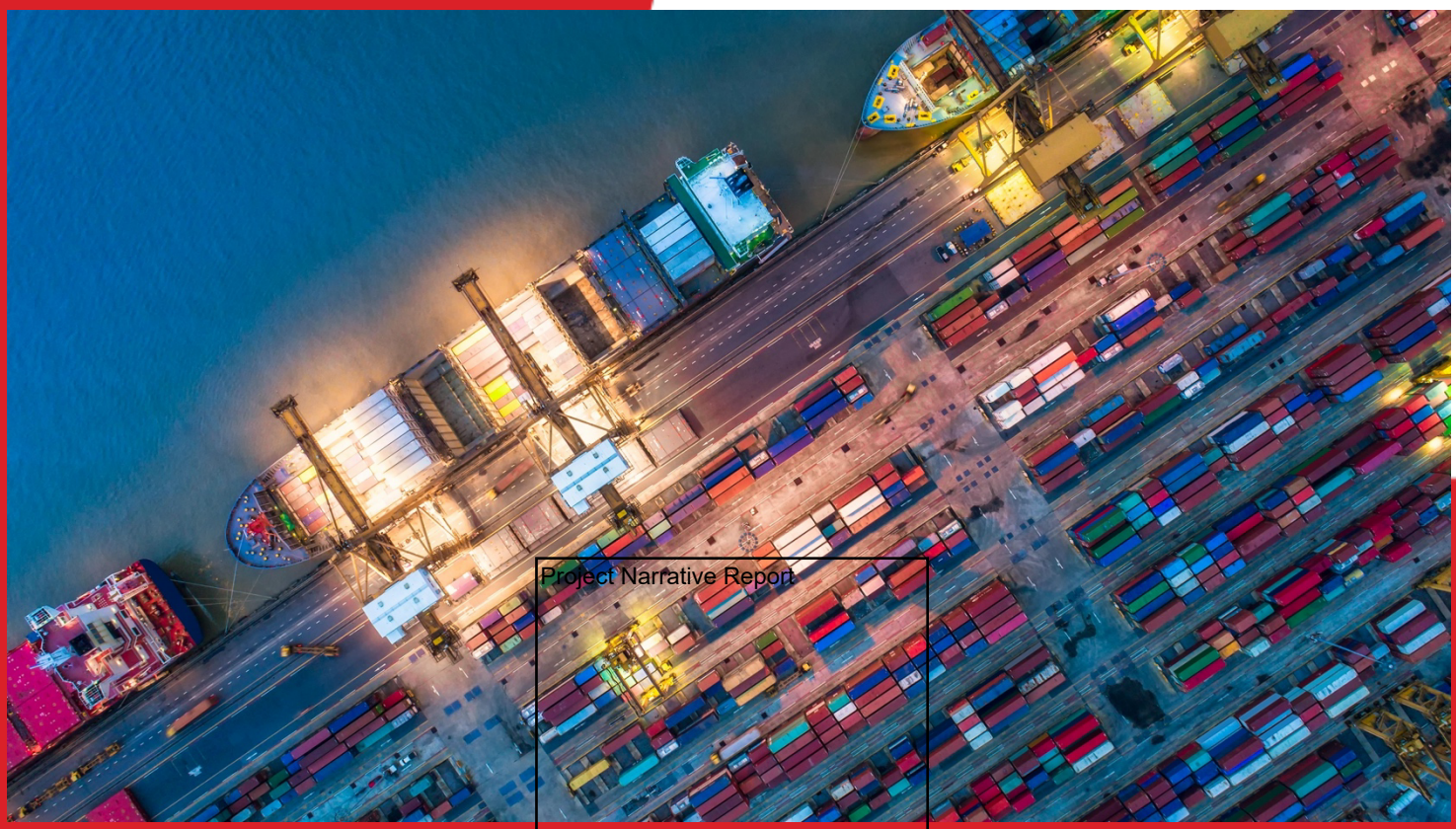

Project Narrative Report

For the project "Alternatives to PP bags"

dss+
Protect. Transform. Sustain.

Project Narrative Report

Alternatives to PP bags

March 2024

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Executive Summary

In 2021 the ICRC, WFP and UNHCR jointly embarked on a project intended to investigate alternatives and innovate solutions to the polypropylene woven bags used for food and relief item packaging. The three humanitarian organizations, deeply entrenched in the space of procurement and supply of essential items to some of the most vulnerable and marginalized communities in the world, supply millions of tonnes of food and non-food commodities globally. In 2018 for example, the ICRC dispatched 150 metric tons of polypropylene (PP) bags around the world while WFP distributed 3.6 million metric tons of food commodities packed in PP woven bags amounting to a minimum of 64 million bags (or 6 500 T of PP). In the same year, the UNHCR utilized PP packaging for non-food commodities amounting to nearly 150 T.

The project aims to address this large-scale concern through the application of eco-design principles to identify and develop potential alternatives. It is funded by Innovation Norway and spearheaded by the ICRC. It includes two key phases – a R&D phase for the design and development of potential alternatives and a field trial phase where these alternatives are tested in the real-world conditions of a humanitarian supply chain and network. The was officially closed in early 2024, although the on-ground testing of the bags ("field trials") is still underway. The project was managed by dss+, a sustainability consultancy and is governed through a Steering Committee that comprises of the three humanitarian organizations, Innovation Norway and the Norwegian Red Cross.

In the first phase (the 'R&D phase'), the specifications and requirements that any alternative would need to meet were defined. This included type of commodity to be transported (both food and non-food), range of applications (such as the 5kg to 90kg carrying capacity) and specific quality criteria (UV resistance, pest resistance, etc.). Based on these specifications, a long list of potential materials was first defined, which included a range of options such as improved PP, recycled PP, bioplastics, paper, natural fabrics (like jute, bamboo and cotton), etc. From here, a short list was derived through a multicriteria assessment where the relative performance of these materials was compared to the baseline, i.e., the PP bags currently in use. The criteria considered for this assessment included environmental, social and economic criteria such as CO_2 emissions, water consumption, acceptability by supported communities, cost, technical maturity and global production capacity.

The multi-criteria assessment recommended the following materials to be developed as solutions – PP bags with improved performance, bags made with recycled PP (for non-food applications only), bags made from cellulose, and bags made from vegetal fibres (excluding cotton). These options were then presented in a Terms of Reference (ToR) where companies, institutes and organizations were invited to present a solution which could be developed into a feasible alternative. Five 'lots' were proposed in the ToR:

Lot	Type of solution
1	Recycled PP
2	PP with an improved resistance and lifetime
3	Bags based on cellulose
4	Bags based on vegetal fibers (excluding cotton)
5	Other solutions

The procurement process followed was aligned with the typical ICRC process and featured some innovative activities to increase participation and accessibility for interested respondents. For example, the global and regional networks of the Steering Committee were leveraged to distribute the ToR to a wide and diverse group of stakeholders which included industries, industrial associations, universities, institutes, organizations, etc. Moreover, a series of Open Dialogue sessions were planned which invited interested bidders to engage with the project team to understand the expectations and share their own experiences and concerns. These sessions helped foster an open and two-way communication with potential bidders, which was important for the global nature of the ToR.

Three organizations were selected based on their proposed solutions and are currently developing and prototyping the same. On successful performance against set testing criteria, the solutions will be produced in bulk for field testing (**the 'field trials phase'**). The selected organizations are:

- *AIMPLAS Instituto Tecnológico del Plástico* – a Spanish plastic technology institution that has proposed two potential solutions – (i) an improved PP bag with greater durability & longer life (Lot 1) and (ii) PP bags made partly with recycled PP (Lot 2)
- *Ahsanullah University of Science and Technology (AUST)* – A Bangladeshi textile university that has proposed developing a jute bag with a biopolymer coating or finishing. (Lot 4)
- *Giottoindustrial Networking SA* & University of Applied Sciences and Arts of Southern Switzerland *(SUPS) I*– A consortium consisting of a Swiss consulting firm (Giotto) and university (SUPSI), which is working on developing a natural fiber-based material that has been treated using a layer-by-layer approach[1] (Lot 4)

Their solutions are described below:

AIMPLAS: worked on two lots concurrently. Their lot 1 study aimed to improve mechanical performance of PP bags and elongating their shelf-life. They designed a new bi-layer bag based on PP for food contact. Their lot 2 study aimed to develop the combination of recycled PP (rPP) and virgin PP for the project use case. The objective of this strategy was to obtain bi-layer PP-bags for non-food contact PP bags. As of February 2024, AIMPLAS has produced and dispatched two new bag types for field trials. The bi-layer PP bag with longer shelf life will be field tested in supply chains of all three partner organizations, while the rPP bag will only be tested with the non-food use case of UNHCR.

AUST: worked on a lot 4 project which consists of a jute sack with a coating or finishing made from biopolymers. As a first step in their investigations, they selected the appropriate jute fabric that would be used to make the bags based on the expected performance parameters. They then developed the formulation for the lining, with investigations of biodegradable compounds before arriving at the chosen formulation of natural latex with maize starch. As of February 2024, AUST is preparing to produce the bags for the field trials. They will be testing one design.

Giotto-SUPSI: this consortium investigated an innovative layer-by-layer (LBL) technology-based solution for lot 4 where they will use a vegetal fibre and coat it with solution that will

[1] *This R&D investigation is innovation focused and will not include production of bags for field trials.*

help improve the performance of the fabric. Giotto first identified a specific yarn of jute for further analysis based on various parameters such as fibre type, fibre length, yarn count, etc. The Polymer Engineer Laboratory of SUPSI's Department of Innovative then developed the LBL solution with a key objective to achieve improved hydrophobicity (water resistance) and reduced microbial growth. A solution of silver nitrate, silicon dioxide and polyacrylate was finally used. This bag design was only developed till the prototype phase and was not scaled for the field trials.

Figure 1: A jute sample demonstrating hydrophobicity due to treatment with Layer-by-layer technology (image source: SUPSI)

The comparative design and performance of the designed alternatives are provided below:

Characteristic	**AIMPLAS virgin**	**AIMPLAS recyc**	**AUST**	**GIOTTO-SUPSI**
Main material	Polypropylene	Polypropylene	Jute	Jute
Maturity	Industrial batch	Industrial batch	Prototype	Fabric
Composition	Base fabric (70%): ISPLEN PP 040 Coating (30%): Homopolymer (ISPLEN PP 089): 76.9% AO1: 2.0% AO2: 1.0% UV stabilizer: 5.1% PE: 15%	Base fabric (70%): ISPLEN PP 040 Coating (30%): Homopolymer (ISPLEN PP 089): 59.5% Recycled PP: 39.6% AO1: 0.2% AO2: 0.2% UV stabilizer: 0.5%	Jute fibers – local Coating: Natural latex (89.7%) – local PVAc:7% Softener : 2% Benzoate: 1%, Ammonium Sulphate: 0.3%	Jute fibers - Bangladesh Layer by layer (for 1kg of jute) AgNO3 833 ng SiO2 0.833 g Polyacrylate 0.833 g

Weight (g/m2)	83	83	600	601 (jute = 600 g/m2)
Plastic leakage	Yes	Yes	?	No leakage
Lifetime	Like baseline	Decreased compared to baseline	Up to 5 years (tbc)	Up to 5 years (tbc)
WVTR (g/m2/d)	2.4	4.4	TBD	N/A
OTR (cm3/m2/d)	928	3058	TBD	N/A
Price	0.45 USD/50kgbag (vs 0.38)	?	0.57 USD/50kgbag (vs 0.38)	+ 0.16€/m2 vs reference (tbd)

Criteria	**AIMPLAS virgin**	**AIMPLAS recyc**	**AUST**	**GIOTTO-SUPSI**
Main material	Polypropylene	Polypropylene	Jute	Jute
Adequation with mechanical and physical specifications				
Food contact				
Plastic leakages				
CO_2 impact vs ref (production)				
Water impact vs ref (production)				
Reuse (lifetime)				
Recyclability				

Production capacity				
Time to market				
Price				

Legend:

Much better than baseline		***Same as baseline***			***Much worse than baseline***

In the second phase of the project (the 'field trials phase'), the solutions developed and tested in the R&D investigations are used as packaging in selected supply chains of the three partner organizations. In this context, one supply chain with each organization was considered for the trial, which began in September 2023. An agile approach to the field trial was applied to ensure that the alternatives are used in the diverse, changing and challenging context of humanitarian work.

AIMPLAS was able to carry out industrial production of bags (and sheets for UNHCR), by June-July 2023, however AUST had requested for more time to complete the project steps and engage with the industry partners. Due to this, it was decided that the field trials for the two R&D organizations would be done independently of each other, as and when the bags were ready. The bags are being picked up by the ICRC logistics team and delivered to the suppliers (in case of WFP and UNHCR) and regional office (in case of the ICRC). This step was completed for AIMPLAS in Sept/Oct 2023, while for AUST the bag production and subsequent delivery is still ongoing.

The three field trials selected to test the bag included the following:

- **UNHCR:** A global non-food use case was selected for blankets, which are supplied by Shree Balaji Woollen Mills (SBWM), based in India. Rather than bags, sheets were produced to pack the bales of blankets. The sheets from AIMPLAS have been used to pack blankets and are currently awaiting a work order from UNHCR to be dispatched. The next destination for the pallets (i.e. the UNHCR warehouse) yet to be determined.
- **WFP:** Flour was selected as the use case for the WFP field trial, supplied by a Turkey based company, Doruk. In this case, the AIMPLAS bags were received in early November 2023, following delays at customs. As of now they have not been unpacked or filled by the supplier as currently there are no purchase orders from WFP. The finalization of the subsequent steps (warehouse, beneficiaries) is awaited.
- **ICRC:** In case of ICRC's field trial, the situation is a little more complicated. The local suppliers were collectives and may not have the knowledge and facilities required to print and pack the bags. The bags have been delivered to the ICRC regional headquarters in Cameroon. A short-term procurement is currently being undertaken in the region, and field tests are going to be followed soon by ICRC.

As a part of the project, dss+ has also conducted a detailed baseline lifecycle assessment for the PP bags and their alternatives for all three humanitarian organizations. This LCA follows the cradle-to-grave lifecycle of the PP and aims to quantify the total impact of the PP bags used and supplied by the ICRC, WFP & UNHCR. The results of this LCA are considered in the multicriteria assessment above. Since the field trials have not been completed, this multi-criteria assessment will be finalized/updated by ICRC once data about operation ability of the alternative are received from all field trials.

The planning and execution of the field trials has proven to be quite complex with both expected and unexpected delays – which is not unusual for the context. However, as the field trials progress and more data is received, the performance and suitability of the bags in real humanitarian contexts will be informed and documented in the multicriteria assessment.

In parallel, discussion focusing on scaling-up has been engaged with ICRC, WFP and UNHCR, in close collaboration and under the supervision of Tinkr. A summary report has been delivered by Tinkr, as a complement to the package of deliverables from this "alternative to PP bags" project.

So far, the main conclusions and suggestions for next steps are the following:

AIMPLAS PP-based alternatives are rated below the potential expected when starting the project a few months ago. The alternative implying partially pre-consumer recycled PP (second column in the tables above) is not currently viable because the recycled PP feedstock is not easily accessible, and the results of ageing tests were not good enough. **The bi-layer extended life virgin PP or sheets (first column in the table above) are still viable options for scaling-up but require further investigations, particularly regarding the ageing ability versus level of additives and type of virgin PP.**

GIOTTO jute-based alternative is currently the most viable non-plastic alternative. Nevertheless, it requires further investigations to check the prototype's behaviour, industrial scalability, lifetime in field conditions, beneficiaries' acceptance and reusability potential. The weight can also be optimised. In case the reusability and acceptance are high, this option becomes very interesting, particularly from a social and environmental perspectives. We recommend to follow the developments with Giotto.

AUST jute-based alternative still generates a lot of questions, mostly because of the weight of the alternative, the proportion of coating including partially fossil-based plastics, the much higher price compared to baseline, and the current production constraints.

1. Project Background

As humanitarian organisations, the International Committee of the Red Cross (ICRC), the World Food Programme and the United Nations High Commissioner for Refugees (UNHCR) provide critical support to some of the most vulnerable and marginalised communities in the world, in the form of food, and non-food commodities. In this context, each of the three organisations is engaged in the procurement, storage, movement, and distribution of huge quantities, much of which comes in individual packaging to ease the process of distribution.

For all three organisations, the packaging is usually provided by the commodities suppliers, based on technical specifications as outlined in the relevant terms of references (between the suppliers and the organizations).

To put in perspective the volume of packaging handled, in 2018, the ICRC dispatched 150 metric tons of polypropylene (PP) bags around the world while WFP distributed 3.6 million metric tons of food commodities packed in PP woven bags amounting to a minimum of 64 million bags (or 6 500 T of PP). In the same year, the UNHCR utilized PP packaging for non-food commodities amounting to nearly 150 T. With these high numbers in mind, the three organisations have launched this project to find a sustainable alternative to the current use of PP bags in their activities.

Overview of the Study

The partner organisations have designed and obtained financial support from the Norwegian Agency for Development Cooperation (NORAD) for a project to find a more sustainable packaging material than PP bags, which is used widely for staple food and other commodity packaging. The project will include testing of alternatives in real conditions of usage and will look to encourage the scaling up of the pilot project. The goal of this mission is to manage this project from the design and R&D stage to the pilot trials. This a two-year project was initially expected to end by December 2023, but was extended by one year due to various factors.

The core team from dss+ is supported by two experts, Mr Vincent Mooij & Ms Françoise Poulat, who have extensive experience in the space of plastics, sustainable packaging, and packaging recycling. A steering committee, with representatives from each of the three organisations – WFP, ICRC & UNHCR has also been formed, to provide timely and relevant inputs to the project team on the progression of activities and help take key decisions with respect to the project direction. Over time, the steering committee has also seen participants from experts from allied projects (Patrick Oger), Norwegian Redcross & Innovation Norway.

Purpose of this report

The aim of this project is to provide a 'living' account of the key discussions and decisions taken over the lifetime of the project, especially capturing the suggestions from the project team and the steering committee alike.

2. Project Methodology

Alternatives to PP bags

FUNDING BY: Innovation Norway

PROJECT PARTNERS: ICRC, UNHCR The UN Refugee Agency, WFP

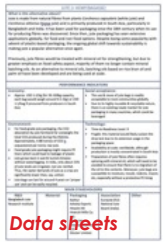
PROJECT MGMT: dss+

To find more sustainable and environmentally friendly alternatives to conventional PP bags used by humanitarian organizations

1 Preparatory phase

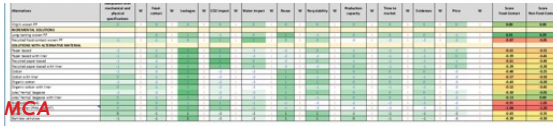
Defining the **performance criteria** for the alternatives *(such as: minimize plastic leakage)*

Apply a **lifecycle approach** to understand impacts of different materials & develop technical data sheets for the different material types



Shortlist most interesting material types through a **Multicriteria Analysis** (MCA)

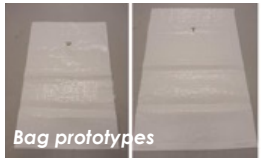
Float a ToR targeting companies, universities, research organizations to propose a solution based on the shortlisted materials & performance criteria – **3 R&D organizations selected**



2 R&D phase

A. AIMPLAS

Spanish Plastics R&D organization developed 2 solutions – PP bag with longer life (incremental solution) and recycled PP based bags

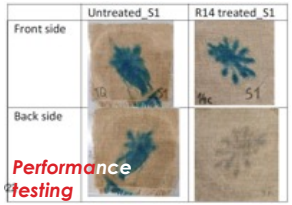


B. AUST

Bangladeshi university working on jute-based bags with a biopolymer coating

C. GIOTTO-SUPSI

Swiss consortium developed jute-based bags treated with layer-by-layer technology



3 Field trials phase

Lab testing to confirm food safety, performance and UV degradation rate

Pilot-scale production of alternative bags for solutions A & B (~5000 pieces or similar)

Field testing of bags in at least 2 Humanitarian supply contexts

Detailed LCA based on solution developed in the R&D phase, with inputs from the Field trials

3. Preparatory phase

April 2021 – August 2022

3.1 Project Kick-off and initial discussions

The project kicked-off with an initial call between the Project team and the steering committee on 13th April 2021. The main aim of this call was to align the project team (dss+) and the larger group (dss+ and steering committee) on the administrative processes & protocols and plan the initial data collation & assessment activities.
It was decided during this call that the project team would need to organise bilateral meetings with each of the organisations to better understand their organization and working, the characteristics of the supply chains at macro level and the main use cases and their specificities (areas, functionalities, end of life of the bags; reuse of the bags in the refugee camps for instance). As there are many suppliers of PP bags and the supply chain systems are complex and vary organisation to organisation, it is also agreed that the project should prioritise 1-2 supply chains (baselines) per agency and a few relevant use cases. The three partner organisations also agreed to develop a list of specifications for the PP bag alternative that are of interest to all of them.

The three bilateral meetings – one with each organization – were planned and conducted through the month of May 2021. The aim of these bilateral meetings included:

1. Understanding the key activities conducted by each organization (that is relevant to this study)
2. Gaining an overview of the supply chain that each organisation utilizes
3. Understanding the needs, expectations, and suggestions from each organisation for the PP bags alternatives.

Each bilateral meeting began with a brief presentation by the project team on the agenda, followed by an open discussion with the WFP, ICRC and UNHCR teams. Following the meeting, each of the organizations also shared relevant data on food/non-food supplies undertaken in 2018-2020, based on a data collection template prepared by the project team. A summary of the data collated at this stage has been provided in the deliverable **Task 1.1 Report.**

During this time, the three organizations also developed a set of technical specifications with what both PP woven bags and the possible alternatives should be compliant. These specifications are described in the figure below.

"Must have"

- Food grade **and** non-food grade options.
- For food-grade: compliant with Drop test (EN 277, ISO 7965-2 or equivalent)
- 5kg to 90 kg size
- Durability 24 month in typical warehouse conditions *(limit to be defined by comparion with current PP woven bags, as per ASTM D4329)*
- Minimum breaking force – horizontal and transversal: 600N.

"Nice to have"

- UV resistance : 50% of tensile strength kept after test according to ISO21898.
- No fumigation needed over time : WVTR< 5 g/m2/day (38°C/90%RH) and OTR< 1500 cc/m²/day (23°C / 0% RH)

"Economics"

- Alternative should not exceed 110% of PP bags cost, i.e. 6-7 tons per ton of food, 0.38 USD per 50kg bag

In addition to the technical specifications listed above, it was also important consider the nuances of PP bag usage at the beneficiary sites:

- PP bags are reused by the beneficiaries for many of their day-to-day activities. It would be good for the selected alternatives to provide similar reusability to the end-users.
- It should be assumed that recycling infrastructure is unlikely to be available across the diverse contexts the three organizations work in, even in the medium term.
- Typical end of life technique applied in the field is burning or dumping into the environment – the selection of the alternative should be cognizant of this.
- Incremental solutions, which improve the current situation without necessarily replacing PP bags altogether can also be considered. This may include the improvement of existing specifications of PP bags, or changes in applied mechanisms, or partial replacement.
- Erasing the plastic issue without shifting impacts elsewhere in the supply chain should be a key driver for the choice of the alternative.

During these initial discussions, the project team (dss+ and the partner organizations) also defined two use cases for exploring alternatives :

- **Food application: Staple bulk food (rice for instance)**
  - **1 global supply chain and 1 regional supply chain from WFP**
- **Non-food application: Blankets (same specifications UNHCR/ICRC)**
  - **1 global supply chain from UNHCR or ICRC**

3.2 Understanding potential alternatives

The initial conversations on the project provided us a clear understanding of what qualities and performance potential alternatives to the PP bags should have, along with other desirable traits. To build on these expectations, an expert workshop was held with Françoise Poulat and Vincent Mooij, who have extensive experience in the packaging sector.

The aim of this workshop was to utilize the learnings from the three organizations to propose alternatives for PP bags that can be considered. The scope for the alternatives was dictated by the 'ideal' vision, which had been developed based on the preceding conversations.

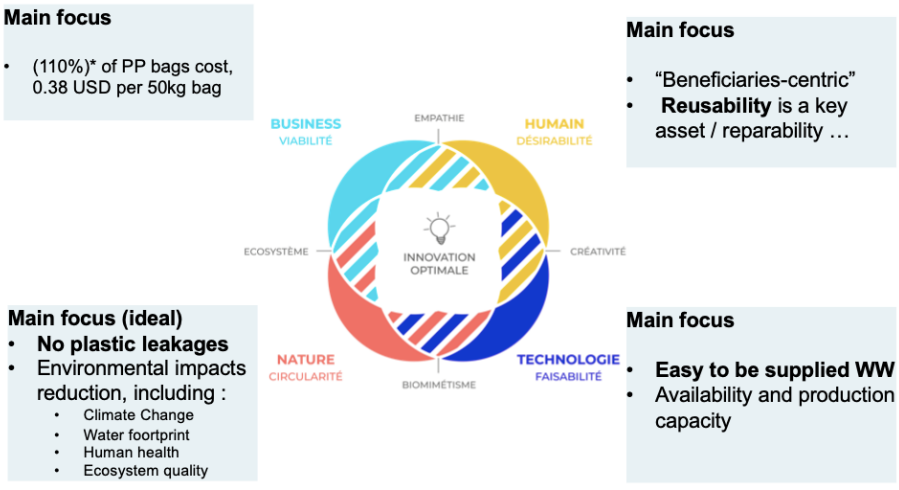
The 'ideal' vision for the alternatives

- **Respects the minimal functional requirements outlined by the three organizations**
- **Easy to be reused/repaired in the communities where it is delivered**
- **No plastic issues at end of life (no micro-plastics)**
- **No increase in environmental impacts along the full supply chain**
- **Easy to be supplied Worldwide.**

Note : recyclability is not an option

The workshop was designed to look at the alternatives from an eco-design perspective and proposed two categories of solutions:

1. Disruptive solutions that would aim to fulfil all aspects of the ideal vision, even if it requires substantial shift from the current practices
2. Incremental solutions that will seek to improve current practices and make them more sustainable, even if very few objectives of the ideal vision are met.



For the workshop, a Miro board was set up to discuss solutions and classify their nature based on four aspects – positive social impact, technical feasibility, environmental sustainability, and business viability. For each of these aspects the project team and the experts highlighted the pros and cons qualitatively. A total of 10 disruptive solutions and 3 incremental solutions were developed at the end of this exercise.

Disruptive Solutions	Incremental Solutions
1. Pure cellulose-based solutions 2. Laminated cellulose-based solutions 3. Biodegradable plastics for home composting 4. Biodegradable plastics for industrial composting 5. Bio-sourced textile-based solutions 6. Rigid containers without refill option 7. Rigid containers with refill option 8. Partnering with local waste collection association to set a recycling scheme 9. Partnership with the plastic waste alliance (large brand owners) to develop collection and recycling schemes 10. Creating tarpaulins from bags	1. Recycled PP bags for non-food uses only 2. Food-grade recycled PP bags produced centrally 3. PP bags with increased durability/ product lifetime

The Miro board can be accessed here.
Through the workshop and after, the group (dss+ team + experts) also put together an initial list of stakeholders that could be considered, which are available in the Miro board.
The solution categories suggested during the expert workshop were deliberated on with the steering committee in August 2021. The partner organization provided the following inputs and insights on the solutions category:

- The solutions suggested should be organized as per feasible timelines in which they could be implemented (i.e. short, medium, or long term), and consider the impacts that they may have on existing systems and supply chains.
- In the short-term, the priority could be to develop a flexible packaging like the current PP bag but made of alternative material, and with possibly an optimized design to facilitate reuse in various contexts.
    - The typology of alternative materials considered is the following: cellulose based materials (with or without a liner), textile-based solutions (mono-material or not), other innovations like stone paper. A multicriteria assessment taking into account the 4 perspectives of sustainability is done for each alternative, with qualitative and quantitative data.
    - The alternative solution should follow the technical specifications identified in 3.1 and be easily supplied worldwide.
    - The new product in its supply chains (regional or global) is less impactful from an environmental perspective than the current equivalent supply chains, in terms of plastic leakages and ideally most of LCA monitorable impacts.
    - From an economical point of view, the alternative is acceptable *(should be completed by the 3 agencies)*.

    - The recyclability of the alternative also needs to be considered in the multicriteria assessment in case collection systems are put into places in the medium term.
- In parallel, the project team could also explore incremental innovation strategies like sourcing recycled PP for the bags for non-food applications, sourcing bio-sourced plastics with similar chemical properties than the fossil-based plastics (like Bio-PET) and designing the bags with PP having an increased lifetime (better UV resistance etc).
- It would also be important to get insights on materials which are not yet ready to be deployed at large scale (biodegradable plastics like PLA, PHA or food grade recycled PP) to understand their attractiveness in medium-to-long term.
- For the medium term, as a complement to the Short-Term strategy[2], a disruptive strategy relying on mature technologies (bags designed to be reused in specific useful products tarpaulins, umbrella / "Lego" approach …) should be favoured. More data from the field would be required to this, along with a deep understanding of the field's needs. Recycling schemes with "large alliance" (logistics insured by large players) should also be explored as an opportunity to implement a collection system.

3.3 Multi-criteria assessment of PP bag alternatives

The project team devised a multi-criteria assessment of the PP bag alternatives based on the discussion with the steering committee (see above). There were 10 criteria selected and weighed on a scale of 1-3 depending on their relative importance. This 'importance' came from the eco-design principles highlighted for the project in the inception meeting, and the subsequent discussions with the steering committee that have followed. The following table lists the key criteria and the weightages that were assigned.

Criteria	Meaning & reason for inclusion	Weightage
Meeting physical & mechanical specification	The alternative must be able to perform as per the needs outlined by the three organizations	3
Food-contact	The alternative must be food-safe for food-based usage	3
Leakages	The plastic leakages to the environment must be minimal	3
Carbon dioxide impact	The GHG emissions during the production and usage of the alternative should be minimal	1
Water impact	The water usage during the production and usage of the alternative should be minimal	1
Reusability	The alternative should be easily reusable by the beneficiaries in the refugee camps	3

[2] Note: Medium-term solutions are out of the scope for the current study

Recyclability	The alternative should be easily recyclable	1
Production capacity	The technology for production of the alternative should be mature and available worldwide at a significant capacity	3
Time to market	The alternative material properties & design should be sufficiently understood and relevant to this project's use cases so that time taken to scale & implement is minimal	3
Price	The cost of the alternative should be competitive with that of woven PP bags	2

Against each of these criteria, the alternatives were scored based on their performance relative to PP bags – i.e. if they performed better, they were given a positive score (+1,+2,+3) and if they performed worse, they were given a negative score (-1,-2,-3) the summation of the weighted scores for each alternative gave the final score, as described in the table below:

Alternatives	Score Food-Contact	Score Non Food-Contact
Virgin woven PP	0.00	0.00
INCREMENTAL SOLUTIONS		
Long-lasting woven PP	**0.25**	**0.29**
Recycled food-contact woven PP	**-0.87**	N/A
Recycled non food-contact woven PP	N/A	**-0.85**
SOLUTIONS WITH ALTERNATIVE MATERIAL		
Paper based	-0.61	-0.55
Paper based with liner	-0.39	-0.45
Recycled paper based	-0.61	-0.40
Recycled paper based with liner	-0.39	-0.45
Cotton	-0.48	-0.25
Cotton with liner	-0.57	-0.50
Organic cotton	-0.43	-0.20
Organic cotton with liner	-0.52	-0.45
Jute/ hemp/ bagasse	**-0.30**	**-0.05**
Jute/ hemp/ bagasse with liner	**-0.13**	**-0.00**
Biopolymer (PLA)	-0.91	-1.05
Biopolymer (PHA)	-1.04	-1.20
Lyocell (rayon)	-0.43	-0.35
Bamboo cellulose	-0.39	-0.30

As it can be seen, the best performers included natural textiles like jute, and recycled PP, while the worst performers included bioplastics. These results were presented during the third steering committee discussion.

To provide more context on each potential solution of interest, we also prepared brief, one-page "factsheets" which presents a snapshot of the alternative, its usage history, and a qualitative assessment of impacts on four categories – technology, economy, environment & social.

Revision of the multi-criteria assessment

The multi-criteria assessment presented to the steering committee was assessed against the initial eco-design principles set for the project. It was decided that rather than having these criteria as independent, they could be clubbed under the four heads, as elaborated in the factsheets, i.e. technology, economy, environment & social.
Accordingly, the following weightage was proposed:

Category	Criteria	Criteria Weightage	Category Weightage
Economy	Price	10	10
Social acceptance	Reusability	10	10
Environment	Leakages	3	10
	Carbon dioxide impact	3	
	Water impact	3	
	Recyclability	1	
Technology	Meeting physical & mechanical specification	3	10
	Food-contact	3	
	Production capacity	2	
	Time to market	2	

The revised performance of the alternatives is given below:

Alternatives	Score Food-Contact	Score Non Food-Contact
Virgin woven PP	0.00	0.00
INCREMENTAL SOLUTIONS		
Long-lasting woven PP	**0.35**	**0.39**
Recycled food-contact woven PP	**-0.46**	N/A
Recycled non food-contact woven PP	N/A	**0.14**
SOLUTIONS WITH ALTERNATIVE MATERIAL		
Paper based	-0.84	-0.86
Paper based with liner	-0.66	-0.73
Recycled paper based	-0.68	-0.63
Recycled paper based with liner	**-0.50**	**-0.50**
Cotton	-0.95	-0.87
Cotton with liner	-1.08	-1.08
Organic cotton	-0.88	-0.79

Organic cotton with liner	-1.00	-1.00
Jute/ hemp/ bagasse	**-0.55**	**-0.47**
Jute/ hemp/ bagasse with liner	**-0.55**	**-0.51**
Biopolymer (PLA)	-1.25	-1.33
Biopolymer (PHA)	-1.30	-1.43
Lyocell (rayon)	-0.64	-0.62
Bamboo cellulose	-0.81	-0.79

As it can be seen, in the revised multi-criteria assessment, **long-lasting PP was found to be the best alternative, followed by recycled PP, recycled paper with liner, and natural fibre like jute**. This version of the multi-criteria assessment was finalized by the project team and the steering committee.

3.4 Development and launch of a ToR for selecting R&D organization

The multicriteria assessment provided the project team an understanding of what solution "families" would be of interest to the partner organizations, in the context of the functionalities and favourable properties described earlier. At this stage, the project was ready to initiate the second phase, which would include hiring one or more competent organizations to carry out Research & Development and design solutions in line with the project aim.
The onboarding process for the R&D organizations was in line with the "typical" approach undertaken by the ICRC where a Terms of Reference would be launched and the proposals received in response to this ToR would be reviewed for the strength of the proposed solution, existing expertise of applicant organization, cost competitiveness etc. It was also agreed by the steering committee that the key principles of the fund are considered during the ToR process, and an "open dialogue" process is followed, as outlined by Innovation Norway.

The ToR was finalized by the dss+ project team in discussion with the steering committee in December 2021. It offered interested organizations an opportunity to apply under one or more of FIVE lots, as described below:

- Lot 1: Incremental solution based on PP with improved lifetime
- Lot 2: Incremental solution based on recycled PP
- Lot 3: Solution with a cellulose-based material
- Lot 4: Solution with a material made of vegetal fiber, excluding cotton
- Lot 5: Solution with another material not belonging to the categories mentioned above.

It was decided that ICRC's open-call procurement process would be followed, and the ToR will be rolled out in two phases – the first being an introductory Request for Information (RFI) followed by a more detailed Request for Proposal (RFP).
The RFI went live on ICRC's website on 20th December 2021. Partner organizations and dss+ also shared the RFI in their respective networks and social media (websites, LinkedIn). The RFI closing date was set as 11th January 2022, after which a question-and-answer (Q&A) session was held on 14th January 2022, were interested applicants were encouraged to share any doubts or questions they might have on the proposal. The two main questions asked revolved around the scope of the analytics expected and the expectations

surrounding the manufacturing of the bags. The RFP was shared with the respondents to the RFI on 17th January 2022, with a submission deadline of 7th February 2022 and an email-based Q&A deadline of 25th January 2022.

At the end of this exercise, four proposals were received, of which two corresponded to more than one lot. The following table presents the four bidding organizations and the lots they applied for.

Organization	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
AIMPLAS					
RI.SE					
BILLERUD KORSNAS					
TIGOUN					

During a subsequent Steering Committee meeting, members put forth their perspective on the proposals received, reflecting on various aspects such as relevance, cost, amount of information provided, etc. The total scores provided by the members were then averaged to show the relative score (out of 5) of each proposal, lot-wise is given below.

Organization	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
AIMPLAS	4.4	4.4			
RI.SE	2.9	2.9	3.0	3.0	3.7
BILLERUD KORSNAS			3.0		
TIGOUN			3.5		

Based on the score (see table above), there were some doubts among the group on whether the best available options had been covered in the proposals received. It was observed that while for the first three lots the options suggested were fairly reasonable choices, for lots 4 & 5 there was a clear lack of potential solutions. Moreover, the market that dominates in production of natural fibre packaging (Asia) was not represented.

Three options were suggested as the next steps:

- **First avenue:** The responses received are put "on hold" and another round of ToRs is released. For this second round, steering committee members take efforts to deepen their connections in other contexts while the project management team (dss+) prepares to reach out a wider network by including more private sector players, reaching out to more organizations in regions like Asia, sharing the RFI and subsequent information with associations, media, etc. The main disadvantage of this option would be that it would take a significant amount of time to redo the ToR process.
- **Second avenue:** The steering committee chooses the best from what they have (for example – lots 1 & 2) and in parallel explores opportunities for the other lots.
- **Third avenue:** Proposals are chosen from the lots received

The Steering Committee was generally in agreement with the first option and **collectively agreed on an extension of the project timeline** if it provides an opportunity to get better

alternatives. They also accepted the risk of unchanged results despite the extension – it is possible that despite taking additional time, better proposals are not received in the next round. Additionally, the group agreed to a number of changes that could potentially improve the chances of getting responses.

Recommendations on how the Second round of the ToR could be made more "attractive"

- **Extend the timelines for both RFI & RFP phases (one month for each)**
- **Simplify the ToR requirements and reduce administrative burden for the submission, especially for the RFI phase**
- **Conduct a baseline assessment to understand key suppliers/companies/institutes outside of America/EU that might be interested**
- **Have one (or multiple) open dialogues sessions**
- **Involve the procurement teams in Asia from each partner organization to identify their suppliers or contacts that might be interested**
- **Leverage the communication channels that the partner organizations have in different regions**
- **Increase awareness through magazines, conferences, articles, etc.**

Respondents from the first round were given the opportunity to either edit their proposal for the second round or continue with the proposal submitted before.

The second ToR launch

RFI was launched on 05th April 2022 with a submission deadline of 06th Mayon the ICRC website. As indicated above, the RFI ToR was simplified into a brief 2-page document that only provided an introduction to the applicant, their organization & ability to execute the project requirements, and the solution. In this the ToR round, care was taken to encourage representation from geographies beyond the EU – all steering committee members shared the RFI in their global and regional networks, dss+ shared it directly with a long list of organizations, committees and associations that are working in related fields, as well as will sector news platforms/websites. As planned, two Open Dialogue sessions were held where interested companies/organizations were invited to speak to the project team and partner organizations. These Open Dialogue sessions helped increase understanding of the project and its expectations among the potential R&D organizations. The RFP ToR was launched towards the end of May 2022 and all applicants at the RFI stage were invited to submit the detailed proposal.

The changes planned for the second ToR round proved to be fruitful as interest was received from companies and organizations in Asia, including from Thailand, Bangladesh, and India, including companies, R&D organizations, and universities. The final list of proposals received at the RFP stage are listed below (some RFI proposals chose not to continue to the RFP phase

Organization	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
AIMPLAS, Spain					
RI.SE, Sweden					
BILLERUD KORSNAS,Sweden					
TIGOUN, France/ Sub-Saharan Africa					
AHSANULLAH UNIVERSITY OF SCIENCE & TECHNLOGY, Bangladesh					
PACIFIC JUTE, India					
GIOTTO-SUPSI, Switzerland					

One key observation from the proposals was the status of the solution being offered. While some organizations were suggesting solutions that would need to be designed, developed and prototyped, others were offering solutions that were already "on the shelf", i.e. ready to be sold. The Steering Committee agreed that it was important to both find a good alternative to PP bags and learn from the different solutions, but options already developed with little opportunity for contextualization could be avoided. It would also be good to select organizations that were well connected with the industry, as this link would be important for the Field Trials phase.

Across the seven proposals received, there were many pros and cons see, as described in the table below:

Organization	Lot	Key observations
AIMPLAS, Spain	1 & 2	• Strong proposals for both lots • They can produce/test bags in-house and have good industry connection. • We will need to define how we can check the effectiveness & quality on the field
RI.SE, Sweden	All	• Proposed solutions across all lots but high cost for each solution • Could potentially support other candidates with their packaging expertise
BILLERUD KORSNAS,Sweden	3	• Off the shelf solution with limited relevance to the project contexts
TIGOUN, France/ Sub-Saharan Africa	3	• Would need to check IP and upscaling strategy. • Could be a very fragile solution – similar packaging was used by USAID previous but led to leaks and damages. • They would need to develop hermetic bags that need to be tested on long-term storage
AHSANULLAH UNIVERSITY OF	4	• The proposal itself is affordable and with low financial risk.

SCIENCE & TECHNLOGY, Bangladesh		• However, jute bag is expensive for global use • We would also need to see if they have industrial partners for manufacturing bags for the field trials
PACIFIC JUTE, India	4	• Off the shelf solution with limited relevance to the project contexts
GIOTTO-SUPSI, Switzerland	4	• Interesting/Innovative solution but more relevant to the long term • High-cost solution

Based on the discussion noted above, the following organizations and lots were selected for the R&D phase

Organization	Lot	Notes
AIMPLAS, Spain	1 & 2	
AHSANULLAH UNIVERSITY OF SCIENCE & TECHNLOGY, Bangladesh	4	• They would need to build connections with the industry to support the field trials. • The project team will conduct a field visit to set expectations
GIOTTO-SUPSI, Switzerland	4	• They will be asked to amend the proposal and only produce prototypes (industrial production for field trials will be taken out of scope) so that we can see whether a solution like this could work.

4. R&D Phase

September 2022 – December 2023

4.1 Launch of R&D phase and Open Dialogue Sessions

In the week commencing 19th Sept. 2022, dss+ organized three Open Dialogue sessions for each of the three selected R&D organizations. The aim of these sessions was to introduce the chosen organizations and their solutions to the project network, to facilitate sharing of ideas, expectations, and concerns, while collectively developing opportunities to streamline and de-risk the project. The Open Dialogue Sessions saw participation from various stakeholders such as:

- Project team from the selected R&D organizations
- Representatives from ICRC, WFP & UNHCR, including project focal points and Supply Chain/Logistics representatives (global, regional, and local)
- Suppliers of the participant organizations, including food (Staple foods, Doruk) and non-food (Alpint'er, NRS Relief, Shree Balaji Woolen Mills)
- Project management team from dss+

Some of the key points highlighted during these Open dialogue sessions included the following:

- The need to focus on improving performance under UV radiation as this is a key factor in limiting the life of PP bags – hence especially important for AIMPLAS to consider.
- Jute-based solutions (AUST and Giotto-SUPSI) are often restricted from entering some countries due to potential infestation from Khapra beetles. of Giotto and SUPSI –
- Food safety is a key factor for all solutions being developed, except for the recycled PP solution by AIMPLAS.

4.2 AIMPLAS: Progress of solutions

AIMPLAS is a Spanish Plastic Technology Centre with extensive experience across the plastics value chain. They undertook R&D on two lots concurrently. Their lot 1 study had two main objectives:

- Improving mechanical performance of PP bags based on polymer selection
- Enlarging shelf-life based on additives for UV and thermal stabilization

They identified two strategies to achieve these objectives:

- A one-layer PP bag design made of a combination of different types of PP and stabilization additives
- A new design of bi-layer bag made of PP.

In their experimental design, they investigated four combinations of PP (ranging from 80% - 90% PP homopolymer and 10-20% PP copolymer) along with UV stabilizer ranging from 0.5 to 1%. The key steps in their investigations included testing of current PP bags on weathering

and using the results to inform the design of the new AIMPLAS bags. The solution developed for lot 1 was a bilayer bag as against a monolayer bag that was initially planned, since it showed greater performance and was cheaper.

Their lot 2 study aimed to develop the most suited combination of recycled PP (rPP – chemically recycled) for the Project use case. They investigating this in two ways:

- Testing combinations of rPP & PP homopolymer & copolymer (rPP content ranging from 40% to 100%)
- Developing a **bi-layer bag** made of two layers of PP (woven PP and coating) that will also be tested, the second layer (outer) being produced with **chemically recycled PP** which fulfils FC regulations. Ratio of rPP would be 20% in this case.

The key steps in the investigation include testing the current PP bags, benchmarking recycled PP, testing the defined formulations with rPP (including bi-layer sack), and prototyping & scaling the most suited formulations. For lot 2, they ruled out chemically recycled PP for food contact so the bag produced will only be used for non-food commodities. Due to shortage of time, AIMPLAS was not be able to produce prototypes for testing before the field trials, but they will produced bags from the two best formulations for the field trials and sent samples from this production for testing.

AIMPLAS was also asked to provide colour coding to the different bags they had produced based on type (lot 1 vs lot 2) and geography of field trial. AIMPLAS was unable to get colour bands printed on the bags but have marked the different bag types with unique alphabetic codes. As of Nov 2023, all AIMPLAS bags have been sent for the field trials and are awaiting further action.

4.3 AUST: Progress of solutions

The Department of Textile Engineering, Ahsanullah University of Science and Technology (AUST) based in Bangladesh, have extensive experience in conducting innovation-oriented projects with jute will be participating in the project. They developed a lot 4 project which consisted of a jute sack with a lining made from biopolymers containing starch, one or two fatty acids (acetic, citric, adipic, etc.), gelatine, and sorbitol or glycerol. The resultant bag was expected be non-toxic and biodegradable.

The resin applied to the jute fabric consists of four elements – a thickener, an adhesive, a softener and a performance optimizer. AUST tested multiple chemicals for each of these:

- Thickener: Starch, PVA (Polyvinyl Alcohol)
- Adhesive: Natural Rubber, PVAc (Polyvinyl Acetate)
- Softener: Glycerin, Silicone Softener
- Performance Optimizer: Neem, Margosa Oil, Vanilla Essence

The first formulation tested consisted of starch and was found to be too hygroscopic. Two formulations, which included a coating of PVAc (Poly-vinyl acetate) and natural rubber yielded more favourable results and passed the various tests (Tearing strength test, abrasion resistance test, drop test, printability test & UV resistance test. As of Nov 2023, AUST has finalized formulations for six prototypes under the two solution types mentioned above. They are currently in the process of industrial production of the bags, which has been delayed due to political unrest in the country.

4.4 GIOTTO-SUPSI: progress of solutions

Giotto is a Swiss centre of competence with background and experience in technical textile supply chain. They worked with La Scuola universitaria professionale della Svizzera italiana (SUPSI) to execute the project. The solution suggested by Giotto and SUPSI consisted of vegetal fibres with improved strength and hydrophobic & fungi-bacterial resistance achieved by layer-by-layer (LbL) technology. The Layer by Layer technique is a step by step film build up based on alternate deposition of oppositely charged polyelectrolyte (water-based) solutions).To achieve this, Giotto focused on the identification of vegetal fibres, yarn converting and weaving option in line with the project needs, while SUPSI developed the best LbL formulation.

SUPSI's MEMTilab investigated two multilayer sequences for the LbL technology and defined the number of by-layers. By-Layers deposition was sprayed and impregnation by immersion of the fabric, which in turn made the jute material more hydrophobic, resistant to fungi & bacteria, and more UV stable. Silicon dioxide and polyacrylate were used to impart hydrophobic properties while silver nitrate was used to provide antibacterial properties.

The LbL technology is unique because it uses very low amount of chemicals (a few milligrams per square meters) but imparts significant qualities to the material, such as high repellence and resistance without compromising on the fabric's qualities. As presented in the previous chapter, the Giotto-SUPSI R&D project did not include production of bags and will not be sent for the field trials. however, the solutions developed has shown promise and could potentially be studied further in future. Further information on each R&D trial is available in the final reports from AIMPLAS, AUST & Giotto-SUPSI.

4.5 Comparison of solutions developed

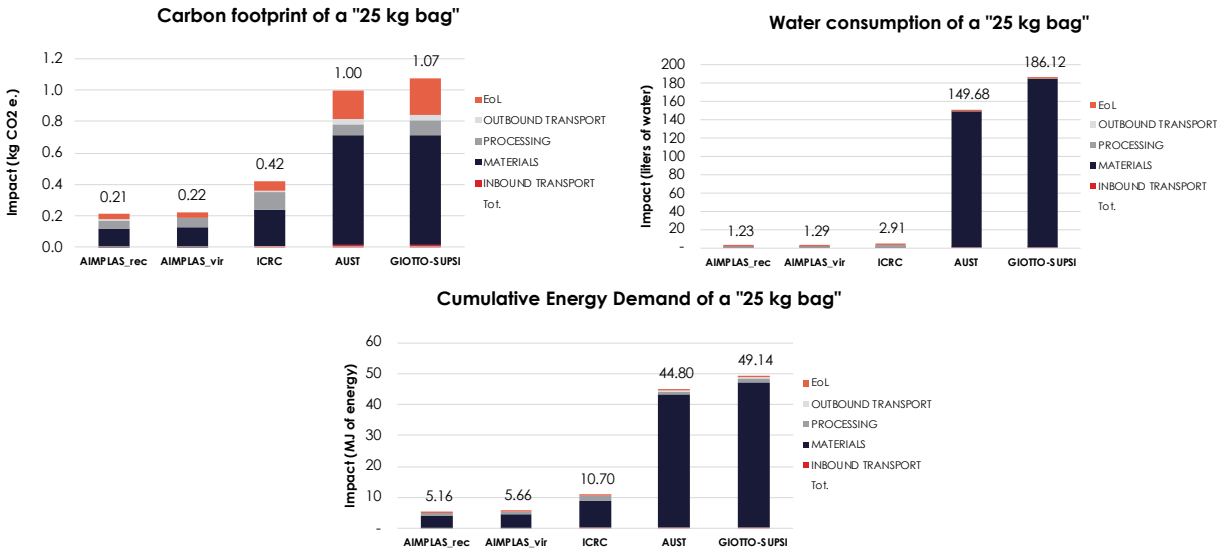
As noted in previous chapters solutions proposed by the three R&D organizations were compared through two means – an LCA and a Multicriterial Assessment. Both these assessments were expected to be carried out at the preparatory stage to direct the discussion towards the most relevant material options, and at the final stage following bag production and the field trials. While the former has been achieved and adequately prepared, the latter stage of the assessments was challenged by the significant delays in the production of the bags and the start of the field trials (please see the next chapter for more detail). Thus the LCA and MCA presented in this section show the comparison of the bags at the closure of the project and do not feature insights from the field. The MCA will be updated to reflect the field trials experience once the relevant information is received (likely mid 2024).

Final LCA

- The project was carried out using professional LCA calculation software (SimaPro) and drawing on a solid international database (Ecoinvent v.3). All alternative scenarios, once built, were analyzed using the following calculation methods:

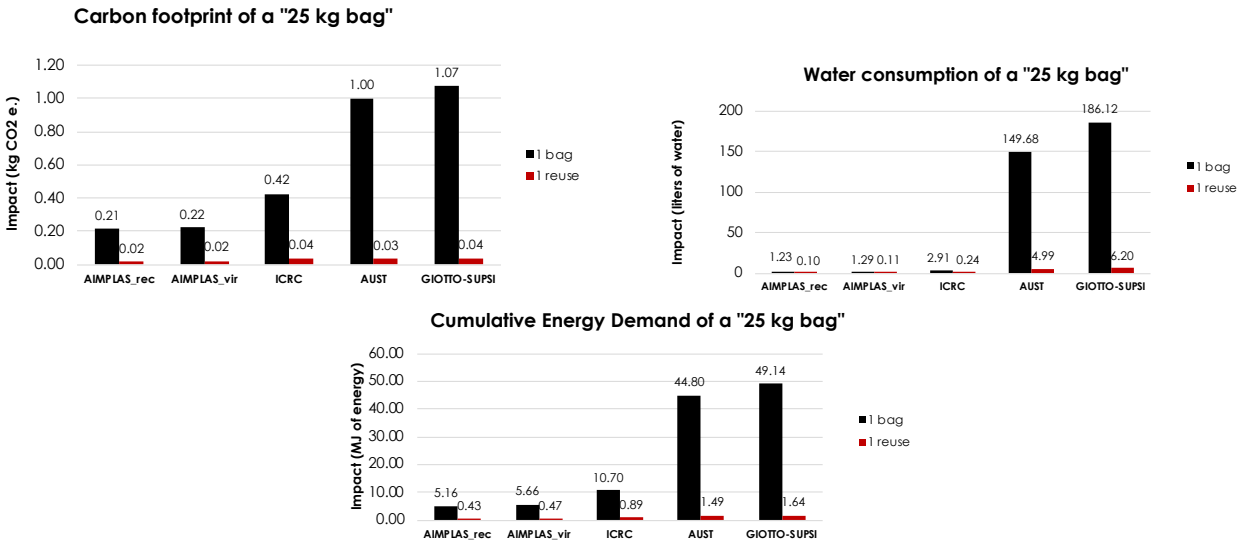
Impact	Name of the method in SimaPro	Details
Carbon footprint	IPCC 2021 GWP100	The method contains the Global Warming Potential (GWP) climate change factors of IPCC (Intergovernmental Panel on Climate Change), with a timeframe of 100 years.
Water consumption	ReCiPe 2016 Midpoint (H)	Water consumption is the use of water in such a way that the water is evaporated, incorporated into products, transferred to other watersheds or disposed into the sea.
Cumulative Energy Demand (CED)	Cumulative Energy Demand	The method accounts for all types of energy (fossil, nuclear, solar, etc.) consumed through the entire lifecycle of the product.

- Three types of bags/sheets were used for baseline, collected from frequent suppliers to each of the three partner organizations. These were, namely, Thread Poly for ICRC (25kg PP bag), Guler & Has for WFP (50kg PP bag), and Shree balaji & Nizam-Alpinter for UNHCR (PP bales made up of two sheets).
- The 4 new types of bags AIMPLAS_virgin; AIMPLAS_recycled; AUST; GIOTTO-SUPSI) were modeled by **complementing the available primary data with information from the "baseline bags"**.
- For all three impact types, similar results were observed:
  - the material always accounts for >50% of the total impact.
  - there is a direct correlation between the weight of the material and the environmental impact of the bag: the 2 jute bags (AUST and GIOTTO-SUPSI) have the highest impact, while the 2 AIMPLAS have the lowest.



- Since all bags are re-used extensively after being received, we also considered the impact of the reuse of bags:
  - Lifetime and Number of reuses were found to be the most relevant aspects for quantifying the real impact of bag alternatives (even more than weight!)

- the greater the number, the lower the impact: If jute bags have a longer lifetime and can be used a greater number of times than plastic bags, the impact of a single use can become competitive with that of plastic bags.



Additional details can be accessed in the LCA report developed for this project.

Project closure MCA

The following table shows the technical characteristics of the alternatives, as it stands in Feb 2024, awaiting inputs from the AUST bag:

Characteristic	**AIMPLAS virgin**	**AIMPLAS recyc**	**AUST**	**GIOTTO-SUPSI**
Main material	Polypropylene	Polypropylene	Jute	Jute
Maturity	Industrial batch	Industrial batch	Prototype	Fabric
Composition	Base fabric (70%): ISPLEN PP 040 Coating (30%): Homopolymer (ISPLEN PP 089): 76.9% AO1: 2.0% AO2: 1.0% UV stabilizer: 5.1% PE: 15%	Base fabric (70%): ISPLEN PP 040 Coating (30%): Homopolymer (ISPLEN PP 089): 59.5% Recycled PP: 39.6% AO1: 0.2% AO2: 0.2% UV stabilizer: 0.5%	Jute fibers – local Coating: Natural latex (89.7%) – local PVAc:7% Softener : 2% Benzoate: 1%, Ammonium Sulphate: 0.3%	Jute fibers - Bangladesh Layer by layer (for 1kg of jute) AgNO3 833 ng SiO2 0.833 g Polyacrylate 0.833 g
Weight (g/m2)	83	83	600	601 (jute = 600 g/m2)

Plastic leakage	Yes	Yes	?	No leakage
Lifetime	Like baseline	Decreased compared to baseline	Up to 5 years (tbc)	Up to 5 years (tbc)
WVTR (g/m2/d)	2.4	4.4	TBD	N/A
OTR (cm3/m2/d)	928	3058	TBD	N/A
Price	0.45 USD/50kgbag (vs 0.38)	?	0.57 USD/50kgbag (vs 0.38)	+ 0.16€/m2 vs reference (tbd)

The MCA of the alternative performance excluding field trials is given below:

Criteria	**AIMPLAS virgin**	**AIMPLAS recyc**	**AUST**	**GIOTTO-SUPSI**
Main material	Polypropylene	Polypropylene	Jute	Jute
Adequation with mechanical and physical specifications				
Food contact				
Plastic leakages				
CO_2 impact vs ref (production)				
Water impact vs ref (production)				
Reuse (lifetime)				
Recyclability				
Production capacity				

Time to market				
Price				

Legend:

Much better than baseline		***Same as baseline***			***Much worse than baseline***

5. Field Trials Phase

5.1 Implementing the field trials

The final phase of the project was to conduct three field trials – one with each partner organization – of the bags prototyped through the R&D phase, under real-life humanitarian conditions. The aim behind this phase was to analyze the suitability of the prototyped solutions to the humanitarian context, and to understand the key challenges and obstacles that may be faced in implementing a novel packaging solution in existing supply chains. For the field trials, the project team spent several months identifying the most feasible supply chains to consider, and coordinating/informing key stakeholders in the selected supply chains (such as suppliers who expressed interest in partnering for the field trials). The finalized supply chains where the field trials are being implemented are described in the image below:

	AIMPLAS		AUST
	LOT 1	LOT 2	LOT 4
ICRC	Field trial in Central Africa region (supplier & destination TBD). Regional HQ is coordinating printing and transport of bag samples regionally.	N/A	Field trial in Central Africa region (supplier & destination TBD). Regional HQ is coordinating printing and transport of bag samples regionally.
WFP	Field trial in Middle East. Bags will be sent to Doruk, Turkey, who will be printing on the bags and sending to a WFP warehouse	N/A	Field trial in Middle East. Bags have been sent to Doruk, Turkey, who will be printing on the bags and sending to a WFP warehouse
UNHCR	Global supply chain for field trial. sheets (not bags) will be sent to Shree Balaji Woolen Mills (SBWM), India who will be packing the bales and sending it to the UNHCR warehouse	Global supply chain for field trial. sheets (not bags) will be sent to Shree Balaji Woolen Mills (SBWM), India who will be packing the bales and sending it to the UNHCR warehouse	Global supply chain for field trial. sheets (not bags) will be sent to Shree Balaji Woolen Mills (SBWM), India who will be packing the bales and sending it to the UNHCR warehouse

The different types of bags/sheets being tested are described in the table below:

Organization	Field Trial - ICRC	Field Trial - WFP	Field Trial - UNHCR
AIMPLAS	1. Solution – extended life PP 2. Baseline – conventional PP bag from Raffia International	1. Solution – extended life PP 2. Baseline – conventional PP bag from Raffia International	1. Solution – extended life PP sheet 2. Solution – Recycled PP sheet 3. Baseline – conventional PP sheet from Raffia International
AUST	3. Solution – jute bag with biopolymer coating	3. Solution – jute bag with biopolymer coating	4. Solution – jute sheet with biopolymer coating
Partner supplier *(SBWM, Doruk & ICRC partner)*	4. Baseline – business as usual PP bag	4. Baseline – business as usual PP bag	5. Baseline – business as usual PP sheet

As it can be seen above, the total bag types being sent for field trials were 4 each for ICRC & WFP and 5 for UNHCR.

5.2 Adopting an agile approach to the field trials

As described in Chapter 3, rice (for ICRC & WFP) and blankets (for UNHCR) had been selected in the early days of the project to serve as the use cases for the various activities in the project. Over time, these use cases have evolved significantly, such that the actual field trials are now based in different geographies and/or are used for a different item.

The key reason behind these changes was the fast-evolving humanitarian ecosystem, where priorities were shifting in response to ongoing conflict in the different parts of the world. **We thus adopted an agile approach to the field trials** and re-calibrated as needed, in response to the trends being observed. For example, initially rice was a good candidate for the field trials due to its high consumption and demand globally, but as we moved closer to this final phase of the project, we observed that rice-based supply chains would not be compatible with the expectations from the field trials. In general, the following trends were observed to affect the planning of the Field Trials:

- The extension in project timelines meant that the activities envisaged for a particular time of the year had now shifted by several months.
- There was a downward trend in demand for some items like rice in some of the geographies that had been previously considered.
- In typical procurement processes, the packaging is often provided by the supplier who may be procuring it from elsewhere. In some cases, suppliers showed low interest in the supporting the project and/or would face challenges in working with bags coming from a different source (for example, they may not have printing facilities if they were procuring from another company).
- The project team preferred working in contexts where visibility on the field trial would be greater.

- The steering committee had also expressed interest in conducting the field trials in "challenging" contexts – to see how well the solutions developed fare in the toughest humanitarian contexts.

The table below presents a comparison of the field trials originally planned (January 2023) to the ones actually implemented (August 2023 onwards), illustrating the agile approach followed for the project.

Partner organization	Field trials original plan (Jan 2023)	Field trials actual implementation (as of Nov 2023)
ICRC	**Item packaged:** Rice **Destination:** Syria **Size of bags:** 25kg **Number of bags:** 1000 **Partner Supplier:** Staple Foods, Pakistan **Warehouse:** Bangui, Central African Republic	**Item packaged:** Beans **Destination:** Central African Republic **Size of bags:** 25kg **Number of bags:** 1000 **Partner Supplier:** *To be decided* **Warehouse:** *To be decided*
WFP	**Item packaged:** Wheat Flour **Destination:** *To be decided* **Size of bags:** 50kg **Number of bags:** 10,000 **Partner Supplier:** Doruk, Turkey **Warehouse:** Afghanistan	**Item packaged:** Wheat Flour **Destination:** *To be decided* **Size of bags:** 50kg **Number of bags:** 500 **Partner Supplier:** Doruk, Turkey **Warehouse:** *To be decided*
UNHCR	**Item packaged:** Blankets **Destination:** *To be decided* **Size of sheets:** *To be decided* **Number of sheets:** *To be decided* **Partner Supplier:** *To be decided* **Warehouse:** *To be decided*	**Item packaged:** Blankets **Destination:** *To be decided* **Size of sheets:** 132cm x 132cm **Number of sheets:** 264 **Partner Supplier:** Shree Balaji Woollen Mills, India **Warehouse:** *To be decided*

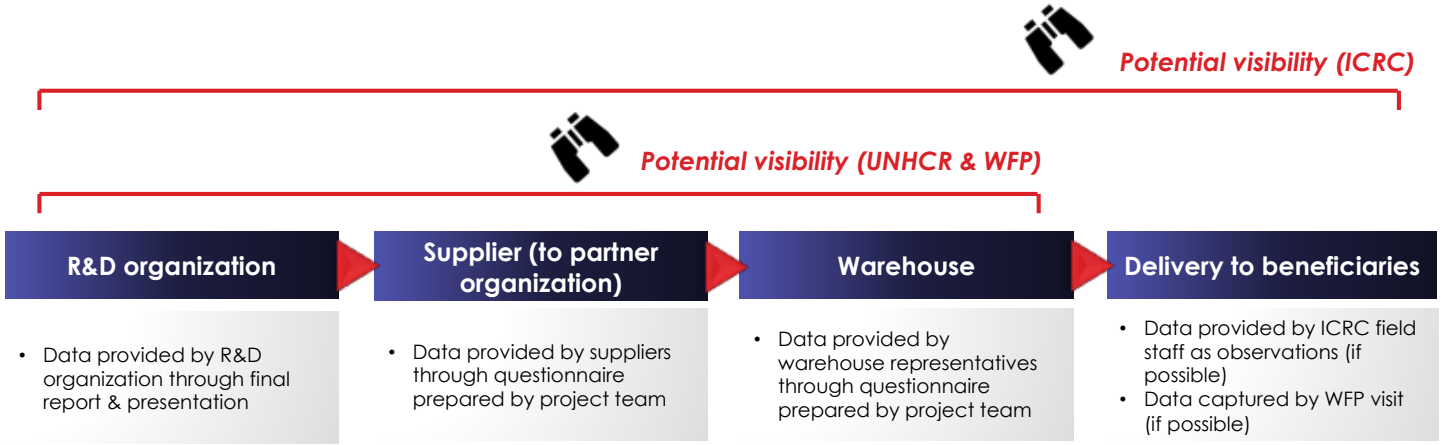
The various "to be decided" data points in the third column also show how changeable the situation has been (and continues to be) throughout the field trials planning process. It is possible that one or more of these trials extend beyond the project timeline, as their continuation is dependent on the procurement priorities in each of the contexts.

5.3 Tracking and data collection through the field trials

The aim of the field trials is to collect data on how well the PP alternatives developed during the project perform in actual humanitarian contexts, especially with regards to the functional and desirable traits defined in chapter 3. It is thus important to have a robust methodology in place to capture relevant information. The following steps were adopted to ensure good quality data collection:

- **Identification of data sources through the supply chain:** Capturing experience from the field would be ideal since the aim of the project is to reduce environmental impact of packaging bags without compromising on their social value. However, apart from ICRC, the likelihood of visibility on the supply chain beyond regional warehouses is low, since both WFO & UNHCR work with several local NGOs or corporate partners.

- **Providing adequate "control" samples:** For each field trial, the partner suppliers have been asked to provide samples of bags they typically use under the same context/shipment so that the performance of the solution bags can be compared to the business as usual. Moreover, the suppliers have also sent their bags to dss+ for testing alongside the solution prototypes. In case of AIMPLAS, they have also provided samples from their Industrial partner (Raffia International) alongside the solution bags.
- **Create awareness of the project, its objectives, and key responsibilities among supply chain stakeholders:** the project team has organized various informative sessions with stakeholders in the partner organizations as well as suppliers to help them understand the project and what they would be required to do. These sessions will also be planned with stakeholders further in the supply chain (such as warehouse managers) once they are identified *(please see next section for more information regarding the status of the field trials)*.
- **Preparing easy-to-follow questionnaires for the different steps in the supply chain:** dss+ has developed simple Excel-based questionnaires for the different supply chain actors (mainly the partner suppliers and warehouse managers) where they can share their experience of storing, filling, sewing, printing on the bags, loading/unloading, etc. They have also been encouraged to provide pictures or videos as well.
- **Actively following up with key supply chain actors to ensure latest information or update is available**: The dss+ team actively communicates with the partner organizations, suppliers, etc., to keep abreast of the situation and ensure any unexpected development is addressed as soon as possible.
- **Providing clear identifiers & markers on bags for field trials**: since there are multiple bag types being studied alongside their BAU counterparts, it is important to be able to distinguish between the different bag types. The project team worked with AIMPLAS to provide unique alphabetic codes to each bag type (including samples from Raffia).



5.4 Status of field trials as of February 2024

Production and dispatch of bags for field trials

- AIMPLAS was able to carry out industrial production of bags (and sheets for UNHCR), by June-July 2023, however AUST had requested for more time to complete the project steps and engage with the industry partners. Due to this, it was decided that the field

trials for the two R&D organizations would be done independently of each other, as and when the bags were ready.

- The bags are being picked up by the ICRC logistics team and delivered to the suppliers (in case of WFP and UNHCR) and regional office (in case of the ICRC).
- This step has already been completed for AIMPLAS in Sept/Oct 2023.
- During the shipment process for AIMPLAS, the project team faced significant delays in delivering to Doruk in Turkey because EU & Turkey have a bilateral trade agreement which requires specific documentation declaring the shipment origin to be from EU (or Turkey), for the shipment to benefit from lower customs tax. The preparation of this document and its physical dispatch to Turkey required several weeks[3] and only then the shipment was released from the holding warehouse at the port of arrival.
- In comparison, the delivery for India & Cameroon did not face any challenges.
- As of January 2024, AUST is yet to begin industrial production due to political unrest and nationwide strikes in Bangladesh.

R&D organization	Supplier (to partner organization)	Warehouse	Delivery to beneficiaries
• AIMPLAS & AUST are working with industrial partners to manufacture about 1000 bags/ 264 sheets for each solution prototype • AIMPLAS has produced two bag types (extended life and recycled PP) & sent it along with a conventional PP bag sample. The rPP option will only be used for the non-food (UNHCR) field trial • AUST has prototyped three types of bags but is yet to begin production (as of Nov 2023)	• Suppliers for the UNHCR (Shree Balaji Woolen Mills (SBWM)) and WFP (Doruk) trials have been identified For ICRC the supplier will be identified based on future demand for beans in the region. • Both SBWM and Doruk have been provided details of the different bag samples and a questionnaire to capture their experience of filling new bags in comparison to their typical bags • AIMPLAS bags have reached SBWM and Doruk, and the regional office of ICRC at Cameroon	• The regional warehouses for the partner organizations will be the last point in the supply chain where direct information on the bags can be captured (for WFP and UNHCR) As of Feb 2024, we do not have visibility on which warehouses the bags will go to after being packed, since we are still awaiting purchase orders for each field trials (in case of AIMPLAS bags) and production of bags (in case of AUST)	• In case of ICRC, they handle supply as well so they may be able to capture information from this stage. However, this is not confirmed and will depend on the supply chain followed going forward • In case of WFP and UNHCR this stage is unlikely to be covered in the data gathering process

Packing and dispatch from the suppliers

- In case of Shree Balaji Woollen Mills (SBWM), the sheets from AIMPLAS have been received and used to pack blankets as expected. SBWM has also submitted the filled questionnaire along with videos of packing. The packed pallets are currently at the SBWM warehouse and awaiting a work order from UNHCR to be dispatched. The next destination for the pallets (i.e. the UNHCR warehouse) yet to be determined.
- In case of Doruk, the bags were received in early November 2023. As of now they have not been unpacked or filled by the supplier as currently there are no purchase orders from WFP than require 50 kg bags. The finalization of the item type (whether wheat flour or something else) and subsequent steps (warehouse, beneficiaries) is awaited.
- In case of ICRC's field trial, the situation is a little more complicated. The local suppliers were collectives and may not have the knowledge and facilities required to print and pack the bags. The bags have been delivered to the ICRC regional headquarters in

[3] The issue was notified on 31 August 2023. The bags were permitted entry and delivered to Doruk on 01 November 2023

Cameroon. A short-term procurement is currently being undertaken in the region, and field tests are going to be followed soon by ICRC

6. Conclusion and lessons learnt

This multi-year, multi-stakeholder project with a potential to impact millions of tonnes in essential goods and similar figures in beneficiaries, has been a significant and transformative learning experience for all stakeholders involved. While at the close of the project we are not able to definitively recommend one solution (due to lack of evidence from the field), the preliminary results show clear differences between the solutions developed under the purview of this project. The **AUST jute-based alternative** is not a viable alternative at this stage, mostly because of the weight of the alternative, the proportion of coating including partially fossil-based plastics, the much higher price compared to baseline, and the current production constraints. Meanwhile, the **AIMPLAS PP-based alternatives** were found to perform below the expectations set at the start of the project as the lifetime of these bags is comparable or even lower than the baseline when starting the project a few months ago. The alternative using partially pre-consumer recycled PP is not readily viable because the recycled PP feedstock is not easily accessible, and the results of ageing tests were not good enough. The bi-layer extended life virgin PP or sheets are still viable options but require further investigations, particularly regarding the ageing ability versus level of additives and type of virgin PP. The **Giotto-SUPSI jute-based alternative** is currently the most viable non-plastic alternative, however it should be remembered that this solution requires further investigations to check the prototype's behaviour, industrial scalability, lifetime in field conditions, beneficiaries' acceptance, and reusability potential, since these were not covered during the project. The weight of the Giotto-SUPSI bag can also be optimised. In case the reusability and acceptance are high, this option becomes very interesting, particularly from a social and environmental perspectives.

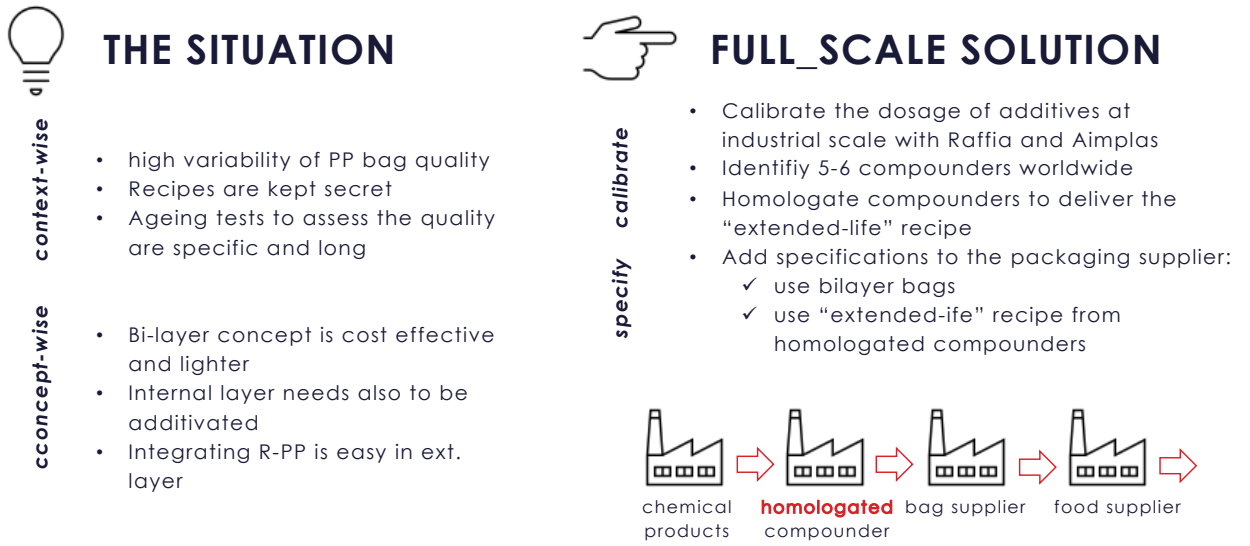
Additionally, the project has highlighted the operational complexities of the humanitarian sector which would need to be kept in mind while implementing any innovations within the sector. The key complexity to consider is the feasibility of the solutions in the global context – in other words, even if a perfect solution is found, how should it be implemented? There are several scenarios possible, some of which include:

- An exclusive contract with a secret or patented design – this severely limits the accessibility to the product, which can be a huge obstacle for high-volume and high-demand items like PP bags.
- A recommendation of bag design that goes into the procurement process – in this case, the specific design of the bag is shared as a part of the ToR – for example, the raw material to be used, the additives and their concentration, the production process, etc. – in this case, the limitation may exist at the suppliers' side to meet these stringent requirements. Indeed, given the type of innovations discussed in this project, it may not be easy to find bag producers that are able to produce bags to the required specifications while remaining competitive.
- A more stringent set of performance standards – her, rather than the bag specifications/"recipe", we recommend a series of performance standards that would need to be met by the bags procured. For example, for a longer lifetime, we can specify what UV test to meet and for how many hours. Similarly other desired performance requirements can be defined as standards including stack-ability, reusability, weight, etc.

Another complexity to consider is the scale at which the solution could be operationalized. Initial expectations from the project were to derive a global solution that could be applied across regional and local contexts, however we now also see the value addition of adopting region specific solutions. For example, in and around South/South East Asia jute could be a viable solution for short distances, due to the significant local manufacturing capability.

Various learnings from the project experience also show significant space and scope for additional research and scale. Namely, the AIMPLAS solutions can be improved with a full-scale study on increasing the lifetime of the bags through a collaborative project with existing network partners of the humanitarian organizations (compounders).

Further investigation of AIMPLAS solution: increased life-time of PP bags



Similarly, as presented already, there is an opportunity to scale the Giotto-SUPSI solution to an industrial scale and launch a field trial.

In conclusion, despite the delays and a 'mixed bag' of positive and negative results from the project, this multi-year effort has amassed a number of learnings that can and should be disseminated across the innovation and humanitarian spaces alike, to advice and educate further projects undertaking similar endeavours.

About dss+

dss+ is a leading provider of operations management consulting services with a purpose of saving lives and creating a sustainable future. dss+ enables companies to build organisational and human capabilities, manage risk, improve operations, achieve sustainability goals and operate more responsibly.

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