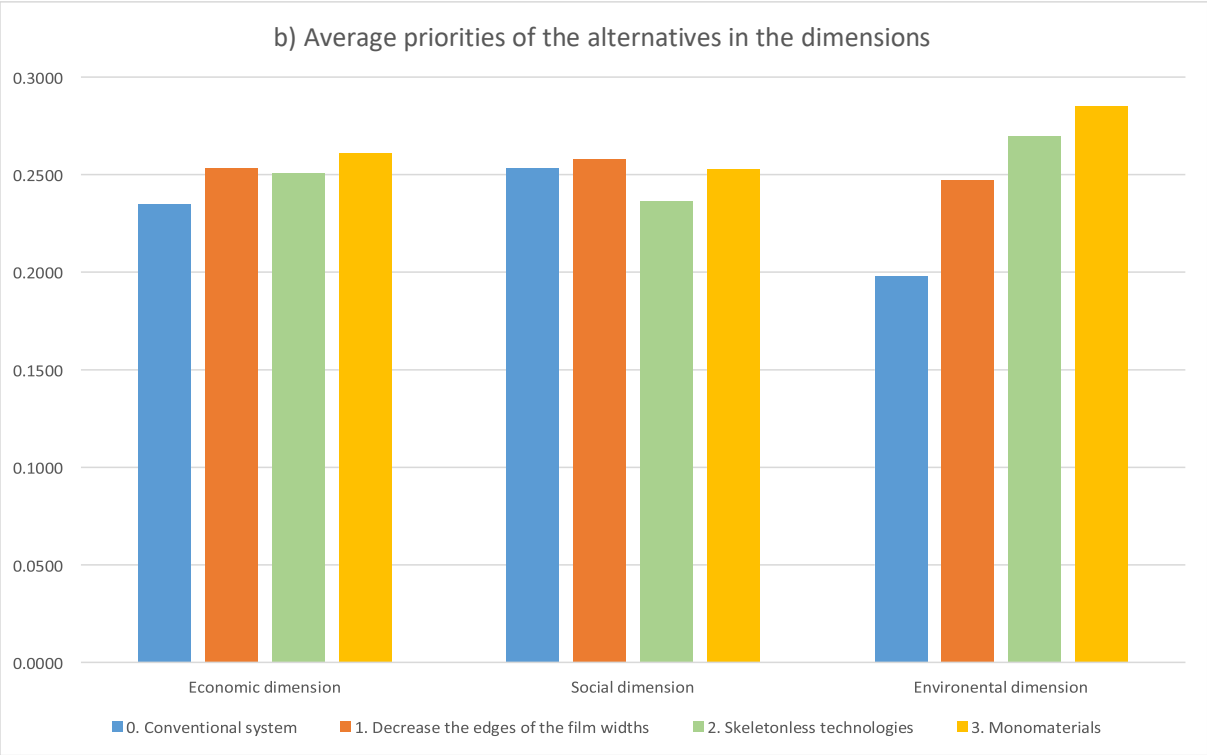
Figure 3.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

At the level of sustainability dimensions, alternative 3 'Monomaterials' stands out slightly in the economic one and more clearly in the environmental one. Alternative 0 'Conventional system' is the worst option economically and above all environmentally. In the social dimension the performance of all the alternatives is very similar.

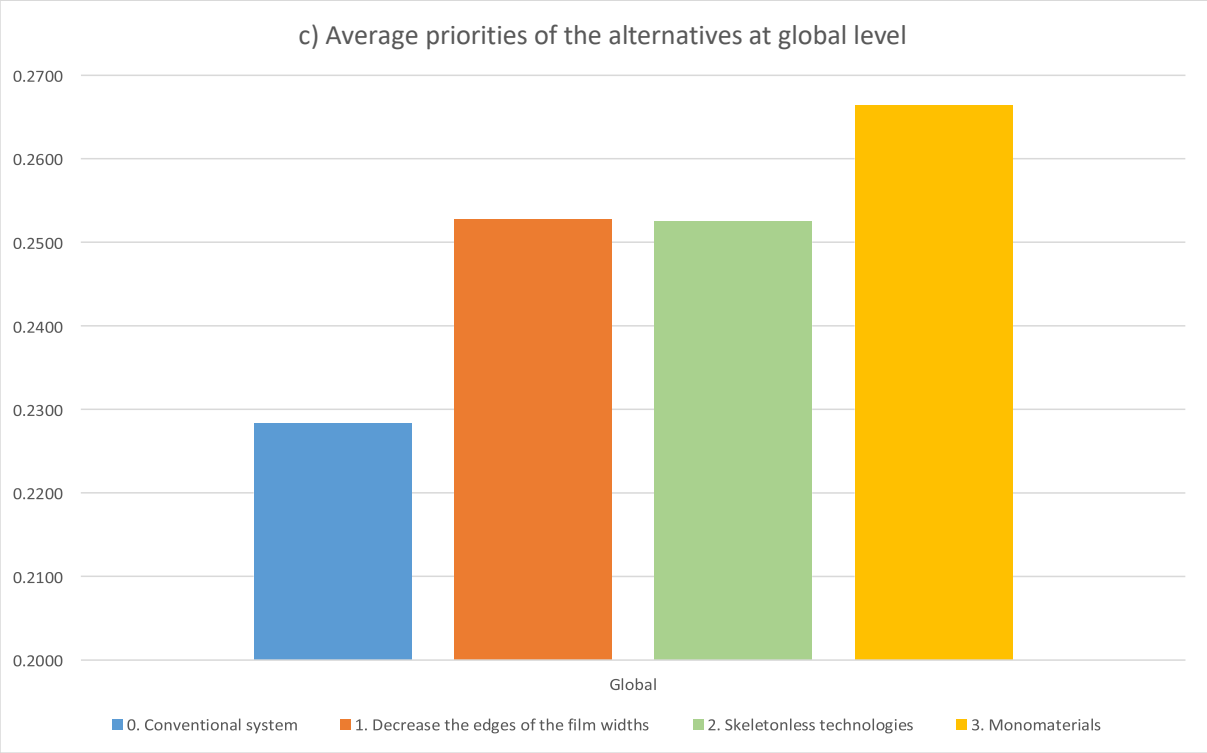
Figure 3.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

At a global level, alternative 3 ‘Monomaterials’ stands out from the two that follow, which are 1 ‘Decrease the edges of the film widths’ and 2 ‘Skeletonless technologies’, which do not differ much from each other. Alternative 0 ‘Conventional system’ is clearly the least sustainable.

Figure 3.c. Average priorities of the alternatives at global level



PILOT 4. OPTIMISING THE RECOVERY OF POST-CONSUMER PACKAGING

Description

The primary packaging system tray-pouch is commonly used. The requirements for vacuum, skin or modified atmosphere storage require complex materials combining sealing layers with barrier layers. These complex materials are not included in sorting instructions at the consumer level. The recommendations given by EPR (Extended Producer Responsibility) bodies are in favour of single materials or complexes that are easily separable or do not interfere with sorting systems. The use of certain dyes or pigments (carbon black, opacifiers) is also detrimental to industrial sorting.

Alternatives

The alternatives analysed are:

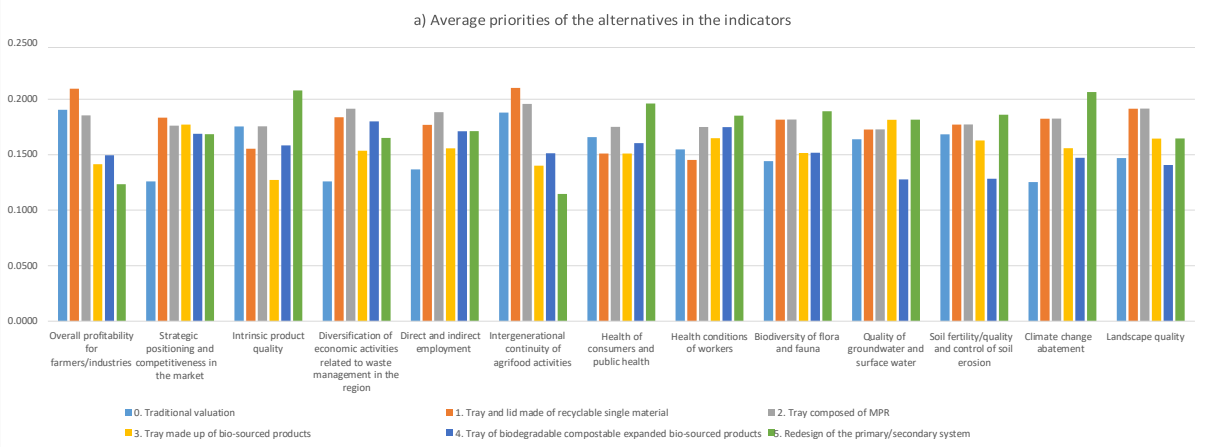
- Alternative 0. Traditional valuation
- Alternative 1. Tray and lid made of recyclable monomaterial (PET, PP)
- Alternative 2. Tray made of MPR
- Alternative 3. Tray composed of bio-sourced products (cellulose, other...)
- Alternative 4. Tray of biodegradable compostable expanded bio-sourced products
- Alternative 5. Redesign the primary/secondary system: reusable active secondary/reduced primary

Priorities of the alternatives in the indicators

In this pilot there is no clear pattern in the performance of the different alternatives in the different indicators. Thus, alternative 1 ‘Tray and lid made of recyclable single material’ stands out in some economic issues such as ‘Overall profitability for farmers/industries’ and ‘Strategic positioning and competitiveness in the market’, and some social issues such as ‘Intergenerational continuity of agrifood activities’, while alternative 5 ‘Redesign of the

primary/secondary system' stands out in some economic issues such as 'Intrinsic product quality', some social issues such as 'Health of consumers and public health' and 'Health conditions of workers', and in some environmental issues such as 'Climate change abatement', 'Biodiversity' and 'Soil fertility/quality and control of soil erosion'.

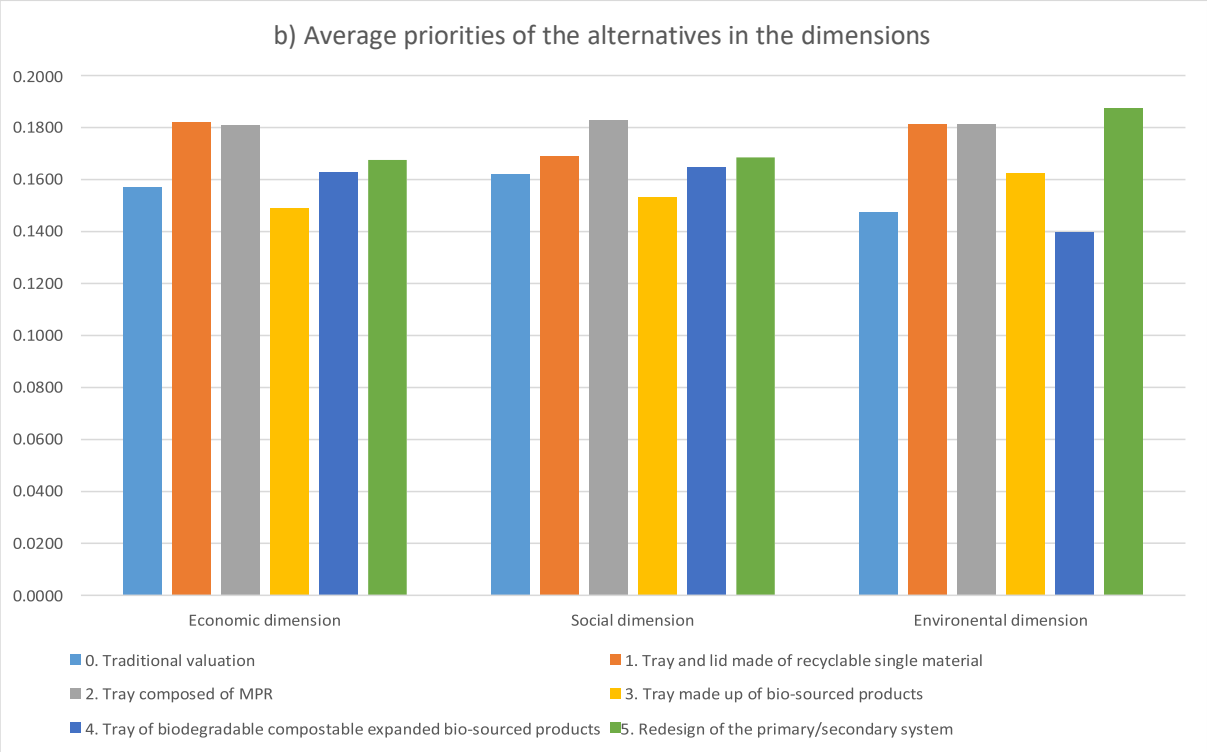
Figure 4.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

Aggregating the performances at the level of sustainability dimensions, this performance not very different from the different alternatives is confirmed. Thus, in each dimension some alternative stands out but not very clearly against the rest. Thus, in the economic dimension, alternative 1 'Tray and lid made of recyclable single material' stands out, but is closely followed by alternative 2 'Tray composed of MPR'. In the social dimension, alternative 2 'Traycomposed of MPR' stands out, in this case with a little more difference from the rest. And in the environmental dimension, alternative 5 'Redesign of the primary/secondary system' stands out but is closely followed by alternative 1 'Tray and lid made of recyclable single material' and alternative 2 'Tray composed of MPR'.

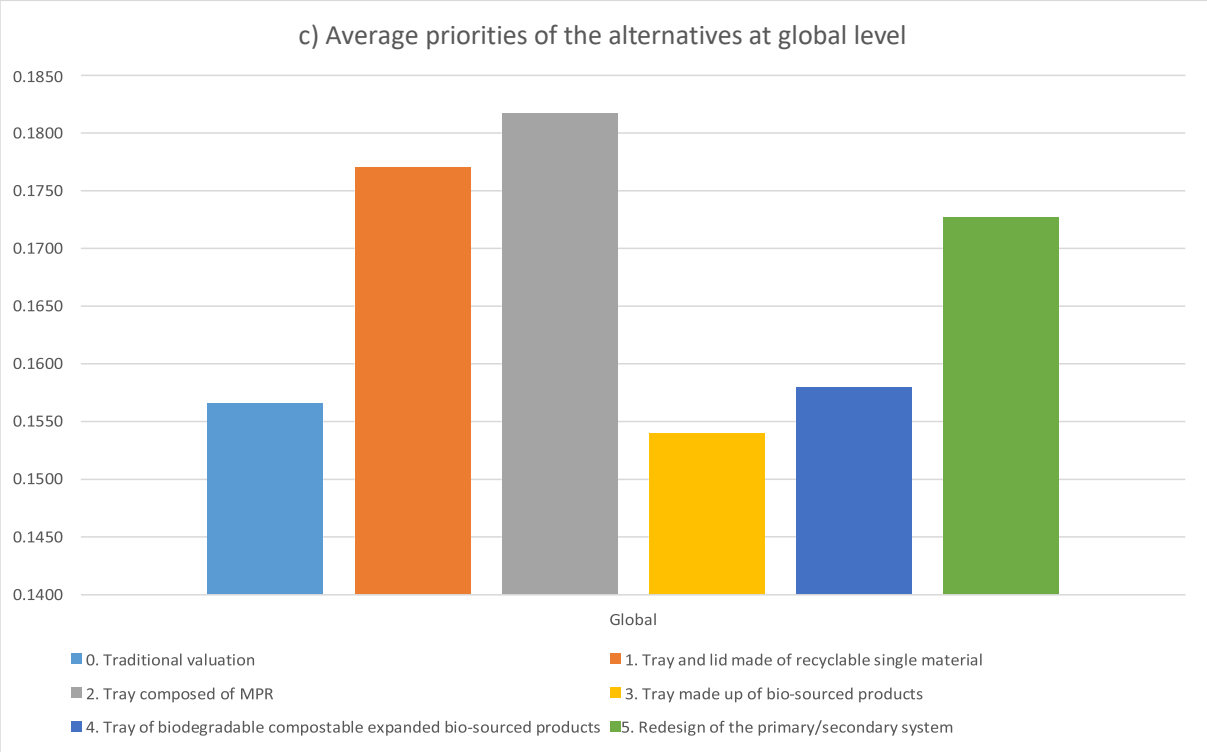
Figure 4.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

On a global level, the differences are clearer. Thus, alterative 2 'Tray composed of MPR' stands out, followed by alternative 1 'Tray and lid made of recyclable single material' and alternative 5 'Redesign of the primary/secondary system'. Alternative 3 'Tray made up of bio-sourced products' is the least sustainable globally.

Figure 4.c. Average priorities of the alternatives at global level



Conclusions for Meat industry (France)

In all the pilots studied there are alternatives to conventional forms that are more sustainable, with the exception of 'Tracks to decrease incoming packaging' where 'Reusable packaging' is the most sustainable.

The following Table summarises for each pilot the best overall alternative to conventional practice:

Table 1. Conventional versus best global alternatives for each pilot

Pilot	Conventional alternative	Best alternative
Tracks to decrease incoming packaging	Reusable packaging	Reusable packaging
Reduce process packaging	Valve bags	Modification of industrial cooking processes
Reduce packaging waste from the packaging process	Conventional system	Monomaterials
Optimising the recovery of post-consumer packaging	Traditional valuation	Tray composed of MPR

4. Dairy production (Italy)

Evaluation

5 experts in dairy production in Italy were surveyed. The indicators evaluated by the experts in all the pilots/practices analysed are:

- Economic dimension/indicators: They refer to the economic aspects of sustainability, relative to farmers/industries economic (market) benefits and costs.
  - Overall profitability for farmers/industries: It refers to incomes minus variable costs. Income and costs are the totals of the economic activity developed by the farmer. It measures how the practices implemented can affect the overall profitability obtained.
  - Strategic positioning and competitiveness in the market: It refers to the fact that early adoption of innovations can improve the company's position in the medium and long term.
  - Economic opportunity of waste management plants to treat waste resulting from proposed innovations. It is referred to the assessment of the economic opportunity for waste treatment in managing waste flows resulting from the proposed innovations.

- Social dimension/indicators: They refer to the social aspects of sustainability. They are social (non-market) benefits and costs. They are:
  - Direct and indirect employment: Jobs generated in the farm and in parallel sectors.
  - Health conditions of workers: Guarantee of good hygienic and health conditions for the farmers/workers

- Environmental dimension/indicators: They refer to the environmental aspects of sustainability. They are:
  - Climate change abatement: Contribution to the fight against climate change as they are processes that emit less CO2.
  - Landscape quality: It refers to aesthetic quality of the landscape in the region.

PILOT 1. ALTERNATIVES TO THE CONVENTIONAL USE OF HIGH DENSITY POLYETHYLENE (HDPE) ROUND BALE NET

Description

From the analysis carried out in the dairy sector, on the sample of livestock farms involved in the experimental phase of the Reinwaste project, it emerges that one of the main non-organic wastes produced is round bale nets and plastic silage films used, which make up about 50% of the all non-organic waste produced by companies. This kind of waste is a valuable component and highly recyclable if clean. The problem encountered currently consists of a considerable technical - economic difficulty both at the farm level and at the treatment plant level, relating to the cleaning of the nets contaminated by straw, hay and soil retained by the mesh. The material that is substantially contaminated is sent for disposal and not for recovery.

Alternatives

The alternatives analysed are:

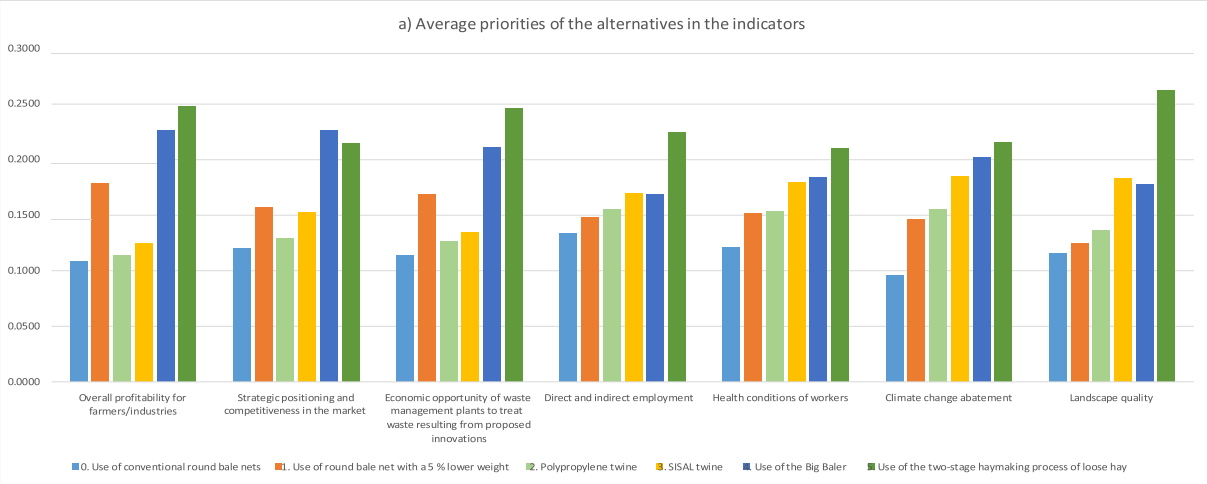
- Alternative 0. Use of conventional round bale nets (high density polyethylene): Mesh net casing used for packing cylindrical bales
- Alternative 1. Use of round bale net with a 5 % lower weight): Mesh net casing with reduced thickness used for packing cylindrical bales
- Alternative 2. Polypropylene twine: Thin rope casing made of polypropylene used for the packaging of bales
- Alternative 3. SISAL twine: Thin rope Sisal wrapper used for packing bales. * Sisal (vegetable textile fiber derived from the leaves of Agave sisalana)
- Alternative 4. Use of the Big Baler: High density pressing for the packaging of large prismatic bales

- Alternative 5. Use of the two-stage haymaking process of loose hay: Haymaking technique which involves a first pre-drying phase in the field and a second phase in which the product is brought loose in the barn to complete drying.

Priorities of the alternatives in the indicators

Alternative 5 ‘Use of the two-stage haymaking process of loose hay’ stands out in almost all indicators, especially environmental indicators such as 'Landscape quality' and social indicators such as 'Direct and indirect employment'. Alternative 4 ‘Use of the Big Baler’ also stands out, especially in the economic ones as ' Strategic positioning and competitiveness in the market'. Alternative 0 ‘Use of conventional round bale nets’ is always the worst option in all indicators.

Figure 1.a. Average priorities of the alternatives in the indicators

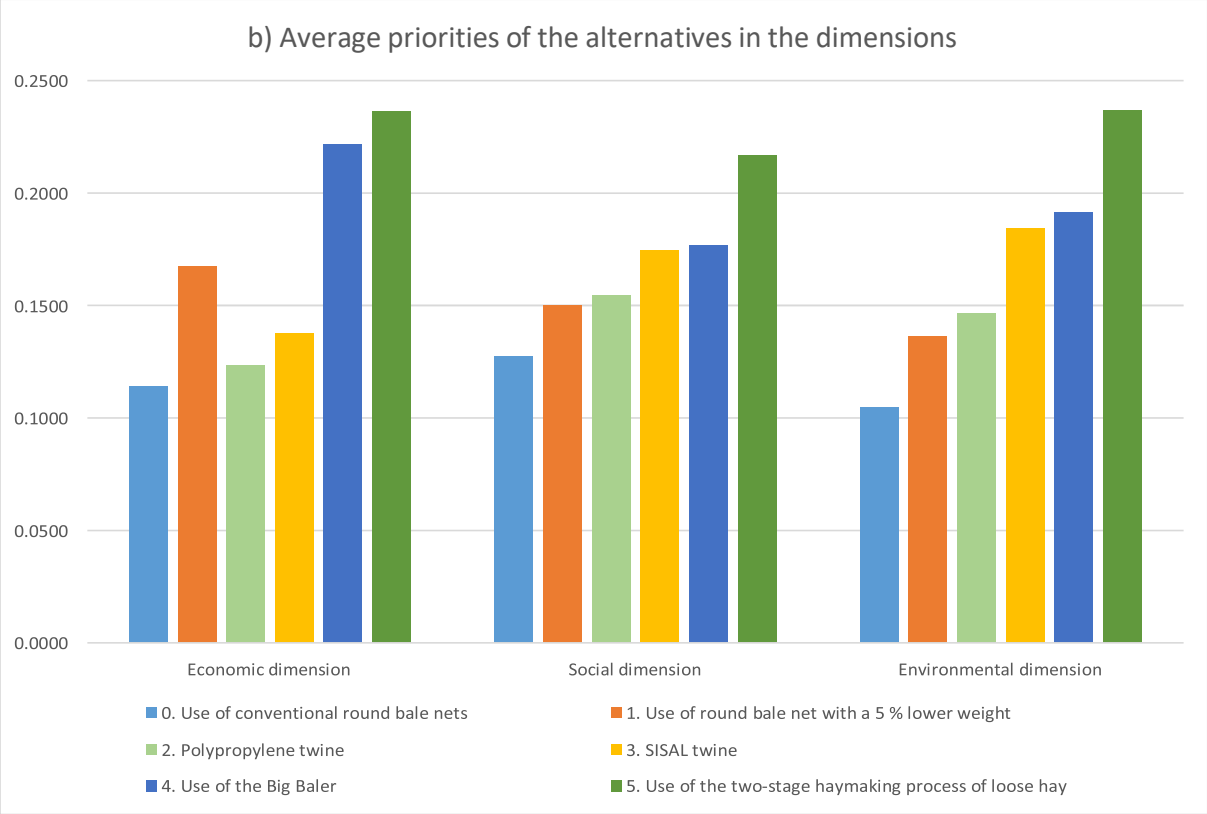


Priorities of the alternatives in the dimensions of sustainability

In terms of the dimensions of sustainability, alternative 5 ‘Use of the two-stage haymaking process of loose hay’ stands out in all three, especially in the environmental and social dimensions. In the economic dimension, it is closely followed by alternative 4 ‘Use of the Big Baler’. Alternative 1 ‘Use of round bale net with a 5 % lower weight’ is the next option at the economic level. Alternatives 3 ‘SISAL twine’ and 2 ‘Polypropylene twine’ have an

intermediate performance in all three dimensions, while alternative 0 ‘Use of conventional round bale nets’ is always the worst.

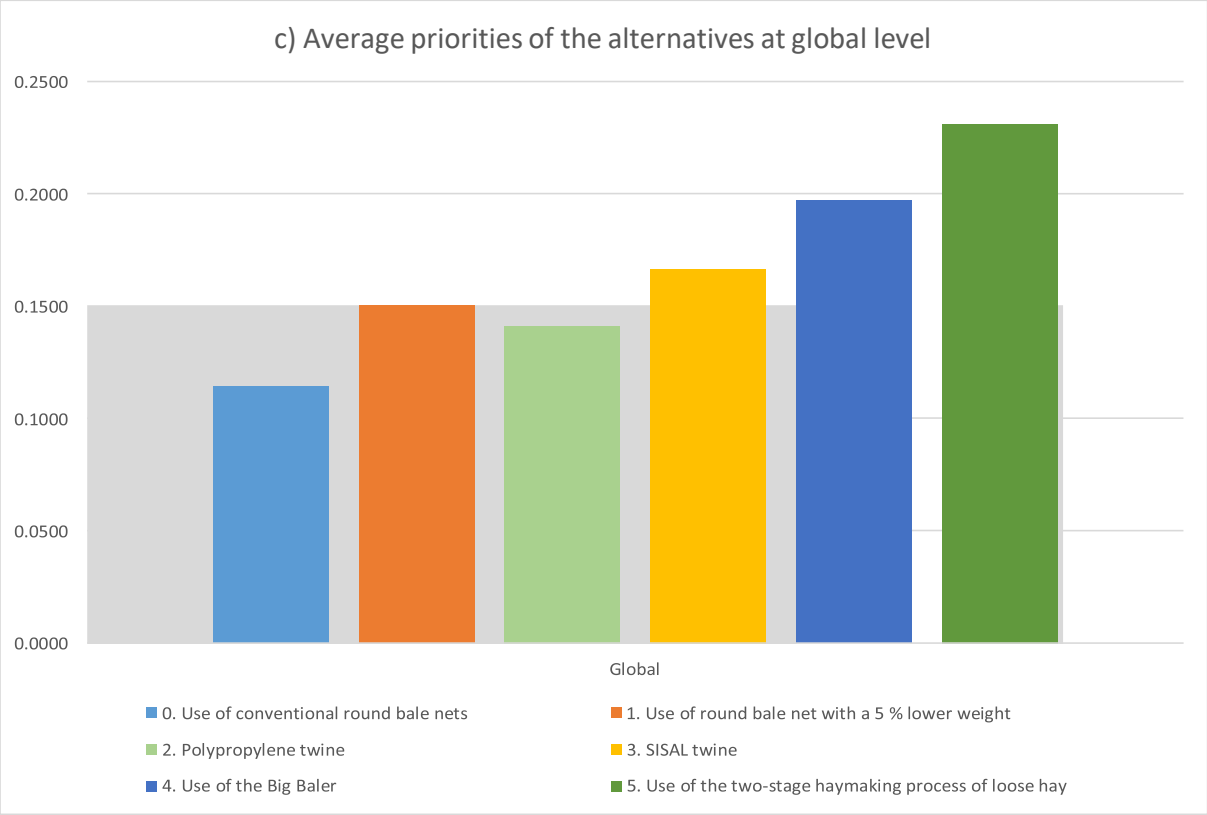
Figure 1.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

On a global level, as a consequence of the behaviour already seen in indicators and dimensions, alternative 5 ‘Use of the two-stage haymaking process of loose hay’ stands out, followed by alternatives 4 ‘Use of the Big Baler’ and 3 ‘SISAL twine’. The worst performance of alternative 0 ‘Use of conventional round bale nets’ should also be noted.

Figure 1.c. Average priorities of the alternatives at global level



PILOT 2. ALTERNATIVES TO PLASTIC SILAGE FILM

Description

From the analysis carried out in dairy sector on the sample of livestock farms involved in the experimental phase of the Reinwaste project, it emerges that one of the main non-organic wastes produced is round bales and plastic silage film used, which make up about 50% of the all non-organic waste produced by companies. This high density polyethylene (HDPE) waste is a valuable component and highly recyclable if clean. The problem encountered currently consists of a considerable technical - economic difficulty both at the farm level and at the treatment plant level, relating to the cleaning of the nets contaminated by straw, hay and soil retained by the mesh. The material that is substantially contaminated is sent for disposal and not for recovery.

Alternatives

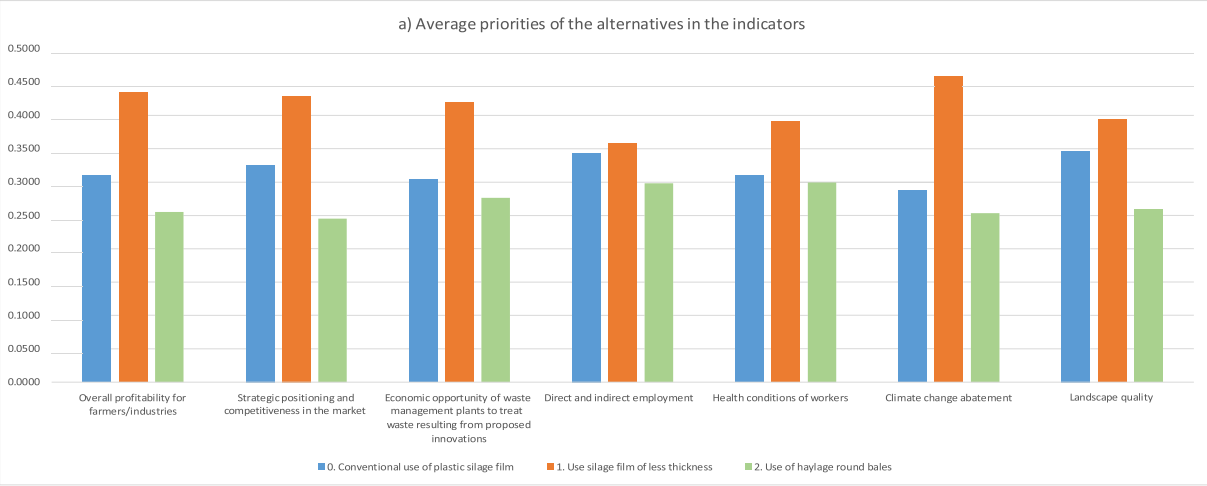
The alternatives analysed are:

- Alternative 0. Conventional use of plastic silage film: Plastic films for covering and protecting silage in order to guarantee their shelf life
- Alternative 1. Use silage film of less thickness: Plastic films for covering and protecting silage in reduced thickness trenches with the use of smaller quantities of plastic materials
- Alternative 2. Use of haylage round bales : Silage technique that involves the complete wrapping of the bales by plastic films.

Priorities of the alternatives in the indicators

Alterative 1 ‘Use silage film of less thickness’ has the best performance on all indicators. It stands out especially in 'Climate change abatement', 'Overall profitability for farmers/industries', 'Strategic positioning and competitiveness in the market' and 'Economic opportunity of waste management plants to treat waste resulting from proposed innovations'. Alternative 2 ‘Use of haylage round bales’ is the worst option in all indicators, below alternative 0 ‘Conventional use of plastic silage film’.

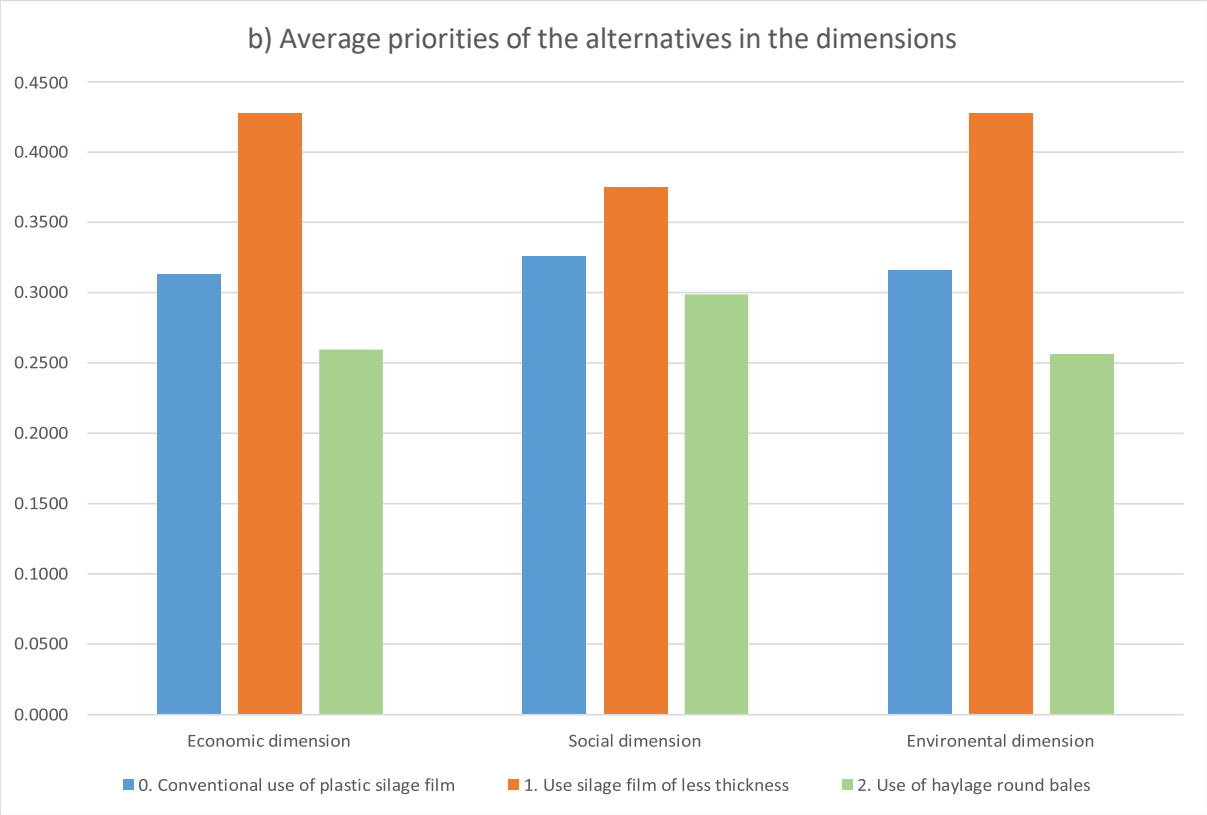
Figure 2.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

At the level of sustainability dimensions, alternative 1 ‘Use silage film of less thickness’ stands out in all of them, but especially in the economic and environmental ones. Alterative 2 ‘Use of haylage round bales’ is the worst in all three dimensions, worse than alternative 0 ‘Conventional use of plastic silage film’.

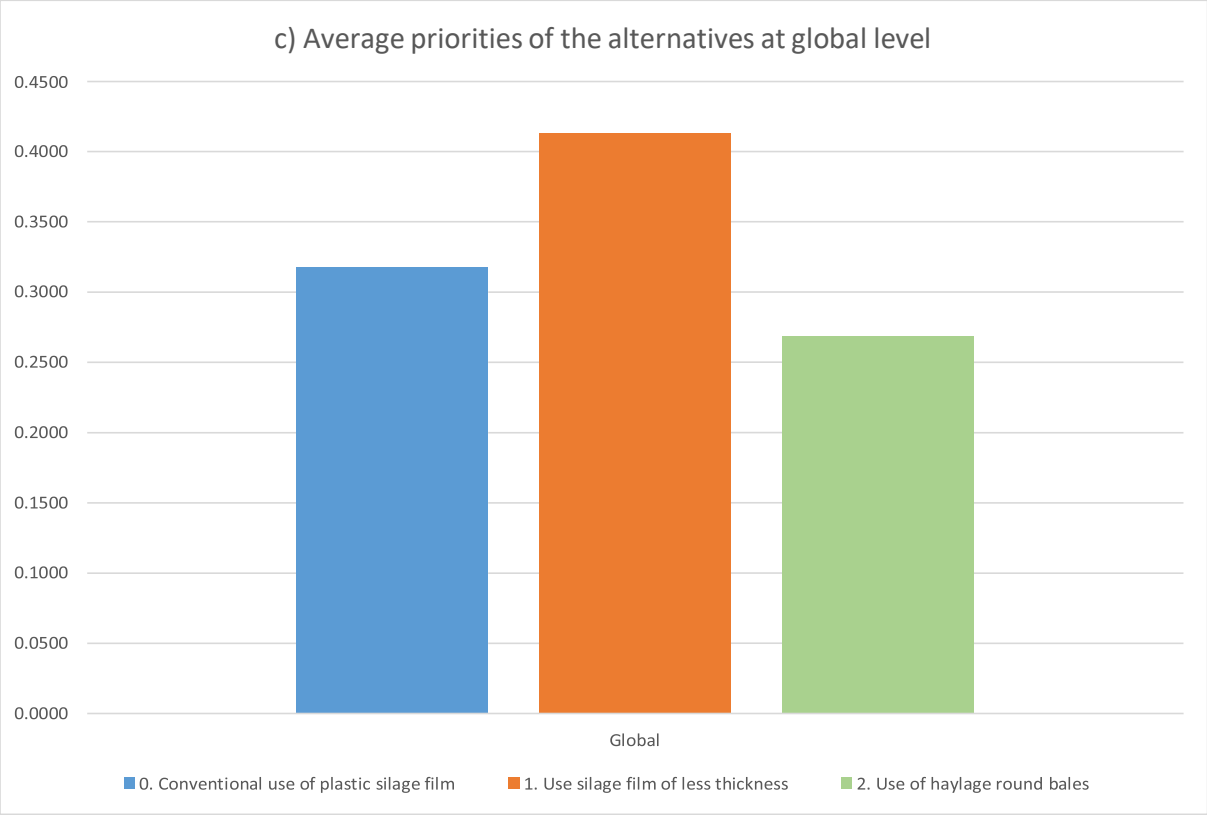
Figure 2.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

At a global level, therefore, alternative 1 ‘Use silage film of less thickness’ stands out, followed by alternative 0 ‘Conventional use of plastic silage film’, the worst being alternative 2 ‘Use of haylage round bales’.

Figure 2.c. Average priorities of the alternatives at global level



Conclusions for Dairy production (Italy)

In this case, the conventional alterative is not always the worst of all. However, alternatives have always been found that perform better than the conventional alternative on a global level.

The following Table summarises for each pilot the best overall alternative to conventional practice:

Table 1. Conventional versus best global alternatives for each pilot

Pilot	Conventional alternative	Best alternative
Alternatives to the conventional use of high density polyethylene (HDPE) round bale net	Use of conventional round bale nets	Use of the two-stage haymaking process of loose hay
Alternatives to plastic silage film	Use silage film of less thickness	Conventional use of plastic silage film

5. Dairy industry (Italy)

Evaluation

5 experts in dairy industry in Italy were surveyed. The indicators evaluated by the experts in all the pilots/practices analysed are:

- Economic dimension/indicators: They refer to the economic aspects of sustainability, relative to farmers/industries economic (market) benefits and costs. They are:
  - Overall profitability for farmers/industries: It refers to incomes minus variable costs. Income and costs are the totals of the economic activity developed by the farmer/industry, not just those associated with the technique being tested. It measures how the practices implemented can affect the overall profitability obtained.
  - Strategic positioning and competitiveness in the market: It refers to the fact that early adoption of innovations can improve the company's position in the medium and long term.
  - Intrinsic product quality: Refers to the quality attributes found within the products obtained by the farmer/industry. It refers to sensory and organoleptic issues, etc.
  - Diversification of economic activities related to waste management in the region: This refers to the presence in the region under study of diversified economic activities related to waste management.

- Social dimension/indicators: They refer to the social aspects of sustainability. They are social (non-market) benefits and costs. They are:
  - Direct and indirect employment: Jobs generated in the farm/industry and in parallel sectors.
  - Intergenerational continuity of agrifood activities: Level of guarantee of continuity of economic activity over time due to the continuation of human capital.
  - Health of consumers and public health: Guarantee of good hygienic and health conditions of the products obtained by the farmers/industry.
  - Health conditions of workers: Guarantee of good hygienic and health conditions for the farmers/workers.

• Environmental dimension/indicators: They refer to the environmental aspects of sustainability. They are environmental (non-market) benefits and costs. They are:

- Biodiversity of flora and fauna: Amount and variety of presence of different living beings present in the environment.
- Quality of groundwater and surface water: Low contamination of groundwater and surface water mainly due to the application of inputs in the production process.
- Soil fertility/quality and control of soil erosion: It is important that the soil is not lost and that its agronomic quality is the best possible.
- Climate change abatement: Contribution to the fight against climate change as they are processes that emit less CO2.
- Landscape quality: It refers to aesthetic quality of the landscape in the region.

PILOT 1. Alternatives solutions to avoid over-packaging issue

Description

Packaging lightweighting is a strategy for optimization through the adoption of thinner and/or lighter packaging materials. Lightweighting reduces the use of resources and the generation of wastes and represents the easiest way to tackle the issue of packaging waste reduction. Packaging primary role is to protect food products and maintain their quality, hence packaging optimization implies the use of as minimum materials as necessary to guarantee its protective functions. Packaging minimization should be taken for granted, Since lightweighting also carries a reduction of costs for the producer, however, many commercial cases prove that significant improvements are still possible and that the use of unnecessary amounts of materials is, in fact, an underestimated issue.

Alternatives

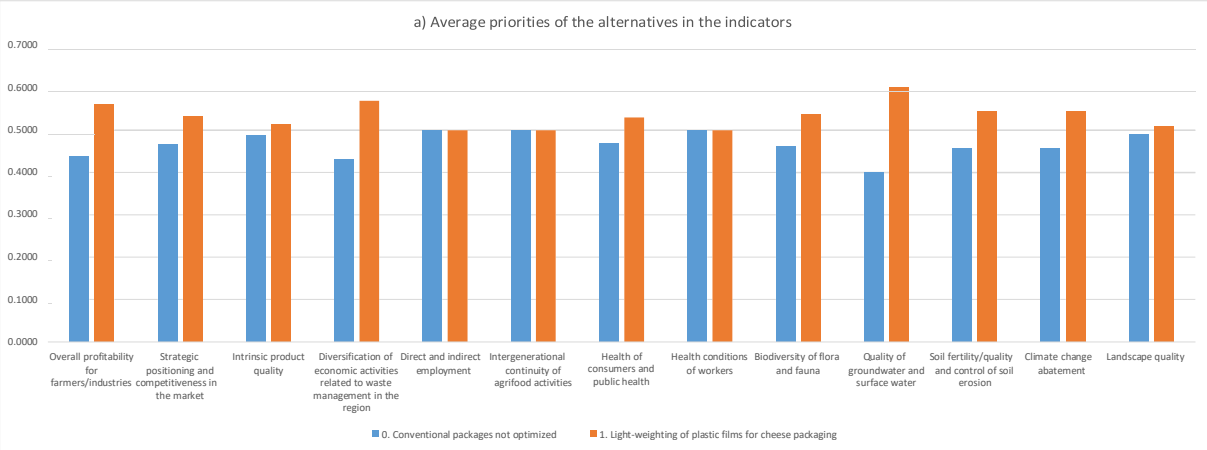
a. Alternative 0. Conventional packages are not always optimized with regards for material thickness

b. Alternative 1. Light-weighting of plastic films for cheese packaging

Priorities of the alternatives in the indicators

Alternative 1 ‘Light-weighting of plastic films for cheese packaging’ is equal or better than alternative 0 ‘Conventional packages are not always optimized with regards for material thickness’ on all indicators (Figure 1.a). It stands out especially in the indicators ‘Quality of groundwater and surface water’, which is economic, ‘Diversification of economic activities related to waste management in the region’ and ‘'Overall profitability for farmers/industries’, which are environmental.

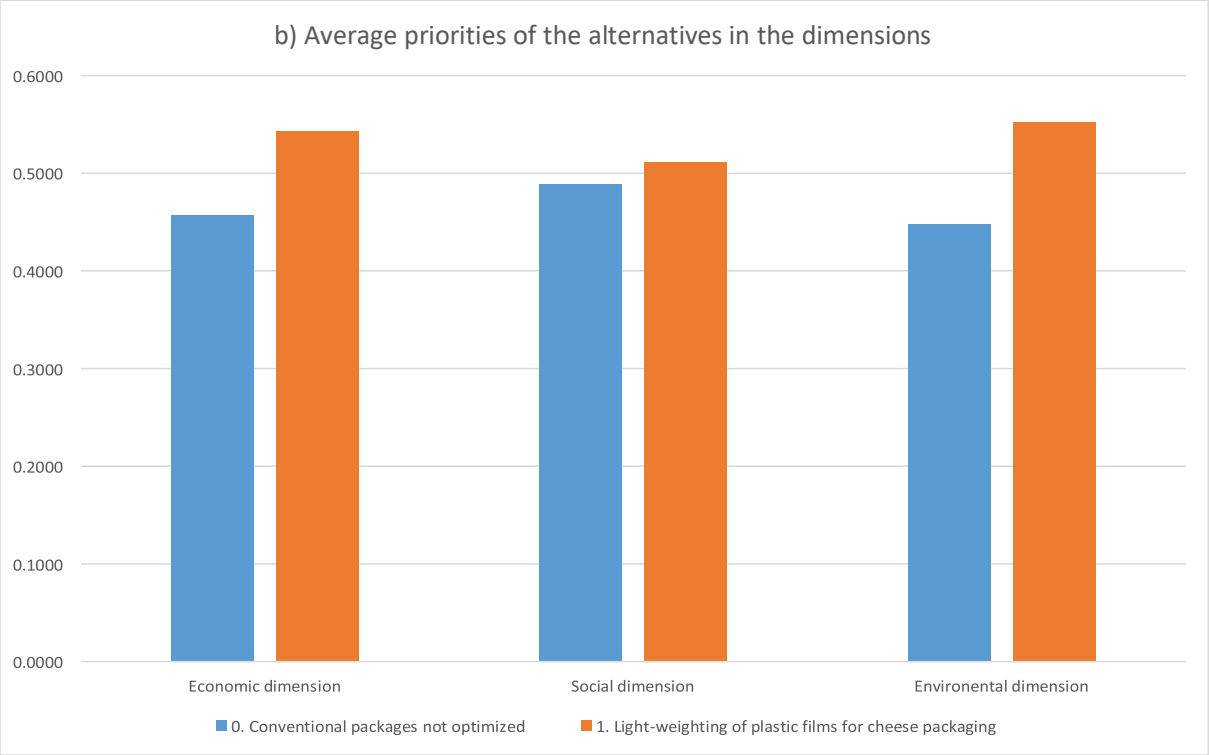
Figure 1.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

In terms of the dimensions of sustainability, alternative 1 ‘Light-weighting of plastic films for cheese packaging’ stands out in all three, especially in the environmental and economic ones (Figure 1.b).

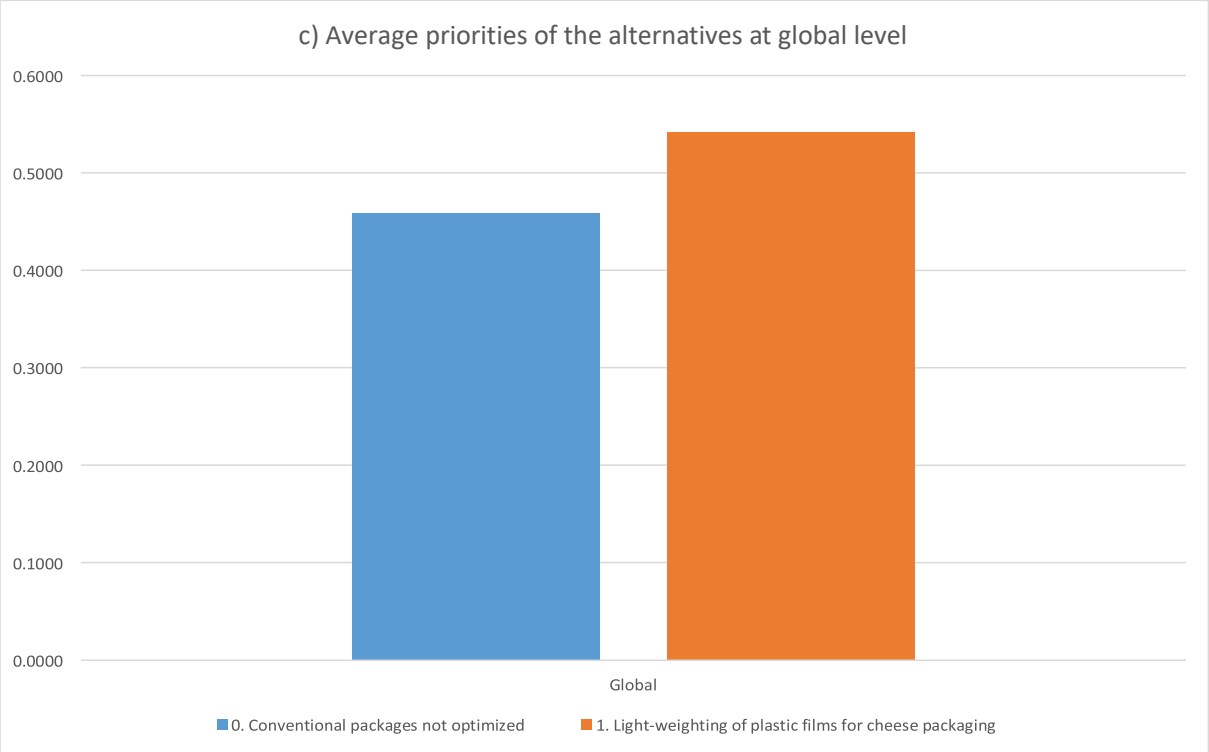
Figure 1.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

On a global level, as a consequence of the performance already seen in indicators and dimensions, alternative 1 'Light-weighting of plastic films for cheese packaging' stands out over alternative 0 'Conventional packages are not always optimized with regards for material thickness' (Figure 1.c).

Figure 1.c. Average priorities of the alternatives at global level



PILOT 2. Replacement of plastic with compostable materials obtained from renewable sources

Description

To date, in the actual waste management system in Italy, plastic trays are notrecycled, irrespective of the nature of the material. This is especially due to the fact that suchpackages combine different materials for gas barrier purpose. Currently, CONAI is assessing the feasibility of recycling PET trays, but other materials widely used for fresh products applications, such as PP and PS, have no alternative scenario other than collection through the plastic waste stream and incineration. PS, in particular, in the expanded form (XPS) is widely used for meat and dairy products. Both the conventional PET, PP and PS trays, and the expanded PS ones, might be substituted by compostable bioplastics for specific applications. The use of synthetic plastic has posed serious ecological problems due to their non-degradability and to the depletion of fossil resources. Bioplastics have recently been proposed as alternatives, at least for certain applications, to fossil-based, non-biodegradable, plastics. The scope is to substitute a conventional type of packaging, which is not recycled, with anew one possible to be addressed to industrial composting.

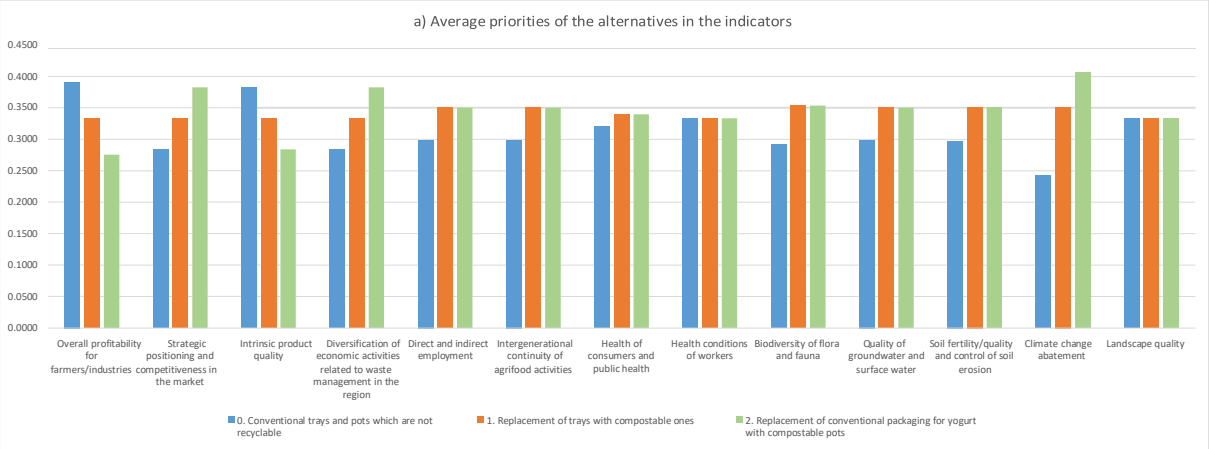
Alternatives

c. Alternative 0. Conventional type of packaging (trays and pots), which are not recycled
d. Alternative 1. Replacement of trays with compostable ones
e. Alternative 2. Replacement of conventional packaging for yogurt with compostable pots

Priorities of the alternatives in the indicators

At the indicators level, alternative 2 'Replacement of conventional packaging for yogurt with compostable pots' stands out in many of them, such as 'Climate change abatement', 'Diversification of economic activities related to waste management in the region' and 'Strategic positioning and competitiveness in the market' (Figure 2.a). It is worth noting that alternative 0 'Conventional type of packaging (trays and pots), which are not recycled' is better in 'Overall profitability for farmers/industries' and 'Intrinsic product quality'. Alternative 1 'Replacement of trays with compostable ones' has an intermediate performance.

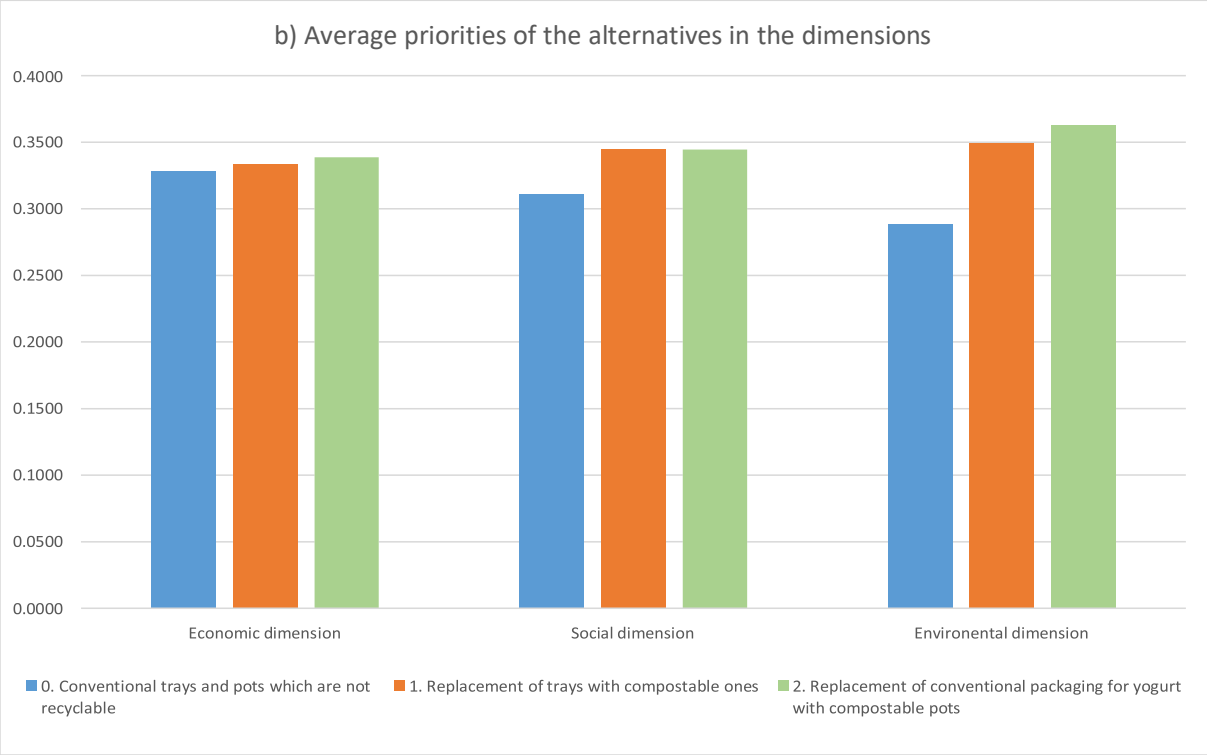
Figure 2.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

The aggregated results in the sustainability dimensions indicate that alternative 2 'Replacement of conventional packaging for yogurt with compostable pots' stands out in the environmental and economic dimensions (Figure 2.b). In the social dimension it performs just like alternative 1 'Replacement of trays with compostable ones'. Alternative 0 'Conventional type of packaging (trays and pots), which are not recycled' is the worst option in all three dimensions.

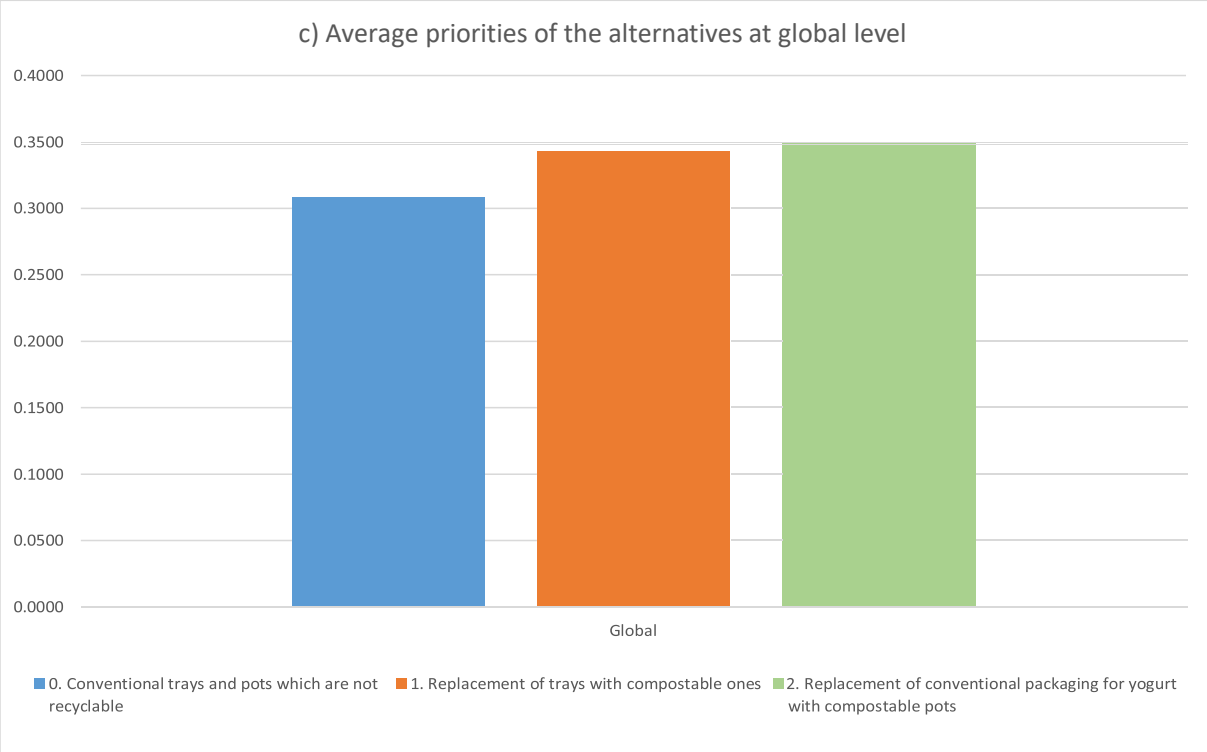
Figure 2.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

At a global level, alternative 2 ‘Replacement of conventional packaging for yogurt with compostable pots’ stands out, followed by alternative 1 ‘Replacement of trays with compostable ones’, being alternative 0 ‘Conventional type of packaging (trays and pots), which are not recycled’ the worst option (Figure 2.c).

Figure 2.c. Average priorities of the alternatives at global level



PILOT 3. Alternative solutions to improve the recyclability of packaging

Description

The optimization of end-of-waste is one of the main targets of the packaging sector and of institutions. Plastic is a resource, prior to being an environmental issue, hence its valorization should be attempted where an improvement can be foreseen. There is a potential room for improvement, by making recyclable plastic waste fractions which, to date, follow routes different from recycling. Such improvement can be achieved primarily through the simplification of packaging materials, whose complexity is the main barrier to recyclability, and through improvements at the selection plants and recycling plants level.

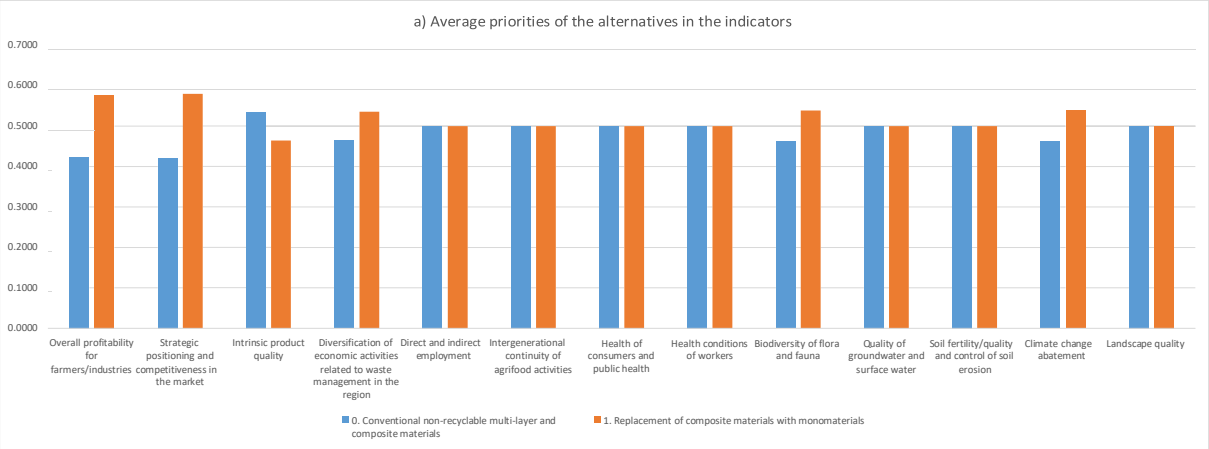
Alternatives

f. Alternative 0. Non-recyclable multi-layer and composite materials
g. Alternative 1. Replacement of composite materials with mono-materials

Priorities of the alternatives in the indicators

Alternative 1 'Replacement of composite materials with mono-materials' performs better or the same as alternative 0 'Non-recyclable multi-layer and composite materials' on almost all indicators (Figure 3.a). Thus, it stands out especially in some economic indicators such as 'Overall profitability for farmers/industries', 'Strategic positioning and competitiveness in the market', and 'Diversification of economic activities related to waste management in the region'. Also, alternative 1 'Replacement of composite materials with mono-materials' performs better in some environmental indicators such as 'Biodiversity of flora and fauna' and 'Climate change abatement'. Alternative 0 'Non-recyclable multi-layer and composite materials' is better only in the 'Intrinsic product quality' indicator.

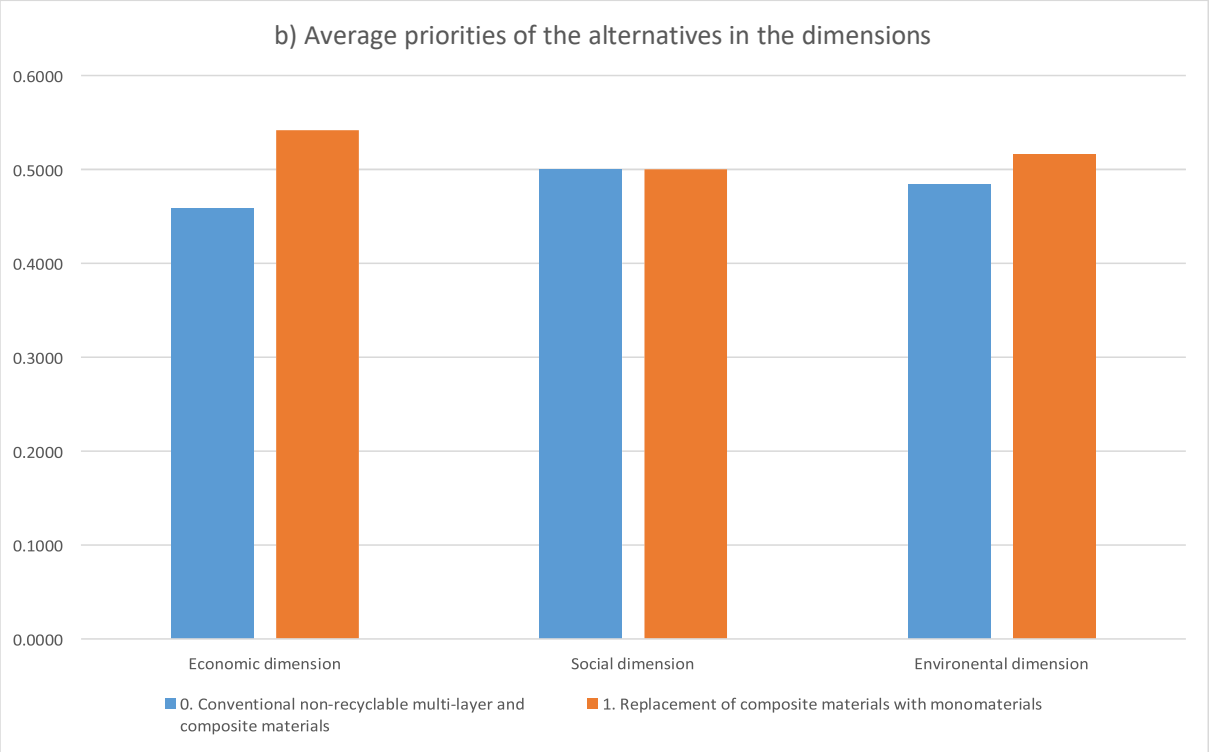
Figure 3.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

At the level of the sustainability dimensions, alternative 1 'Replacement of composite materials with mono-materials' stands out over alternative 0 'Non-recyclable multi-layer and composite materials' in the economic and environmental ones (Figure 3.b). In the social dimension both alternatives perform equally well.

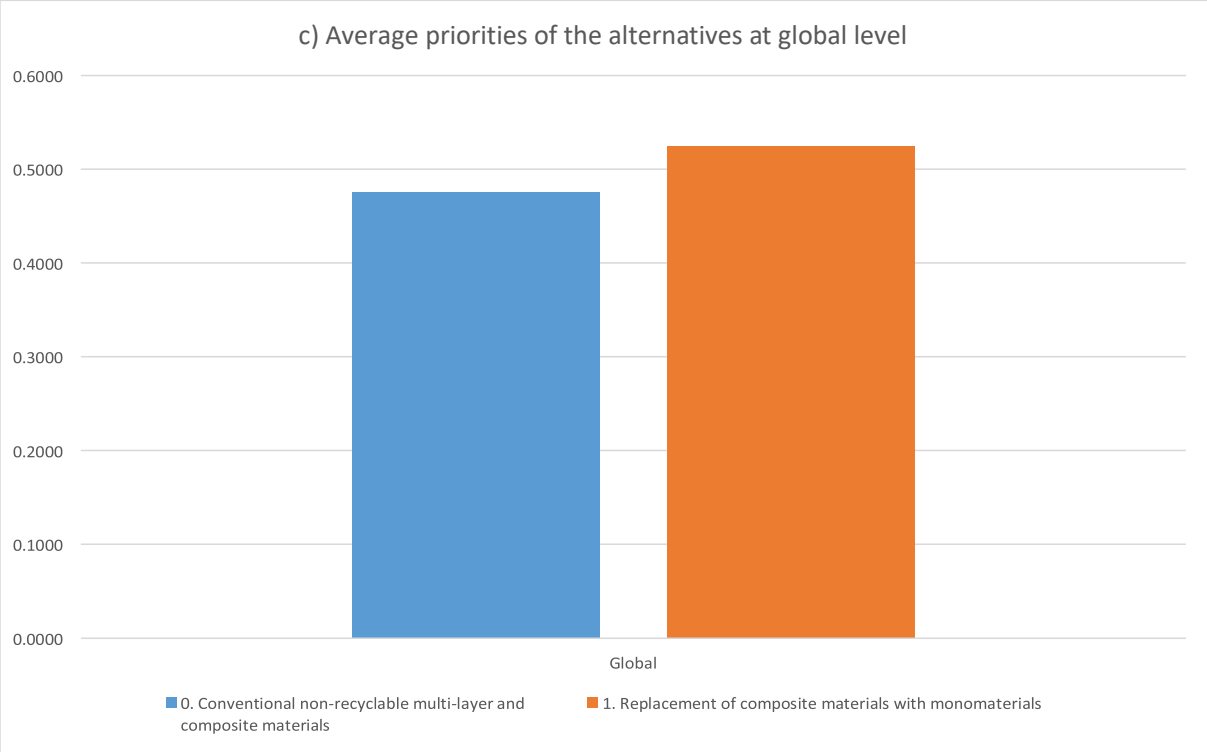
Figure 3.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

At a global level, integrating the performances in the three dimensions of sustainability, alternative 1 'Replacement of composite materials with mono-materials' stands out over alternative 0 'Non-recyclable multi-layer and composite materials' (Figure 3.c).

Figure 3.c. Average priorities of the alternatives at global level



PILOT 4. Integration of inspections on packaging lines of products packed in modified atmosphere

Description

Many dairy products are commonly packed in modified atmosphere, which usually include variable mixtures of CO2 and N2, with the aim of minimizing O2 levels: indeed, O2 is responsible for the growth of aerobic spoilage microorganisms (bacteria and moulds) and for some biochemical alterations resulting in sensory and nutritional changes. Current monitoring of gas levels in modified atmosphere-packaged products consists of O2 and CO2 destructive measurement by needle sampling of headspace. This conventional procedure relies on the use of portable gas-readers, which sample a known volume of headspace through a needle; once the needle has perforated the package, they are sacrificed, generating a mixed waste (packaging + food) with complex disposal management. This destructive approach allows a limited number of controls; moreover, it is not possible to monitor the gas composition in the same package during time, which would be useful, for instance, to evaluate the gas barrier behaviour of a packaging system.

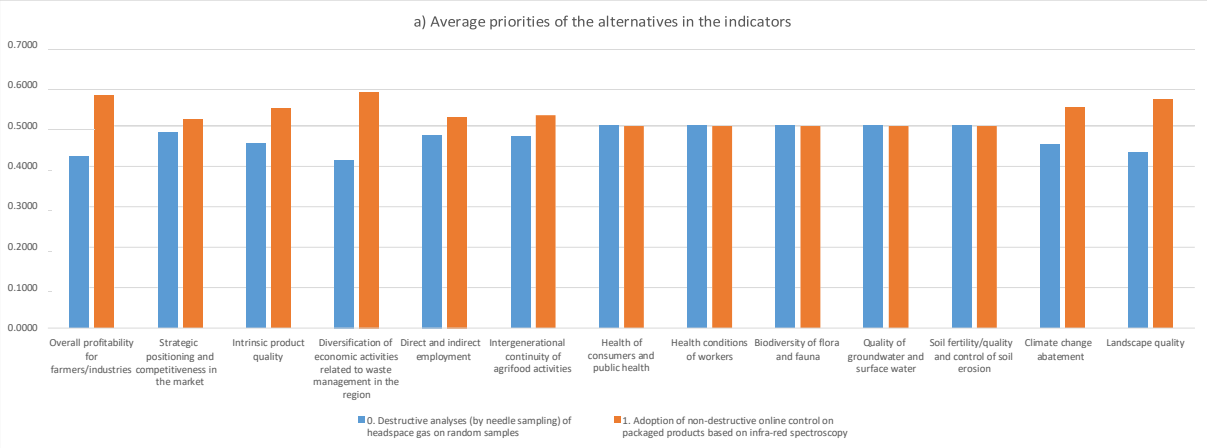
Alternatives

h. Alternative 0. Destructive analyses (by needle sampling) of headspace gas on randomsamples
i. Alternative 1. Adoption of non-destructive online control on packaged products basedon infra-red spectroscopy

Priorities of the alternatives in the indicators

Alternative 1 'Adoption of non-destructive online control on packaged products based on infra-red spectroscopy' performs better or the same as alternative 0 'Destructive analyses (by needle sampling) of headspace gas on random samples' on almost all the indicators evaluated, especially in Overall profitability for farmers/industries', 'Diversification of economic activities related to waste management in the region', which are economic, and 'Landscape quality' and 'Climate change abatement', which are environmental (Figure 4.a).

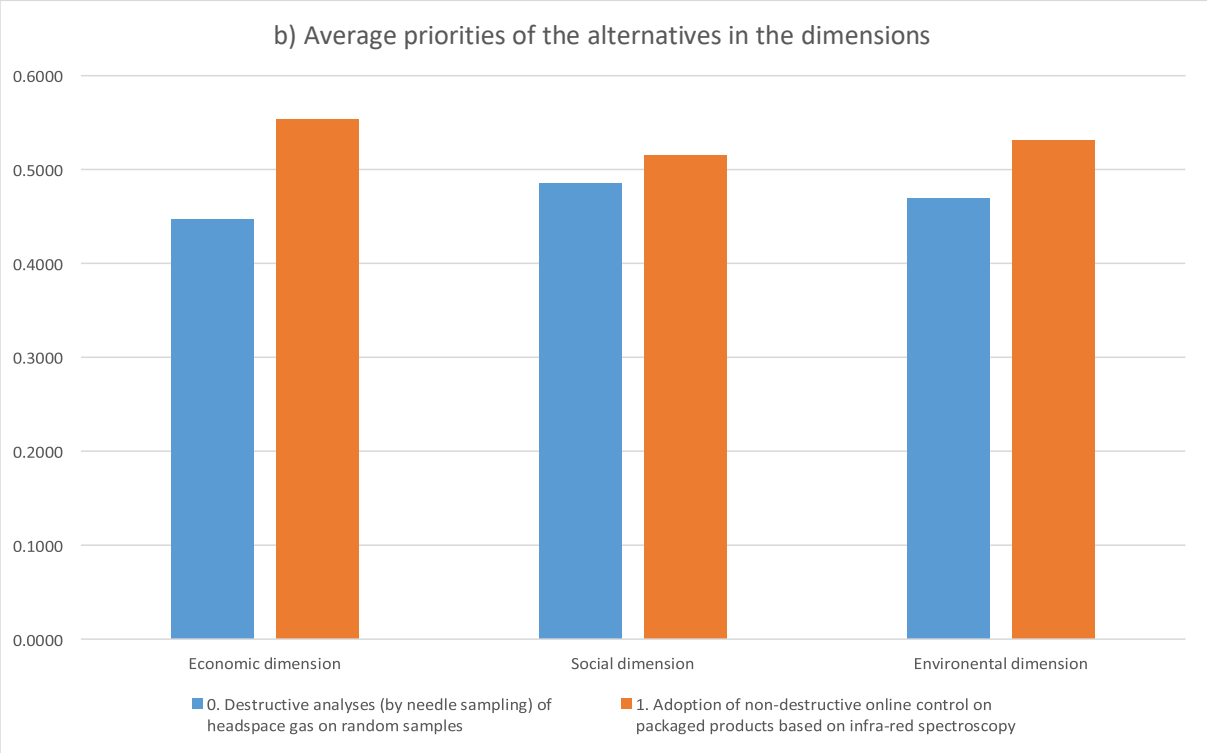
Figure 4.a. Average priorities of the alternatives in the indicators



Priorities of the alternatives in the dimensions of sustainability

This pattern of superiority is maintained at the level of sustainability dimensions, outstanding Alternative 1 'Adoption of non-destructive online control on packaged products based on infra-red spectroscopy' over alternative 0 'Destructive analyses (by needle sampling) of headspace gas on random samples' in the three dimensions, especially in the economic and environmental ones (Figure 4.b).

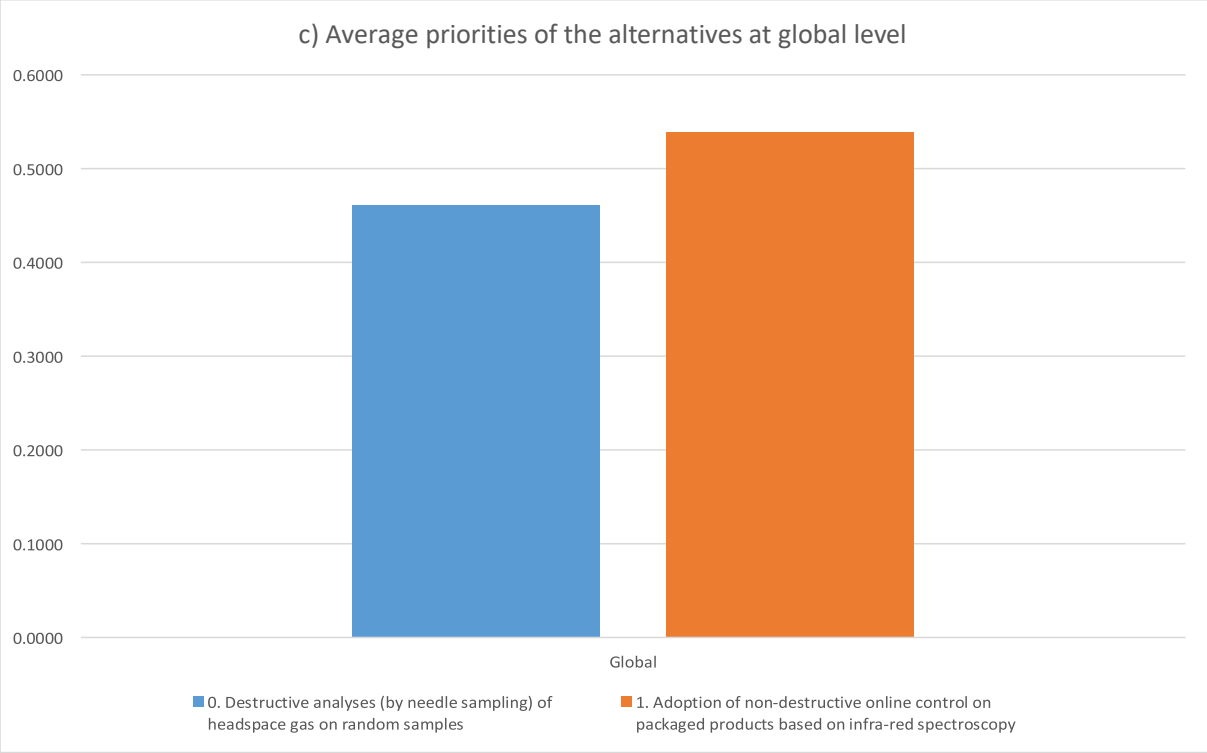
Figure 4.b. Average priorities of the alternatives in the dimensions



Priorities of the alternatives at global level

As a consequence, the performance of alternative 1 'Adoption of non-destructive online control on packaged products based on infra-red spectroscopy' is better than that of alternative 0 'Destructive analyses (by needle sampling) of headspace gas on random samples', at a global level (Figure 4.c).

Figure 4.c. Average priorities of the alternatives at global level



Conclusions for Dairy industry (Italy)

For all the pilots studied there are not many alternatives to the conventional ones. However, they always perform better globally than the alternatives currently used in a conventional way. Differences are particularly evident in the environmental and economic dimensions, while they are not very high in the social dimension.

The following Table summarises for each pilot the best overall alternative to conventional practice:

Table 1. Conventional versus best global alternatives for each pilot

Pilot	Conventional alternative	Best alternative
Alternatives solutions to avoid over-packaging issue	Conventional packages are not always optimized with regards for material thickness	Light-weighting of plastic films for cheese packaging
Replacement of plastic with compostable materials obtained from renewable sources	Conventional type of packaging (trays and pots), which are not recycled	Replacement of conventional packaging for yogurt with compostable pots
Alternative solutions to improve the recyclability of packaging	Non-recyclable multi-layer and composite materials	Replacement of composite materials with mono-materials
Integration of inspections on packaging lines of products packed in modified atmosphere	Destructive analyses (by needle sampling) of headspace gas on random samples	Adoption of non-destructive online control on packaged products based on infra-red spectroscopy