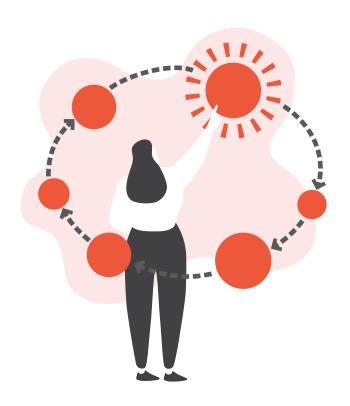
### **PR.4**

Identify
sustainability
hotspots across
the value chain

### Requires dialogue

To know where eco-innovation is most needed and generate the biggest improvements in overall sustainability performance, by identifying 'sustainability hotspots'.



### **INPUTS**

 A list of specific environmental, social and economic impacts that occur across the value chain.

### **OUTPUTS**

• Identification of the sustainability hotspots that occur across the value chain, used in the activities *PR.6 Develop a value chain vision* and *ST.6 Update the sustainability hotspots*.



Sustainability hotspots are the most significant impacts in the value chain or the life cycle of a product or service system and can be used to identify impact improvement opportunities and to prioritize impact reduction actions (UN Environment/SETAC, 2014). To identify sustainability hotspots we can use 'hotspot analysis', which helps to filter and distil large volumes of information to identify and prioritise hotspots for further investigation or action by industry, governments and other stakeholders. Hotspot analysis enables you to prioritise resources and actions in industry sectors, product categories or individual products that really matter by virtue of their environmental, social and ethical impact profile and /or their physical trading volumes and economic value in the economy. A common feature of hotspots analysis is the presentation of information and findings in accessible formats, including for non-technical audiences, who are often the key decision-makers in policy and business settings (UN Environment/ SETAC, 2014).

Identifying sustainability hotspots is a key activity within 'Life Cycle Thinking'. Life Cycle Thinking is a mostly qualitative approach to understand how our choices influence what happens at each of the stages of the life cycle of a product or service: from raw material acquisition through manufacture, distribution, product use and disposal. This approach is needed in order for us to balance tradeoffs and positively impact the economy, the environment, and society (UN Environment, 2004).

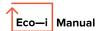
### **HOW TO GO ABOUT IT**

#### Create the life cycle inventory

- Prepare a life cycle inventory diagram that shows each of the main activities that occur in each phase of the product life cycle (Raw material extraction, Production, Transportation, Use, and End-oflife), the physical inputs to each activity (use of material, water, energy) and the outputs of each activity in terms of the 'Product outputs' (intermediary products and by-products) and 'Emissions' (emissions to air, water and soil).
- 2. Decide which of the activities you will include in your analysis and which you will not. Use these decisions to draw the 'Life cycle boundary' on your life cycle inventory diagram.
- 3. Using the life cycle inventory diagram and the life cycle boundary you have selected, fill in the first four columns of the *Life Cycle Thinking template*, which capture the key physical inputs and outputs throughout the five major life cycle stages.

### Identify the life cycle impacts and sustainability hotspots

- 4. Using the life cycle inventory, fill in the remaining columns of the Life Cycle Thinking template with corresponding environmental, social and economic impacts that occur across the value chain, proceeding activity by activity. Note that the social impacts are categorised by stakeholder, as follows:
  - On workers Examples of possible social impacts on workers include: health & safety, wages, social benefits, working hours, child labour, forced labour, discrimination, freedom of association and collective bargaining, employment relationship,



training and education, work-life balance, job satisfaction and engagement, and gender equality

- On customers/cunsumers Examples of possible social impacts on custumers and consumers include: health & safety, gender equality, experienced well-being, and privacy.
- On other stakeholders Examples of possible social impacts on other stakeholders include: health & safety, noise, odours, access to tangible resources, local capacity building, employment, and community engagement
- Rate each of the sustainability impacts you have identified using
  the scale 'Low', 'Medium' and 'High' impact. These ratings should
  be based on your understanding of how significant the impacts
  and will be, although these ratings will be quite subjective at this
  stage. Any impact that must be controlled to comply with local
  or international legislation relevant to companies in the value
  chain, or the conditions of a permit, should automatically be given
  a 'High' rating. This is indicated in the example below by the
  letter in brackets, where: H= High, M= Medium, L=Low. A '+' sign
  indicates a positive sustainability impact
- 5. Decide where the sustainability hotspots are by:
  - Identifying cells of the Life Cycle Thinking matrix that contain several different medium or high-rated impacts.
  - Identifying activities that lead to several different medium or high-rated impacts.
- 6. Make a note of the sustainability hotspots you have identified.

#### **Template of Life Cycle Inventory**

Emissions	Activities out of scope
Key activities and product outputs	
Inputs	
Raw materials Production Transportation Use End of life	

## Life cycle inventory

Project

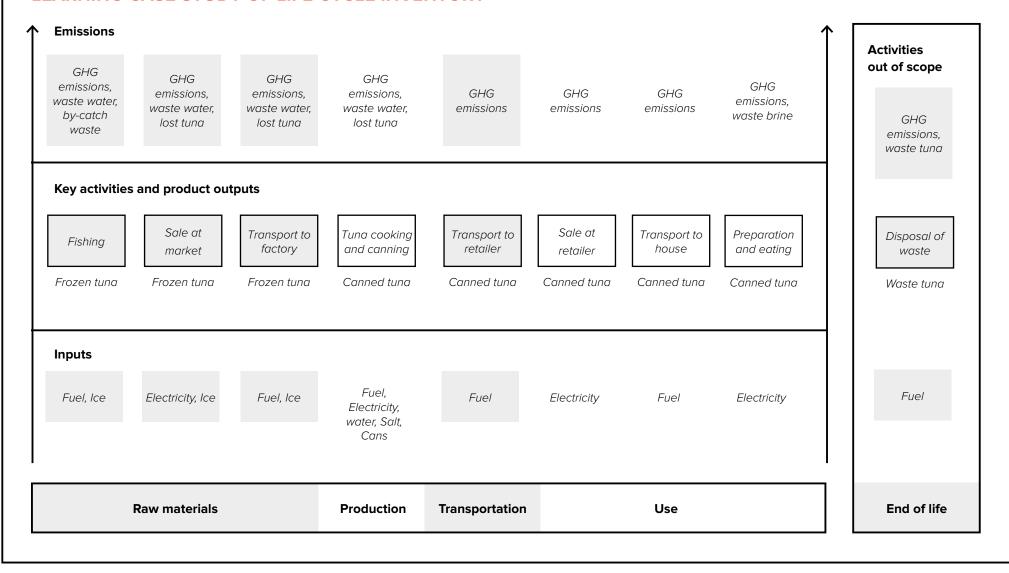
Date

Version

Emissions	Activities out of scope
Key activities and product outputs	
Inputs	
Raw materials Production Transportation Use End of life	



### LEARNING CASE STUDY OF LIFE CYCLE INVENTORY





Using the previous diagram, the first half of the *Life Cycle Thinking template* is completed (see the underlined column headings). The sustainability impacts are then listed and evaluated in the second half of the *Life Cycle Thinking template* (the rest) - as shown on the following page.

The results of *Life Cycle Thinking template* is that for the tuna processing value chain described in the case study the sustainability hotspots are:

- Fishing activity, which is linked to the medium and high impacts
  of tuna stock depletion, slavery-like conditions on board fishing
  vessels, rising cost of fresh tuna supplies, and fishermen leaving
  industry to seek higher wages.
- Energy intensity of the production phase, which is caused by fuel use for cold storage at factory and the high energy use in cooking process.
- Significant fish loss and waste caused by fish loss at market, damaging of tins during transportation, and tuna wasted by the consumer.

### **Template of Life Cycle Thinking**

						nmental acts	Soc	ial Impact	ts	Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability

## Life cycle thinking

Project Date Version

					Environme	ntal impacts		Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability



### LEARNING CASE STUDY OF LIFE CYCLE THINKING

					Environmental	impacts	:	Social Impacts	5	Economic impacts
Phase	Activity	<u>Inputs</u>	Product outputs	<u>Emissions</u>	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
	• Fishing	• Fuel (diesel) • Ice	• Frozen tuna (at dock)	<ul><li>GHG emissions</li><li>Waste water</li><li>By-catch (wasted)</li></ul>	Resource     depletion - fossil     fuels (M)	Climate change (M)  Marine species extinction (H)	<ul> <li>Falling wages forcing fishers to leave industry (M)</li> <li>Slavery like conditions on some fishing vessels (H)</li> </ul>			
Materials	• Sale at market	• Electricity (100% coal) • Ice	• Frozen tuna (at dock)	GHG emissions Waste water Lost tuna	Resource     depletion - fossil     fuels (L)	• Climate change (L)	Jobs secured at market (M)		Noise -     from early     morning lorry     movements     (L)	<ul> <li>Rising cost of tuna - due to dwindling stocks (H)</li> <li>+Revenue to fisher people (M)</li> <li>Cost of lost tuna (M)</li> </ul>
	• Transport to factory	• Fuel (diesel) • Ice	• Frozen tuna (at factory)	<ul><li>GHG emissions</li><li>Waste water</li><li>Lost tuna</li></ul>	Resource     depletion - fossil     fuels (L)	• Climate change (L)	Jobs secured for delivery driver (M)			• Cost of lost tuna (M)

					Environme	ental impacts		Social Impacts		Economic impacts
Phase	<u>Activity</u>	<u>Inputs</u>	Product outputs	<u>Emissions</u>	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
Production	• Tuna cooking and canning	<ul> <li>Fuel (diesel)</li> <li>Electricity (100% coal)</li> <li>Water</li> <li>Cans</li> <li>Salt</li> </ul>	Canned tuna (at factory)	<ul><li>GHG emissions</li><li>Waste water</li><li>Lost tuna</li></ul>	Resource depletion - fossil fuels (H) Water consumption (M)	Climate change (H)  Eutrophication (M)  Eutrophication (M)	Jobs secured at factory (M)			Cost of lost tuna (M) depletionFossil fuels (M)
Transportation	• Transport to retailer	<ul><li>Fuel (diesel)</li><li>Pallets</li></ul>	Canned tuna (at retailer)	GHG emissions  Lost tuna (damaged cans)	• Resource depletion - fossil fuels (L)	Climate change (L)	Jobs secured for delivery driver (M)		Noise -     from early     morning     lorry     movements     (L)	<ul> <li>Cost of lost tuna (M)</li> <li>Cost of transportation (L)</li> </ul>
	Sale at retailer	• Electricity (100% coal)	Canned tuna (at retailer)	• GHG emissions	• Resource depletion - fossil fuels (L)	• Climate change (L)	Jobs secured at retailer (M)			Revenue to retailer (M) Revenue to producer (M)
Use	Transport to house	• Fuel (petrol)	Canned tuna (at house)	• GHG emissions	• Resource depletion - fossil fuels (L)	• Climate change (L)				
_	Preparation and eating	• Electricity (100% coal)	• Waste tuna (at home)	• GHG emissions	• Resource depletion - fossil fuels (L)	• Climate change (L)		Human health consumption of tuna (L) Human health risk - mercury content of tuna (M)		
End of life	Disposal of waste	• Fuel (diesel)	• Waste tuna (at landfill)	• GHG emissions	• Resource depletion - fossil fuels (L)	Climate change (L)	Jobs secured at waste management company (M)		Bad odours from landfill site (L)	



### **TIPS & TRICKS**

#### **HELP TO SPOT IMPACTS**

If you are struggling to identify sustainability impacts consider the following prompts:

- Where and when are the most significant costs incurred across the life cycle of the product?
- What are the most significant resources (energy, materials and water) consumed throughout the product life cycle?
- Where are resources being wasted or underutilized?
- Where are there toxic chemicals used and how are they prevented from impacting the environment or human health?
- How does the product value chain impact on local stakeholders?

 Are there some positive impacts as well as the negative?

### DESK RESEARCH ACTIVITY

This activity is intended to be completed through desk research. You should not contact prospective client companies during this activity to help gather information as there will generally be other sources and making contact too early may frustrate the potential client and make them less willing to engage with you at a later stage.

#### **KEEP IMPACTS SPECIFIC**

Try to make the impacts you capture as specific and detailed as possible.

#### **POSITIVE IMPACTS**

Remember that impacts can be positive as well as negative. For example, "Jobs secured at factory" is a positive social impact that could be captured in the Production phase.

#### **MULTIPLE IMPACTS**

An activity can have multiple types of sustainability impact. In these cases list the activity and its impact in each of the relevant cells.

### **BACKGROUND INFORMATION**

#### References and resources

Hotspot analysis:

 "Hotspots Analysis: mapping of existing methodologies, tools and guidance and initial recommendations for the development of global guidance" (2014). UN Environment DTIE, Paris. Available from: <a href="http://www.lifecycleinitiative.org/wp-content/uploads/2014/12/UNEP-Hotspots-Mapping-Project-Final-Report-Phase-1.pdf">http://www.lifecycleinitiative.org/wp-content/uploads/2014/12/UNEP-Hotspots-Mapping-Project-Final-Report-Phase-1.pdf</a>

Life Cycle Assessment:

- Joint UN Environment-SETAC Life Cycle Initiative. Available from: http://www.life cycleinitiative.org/
- UN Environment, (2009). Guidelines for Social Life Cycle Assessment of Products. UN Environment, Paris. Available from: <a href="http://www.unep.org/publications/search/pub\_details\_s.asp?ID=4102">http://www.unep.org/publications/search/pub\_details\_s.asp?ID=4102</a>

Social Impact Assessment

 Handbook for Product Social Impact Assessment Available from: http://product-social-impact-assessment.com/

Further resources are provided in the 'Background information' for the activity *PR.5 Identify the general opportunities and threats across* the value chain.

Also further information in the Agri-food, Chemicals and Metals Supplements



### **TIPS & TRICKS**

## IDENTIFY WHICH STAGE OF THE VALUE CHAIN HAS THE HIGHEST SUSTAINABILITY IMPACT

When identifying the sustainability hotspots, keep in mind that majority of the environmental and social impacts are in the production stage of the value chain in many agrifood markets. The recent report Food Systems and Natural Resources from UN **Environment International** Resource Panel shows the relative impacts of different stages of the agri-food value chain (Figure 5). The impact of the production phase will vary between different markets, but is generally very high for animal based foods. → Refer to *Background Information* for more details.

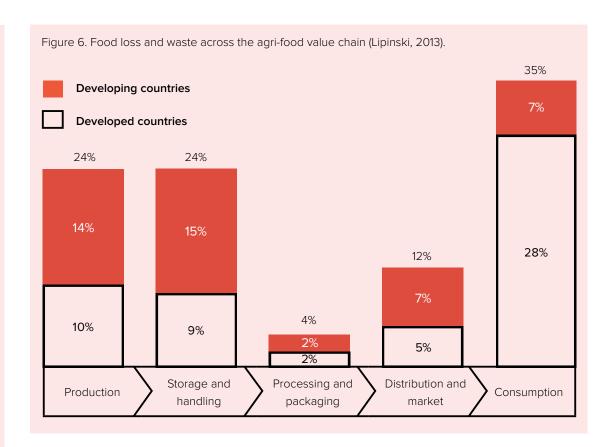
Figure 5. Environmental sustainability impact of different stages of the agri-food value chain (UN Environment, 2016)

Natural Resources	Producing	Processing & packaging	Distributing & Retailing	Consuming	Managing waste						
Renewable resource	es	n	n	0	-						
Land, soils and landscape	Cropping: grazing crop, hunting ● ●	Sites for factories ●	Sites for transtport and storage, infrastructure •		Sites for landfill ●						
Water	Irrigation: aquaculture ● ●	Washing; cooking ●		Cooking ●	Dumping and removing waste ●						
Biodiversity and ecosystems services	Pollination, pest control, water and nutrient regulation	Biomass for paper and card ●	Livestock for transport ●	Food variety charcoal and wood for cooking ● ●	Microbes to aid decomposition						
Generic resources	••••	•									
Non-renewable reso	rces										
Minerals	PK etc, for fertilizer and feed, chalk (liming) machinery  ● ● ● ●	Iron, tin, bauxite (AI), kaolin and other resources for packaging ● ●	Iron and other resources for transport, infraestructure ● ●	Iron and other resources for cooking and storage, equipement ●	Iron and other resources for incinerators ●						
Fossil fuels	Fertilizer and agrichemical production, machinery • • •	For cleaning, drying, processing, packaging	For transport and warehousing, freezing and cooling, heating and lighting in shop • • •	Cooking, cleaning ●	Collecting, recycling, purifying						



### IDENTIFY WHERE FOOD LOSS AND WASTE OC-CURS IN THE VALUE CHAIN

Food loss and waste is a big issue in the agri-food value chain but also an opportunity for improvement and innovation. Different solutions are needed depending on where in the value chain food loss and waste occurs. In developing countries most loss and waste is generated during the production and handling and storage stages, while in developed countries it is in the consumption stage (Figure 6). In developing countries the loss and waste is generated mostly due to a lack of technology for storage and processing of food as well as a lack of cooperation between the value chain stakeholders. while in developed countries a large part of the waste is created due to unsustainable consumption behaviour.





From the diverse processed fruits and vegetable markets you have, at this stage, chosen to focus on the canned mango pulp market. You started by identifying all major stages in the canned mango pulp value chain, as shown in Figure 7. This figure helped to provide a basic understanding of the canned mango value chain and a systematic consideration of each stage of the mango life cycle and related inputs and outputs. The sustainability impacts of each stage of the value chain were detailed using the *Life Cycle Thinking* template. Lastly the sustainability hotspots were summarised completing the *Lifeycle Thinking* template.

Figure 7. Schematic representation of the life cycle of canned mango pulp

Production	Storage and handling	Processing and packaging	Distribution and market	Consumption	End of life
Growing of	Mangoes collected	Pre-processing	Palletising and	• End user	Handling of food
mangoes	by agent	• Pulping	storage	consumption	waste and packaging
Hand harvest into	• Purchase	Canning	• Importer wholesale		material
buckets or baskets		Sterilisation	• Retail		



### LEARNING CASE STUDY OF LIFE CYCLE THINKING

					Environme	ntal impacts		Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
	Growing	Fertilizers, pesticides, water, fuel (diesel)		GHG, solid waste, agri- chemical emissions to soil and water, lost mangoes	Resource depletion – fossil fuels and Phosphates (M) Water consumption (M)	<ul> <li>Climate change (M)</li> <li>Soil degradation (H)</li> <li>Biodiversity loss (L)</li> <li>Land use (L)</li> </ul>	<ul> <li>Impact on health when handling agri- chemicals (H)</li> <li>Unsatisfactory working conditions and wages on farms (M)</li> </ul>			<ul> <li>Farmers growing others, more profitable crops (M)</li> <li>Revenue for farmers (M)</li> </ul>
Production	Harvest	• Fuel (diesel)	• Fresh mangoes (at farm)	• GHG, lost mangoes	• Resource depletion — fossil fuels (L)	Climate change (L)	Seasonal jobs secured (M)			Cost of lost mango (M) Bad harvest practices can lead to lower quality outputs (M)
	Transport to collectors	• Fuel (diesel)	• Fresh mangoes (at agents)	• GHG, waste water, lost mangoes	• Resource depletion – fossil fuels (L)	• Climate change (L)	Jobs secured for delivery driver (M)		Noise from trucks (L)	• Cost of lost mango (M)

					Environmen	tal impacts	Soc	cial Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
Storage and handling	Sale by agent	• Electricity (100% coal)	• Fresh mangoes (at agents)	GHG, waste water, lost mangoes	Resource     depletion —     fossil fuels (L)	• Climate change (L)	Jobs secured at agent (M)			Cost of lost mango (H) Revenue for agents (M)
Storage an	Transport to company	• Fuel (diesel)	• Fresh mangoes at (at factory)	• GHG, waste water, lost mangoes	• Resource depletion – fossil fuels (L)	• Climate change (L)	Jobs secured for delivery driver (M)		Noise from trucks (L)	
	Pre- processing	Ripening chemicals, chlorinated water	Mangoes ready for processing	• Waste water, lost mangoes	• Resource depletion – Chemicals (L)	• Pollution to water and soil (L)	Health concerns from handling rip- ening chemicals (M)     Jobs secured at factory (M)			Revenue to manufacturer (M) Cost of lost mango (M)
d packaging	Pulping	Electricity and steam (100% coal), sugar, additives	• Mango pulp	Waste water, solid waste (mango peel and seed), GHG, lost mango pulp			Jobs secured at factory (M)			Revenue to manufacturer (M) Cost of lost mango (M)
Processing and	Canning	Tin sheets, electricity (100% coal)	• Canned mango pulp	GHG     emissions,     lost canned     mango pulp	Resource depletion – fossil fuels (L) Depletion of tin (L)	Climate change (L)	Jobs secured at factory (M)			Revenue to manufacturer (M) Cost of lost mango (L)
	Heat treatment	• Electricity (100% coal)	Canned mango pulp (at factory)	• GHG emissions	Resource     depletion —     fossil fuels (M)	Climate change (M)	Jobs secured at factory (M)	Increased food safety of canned mango pulp (H)		Revenue to manufacturer (M) Cost of lost mango (L)

					Environme	ental impacts	T	Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
	Storage at factory	• Electricity (100% coal)	Canned     mango pulp     (at storage)	• GHG emissions	• Resource depletion – fossil fuels (L)	Climate change (L)				
Distribution and market	Sales at wholesaler and retailer	• Electricity (100% coal)	• Canned mango pulp (at wholesaler/ retailer)	• GHG emissions, lost canned mango pulp	• Resource depletion – fossil fuels (L)	• Climate change (L)	Jobs secured at wholesalers /retailer (M)			Cost of lost mango (L)
Distribu	Transportation to wholesale and retail	• Fuel (diesel)	Canned     mango     pulp (at     wholesaler/     retailer)	• GHG emissions, lost canned mango pulp	• Resource depletion – fossil fuels (L)	• Climate change (L)	Jobs secured for delivery driver (M)			
di di	Transportation by consumer	• Fuel (diesel, petrol)	Canned mango (at consumer)	• GHG emissions	• Resource depletion – fossil fuels (L)	• Climate change (L)				
Use	Preparation (if used for cooking) and consumption	• Electricity (coal, water)	Waste mango pulp, waster packaging material (at consumer)	• GHG emissions, food waste	Resource depletion – fossil fuels (L)	• Climate change (L)		High     nutritional     value of     mango pulp (M)		
End of life	Waste disposal	• Fuel (diesel)	Waste mango pulp, waster packaging material (at landfill)	• GHG emissions	• Resource depletion – fossil fuels (L)	• Climate change (L)	Jobs secured at waste management (M)		Bad odours from landfill site	



The sustainability hotspots for the canned mango pulp value chain are summarised below. Some of the major hotspots include:

- Production: Use of harmful fertilizers and pesticides causing water and land pollution as well as exposing farmers to harmful chemicals
- Handling and Storage: Post-harvest waste is high.
- Processing: High-energy use for processes such as pasteurization, drying, frying, blanching, boiling etc.
- End-of-life: Packaging waste typically ends up in landfill without reuse or recycling.

### **BACKGROUND INFORMATION**

#### Sustainability hotspots in the agri-food value chain

The agri-food value chain has a major environmental, social and economic impact at the global and local level. Many agri-food subsectors, such as livestock farming, meat, and dairy processing are high on the priority list urgently requiring efficient resource management practices and sustainability improvements according to UN Environment's International Resource Panel (UN Environment, 2012).

The environmental impacts of the agri-food value chain include arable land depletion, greenhouse gas (GHG) emissions, deforestation, loss of biodiversity, pollution, potable water and non-renewable resource depletion. Also, the economic and social impacts of the agri-food value chain are substantial as the agri-food value chain employs a large part of the world's population. Furthermore, according to FAO, globally around 30% of the food suitable for human consumption is lost or wasted due to inefficient practices along the food value chain. This creates risks for food security and puts unnecessary pressure on natural resources (FAO, 2011a).

General hotspots in the agri-food value chain include:

- **Greenhouse gas emission** 20% of global GHG emission is attributed to the agri-food value chain (Garnett, 2008). The largest contribution comes from the production stage in the value chain.
- Consumption of non-renewable resources The agri-food value chain (including cooking and other preparation) consumes 30% of the global energy produced, most of which comes from fossil sources, making it a major contributor to non-renewable resource depletion (FAO, 2011b). Other non-renewable resources used by the agri-food value chain include metals, mostly for packaging, and non-metallic minerals, such as salts and phosphates.



- Pollution The agri-food value chain has a moderate contribution
  to pollution compared to other heavy industry. The largest
  contribution comes from the production and usage of fertilizers
  and pesticides. Soil and water are mostly polluted with nitrogen
  and phosphorus affecting the ecosystem as well as humans
  directly. There is also a major impact of heavy-metal containing
  fertilizers on reduction of arable land. Other pollutants from the
  agri-food value chain may include waste water, solid waste and air
  emissions by the processing industry.
- Potable water consumption Agriculture is the largest user of
  water in all regions of the world except Europe and North America
  (AQUASTAT). Water is mainly used for irrigation of crops but is
  also consumed by livestock. For food and drinks products, the
  volume of water used in the processing stage is often less in
  the production stage. However, this will vary depending on the
  subsector (AQUASTAT).
- Land use and degradation -12% of the global land area is currently being used for cultivation of agricultural crops according to FAO (2011b). Poor practices in agriculture, such as over-cultivation, overgrazing and forest conversion, are a significant contributor to environmental problems such as degradation of soil quality and arable land depletion. Land degradation has accelerated during the 20th century due to the increasing and combined pressures of agricultural and livestock production, urbanization, deforestation, and extreme weather events, such as droughts and coastal surges (which salinate land).
- Waste generation According to the FAO (2011a), 32% by weight, or approximately 24% by calorific value, of all food produced in

the world was lost or wasted in 2009. "Food loss and waste" refers to the edible parts of plants and animals that are produced or harvested for human consumption but that are not ultimately consumed by people. In particular, "food loss" refers to food that spills, spoils, is of inferior quality (unconventional shape, damaged etc.), or otherwise gets lost before it reaches the consumer. Food loss is the unintended result of an agricultural process or a technical limitation in storage, infrastructure, processing, packaging, or marketing. "Food waste" refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded. Food waste is the result of negligence or a conscious decision to throw food away. Food loss and waste have many negative economic and environmental impacts. Economically, food waste is a lost investment that can reduce farmers' incomes and increase consumers' expenses. Environmentally, food loss and waste cause unnecessary greenhouse gas emissions and inefficient use of water and land.



#### References

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Lipinski, B. et al. (2013). "Reducing Food Loss and Waste." Working Paper, Instalment 2 of Creating a Sustainable Food Future. Washington, DC: World Resources Institute. Available from: <a href="http://www.wri.org/sites/default/files/reducing\_food\_loss\_and\_waste.pdf">http://www.wri.org/sites/default/files/reducing\_food\_loss\_and\_waste.pdf</a>

UN Environment (2012) Responsible Resource Management for a Sustainable World: Findings from the International Resource Panel. Available from: <a href="http://www.unep.org/resourcepanel/Portals/50244/">http://www.unep.org/resourcepanel/Portals/50244/</a> <a href="publications/SYNOPSIS%20Final%20compressed.pdf">http://www.unep.org/resourcepanel/Portals/50244/</a> <a href="publications/SYNOPSIS%20Final%20compressed.pdf">publications/SYNOPSIS%20Final%20compressed.pdf</a>

FAO (2011a). Global food losses and food waste – Extent, causes and prevention. Available from: <a href="http://www.fao.org/docrep/014/mb060e/">http://www.fao.org/docrep/014/mb060e/</a> mb060e.pdf

Garnett, T., (2008). Cooking up a storm: Food, greenhouse gas emissions and our changing climate. Available from: <a href="http://www.fcrn.org.uk/sites/default/files/CuaS\_web.pdf">http://www.fcrn.org.uk/sites/default/files/CuaS\_web.pdf</a>

AQUASTAT Main Database.

Thematic discussion available from: <a href="http://www.fao.org/nr/water/">http://www.fao.org/nr/water/</a> aquastat/water\_use/index.stm

FAO (2011b). The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. Available from: http://www.fao.org/docrep/017/i1688e/i1688e.pdf



### **TIPS & TRICKS**

### USE CHEMICALS OF CONCERN LISTS TO IDENTIFY HEALTH AND ENVIRONMENT RELATED SUSTAINABILITY HOTSPOTS

Industry, NGO and public authority lists containing chemicals of concern or restricted substances, such as the CHEMSEC SIN (Substitute It Now!) list, California's Chemical of Concern list, or the Zero Discharge of Hazardous Chemicals (ZDHC) industry initiative Restricted Substances List (RSL) are being increasingly used as a basis for eliminating hazardous substances from a product's life cycle. Check legislation, standards and lists that apply to your region and value chain in order to identify chemicals that are sustainability hotspots and should be prioritized for action.

#### **IDENTIFY HOW RESOURCE SCARCITY AFFECTS THE VALUE CHAIN**

Scarcity in resources, including energy, water and rare earth minerals, can be a concern for companies. Chemical production is energy and water intensive. Rising energy prices may spur the sector to continue its efforts to improve energy efficiency. Higher energy prices and climate change concerns may also drive chemical companies to diversify their feedstock base away from fossil fuels. Recuperating valuable raw materials, known as urban mining, will be increasingly important in this context. The following case study demonstrates how resource scarcity can lead to eco-innovation in the value chain by working with partners to recover and chemically recycle valuable chemical feedstock from end-of-life material.

#### Industry example 1: Collection, recovery and chemical recycling of PTFE from end-of-life material

PTFE is a specialty high-performance thermoplastic polymer used in many end markets, e.g. in the automotive sector and in consumer goods, such as functional clothing and cookware. The PTFE value chain is typically linear: commodities production, polymerisation, usage in consumer goods, and end-of-life via incineration or disposal on landfills. However, it utilises non-renewable inputs (e.g. CaF2) and consumes large amounts of energy. A new chemical recycling process developed by Dyneon, a 3M subsidiary specialised in fluoropolymer production, transfers the linear value chain into a circular one. PTFE at its end-of-life is collected, depolymerised and the monomers are used again to produce new PTFE. Recycling of PTFE led to significant reductions in materials, waste and energy demand, thereby alleviating resource scarcity and closing the value chain. For instance 1 ton of recovered monomer saves, amongst others, 5 tonnes chlorine, 2 tonnes sulphuric acid as well as 10 tonnes of CO2 emissions and acid waste. Moreover, the energy demand can be decreased by 50% and the CaF2 cycle is closed (3M Dyneon, 2013).

### BUILD ON SUSTAINABILITY HOTSPOTS RESULTING FROM EMERGING TRENDS

Emerging trends in different regions and countries can provide insight on sustainability hotspots. For example, under the *trend human* health, a general hotspot related to the chemical sector could include increased knowledge of the adverse effects of hazardous chemicals. → Refer to 'Background *Information*' for an overview of trends and generalized sustainability impacts.



### LEARNING CASE STUDY OF LIFE CYCLE INVENTORY

•	Em	ISS	10	ns

GHG emissions. waste water. run-off residues. Cotton waste

GHG emissions. Dust, Fiber/ varn waste

GHG emissions. waste water. caustic soda, heavy metals, organic waste

GHG emissions. waste water. salt, dyestuffs, tensides, VOC, pigments

GHG emissions. waste water, solid waste

GHG emissions. waste water. fabric waste, packaging waste

GHG emissions, damaged and unsold garments

**GHG** emissions, waste water

GHG emissions. waste garments

#### Key activities and product outputs

Cotton cultivation

Cotton

**Fabric** production, spinning/ waeving

Fabric

Pre-treatment: sizina. bleaching...

> Pre-treated fabric

Dyeing and printing

Dyed fabric

Finishing

finished fabric

Garment manufacturing

Garments

Wholesale / retail

Sold garments

Use (washing and drying)

Canned tuna

Disposal / recycling

Waste tuna

### Inputs

Fuel, Water

Electricity, Lubricants Sizing agents, caustic soda. Peroxide, fuel, electricity. stabilising agents, water

Salt, dyestuffs, tensides. solvents. pigments, water, fuel, electricity

Resins, catalysts, enzymes, softener, tensides. additives, water, fuel, electricity

Electricity. lubricants, packaging, preservatives

Electricity

Electricity, water. detergents, additives

Fuel

Raw materials

**Production** 

Use

**End-of-life** 

<sup>\*</sup>Grey faded used to visually set apart life cycle phases



### LEARNING CASE STUDY OF LIFE CYCLE THINKING

					Environmenta	l impacts		Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	<u>Emissions</u>	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
Materials	Cotton cultivation	<ul> <li>Fuel (diesel)</li> <li>Water</li> <li>Pesticides</li> <li>Herbicides</li> </ul>	Cotton     Polyester     Textile chemicals	GHG     emissions     Waste water     Run-off     residues     Cotton waste	Farming water and agrochemical intensive (150g pesticides and 220o L water for a shirt) (M)     Petrochemical feedstock for polyester is nonrenewable (M)     Solvent waste and wastewater from pigment production (M)	Agro-     chemical     intensive     farming     leads to soil     degradation     and polluted     water     sources (M)	Farmers often lack protective equipment and are exposed to toxic herbicides and pesticides (M) Cotton farmers leaving industry replaced with automation, higer wages (L)			Rising costs of synthetic feedstock and cotton (H) Revenue to cotton farmers (M) Cost of lost cotton (M)
Production	Fabric production (speaning / weaving)	Electricity     (100% coal)     Cotton     Lubricants	• Fabric	GHG emissions  Dust Yarn/fiber waste	<ul> <li>Resource depletion - fossil fuels (L)</li> <li>Waste fabric (L)</li> </ul>	• Climate change (L)				<ul> <li>High electricity costs for fabric production (M)</li> <li>Cost of fabric (L)</li> </ul>

					Environme	Environmental impacts		Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
	Pre-treatment (sizing, bleaching, etc)	<ul> <li>Fabric</li> <li>Agents</li> <li>Sizing</li> <li>Caustic</li> <li>Soda</li> <li>Peroxide</li> <li>Stabilizing</li> <li>Water</li> <li>Fuel</li> <li>Electricity</li> </ul>	• Pre-treated fabric	GHG emissions  Waste water  Caustic soda  Heavy metals  Organic waste	• Water consumption (M)	NPEOs used in textile wet processing degrade into nonyphenol in the environment which is toxic to aquatic organisms and may cause harm to unborn children (H)			• NPEOs used in textile wet processing degrade into nonyphenol in the environment which is toxic to aquatic organisms and may cause harm to unborn children (H)	
Production	Dyeing and printing	<ul> <li>Pre-treated fabric</li> <li>Salt</li> <li>Dyestuff</li> <li>Tensides</li> <li>Solvents</li> <li>Pigments</li> <li>Water</li> <li>Fuel</li> <li>Electricity</li> </ul>	• Dyed fabric	• GHG emissions • Waste water • Salt • Dyestuff • Tensides • VOC • Pigments	• Water consumption (M)	High     biochemical     oxygen     demand of     wastewater     effluent     affecting     local aquatic     environment     (M)	Azo dyes     which     degrade to     form listed     aromatic     amines (e.g.     benzidime),     many of     which cause     or are     suspected to     cause cancer     (H)		Azo dyes which degrade to form listed aromatic amines (e.g. benzidime), many of which cause or are suspected to cause cancer (H)	
	Garment manufacturing	Garments     Electricity	• Sold garments	GHG emissions Damaged unsold garments			Textile value chain employs a large number of low-skill labourers (H)			• Cost of lost fabric (H)

					Environmental	impacts		Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
Production	Finishing	<ul> <li>Dyed Fabric</li> <li>Resins</li> <li>Catalysts</li> <li>Enzymes</li> <li>Softener</li> <li>Tensides</li> <li>Additives</li> <li>Water</li> <li>Fuel</li> <li>Electricity</li> </ul>	• Finished fabric	GHG     emissions     Waste     water     Solid     waste					Conflict     with local     communities     over waste     water and     sludge     production     (L)	• Waste water treatment costs (M)
	Wholesale / Retail	Garments     Electricity	• Sold garments	GHG Emissions Damaged / unsold garments						<ul> <li>Cost of lost / unsold garments (M)</li> <li>Revenue to retailers (M)</li> <li>Revenue to producers (N)</li> </ul>
Use	Use (wear, wash, dry)	Electricity     Water     Detergents     Laundry     additives	• Used / damaged garments	GHG     emissions     Waste     water	Most clothes discarded after 2 years (H)     Electricity consumption (typically fossil fuel) (H)     High detergent consumption from washing clothes (H)     High electricity use for tumbler dryers (H)	Micro- plastics from synthetic clothing released during drying affect marine life (L)     Eutro- phication (M)     Climate change (L)	Growing market for sustainable manuf- acturing clothes (H)	Formal-dehyde used to preserve textiles in transit found in textiles used by consumers and may cause cancer (H)  Concers over safety of chemicals used in textiles, especially for infants and toddlers (H)		Cost of washing and drying (M)



					Environme	ental impacts		Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
End of life	Disposal and recycling	Used /     Damaged     garments     Fuel	• Waste garments	• GHG emissions	Most clothes landfilled after use and not reused or recycled (H)				Leachate from landfilled textiles can enter groundwater causing adverse health effects (L)	

The sustainability hotspots for the textiles value chain described in the case study are:

- Raw material extraction through cultivation of cotton is resource intensive (water, chemicals), degrading land and exposing farmers to harmful pesticides and herbicides.
- Impact of chemicals used during production (and use), such as nonylphenol ethoxylates (NPEOs) used in wet textile processing are known to degrade in the environment to endocrine disruptors; and formaldehyde used as a preservative during transport is suspected of causing cancer.
- Use: high detergent and water use from washing clothes; high electricity use from tumble drying of apparel.

• End-of-life: textiles typically discarded after 2 years of use and thrown in landfill without reuse or recycling. Further environmental and human health effects resulting from the decomposition of clothing in landfills.



### **BACKGROUND INFORMATION**

### General sustainability challenges related to the chemical industry

Table 9: Overview of trends relevant to the chemical industry and related sustainability challenges Deloitte, 2011; Grossman, 2013; A.T. Kearney, 2012; Population Reference Bureau, 2006)

Trends	Sustainability challenges and unmeet needs	General opportunities for eco-innovation
Globalization	<ul> <li>Commonality trends (standardisation of parts and components in supply chain), integration of regional economies and cultures</li> <li>Global impact of local events</li> <li>Global markets, including capital; global supply chains</li> <li>Global competition, effects of low-cost labour, shift of value chains</li> <li>Growing chemical markets, e.g. China</li> </ul>	<ul> <li>New business models</li> <li>Closed material cycles based on a "cradle to cradle" thinking</li> <li>New emerging markets</li> </ul>
Demographic change	<ul> <li>Human population changes including size, age, gender, race, income, and location;</li> <li>Growing middle class in developing and emerging economies</li> <li>Population growth (in particular in Eastern, Middle, and Western Africa)</li> <li>Aging populations (in particular in the developed world as well as in China and Latin America)</li> </ul>	<ul> <li>Increased demand for other products (e.g. due to altered age structures)</li> <li>Resource efficiency</li> <li>Recycling</li> <li>New business models</li> </ul>
Urbanization	<ul> <li>More people living in cities and suburbs</li> <li>Strong growth of megacities and supporting infrastructure and housing</li> <li>Concentration of regional economies, knowledge, resource consumption and waste generation in urban areas</li> </ul>	<ul><li> Urban mining</li><li> Resource efficiency</li><li> New consumption models</li><li> More sustainable infrastructure</li></ul>
Patterns of mobility	<ul> <li>Increased movement of people and freight</li> <li>Altered movement in terms of mode, distance, frequency, time in transit, and regions</li> </ul>	<ul><li>New business models</li><li>Light-weight solutions</li><li>More sustainable infrastructure</li></ul>

Trends	Sustainability challenges and unmeet needs	General opportunities for eco-innovation
Natural Resource Scarcity	Availability and costs of natural resources (petroleum, minerals, rare earth metals), energy, clean water, food, and energy alternatives     Increasing prices of raw materials/petrochemicals	<ul> <li>Advanced technical solutions</li> <li>Closed material cycles</li> <li>Urban mining</li> <li>Resource efficiency</li> <li>Energy efficiency</li> <li>Reduce, Reuse, Recover, Recycle Systems</li> <li>Increased value of more sustainable and resource efficient solutions</li> </ul>
Environment and Sustainability	<ul> <li>Impact of climate change (severe weather, land erosion, etc.)</li> <li>Impact of increasing waste (e.g. e-waste) on ecosystems</li> <li>Protection, preservation, and restoration of the environment, biodiversity and ecosystem functionality</li> <li>Increasing awareness</li> </ul>	<ul> <li>Emissions reduction</li> <li>Renewable raw materials</li> <li>Waste reduction</li> <li>Recycling and reuse</li> <li>Green chemistry</li> </ul>
Consumption Patterns	<ul> <li>Major shifts in demand for goods and services, such as luxuries in China and India;</li> <li>Growing middle class in developing markets; a wealthier developing world leading to increased consumption</li> <li>Increasing demand for sustainable products and services</li> </ul>	<ul> <li>Demand for greener products</li> <li>Energy efficiency</li> <li>Resource efficiency</li> <li>Closed material cycles</li> <li>New consumption models and solutions (sharing, product servicing, etc.)</li> </ul>
Technological Convergence and New Technology	<ul> <li>Technologies in addition to information technology (IT) performing similar tasks</li> <li>Technologies combining synergies for accelerated technological change</li> <li>Demand for more open information and access to the internet</li> </ul>	<ul> <li>Substitution of the use of hazardous chemicals</li> <li>Optimization of the use of chemicals</li> <li>Product centric recycling</li> <li>New models of production and consumption</li> <li>Leapfrogging opportunities</li> <li>Bio-mimicry</li> <li>Inherently safer processes</li> </ul>
Human Health	<ul> <li>Increased knowledge of adverse effects of hazardous chemicals</li> <li>Expanded and intensified health care, disease prevention</li> <li>Self-management of health; consciousness about health issues;</li> </ul>	<ul> <li>Biodegradable products</li> <li>Renewable feedstocks</li> <li>Non-hazardous chemical substances</li> <li>Emissions reduction</li> <li>Safer production</li> </ul>



Trends	Sustainability challenges and unmeet needs	General opportunities for eco-innovation
Regulation, Activism, Public Perception	<ul> <li>Increasing role of social media, potential global impact of local event fuelled by the age of access to open information through internet</li> <li>Increase in regulations promoting sustainability, resource efficiency, and human health (e.g. REACH, WEEE, Stockholm, Basel, and Rotterdam conventions)</li> <li>Increase in voluntary industry standards throughout value chain</li> <li>Increased demand for transparency in sustainability reporting</li> </ul>	<ul> <li>Emissions reduction</li> <li>Closed material cycles</li> <li>Energy efficiency</li> <li>Resource efficiency</li> <li>Substitution with safer chemicals</li> <li>Safer production processes</li> <li>Green chemistry</li> <li>Financial mechanism that favour more sustainable solutions</li> </ul>

#### References

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### LEARNING CASE STUDY OF LIFE CYCLE INVENTORY

Raw naterials			Production			Use	End of life
Inputs Fuel, Water	Energy	Lubrucants, Energy	Chemicals, Solvents, Pigments, Water, Energy	Energy, Metal parts	Fuel, Packaging material		Energy, Metal waste
Raw material	Metals	Metal parts	Painted metal parts	Metal product	Garments	product	
Raw material extraction	Metal production	Metal parts manufacturing	Painting	Product assembly	Packaging/ transportation	Use End-of -life	Disposal / recycling
Key activities a	and product outp	uts					
GHG emissions, waste water	GHG emissions, metal waste	GHG emissions, waste water, cutting scrap, swarf, metal waste	GHG emissions, waste water, paint overspray sludge, sludge, rise-off chemicals	GHG emissions	GHG emissions, waste water		



### LEARNING CASE STUDY OF LIFE CYCLE THINKING

As a summary of the filled templated showed below, some sustainability challenges and opportunities that a small metal producer might be facing are:

Sustainability hotspots (economic, environmental, social) for metal manufacturers are:

- Raw material scarcity and price volatility of metals (economic, environmental)
- Consumers are becoming increasingly aware of the mining conditions and want to ensure their products are sustainably sourced (environmental, social)
- Raw metals production consumes a lot of energy (economic, environmental)

- Inefficient use of metal feedstock and generation of metal waste along the metal value chain (economic, environmental)
- Health concerns related to hazardous substances used for the metal processing/treatment and paints (e.g. lead is used in bright colours) (environmental, social)
- Generation of hazardous waste related to electroplating and painting processes along the value chain (economic, environmental)
- Increasing concerns about health impacts for society and the environment due to the release of hazardous substances (e.g. lead containing compounds) from metal products after disposal (environmental, social)

					Environmental impacts		Social Impacts			Economic impacts
Phase	Activity	<u>Inputs</u>	Product outputs	<u>Emissions</u>	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
Materials	Extraction of raw materials	• Energy	• Raw materials	Waste water     GHG     emissions	Unsustainable extraction of minerals, metal ores, hydrocarbons	Impact on biodiversity Claim of natural areas Leaving exploited soils	<ul> <li>Bad working conditions for extraction</li> <li>Health issues related to mining hazardous substances: mineral lubricants, solvents and lead points.</li> </ul>		Geopolitical conflict over natural resources	<ul> <li>Price volatility of raw materials</li> <li>High prices of high tech materials (titanium/coal)</li> </ul>

					Environme	Environmental impacts		cial Impacts		Economic impacts
Phase	<u>Activity</u>	<u>Inputs</u>	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
	Production of metals, rubber, plastics, various parts, chemicals (solvents, lead paints)	• Energy raw materials	<ul> <li>Metals</li> <li>Rubber</li> <li>Plastics</li> <li>Various parts</li> <li>Chemicals (solvents and lead paints)</li> </ul>	Hazardous waste (paints, solvents, chemicals for metal treatment)     Emissions (e.g. VOC)	Unsustainable production	Dumping of hazardous waste     Accumulation of substances in the soil and ground water	Bad working conditions in production site Gender issues Safety issues: welding, paints, coating, solvents.			
Production	Frame manufacturing	• Energy • Materials	• Metal waste frame				<ul> <li>Bad working conditions in production site</li> <li>Gender issues</li> <li>Safety issues: welding, paints, coating, solvents.</li> </ul>			
Pro	Painting	• Materials for paint	• Painting waste	• Waste water	• Lead for paints	Dumping of hazardous waste     Accumulation of substances in the soil and ground water	<ul> <li>Bad working conditions in production site</li> <li>Gender issues</li> <li>Safety issues: welding, paints, coating, solvents.</li> </ul>			
	Wheel manufacturing	• Raw materials	• Metal waste wheels				<ul> <li>Bad working conditions in production site</li> <li>Gender issues</li> <li>Safety issues: welding, paints, coating, solvents.</li> </ul>			

					Environn	nental impacts		Social Impacts		Economic impacts
Phase	Activity	Inputs	Product outputs	Emissions	Resource use	Ecosystem quality	On workers	On consumers	On stakeholders	Profitability
	Bike assembly	• Frame and wheels	• Bike				<ul> <li>Bad working conditions in production site</li> <li>Gender issues</li> <li>Safety issues: welding, paints, coating, solvents.</li> </ul>			Low-cost competitors are threatening the already low net profit margin as well as market share
Transportation	Transport to retailer	• Fuel	• Bike (at retailer)	GHG     emissions     Metal     scrap from     damaged     bikes	Resource depletion (fossil fuels)	• Climate change			• Noise	Cost of transportation
Use	Use							<ul> <li>The population riding bikes is expected to rise from 10% to 15% in the next five years.</li> <li>Consumers are keeping their bikes longer, investing instead in repairs, new parts and accessories instead of buying new ones.</li> </ul>	• The LOHAS (Lifestyle of Health and Sustainability) market segment is growing rapidly, over 15% per year. The LOHAS segment is willing to pay a 20% premmium bikes.	Low price due to competition     LOHAS segment has a potential market size of 0.6-1.3m\$.
End of life	No recycling		• No recycling	• Waste e.g. tyres, plastic		Waste dumping     Lead     accumulation in     soil and water     leading to lead     poisoning			Generation     of waste lead     poisoning	Valuable metals are disposed off Emerging of second hand market competition



### **BACKGROUND INFORMATION**

Over the course of a typical production process chain 25% of the amount of metal input is lost as scrap, as shown in Figure 3 below.

Material - Input

3500t

Material - Output

2645t

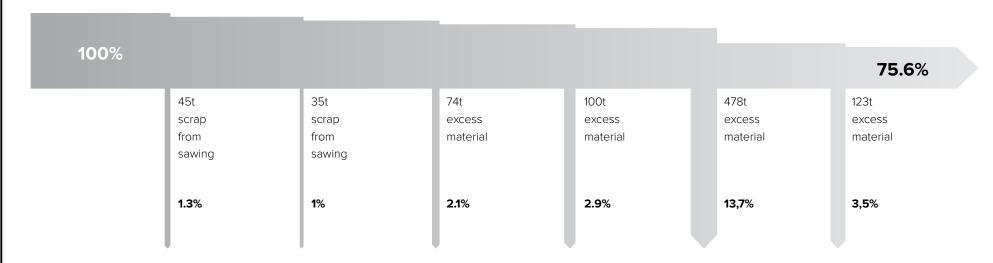


Figure 3: Material input and output of metal production



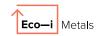
The following table summarizes sustainability opportunities across the metal production processes.

Table 3: Production, product and management activities with sustainability opportunities across the metals sector

Production processes	Sustainability opportunities		
Shaping (forming, casting, powder metallurgy)	<ul> <li>Energy efficiency:</li> <li>Reducing the preheating temperature of starting material for forging</li> <li>Using high temperature superconducting magnets for heating to forge increasing the efficiency by 15% compared to induction heating</li> <li>Use of SiC semiconductors instead of silicon based semiconductors as inverter for getting voltage required for specific manufacturing processes since they can be operated at higher temperatures with lower losses and imply higher heat recovery efficiency due to a higher transmission rate and a higher temperature difference</li> </ul>	Heat recovery:     Using waste heat of forging by bringing forged pieces to an isolated cupboard and recovering the energy using latent energy storages     Heat transfer between consecutive process steps e.g. between forging and rolling mill which can reduce consumption by 50%     Use of waste heat of drawing furnace for heating subsequent process baths (e.g. surface treatment)	Material efficiency:
	In general:  Use of renewable energy  Minimize scale through special coating to protect for	rging tools	



Production processes	Sustainability opportunities		
Material removal (conventional machining, abrasive processes, non- traditional machining)	Energy efficiency: Speed-controlled ventilator instead of conventional compression cooler which reduces power consumption by 70%	Material efficiency:     Punching without generating sheet skeleton by re-positioning sheet on worktop     Use of alternative, material saving manufacturing processes (e.g. casting instead of machining part out of bulk material)     Reduction of reject	
	In general:  Reduce process steps Reduce lubricants, Use water-based lubricants with biopolymers as they are more environmentally friendly, render machines easier and also provide cooling		
Assembly (Welding, brazing, soldering, adhesive bonding, mechanical assembly)	<ul> <li>Energy efficiency:</li> <li>Soldering instead of brazing where possible (lower energy input)</li> <li>Use of different filler wire for welding which requires less energy to melt</li> </ul>	Material efficiency:  Use welding process which does not require the adding of filler wire where possible  Alternative design for use of less filler wire or adhesive	
	In general:  • Substitute welding material/consumable with a lower fume-generating or a less toxic one  • Local exhaust ventilation systems for alloys (e.g. prevent Cr(VI) exposure		
Surface preparation and cleaning	Material efficiency (water, chemicals):  Counter-rinse processes  Cleaning optimisation (e.g. temperature, contacting)  Reduce grease on surface in prior steps (e.g. optimise machining, cooperate with metal suppliers)  Use enclosed cleaning machines (e.g. VOC capture & reuse)	Safer chemicals:  Replace with mechanical cleaning Substitution with safer chemicals	
	In general:  • Substitute welding material/consumable with a lower fume-generating or a less toxic one  • Local exhaust ventilation systems for alloys (e.g. prevent Cr(VI) exposure		



Production processes	Sustainability opportunities		
Finishing (electroplating, coating, paint application)	Energy efficiency:  • Optimisation of plating temperature and general process conditions	<ul> <li>Material efficiency: <ul> <li>Plating internal recycling/filtration and reuse of plating bath</li> <li>Plating external recycling of plating bath and recovery of sludge metals</li> <li>Switch paint application technique (e.g. dipping vs. spray), HVLP, electrostatic or powder coating</li> <li>Reduce overspray for painting: e.g. switch to HVLP spray or electrostatic sprafor higher efficiencies</li> <li>Optimize existing equipment by implementing SOP's and training programme</li> <li>Reduce waste: use heated hose for paint supply for two-component paint</li> <li>Alternatives to solvent-based paint application: buy pre-painted parts, UV paints, water-based paints, etc.</li> </ul> </li> </ul>	
	Various: • Reduce cleaning and preparation steps		
Heat treatment	Energy efficiency:  Measurement of part temperature for optimizing treatment temperature and residence time  Heat recovery from water (for low-carbon steel), oil (for high-carbon steel) or air quenching  Direct hardening of steel heated by the forging process  Reducing losses during pre-treatment, i.e. cleaning and drying, by using a closed system for cleaning with an integrated vacuum system for drying whereby the cleaning fluid is warmed up by waste heat from the furnace, so no additional heat for drying needs to be provided  Bringing warm rolled metal sheets directly to the heat treatment furnace, which is possible through temperature measurement of the furnace and sheets for being able to regulate the furnace		



Design	Sustainability opportunities	
Life cycle design for sustainability <sup>5</sup>	<ul> <li>Material saving design through using for instance design parts which can be casts rather than parts that need to be machined out of bulk material</li> <li>Favour the use of materials whose procurement does not harm the environment or people</li> <li>Energy saving design through for instance involving less energy intensive production steps and a lower number of production steps</li> <li>Design for reparability and recyclability</li> </ul>	
Management opportunities	Sustainability opportunities	
Sustainable procurement	<ul> <li>Choose input material carefully</li> <li>Main inputs are: ferrous, non-ferrous metals, chemicals (cleaning agents, paints, plating), packaging material, additives and working materials: heat-transfer medium, lubricants, transformer fluids</li> <li>Increase use of renewable and recyclable materials</li> <li>Substitute hazardous materials</li> </ul>	
Material management	Reduce the use of materials Reduce lost materials	
Manufacturing process	<ul> <li>Reduce water use</li> <li>Increase energy efficiency</li> <li>Reduce emissions</li> <li>Comply to regulations</li> <li>Technical assistance</li> </ul>	
Logistics	<ul> <li>Lean manufacturing system</li> <li>Integrated on-line logistics system</li> <li>Environmental management systems, environmental strategies and monitoring</li> </ul>	
Waste management	<ul> <li>Prevention, reduction, collection, separation, recycling</li> <li>Possibility to recycle hazardous waste or use it for energy production</li> </ul>	

 $<sup>{}^{\</sup>underline{5}}\underline{\,http://www.d4s-sbs.org/d4s\_sbs\_manual\_site.pdf}$ 



#### References

Examples of relevant labels, industry standards, voluntary initiatives:

Industry standards:

 ISO certificates. 9001 Quality management. 14000 Environmental management. 26000 Social responsibility. 50001 Energy management. Available from: www.iso.org

#### Labels:

- Green Label Singapore. Available from: http://www.sec.org.sg/sgls/ specifically for example a green label CATEGORY 043 for products made from at least 50% mixed recycled materials including iron, copper, nickel and zinc.
- SIRIM QAS Malaysia Green label. Available from: http://www.sirimgas.com

#### Voluntary Initiatives:

- Global Reporting Initiative guidance for sustainability reporting.
   Available from: www.globalreporting.org
- GRI Mining & Metals Guidance. Available from: https://www. globalreporting.org/resourcelibrary/MMSS-Complete.pdf
- GRI Electric Utilities Sector. Available from: https://www. globalreporting.org/reporting/sector-guidance/sector-guidance/ electric-utilities/Pages/default.aspx
- ICMM Material Stewardship is an approach helping companies to regard the entire life cycle of their products and take responsibility for the impacts of their production or goods. Available from: http:// www.icmm.com/page/84173/materials-stewardship

- Aluminium Stewardship Initiative (ASI), Switzerland seeks
  to mobilise a broad base of stakeholders to foster greater
  sustainability and transparency throughout the aluminium industry.
  Available from: http://aluminium-stewardship.org/
- Ultra-Light Steel Auto Body (ULSAB) initiative. Available from: http://www.autosteel.org/Programs/ULSAB.aspx