Food Residues Biorefineries: Design strategy based on multifeedstocks analysis

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RECONSTRUCCIÓN DEL TEJIDO SOCIAL EN ZONAS DE POSCONFLICTO EN COLOMBIA

Content

1. Introduction

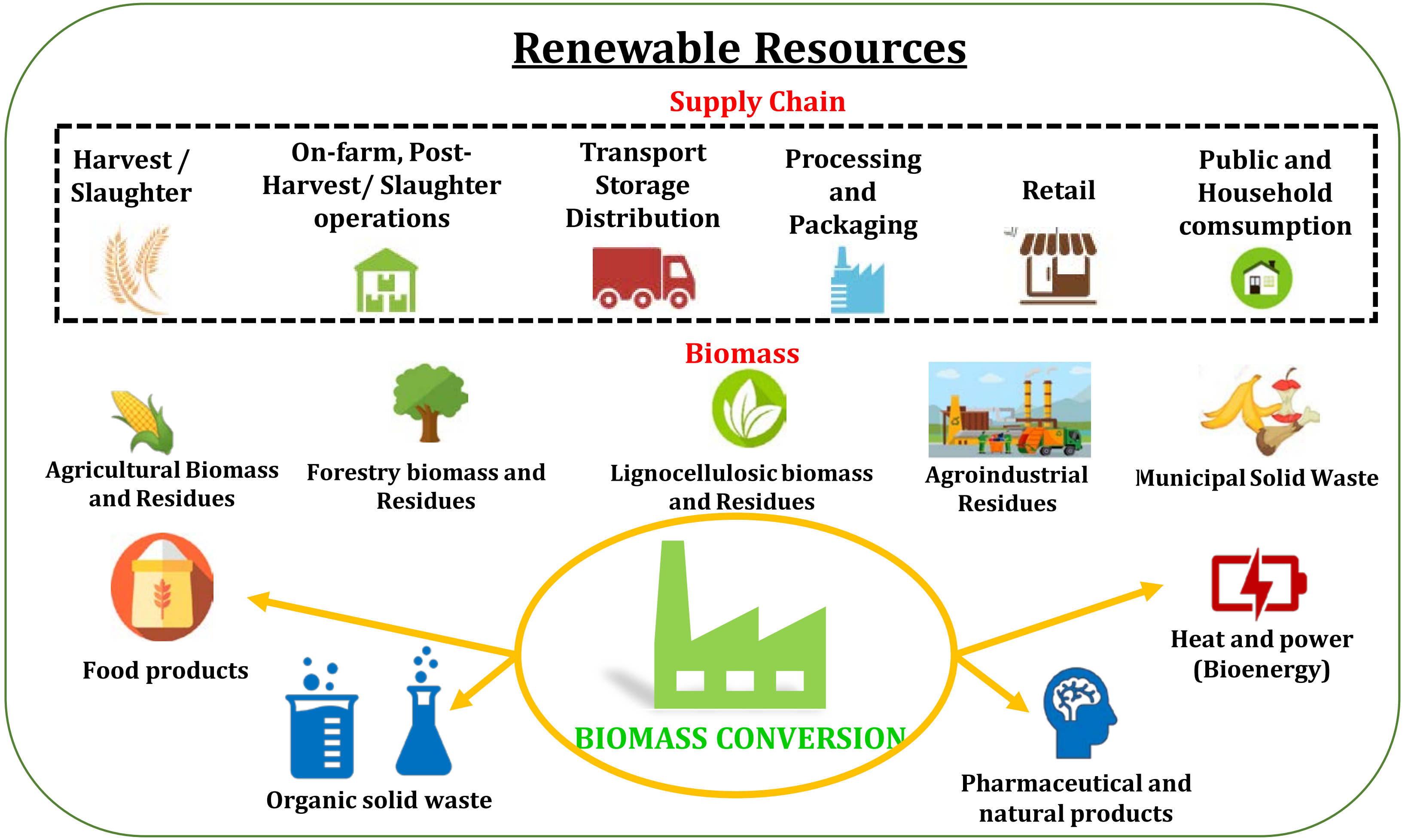
No Renewable Resources

Traditional linear economy scheme - Oil-based economy.

Make → Use → Dispose

Global Warming
Ozone depletion
Natural resources pollution
Acid precipitation
Oil spills

Alternative for improving the efficiency and sustainability of different types of productive chains:



1. Introduction

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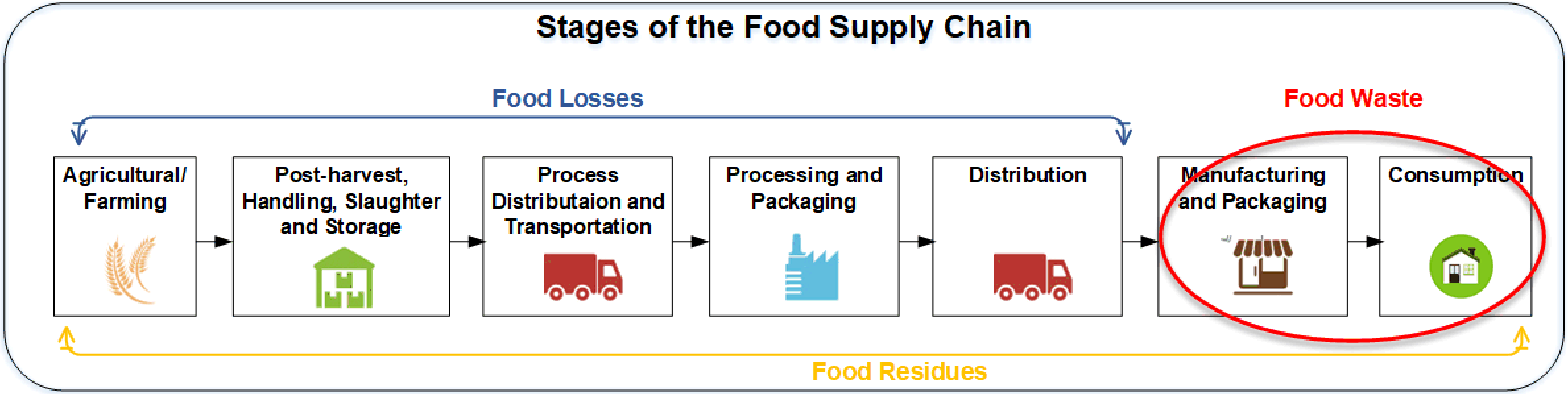
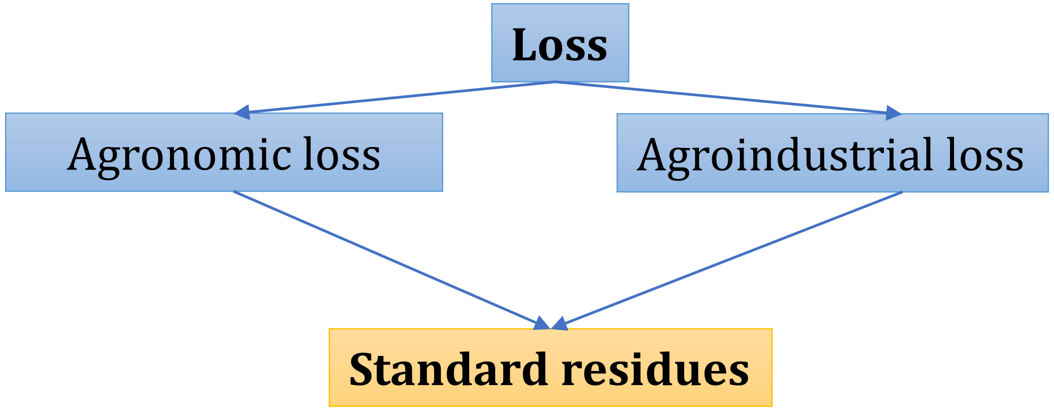
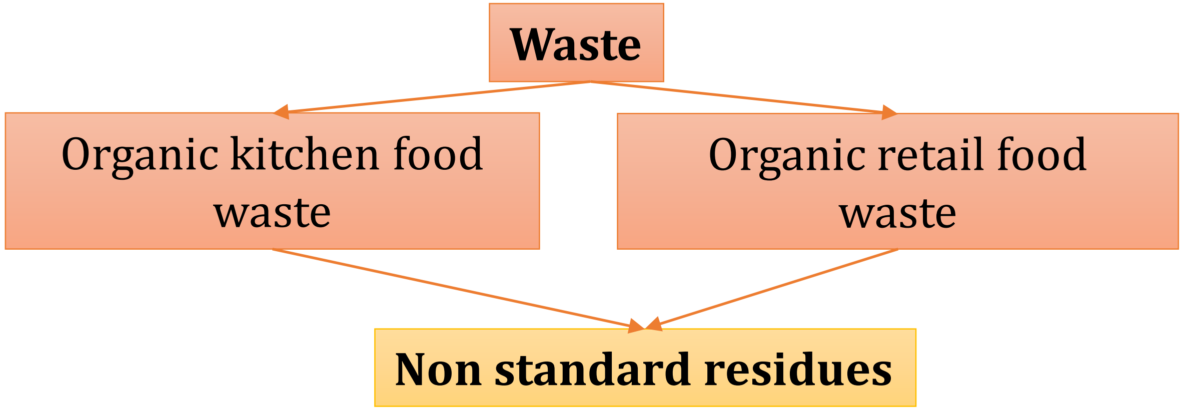
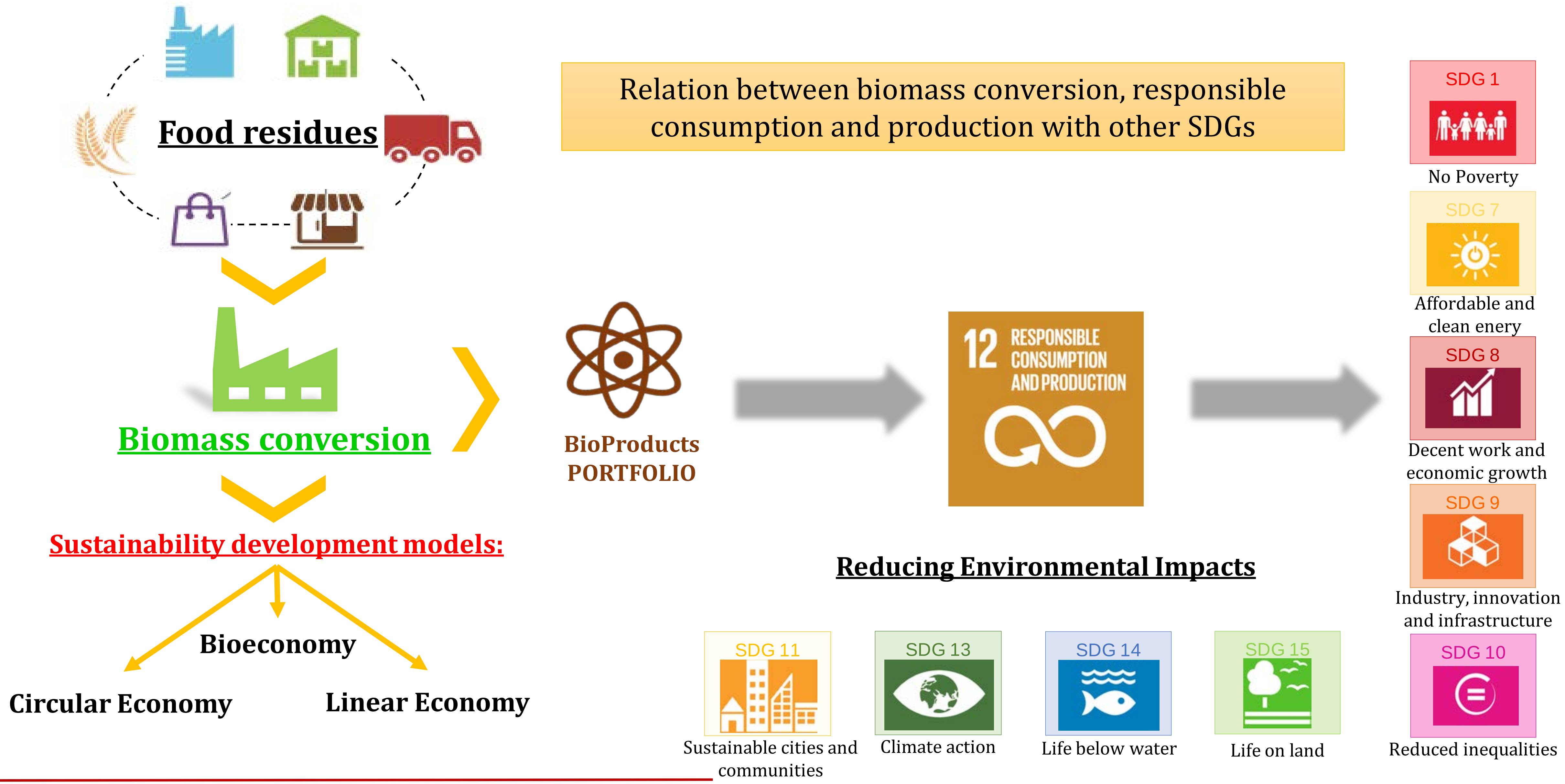


Figure 1. Residues classification generated in the stages of the supply chain





1. Introduction



2. Research objective

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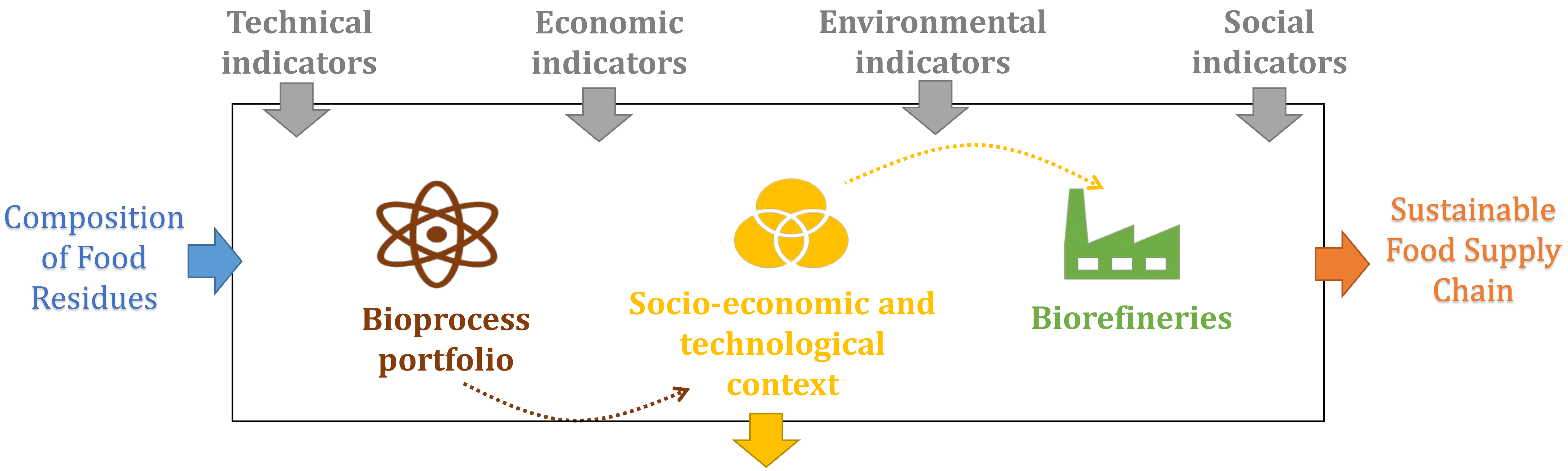
This work focuses on proposing a new strategy for defining the best technological configurations using concepts of composition of the feedstocks (including the multifeedstocks), platforms and products for Food Residues Biorefineries



Different configurations or scenarios of Food Residues Valorization to be implemented in the supply chain

Biorefinery design strategy for biomass valorization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Analysis of the routes for biomass processing towards sustainable development in the conceptual design step: Strategy based on the compendium of bioprocesses portfolio

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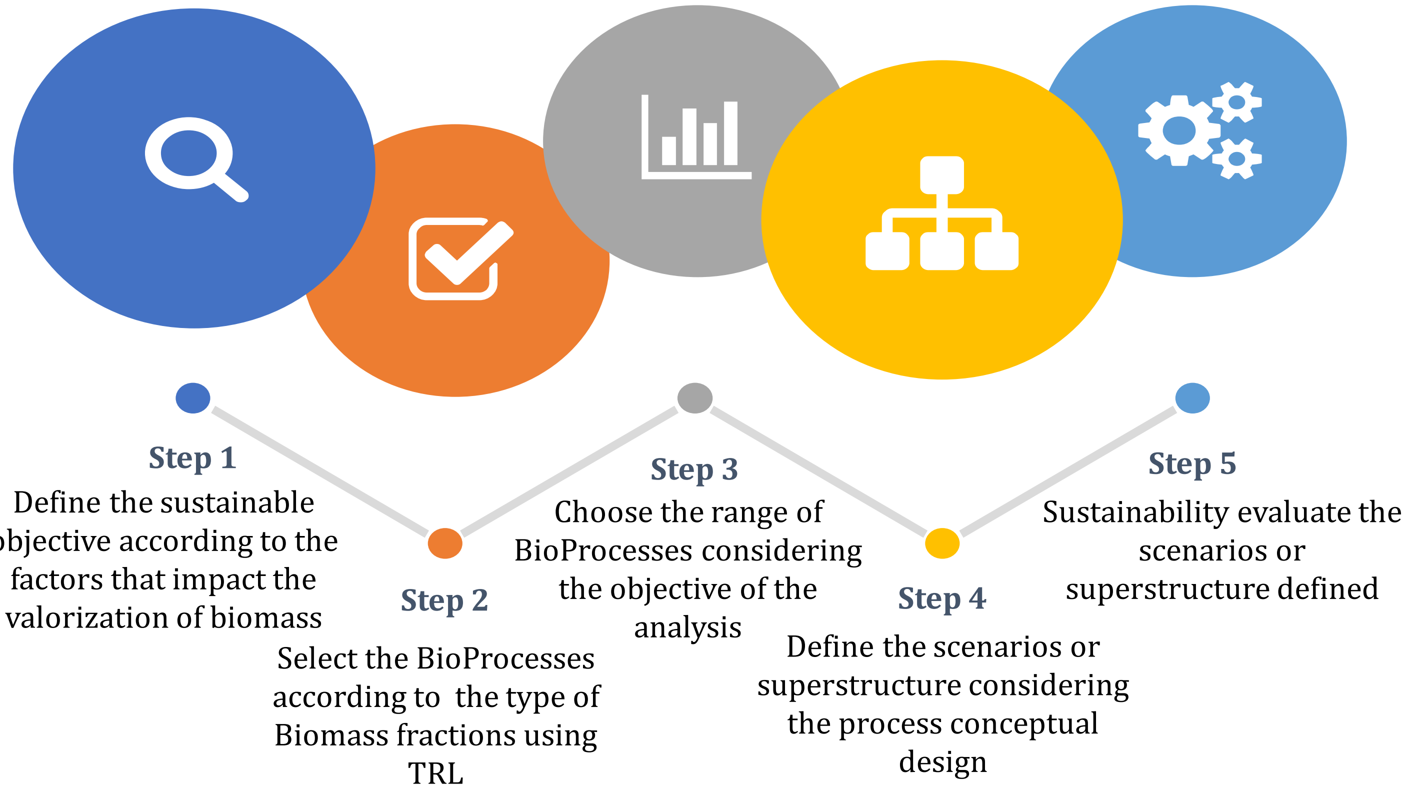
BioProducts PORTFOLIO

Economic dimension

Environmental dimension

Social dimension



LIMITING FACTORS

- ✓ The technological context of the analyzed region;
- ✓ The type of products to be obtained based on the context;
- ✓ The economic viability of the products based on the generation scale;
- ✓ What type of benefit (economic, environmental, and/or social) is targeted to be achieved in the productive chain.

3. Methodology

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Bioprocesses portfolio

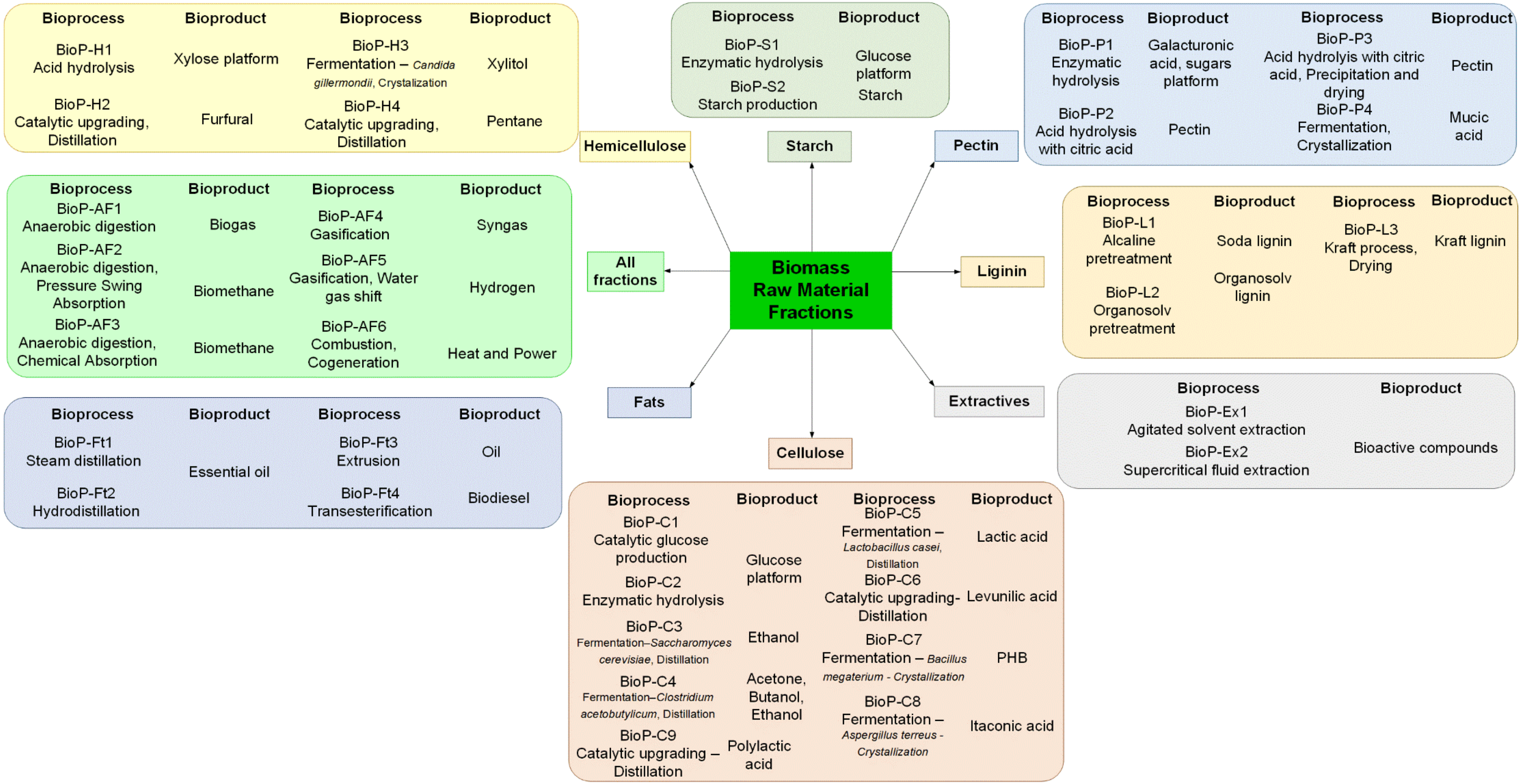

Figure 2. Bioprocesses addressed to upgrade each fraction of biomass

3. Methodology

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Bioprocesses portfolio

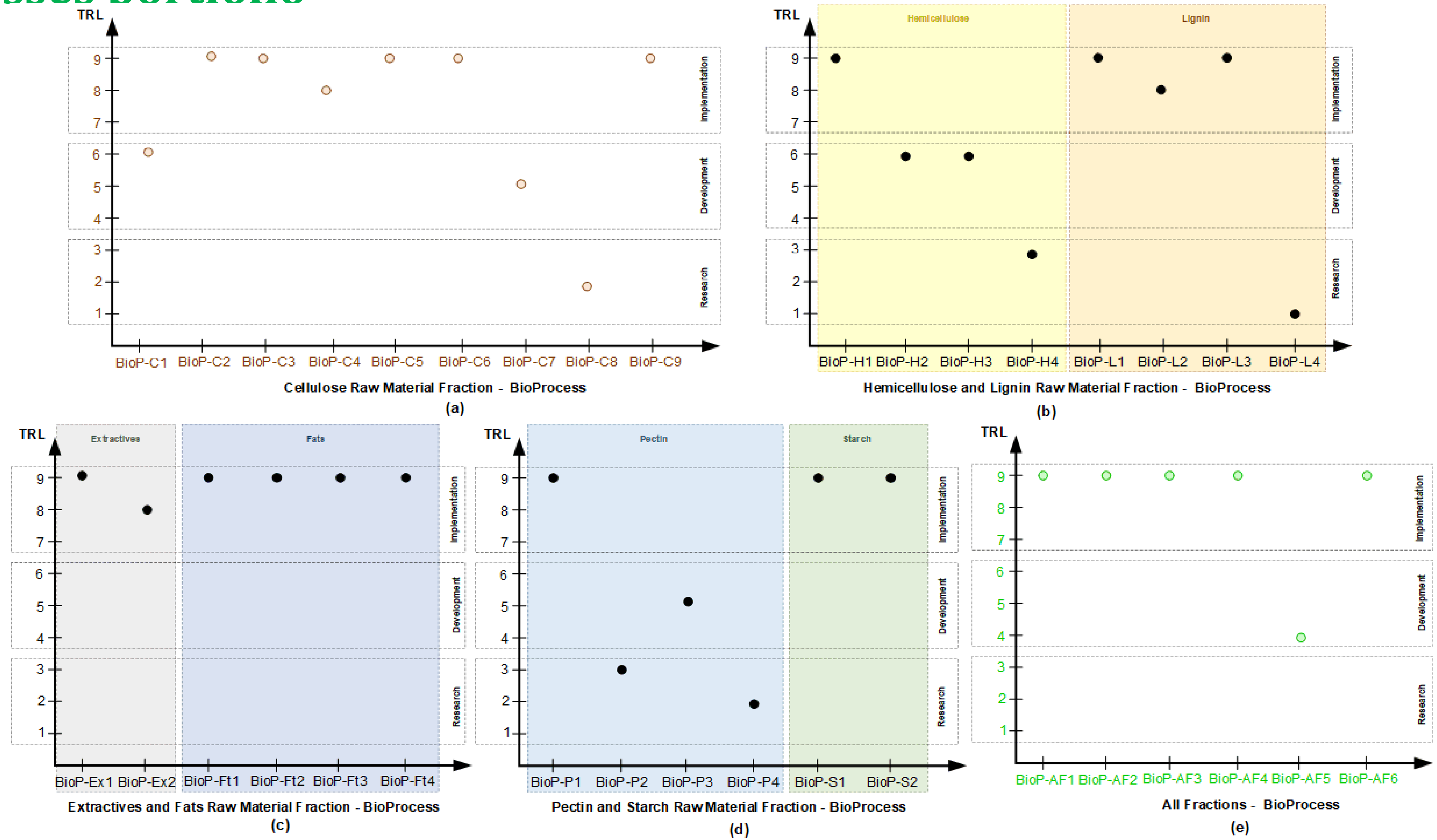


Figure 3. Bioprocess and TRL relation (a) cellulose; (b); hemicellulose and lignin (c); extractives and fats (d); pectin and starch (e) all fractions raw material

3. Methodology

Cellulose fraction

Table 1. Mass, energy, economic and environmental indicators

			Mass indicators		Energy indicators		Economic indicators			Environmental indicator
BioProcess	Platform	BioProcess	Yield (ton of product/Ton raw material fraction	Carbon conversion efficiency (%)	Power requirement (kWh/Ton raw material fraction)	Thermal energy consumption (MJth/kg raw material fraction)	CapEx* (MUSD)	OpEx* (MUSD)	Production cost/Selling price ratio	Climate change (kg CO2 eq/Product)
Catalytic glucose production from CELLULOSE	Glucose platform - Catalytic	BioP-Pt1	0.41	37.05	0.72	2.40 (H:80.5%, C: 19.5%)	a: 0.23 b: 0.09	a: 0.17 b: 0.39	30,5	0.48
Enzymatic hydrolysis from CELLULOSE	Glucose platform - Enzymes	BioP-Pt2	0.80	92.60	1.80	0.73 (L:100%)	a: 1.42 b: 0.53	a: 0.46 b: 1.05	0,21	0.28
Fermentation - Saccharomyces cerevisiae, Distillation	Ethanol	BioP-C1	0.30	46.20	4.00	61.90 (M: 1%, L: 76%, C: 23%)	a: 1.82 b: 0.67	a: 0.46 b: 1.05	1.00	1,38
Fermentation - Clostridium acetobutylicum, Distillation	ABE	BioP-C2	0.25	40.51	1.50	0.07 (M: 98.2, C:1.8)	a: 0.26 b: 0.59	a: 0.15 b: 0.34	2.41	2,41
Fermentation - Lactobacillus casei, Distillation	Lactic acid	BioP-C3	0.66	65.75	3.10	44.30 (M: 1.3%, L: 9%, C: 89.7%)	a: 1.44 b: 0.53	a: 18.36 b: 41.55	3,11	3.16
Catalytic upgrading - Distillation	Levunilic acid	BioP-C4	0.56	72.75	8.8	31.00 (H: 63%, M: 24%, C: 13%)	a: 1.53 b: 0.57	a: 0.35 b: 0.80	0,20	2.89
Fermentation - Bacillus megaterium	PHB	BioP-C5	0.23	32.11	8.86	24.87 (L: 95%, C: 5%)	a: 3.69 b: 1.36	a: 0.99 b: 2.23	0,79	1.45
Fermentation - Aspergillus Terreus	Itaconic acid	BioP-C6	0.52	60.30	11.83	75.38 (L: 96%, C: 4%)	a: 2.19 b: 0.81	a: 4.73 b: 10.71	1,96	1.12
Catalytic upgrading - Distillation	Polylactic acid	BioP-C7	1.95	N.A.	17.17	0.1 (L:100%)	a: 0.16 b: 0.36	a: 0.25 b: 0.57	35.5	1.96

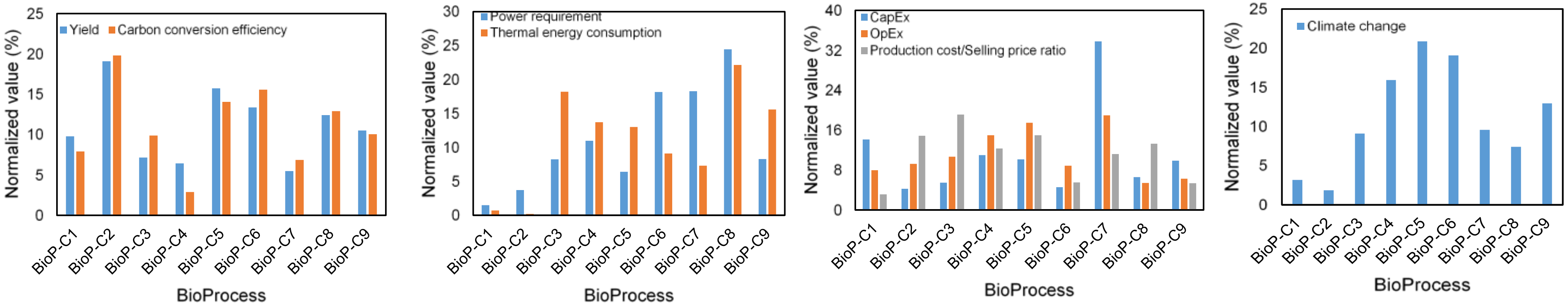
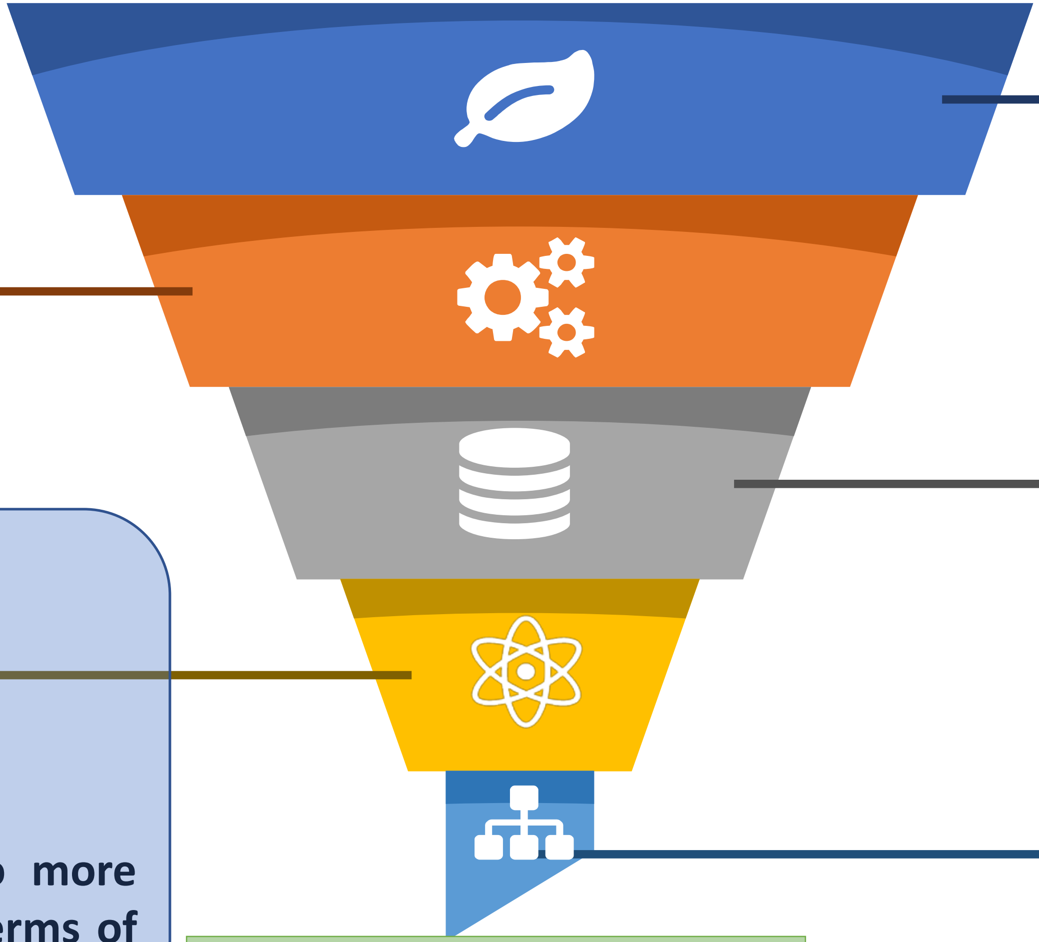


Figure 4. Mass, energy, economic and envornmental indicators of cellulose bioprocesses

3. Methodology

Strategy based on portfolio of BioProcesses according to Food residues valorization:



Value chain

Identifying the stages and actors corresponding to the first three stages of the value chain

The needs of the stages and actors

Contextualizes the possible FR valorization routes with the needs of the value chain

The characterization of the FR generated

(i)Generation place; (ii) Total generation volume: generation cycle, quantity, status: (iii) Chemical composition; (iv) Current use

The possible forms of integration

Food loss integration;

Food waste integration:

Food loss and Food Waste integration.

MULTIFEEDSTOCKS are just 2 o more feedstocks to be considered in terms of compositions to be summed strategically

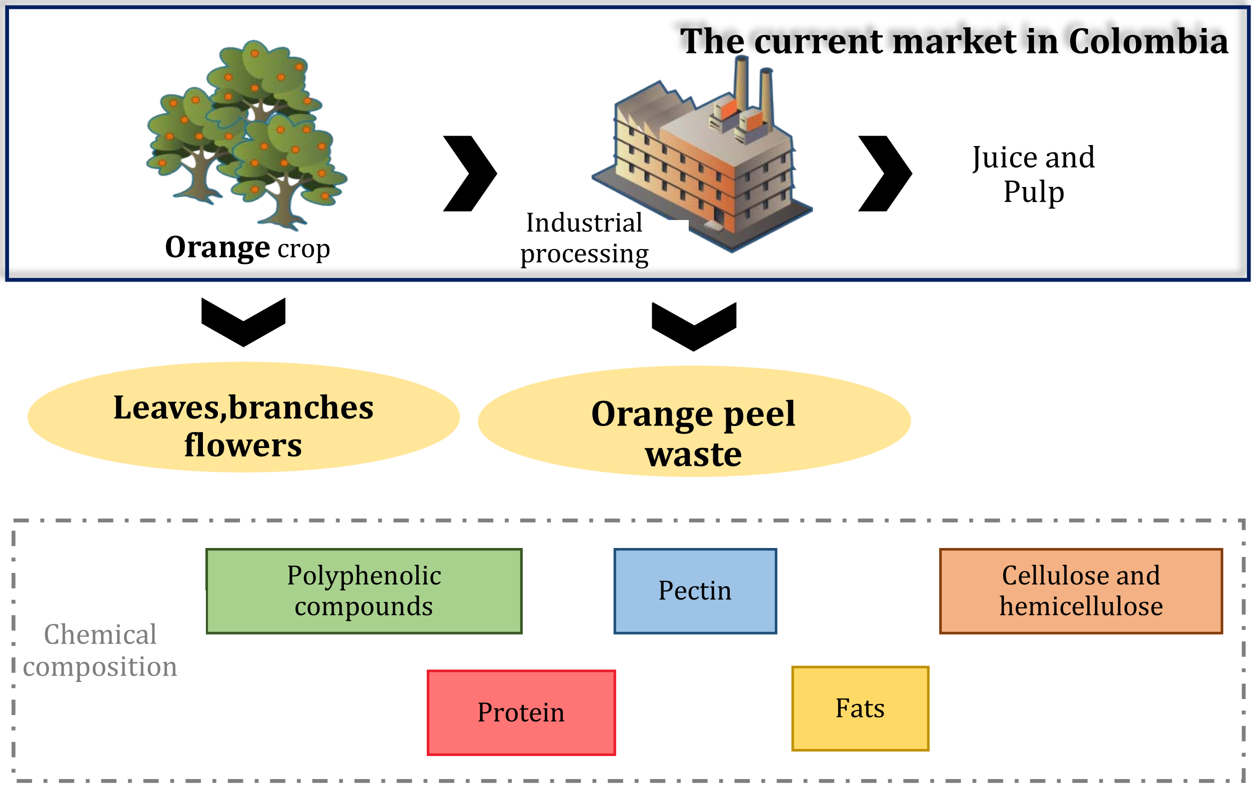
Strategy of biomass valorization

Portfolio of bioprocess

Food residues conversion routes easier to implement

3. Methodology

Example: Orange Peel Wastes (Food Loss)



The bioprocesses were filtered from the Technological Readiness Level (TRL implemented) and the lowest values of operating costs (OpEx) and capital cost (CapEx).

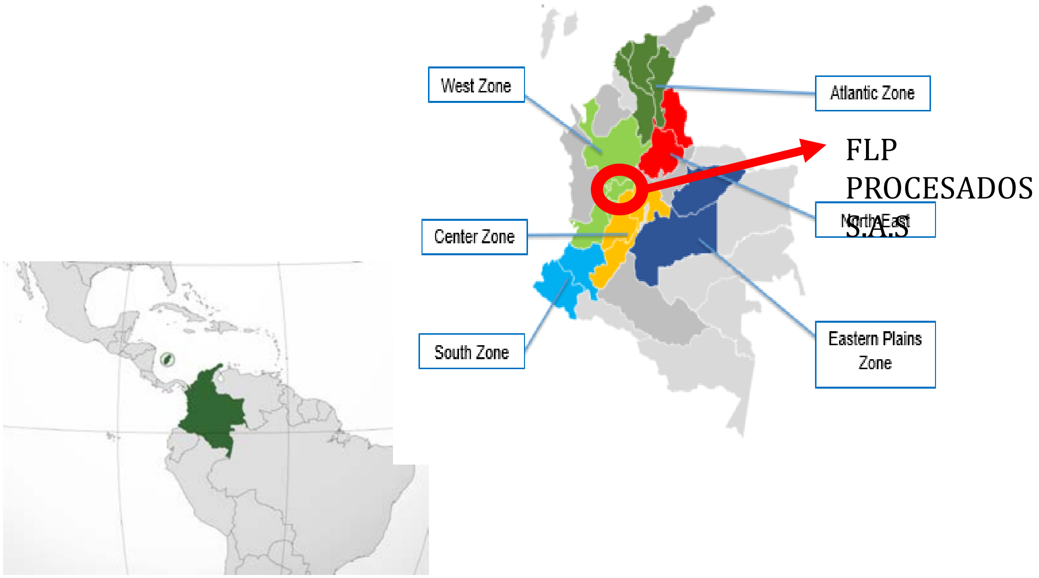


Figure 2. Characterization of zones production

- ✓ OPW generated in a small-scale industry with a flow of 140 kg/h was considered.
- ✓ The value chain identification includes the stages of producers (crop) and processors (agribusiness).
- ✓ Agricultural residues such as leaves, branches, and flowers are generated in the producer stage (2 and 2.8 tons per hectare per year).
- ✓ These residues are disposed of in the field.

4. Results

Application of the strategy:

Step 1

Define the sustainable objective according to the factors that impact the valorization of biomass

The objective of valorization was to increment the economic impact of the use of FL

Step 2

Select the BioProcesses according to the type of Biomass fractions using TRL

Extractives: Bioactive compounds by agitated solvent extraction and supercritical fluid extraction.
Cellulose: Glucose by catalytic process and enzymatic hydrolysis, Ethanol, ABE; Lactic acid, Levunilic acid; Polylactic acid
Hemicellulose: Xylose production by acid hydrolysis, Furfural, Xylitol and Pentane
Pectin: Pectin extraction
Starch: Glucose production by enzymatic hydrolysis.
All residual fraction: Biogas production

Step 3

Choose the range of BioProcesses considering the objective of the analysis

Extractives: Bioactive compounds by agitated solvent extraction
All residual fraction: Biogas production

4. Results

Step 4

Define the scenarios or superstructure considering the process conceptual design



Scenario 1

valorizing the leaves, stems, and flowers in the producer stage to obtain biogas

Scenario 2

The OPW valorization for the production of bioactive compounds and biogas




Scenario 3

The integration of the residues from the producer stage and the transformation stage to obtain polyphenolic compounds (from OPW) and biogas (from the mixture of exhausted OPW and leaves, stems, and flowers).

4. Results

Step 5

Sustainability evaluate the scenarios or superstructure defined

The first analysis involved the evaluation and comparison of the three scenarios in terms of the economic metrics considering a fixed flow rate.

Expected at Higher scales Sc.3

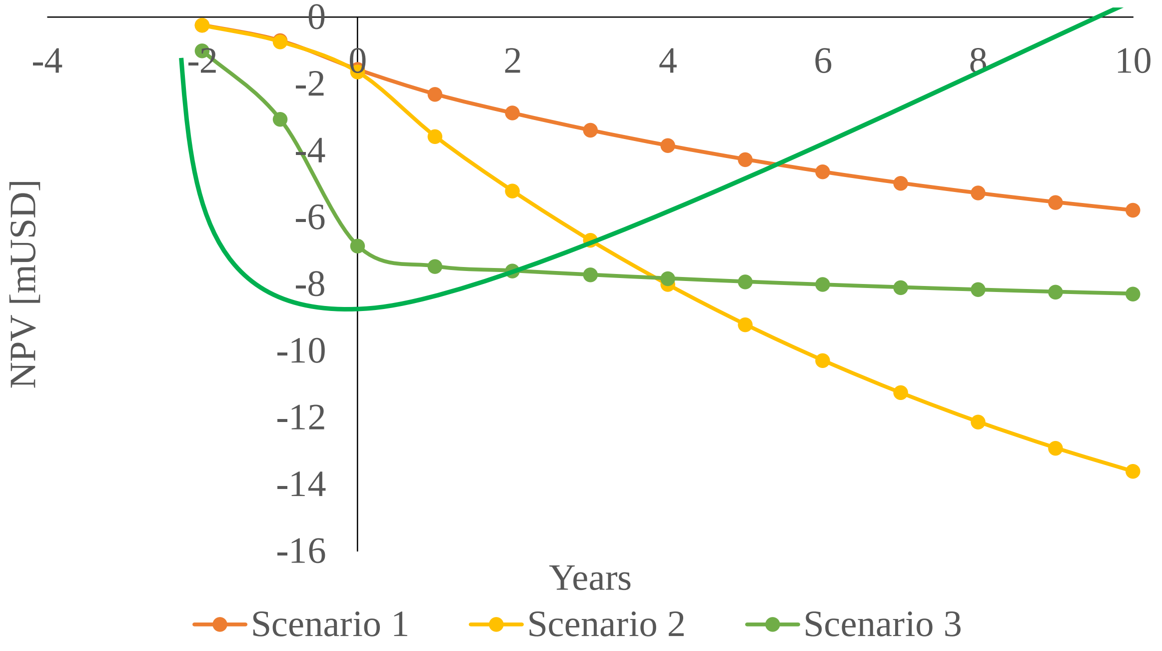


Figure 5. Net present value over the project lifetime for each scenario.

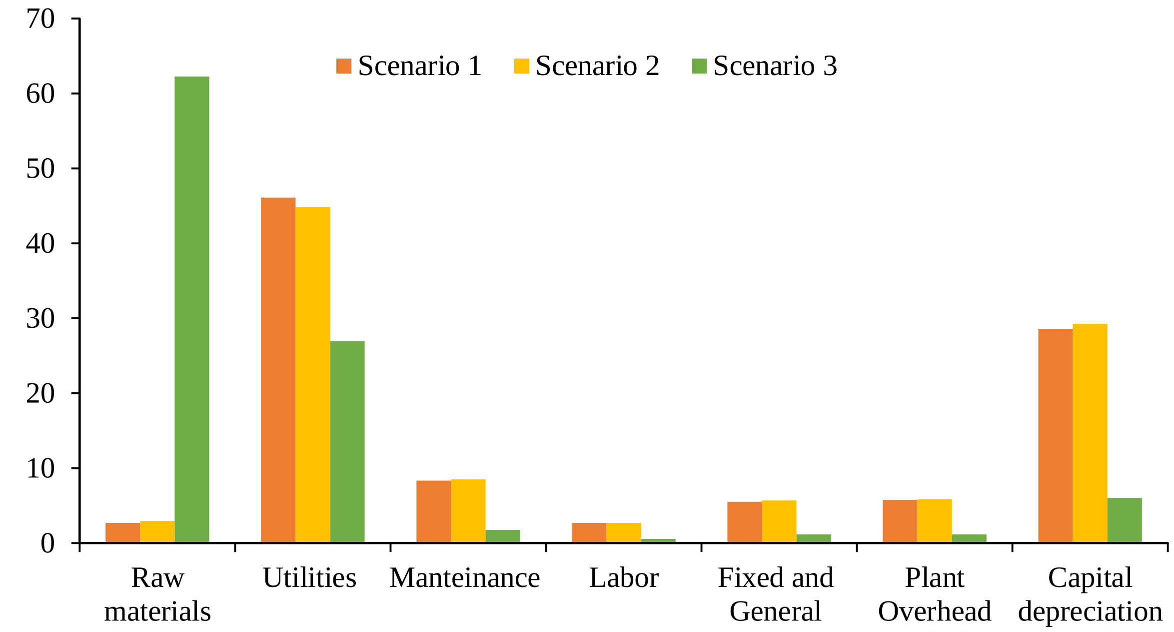


Figure 6. Costs distribution of the proposed biorefineries at a processing scale of raw material of 140 kg/h.

4. Results

Step 5

Sustainability evaluate the scenarios or superstructure defined

The second analysis was done to understand the influence of the scale in each scenario in terms of the economic metrics

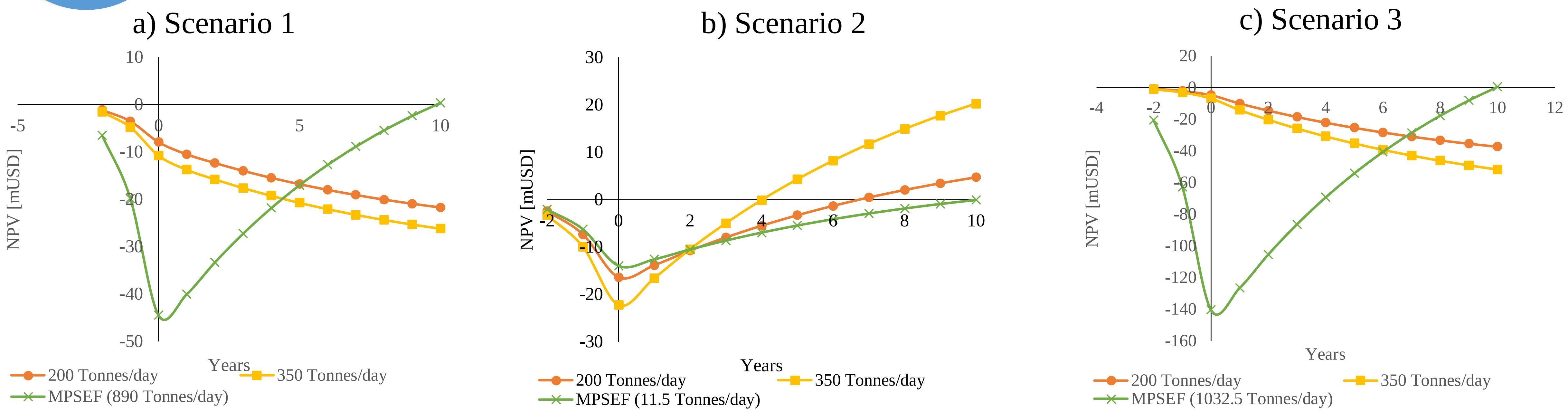


Figure 7. Economic performance of the OPW biorefineries at different scales over the project lifetime for each scenario. a) Scenario 1, b) Scenario 2, c) Scenario 3.

The application of the Food Residues valorization strategy determined the best scenario considering the stated objective. In this sense, scenario 2 has a Minimum Processing Scale for Economic Feasibility (MYSELF) with a lower raw material flow than scenarios 1 and 3 (it is necessary to increase the processing scale from 3.36 tons/day to 11.5 tons/day)

5. Conclusion

- Food Residues integration as an alternative for the generation of added-value products can improve the value chain sustainability since emissions of polluting agents are reduced.
- Indeed, the analyzed case study allowed to elucidate how the generation of added-value products such as polyphenolic compounds increases the viability of the orange value chain through the implementation of biorefinery with good economic performance.
- Finally, an analysis related to the possible scale and technologies to be introduced are a fundamental input to propose valorization alternatives. Finally, the proposed methodology can be applied to any food waste since the value chains are already previously defined and the disposal problems are current problems that require a contextualized solution.

6. Acknowledgments

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