Recycling Technologies in Textile Industry

Promotion for Sustainability in the Textile and Garment Industry in Asia-FABRIC

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Recycling Technologies in Textile Industry

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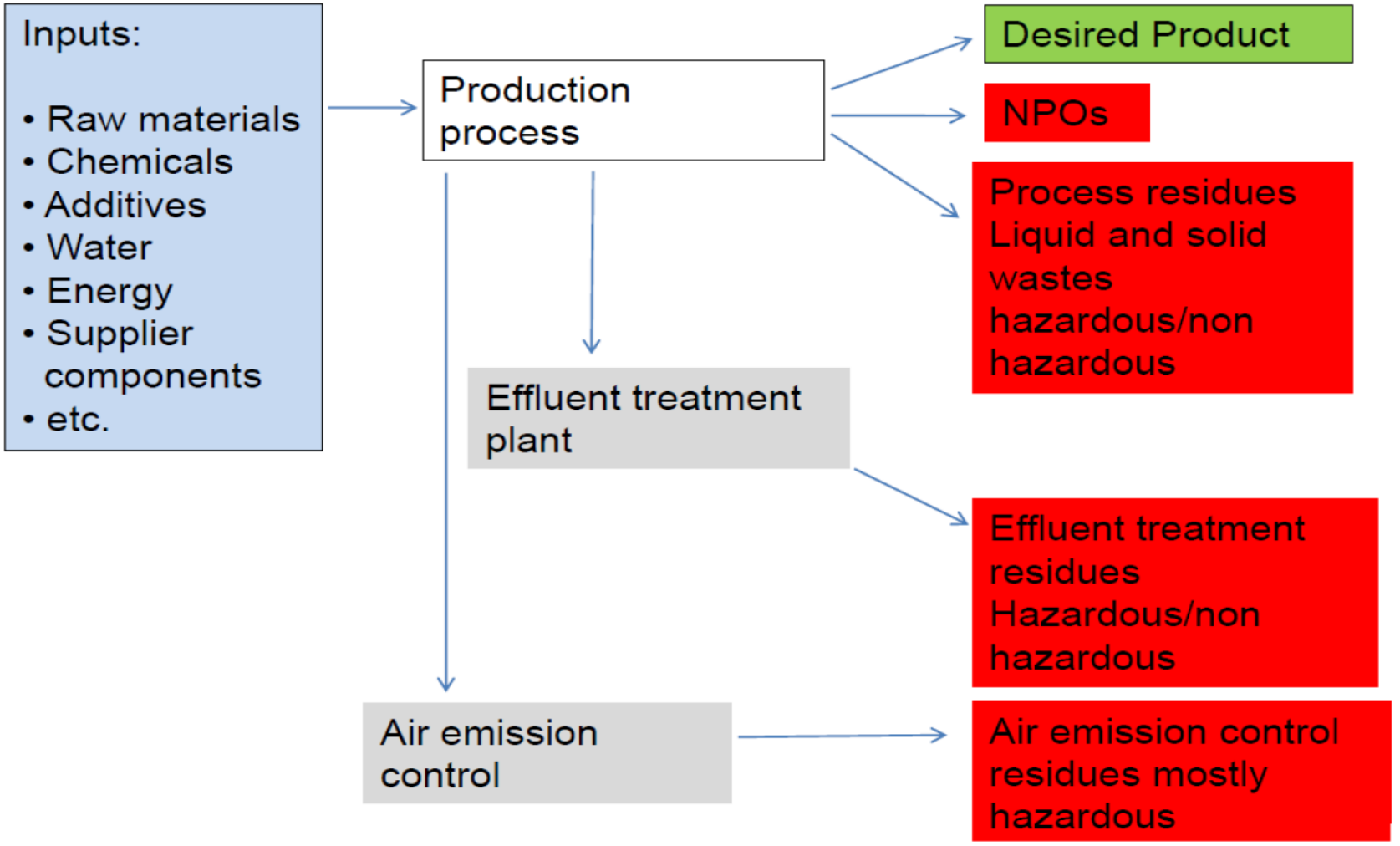
Outline

- Sources of miscellaneous solid wastes in textile processing.
- Categorisation of miscellaneous solid wastes: packaging materials, empty chemical containers, plastic wastes and other disposables including personal protective equipment, preventive healthcare wastes such as masks.
- Production wastes from manufacturing - dyeing factories & garment manufacturing.
- Steps to prevent, reduce & recycle miscellaneous solid wastes.
- Drawing suitable guidelines.

Possible Sources of Waste



Waste vs Hazardous waste

Solid waste represents pollution and unnecessary waste of resources, and hazardous waste contributes to pollution, natural capital degradation, health problems, and premature deaths.

We Throw Away Huge Amounts of Useful Things and Hazardous Materials

- Solid waste
  - Industrial solid
  - Municipal solid waste (MSW)
  - Hazardous, toxic, waste

- Hazardous wastes
  - Organic compounds
  - Toxic heavy metals
  - Radioactive waste

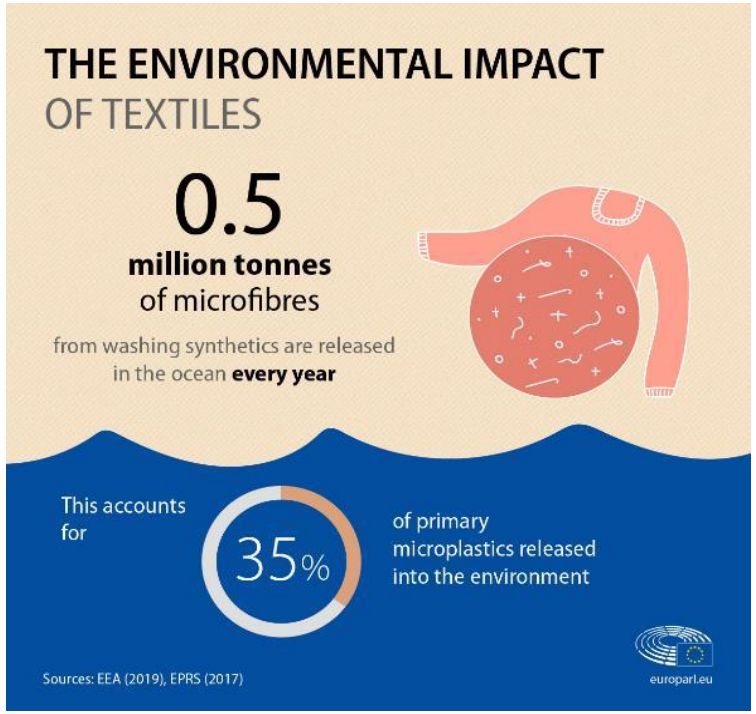
Solid Waste in Textile factories

Baseline investigations can distinguish major waste fraction like:

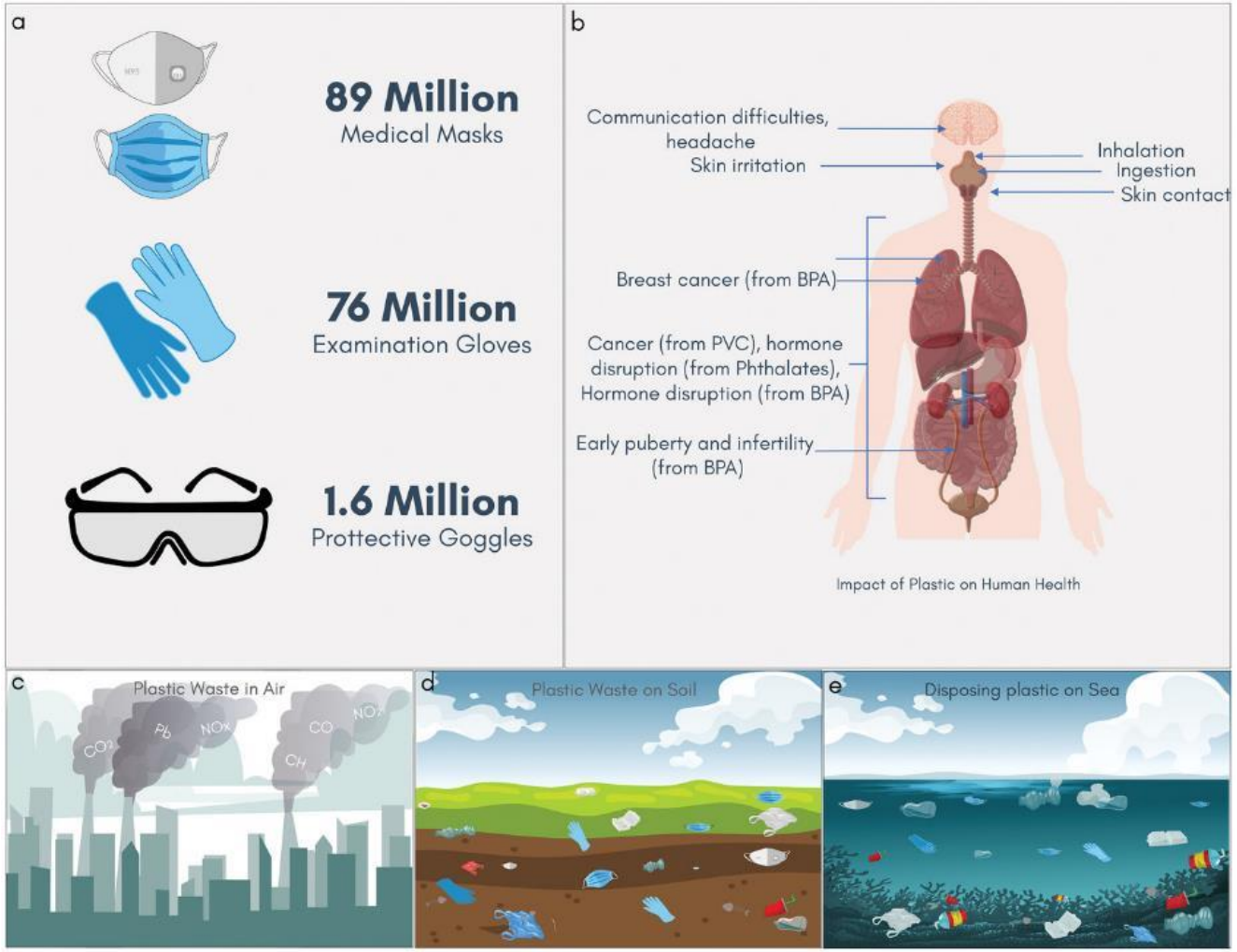
- Fabric waste
- Residual plastics
- Paper
- Cardboard
- Leather scrap
- Empty chemical containers
- Polystyrene
- Metal scrap
- Organic waste
- Electric and electronic waste
- Sewage treatment sludge
- Others

The UN Economic Commission for Europe (UNECE) identified the textiles industry as a significant contributor to plastic entering the ocean.

Textile wastes account for almost 5% of all landfill spaces, according to the US Environmental Protection Agency (USEPA); however, the recycled postconsumer textile wastes are barely 15% annually, and thus, a huge 85% of the waste ends up in landfills.



Source: Vadicherla T, Saravanan D. 10.1007/978-981-287-065-0_5



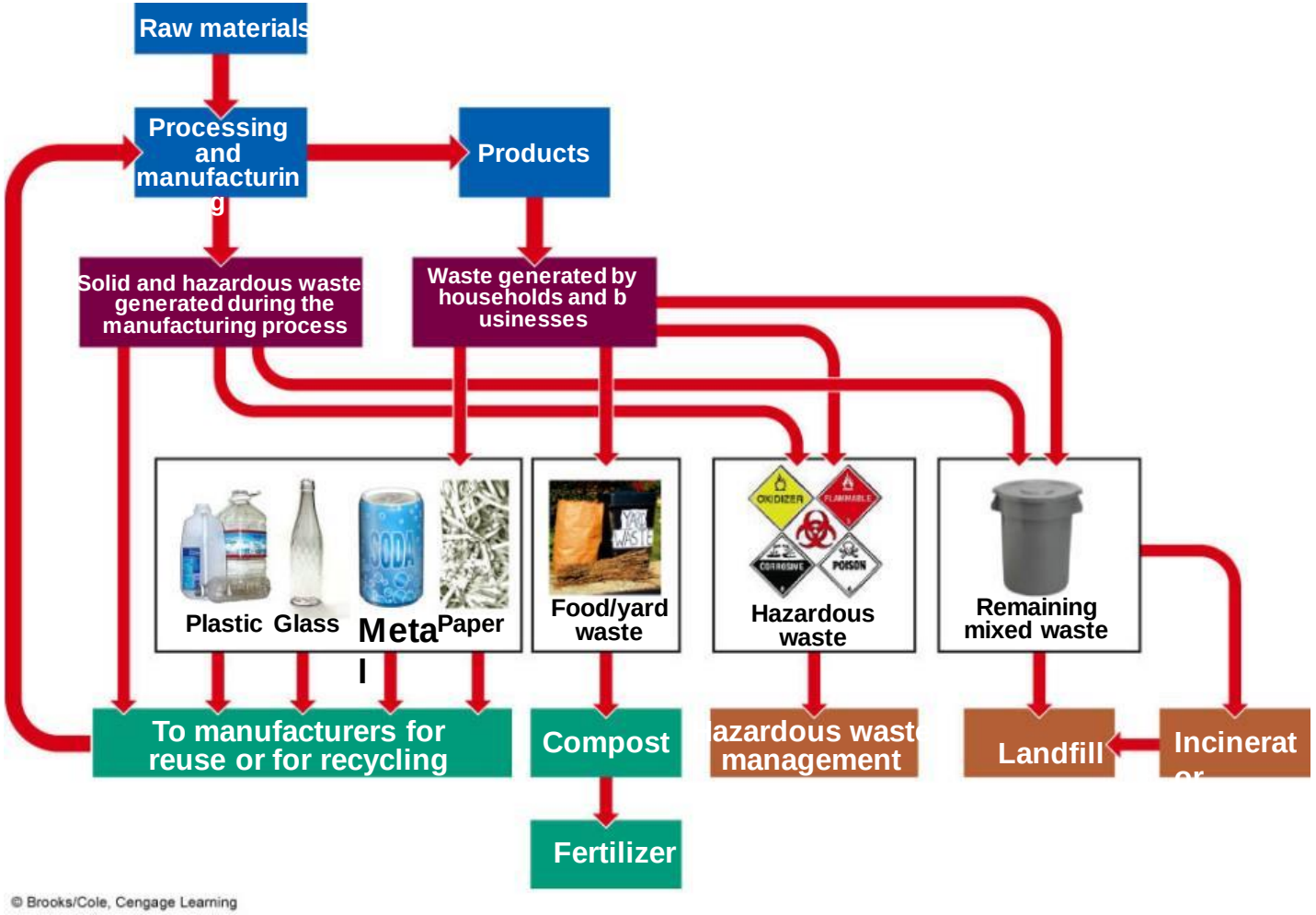
Uddin, M.A., Afroj, S., Hasan, T., Carr, C., Novoselov, K.S. and Karim, N., 2022. Environmental Impacts of Personal Protective Clothing Used to Combat COVID-19. Advanced Sustainable Systems, 6(1), p.2100176.

How Should We Deal with Solid Waste?

A sustainable approach to solid waste is first to reduce it, then to reuse or recycle it, and finally to safely dispose of what is left.

Integrated Waste Management: Priorities for Dealing with Solid Waste

Integrated Waste Management



Questions

Question 1**:** What happens to the solid waste you produce?

Question 2: How much value is lost in material waste in textile production chain?

Approximately 0.70 USD is lost for every piece of apparel export.

Source: Maeen Md Khairul Akter, Upama Nasrin Haq, Md Mazedul Islam, Mohammad Abbas Uddin, Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh, Cleaner Environmental Systems, 10.1016/j.cesys.2022.100070, (100070), (2022).

Material waste from textile-apparel production chain.

Industry	Raw Materials	Material Waste
Spinning	Cotton and other natural fibres, synthetic fibres	Cotton lint, damaged yarn, unfinished cones
Knitting/ weaving	Natural and synthetic yarn	Fly fibre, scrap yarn, greige/unfinished fabric
Wet processing	Greige/unfinished fabric	Rejected coloured fabric, excess finished fabric
Apparel	Finished fabric	Fabric cut pieces (cutting waste), excess development samples, excess apparel

Maeen Md Khairul Akter, Upama Nasrin Haq, Md Mazedul Islam, Mohammad Abbas Uddin, Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh, Cleaner Environmental Systems, 10.1016/j.cesys.2022.100070, (100070), (2022).

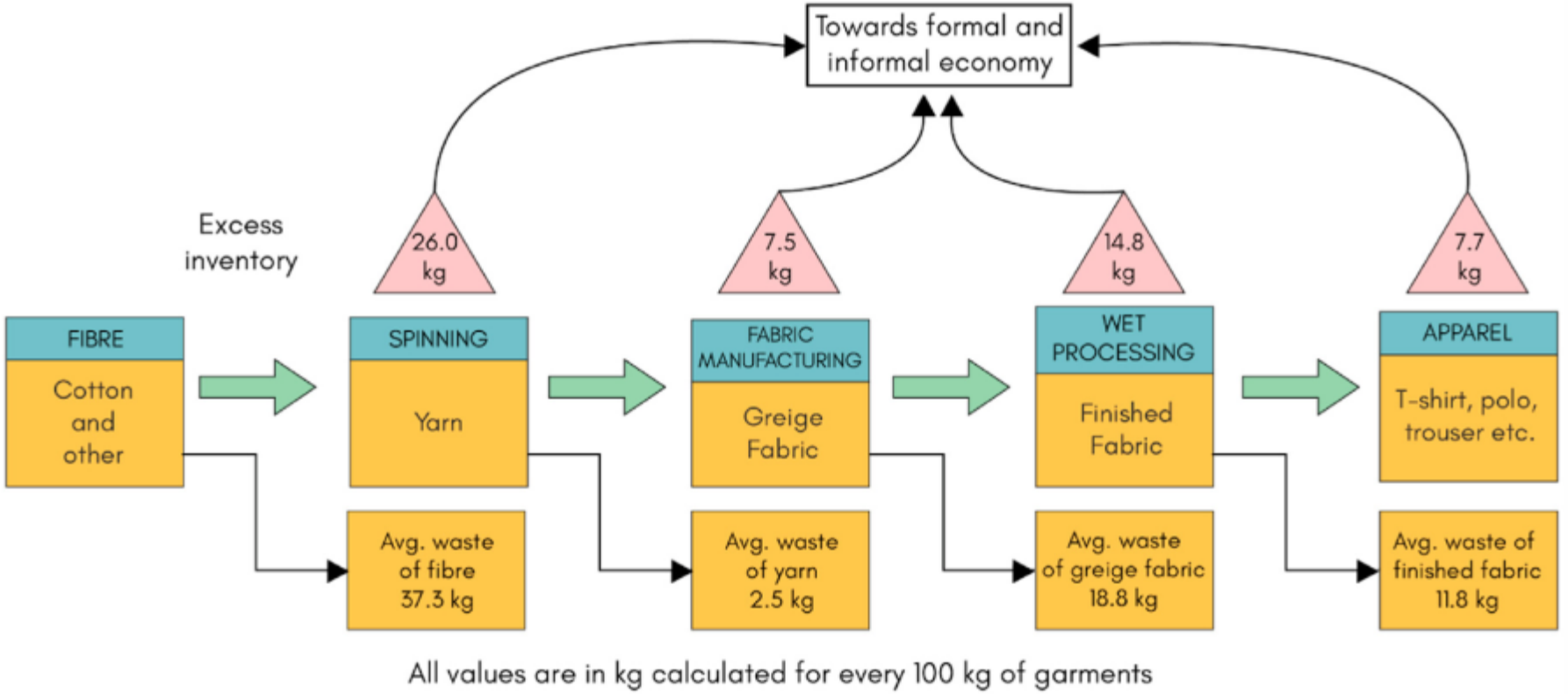


Fig. 4. Amount of material lost in the textile-apparel production chain.

Maeen Md Khairul Akter, Upama Nasrin Haq, Md Mazedul Islam, Mohammad Abbas Uddin, Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh, Cleaner Environmental Systems, 10.1016/j.cesys.2022.100070, (100070), (2022).

Group Exercise

What will be the Practical action to reduce solid waste in the context of Textile and RMG industry of Bangladesh?

Group A – Packaging

Group B – Paper and accessories

Group C – Dyed Fabric in Dyeing

Group D – Excess garment production

Time 5 minutes. Present your argument by Group representative

Who is concerned about waste management?

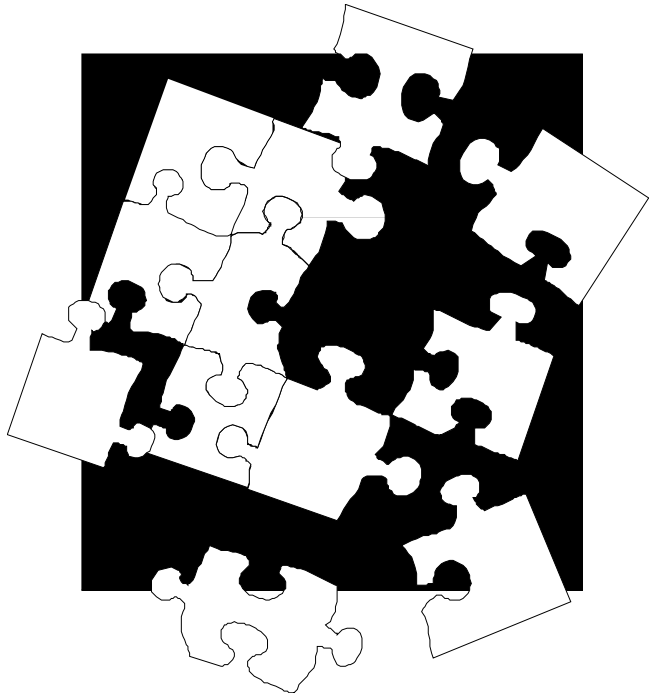
Key stakeholders include:

- waste generators
- waste disposal workers including those handling and transporting waste
- industrial development agencies and institutions
- environmental protection agencies
- neighbours of waste facilities
- ordinary citizens everywhere

Difficulties

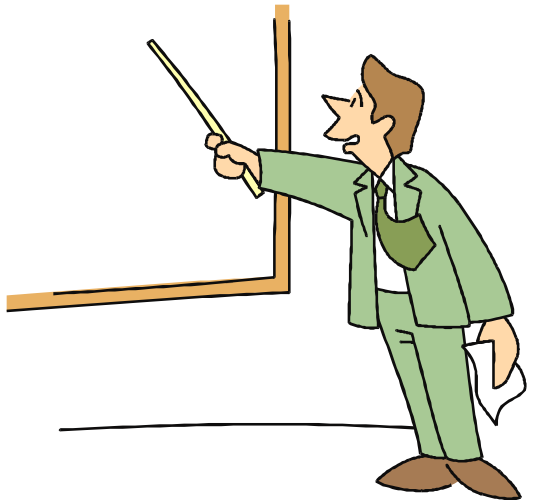
Need to fit the pieces together:

- basic information
- development
- implementation
- enforcement
- communication and training



Resources needed

- Financial investment
- Technical assistance
- Training for personnel
- Public information and communication with industry



Questions for you

- Differentiate between waste and hazardous waste
- How much solid waste is generated in typical garment and textile factory?
- How empty chemical container should be disposed off?

Annual costs

globally, the annual cost to consumers of throwing out clothing that they could continue to wear is estimated at **$460 billion**

Circular Economy as a paradigm shift

Linear	Circular
Raw materials & waste	Raw materials only
Competition	Collaboration
Individuals	Ecosystem
Do less bad	Do good and positive
Added value	Shared value
Standardised production	Local and adapted production
Downcycling	Upcycling

Circular economy model

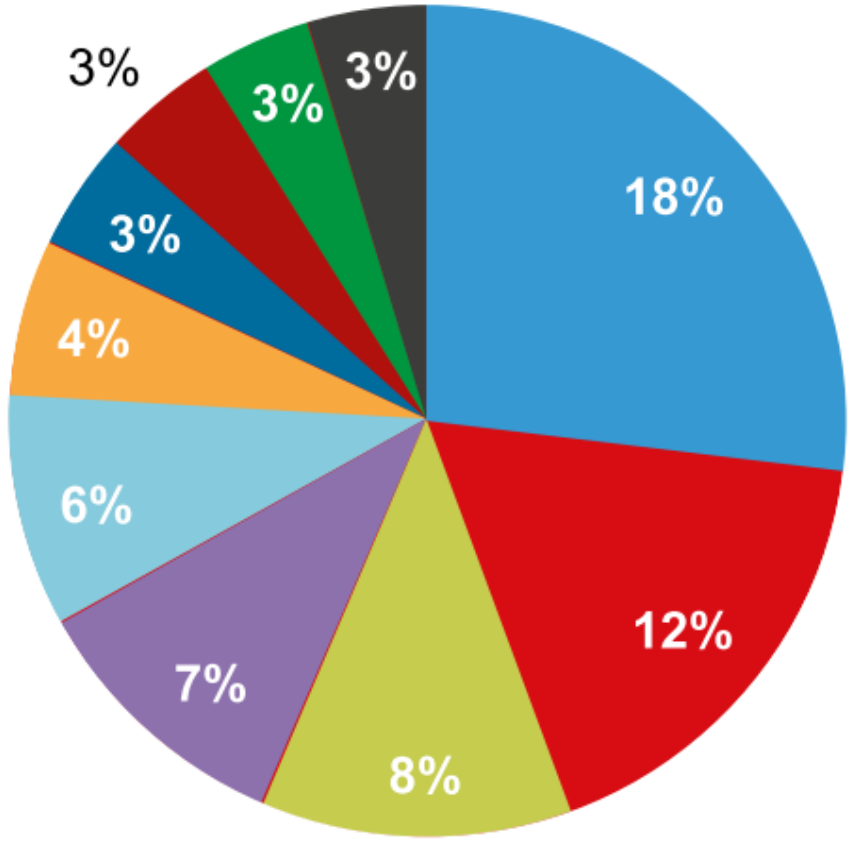
The 4Rs

- Re-design
- Reduce
- Reuse
- Recycle

Seven strategies:

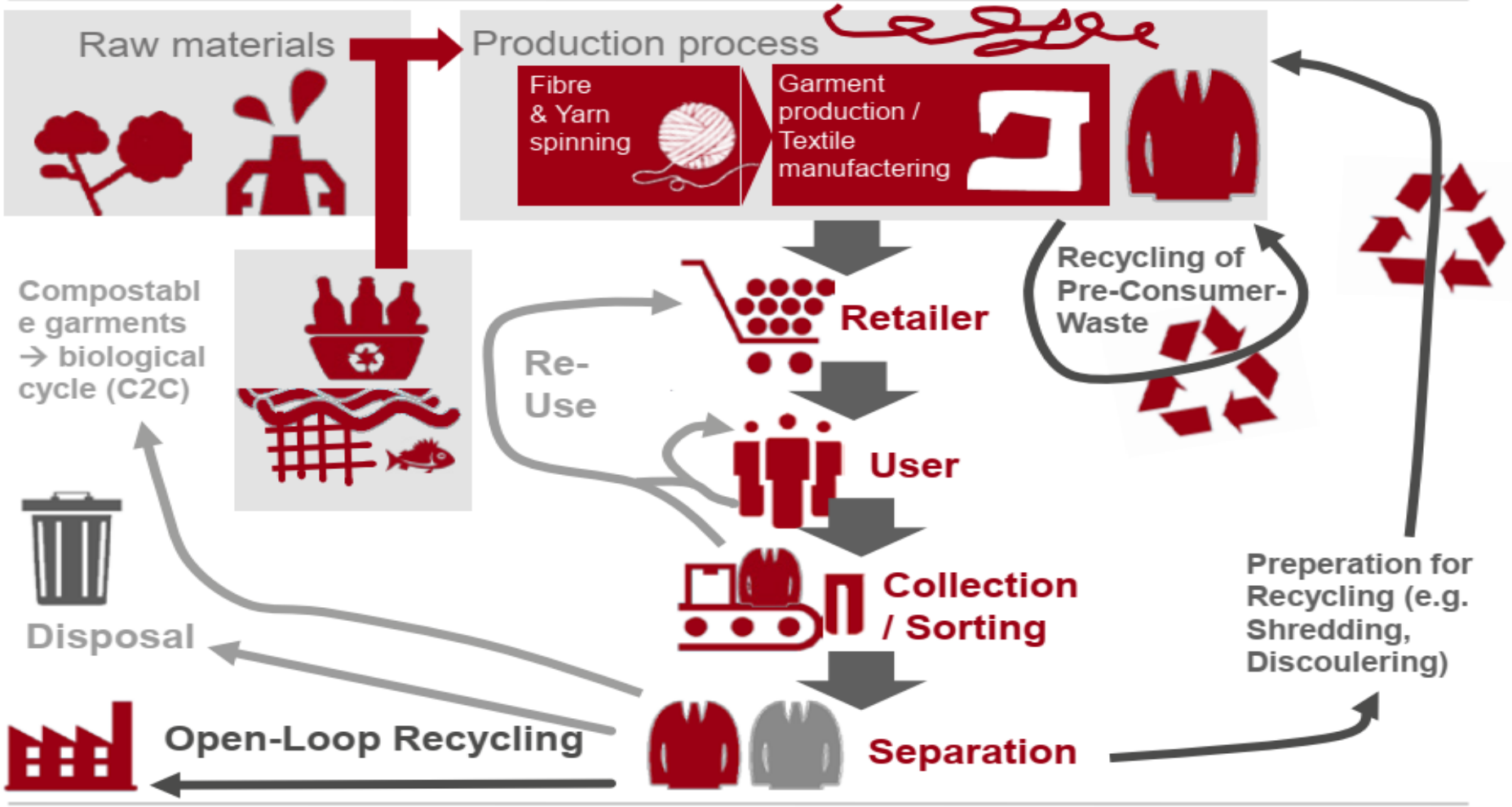
1. Redesign manufacturing processes and products to use less material and energy
2. Redesign manufacturing processes to produce less waste and pollution
3. Develop products that are easy to repair, reuse, remanufacture, compost, or recycle
4. Eliminate or reduce unnecessary packaging
5. Use fee-per-bag waste collection systems
6. Establish cradle-to grave responsibility
7. Restructure urban transportation systems

Top ten exporters of used textiles (share of total mass exported globally)



(adapted from WRAP 2016)

Textile recycling at a glance



Textile recycling approaches as well as technologies and their integration into product life cycle (own depiction based on Ellen MacArthur Foundation 2017a, Greenblue 2017, Norden 2014, Norden 2017, Re:newcell 2018)

Solutions and best practices

Maeen Md Khairul Akter, Upama Nasrin Haq, Md Mazedul Islam, Mohammad Abbas Uddin, Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh, Cleaner Environmental Systems, 10.1016/j.cesys.2022.100070, (100070), (2022).

Recycling technologies

- Chemical recycling
- Mechanical recycling

Innovative closed-loop recycling technologies

- Infinited Fiber (Relooping Fashion Initiative)
- re:newcell pulp
- Refibra (Lenzing)
- Innovative chemical polymer recycling (Worn Again/HKRITA/Evrnu)

Infinited Fiber (Relooping Fashion Initiative)

The “infinited fiber” is a recycled fibre produced from cotton rich textile waste and other biomaterials like wood. As the name suggest the fibre can be recycled theoretically infinitely.

The process was developed by the VTT Technical Research Center of Finland and the Infinited Fiber Company which got established in this context. A carbamate cellulose dissolution technique constitutes the centrepiece of the process and common methods from the pulp industry are utilised to remove polyester residues from the cotton (EurekAlert! 2017).

As no downgrading takes place during this process, the fibre has the same quality as a typical viscose fibre. Additionally, environmental benefits in comparison to viscose manufacturing exist. For instance, one third less CO2-equivalents and 98% less water are needed and harmful chemicals like carbon disulphide can be avoided.

According to details provided by the developer, the technology should be 20 to 40% more economical than competing solutions. Currently testing on industrial scale takes place while the process is being further refined for large-scale industrial production (The Infinited Fiber Company 2018).

re:newcell pulp

The re:newcell pulp was developed at the Royal Institute of Technology in Stockholm. SKS Textile and H&M are partners of the company re:newcell which was founded for commercialisation of this technology. Since 2017, it is engaged with the operation of the first demonstration plant opened in Sweden. In the re:newcell process post-consumer garments are shredded and a chemical solvent breaks down the pieces to molecular level, thus producing a recycled dissolving pulp and in a further step a viscose fibre (Norden 2014).

No harmful chemicals are needed in the process (Launch 2017) and the produced fibre has at least the same quality of a virgin fibre. In case of pure cotton, no addition of virgin fibre is necessary and 100 percent recycling can be achieved.
The output fibres are biodegradable and in general the recycling process is more environmental-friendly than wood processing (personal communication 2018). According to interviewed experts, the process is still energy intensive due to the drying process but does not exceed the energy demand of conventional viscose production.
Although the fibre quality is very high, certain characteristics of end-products compared to virgin materials may lead to issues in further processing steps. The current annual capacity of the demonstration plant is 7,000 tons, with a full-scale plant being planned to produce 30,000 tons of re:newcell pulp per year. The small scale of the current plant leads to high costs but in a larger scale cost advantages are expected to be achieved because the input material is mostly free of charge.

Refibra (Lenzing)

The Austrian company Lenzing uses undyed cotton pre-consumer waste as input replacing part of the wood as raw material in pulp fibre production to integrate recycling material in the company's conventional Lyocell production process. The resulting Refibra fibre is used by companies, for example, Patagonia.

According to expert interviews, the fibre quality is the same as for raw material from wood if undyed, homogenous pre-consumer waste is used (personal communication 2018). Additionally, a life cycle assessment (LCA) conducted by the company showed that Refibra entails significant environmental benefits compared to a conventional viscose fibre. However, up to now, just 20% recycled content is possible in Refibra fibres.

Considering that Refibra fibre is mainly used in addition to virgin cotton (e.g. 20% Refibra content in jeans), the actual content of recycled fibres is even lower. Moreover, costs are higher than using wood as raw material. Research is conducted in order to increase the recycled content and on the utilization of post-consumer waste which is stated as a long-term goal by Lenzing (ibid.).

Innovative chemical polymer recycling (Worn Again/HKRITA/Evrnu)

An innovative chemical polymer recycling approach for synthetic as well as natural fibres (namely polyester and cotton) has been developed by Worn Again. The company is working together with brands and retailers such as H&M and Puma.

The first step in the process is the separation and recapturing of polyester and cotton followed by different processing approaches depending on the fibre type. Polyester is dissolved, embedded contaminants are extracted and a resin as the intermediate product is produced. The resin is then processed into a polymer and converted into virgin equivalent polyester. According to interviews, the innovative aspect of the process is that polyester is not depolymerized into monomers but recaptured directly, thus leading to energy savings in comparison to other recycling technologies (personal communication 2018). However, energy consumption is still comparatively high.

In the case of cotton, dissolving takes places accompanied by the decoupling of dyes as well as contaminants and is followed by separation to produce a pulp, which is equivalent to viscose. 20% of impurities can be filtered out and a broad range of inputs is possible as pure and blended materials can be used (Greenblue 2017). The process is currently costly but the goal is to compete with virgin material in terms of price. One potential social benefits of commercialisation is that the establishment of chemical recycling plants in Europe could boost job generation.

Another approach of textile-to-textile recycling was developed by H&M at the Hong Kong Research Institute of Textiles and Apparel (HKRITA). The process is comparatively well developed and currently applied in a pre-industrialised plant opened in Hong Kong in September 2018. Based on chemical and hydrothermal treatment under pressure this approach is also able to recycle cotton and polyester blends into new fabric and yarns (H&M Foundation 2018). However, cotton which is processed to cellulose powders is not used for new garments in a closed loop but functional products like super-absorbency materials. A biodegradable green chemical is utilized but energy consumption is quite high due to generated heat and pressure.

Sorting technologies

- Fibersort
- SIPTex
- Textiles4Textiles

Fibersort

Circle Economy, a Dutch social cooperative enterprise, developed the so-called Fibersort technology together with collectors, sorters and recycling experts (Ellen MacArthur Foundation 2017a).

Fibersort is an automatic sorting system of mixed post-consumer textiles (simultaneously by colour and fibre type) using near infrared spectroscopy (NIRS) which allows the detection of garments from cotton, wool, viscose, polyester, acrylic and nylon (Ellen MacArthur Foundation 2017a).

The sorted fibres have a low level of contamination and can serve as mono-fibre inputs in mechanical as well as chemical recycling for high value textile-to-textile recyclers (Greenblue 2017).

SIPTex

Another innovative sorting technology is SIPTex established by Vinnova in collaboration with Boer Group, amongst other partners. Like Fibersort, SIPTex is also based on NIRS as well as visible spectroscopy technology (Norden 2015).

The separation of identified clothes is conducted by compressed air. This technology does not allow for the separation of fibres as it is only sorting garments by those fibre type, which accounts for the majority of a garment (Ellen MacArthur Foundation 2017a).

Textiles4Textiles

Textiles4Textiles (T4T) is another NIRS sorting technology that separates clothing items (Norden 2015). Wieland Textiles and the Laserzentrum Hannover (LSH) as one amongst various partners developed the technology.

It can separate used textile material according to fibre composition and colour allowing the separation of 300 fractions in theory. Currently however, it is just applied for less than ten fractions.
In case of sorting by colour, there is no need for bleaching or re-dyeing before the subsequent recycling stages avoiding chemicals and thus environmental benefits. Moreover, these innovative sorting technologies can generate cost savings for the substitution of manual sorting but commonly require high upfront investments as well as large volumes of textiles in order to be cost effective (Norden 2015).

Large facilities, investors and demand for unmixed used clothes will be necessary for market penetration of these technologies. Job implications can occur if replacement of manual sorting takes places but the creation of high-skilled jobs can also apply if these facilities will be engineered.

Challenges and barriers

- Low-grade quality of collected textiles, insufficient data on amount of collected textiles and lack of standards for collection and processing
- Lack of consumer awareness and insufficient education on circularity across schools for textile (design)
- Limited information exchange, low market penetration of innovative start-ups and path dependencies for established businesses in competitive market environments
- Externalisation of costs, underdeveloped infrastructure for separate collection and recycling, textile exports and lack of funding
- Absence of extended producer responsibility (EPR), inconsistent policies, lack of global governance mechanism for textile supply chains and regulatory barriers

Solutions and best practices

- Integration of learning modules on circular economy into curricula for secondary and higher education
- Incremental innovation and disruptive business models which encourage circular production and consumption patterns
- International collaboration and the role of multi-stakeholder initiatives
- Enabling regulations, soft policies as well as research and development for circular economy principles in the textile sector
- Strategies to overcome challenges in recycling technologies

Questions for you

1. How circular economy is different from other concepts?
2. What are the 4Rs concept here?
3. How Vietnam may Championing to some extent on Circular economy on textile material context?

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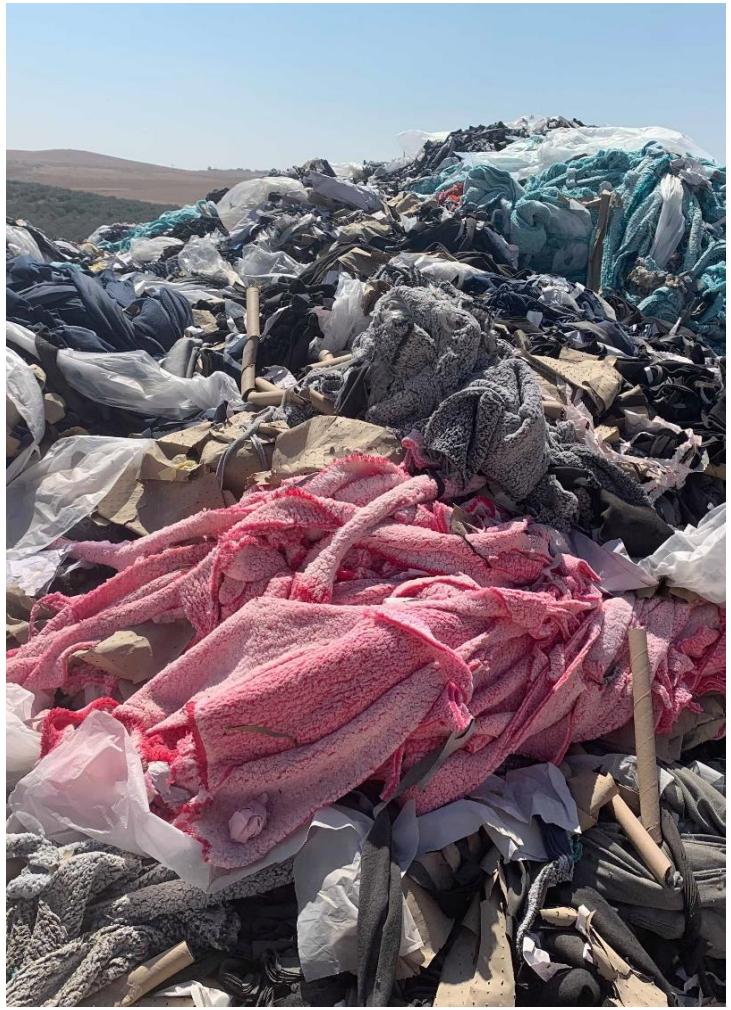
CIRCULARITY OPTIONS AT THE FACTORY LEVEL

a) Reducing Manufacturing Waste

- *apply innovativ CAD cutting devices,*
- *Avoid overproduction and deadstocks,*
- *Re-cutting and sewn to lower sized products and the local market,*
- *Apply eco-design principles to optimise resource use, consider recyclability in the design process,*



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CIRCULARITY OPTIONS AT THE FACTORY LEVEL

b) Collection, Separation and Recycling

- *At site sorting, by colour, type of fiber, size of cuttings,*
- *Fluffing on factory level*
- *Develop a joint fluffing initiative within HIE,*
- *Downcycling of non-reusable fraction into industrial rags, upholstery filling and insulation*

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CIRCULARITY OPTIONS AT THE FACTORY LEVEL

c) Upcycling

- *Develop initiatives with SME‘s and start ups to use large and medium sized cuttings for the production of new products*
- *Reuse recycled mono fibre fractions for respinning together with virgin fibres (so far yarn production is part of the factories value chain – degree of vertical integration))*

Upscaling potentials

- Development of a platform for waste exchange to get parties (factories, suppliers, handlers, recycler, brands) connected,
- Identify and develop initiatives to use large and medium sized cuttings for the production of new products ,
- Develop a joint fluffing initiative within HIE and byond including manufacturing capacities for downcycle products,
- Explore reuse and export oportunities for well sorted and clean mono fractions, like cotton…

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