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Plastic Credits – Financing the Transition to the Global Circular Economy

Final Assessment Report on the Pilot Regions Goa, Maharashtra, Kerala

For: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Executive Summary

Baseline Assessment Report

The project "Plastic Credits – Financing the Transition to the Global Circular Economy" supports the implementation of a waste management structure in India´s rural regions. By that it aims to improve the current waste collection and treatment structures in the pilot regions Goa, Maharashtra, and Kerala. Herein, the project focuses on low value plastics (LVP), and especially multi-layer plastics (MLP), that have no market value. In order to analyze the environmental impacts of the project, an Environmental Impact Assessment (EIA) was conducted. The considered environmental components comprise: greenhouse gas emissions, usage of primary resources, impacts on marine and terrestrial wildlife, standard of living, and economic costs.

Nowadays, 11.6 million tonnes of MLP waste are generated in India each year of which only an estimated 3.6% are collected. The situation in the pilot regions is comparable: In Goa, 25 kilo tonnes of MLP are generated per year, a share of 11% is collected. In Maharashtra, a value of 13 kilo tonnes of MLP generation was estimated of which nothing is collected. For Kerala, no data regarding MLP waste generation and collection is available. The low collection rates imply that most waste is being openly landfilled, dumped into the environment, or burned in an uncontrolled way.

Interim Assessment Report

Within the framework of this project, a value chain for the collection of plastic waste from households and its treatment was set up in each of the three pilot regions. The collection and sorting were carried out by the partner organizations vRecycle in Goa, EcoSattva in Maharashtra and Greenworms in Kerala. The project partner rePurpose was responsible for the overall coordination. Over six months, from April to September 2022, MLP and other LVP waste was collected and then sorted at material recovery facilities. After sorting, the waste was sent for further processing either to cement kilns, where it was used as substitute fuel (i.e., co-processed), or to a recycling facility, where it was mechanically recycled (i.e., reprocessed).

The conducted EIA is structured by an Environmental Impact Assessment Matrix that contains the relevant project activities as rows and the environmental components as columns. Herein, the components cover the impacts that are generated by the project activities on the environment. By a literature review, eight main environmental impacts were identified that are clustered into four categories: Physical/Chemical, Biological/Ecological, Sociological/Cultural, Economic/Operational. They are further differentiated between direct and indirect impacts. The impacts on marine and terrestrial wildlife, on social components like employment and health, as well as the economic impacts of the project on the fishing and tourism industry are qualitatively analyzed. The direct changes of CO_2 emissions and the saving of raw materials are quantitatively estimated by considering the emissions from the use of plastic in cement kilns in comparison to fossil fuels (like coal) which is substituted. Additionally, emissions for the recycling process are calculated for the amount of recycled plastic.

Final Assessment Report

During the project implementation phase, a total of 2 138 175 kg of plastic waste has been collected referring to 2 095 555 plastic credits that were generated through this project. A share of 421 tonnes of LVP waste were co-processed in Goa, another 265 tonnes were co-processed in the region of Aurangabad in Maharashtra. In Kerala, 999 tonnes of MLP were co-processed and 411 tonnes that comprise other LVP were mechanically recycled.

Various positive impacts of the project activities on the environment were identified. First, through the project activities and the substitution of fuel in cement kilns by plastic waste, around 2.2 kt of CO2eq have been saved. This corresponds to a reduction in the usage of raw materials of 2.3 kt of coal. Additionally, 0.4 kt of primary plastic were substituted by recycling a part of the plastic waste that was collected during the project phase. Furthermore, by reducing the amount of plastic in the environment, the project contributes to the cleanliness of the nearby areas and oceans and hence reduces the negative consequences of plastic debris and microplastics on marine and terrestrial wildlife in the regions Goa, Maharashtra and Kerala. While larger plastic particles (>20 mm) and plastic threads are more likely to cause entanglement of marine and terrestrial animals, smaller plastic particles (<5 mm) affect organisms through ingestion and subsequent health impairments. An additional threat is posed to wildlife by toxic substances which are contained in the plastic particles. These either originate from the production process, or from the surrounding and accumulate on the particles. Moreover, by damaging fishing vessels, reducing fishing time on sea and supporting a declining fish stock, marine plastic litter impacts India's marine fishing industry. Assumably, the economic losses for the country due to these impacts are millions of Euros each year. Furthermore, plastic litter affects tourists' choices for travel destinations as well as the length of their visits. Hence, by cleaning up dirty areas, the revenue of the tourism sector, which is an important pillar of India's economy, can be increased significantly. Through the collection of plastic waste as done in this project, the environmental pollution by plastic litter is reduced and the economic revenue of industries like fisheries and tourism is increased.

Social components of the project include the positive impact on human health through a cleaner environment and the creation of job opportunities along the value chain. Plastic in general and plastic waste in particular poses a threat to human health when it enters the body. On the one hand, microplastics can mechanically irritate the organism and cause inflammatory reactions. On the other hand, they can release toxic substances into the body. These negative impacts are reduced by the collection of plastic waste and its appropriate treatment. Furthermore, the creation and support of job opportunities by this project within the waste collection sector has created significantly better working conditions, especially for women. This holds true not only because women have been transferred from the informal waste management sector to the formal one, but also due to the provision of personal protective equipment and health insurance coverage to many of the workers. At the end of the project implementation phase, 379 workers in Kerala, 109 in Maharashtra and 23 in Goa were involved in collection, pre-processing and separation activities. Since almost exclusively women are employed for waste segregation, women empowerment has been observed as a social benefit as well.

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1 Introduction

This report is complementary to the previous Baseline Assessment Report (Wuppertal Institute & rePurpose, 2022a) and the Interim Assessment Report (Wuppertal Institute & rePurpose, 2022b). The Baseline Assessment Report provides an overview on the issue of plastic waste in India and of this Circular Solutions pilot project. It presents data on waste generation and waste management in the three pilot regions Aurangabad (Maharashtra), Goa and Kerala. The Interim Assessment Report provides more detail and describes the project setup in the respective pilot region. It also contains a description of the methodology for the Environmental Impact Assessment (EIA), presents first results on the Environmental Impact Assessment Matrix and on the calculations of the greenhouse gas emissions emitted along the value chains that were set up.

Against this background, this Final Assessment Report firstly presents evaluated data on the amount of plastic waste collected and managed throughout the implementation phase of the project from April until September 2022 (section 2). Furthermore, it comprises the final results of the EIA (section 3). The report concludes with a discussion on the outcomes of the pilot projects as well as shortcomings, particularly with regard to the overall concept of plastic credits (section 5).

2 Data presentation

In this chapter, the data gathered in the three pilot regions over the period of the project implementation phase is presented. These include the amount of plastic waste collected and processed as well as reported information on the households from which the waste was picked. A detailed description of the project setups and processes within each region can be found in section 2 of the Interim Assessment Report (Wuppertal Institute & rePurpose, 2022b).[1]

In the following, the amounts of collected low value plastic (LVP) waste and the numbers of households paying a user fee will be presented in figures. Figure 1 shows the respective data for Goa. In each month of the implementation phase of the project from April to September 2022, a value between 68 and 98 tonnes were collected resulting in a sum of 458 tonnes of LVP. These were gathered from more than 41 000 households that are paying a user fee and of which about 97% separate their waste.

Figure 2 shows the amount of collected plastic and the numbers of households in the region of Aurangabad in Maharashtra. The month with the highest collection rate was April (58 tonnes), which decreased over the six months to 32 tonnes in September. The decrease might be due to different reasons including weather conditions. In total, 269 tonnes of LVP were collected in Aurangabad. A percentage of 90% to 95% of the about 60 000 households from where the waste was collected separate the waste at the source.

In the case of Kerala, a share of the LVP was sent to the recycling facility in Erode, Tamil Nadu where it was mechanically recycled.[2] This part will be referred to as recyclable flexibles (RF) in the following. Figure 3 depicts the volume of LVP that was collected over the time of the project implementation phase in Kerala. Every month more than 200 tonnes of plastic waste were collected resulting in a total of 1 411 tonnes gathered throughout the project. Figure 3 further shows that the number of households that pay a user fee in Kerala increased steadily from about 28 400 in April to more than 31 000 households in September. This increase might be due to the addition of a new village to the collection scheme in April.

Figure 4 shows the amount of LVP waste that was processed within each of the three regions. As in Maharashtra and Goa most of the LVP consists of non-recyclable MLP, all waste was sent to a cement kiln where it was used as substitute fuel. In Maharashtra, a total of 265 tonnes were treated in a cement kiln, which is 98% of the collected amount. Another 421 tonnes of LVP waste were co-processed in Goa (92% of the collected amount). The differences in the amount of collected and processed plastic are due to losses during the pre-processing step. In Kerala, 999 tonnes of collected MLP were processed in a cement kiln and 411 tonnes of the collected RF were mechanically recycled. Overall, a total of 1 685 tonnes of LVP was co-processed in a cement kiln and 411 tonnes of LVP were re-processed in a recycling facility. As one kilogram of processed plastic waste refers to one plastic credit, it can be concluded that

1 For detailed information about the workers that were involved in the process, see subsection 3.3.1.

2 In the Interim Assessment Report (Wuppertal Institute & rePurpose, 2022b), it was falsely stated that the recycling facility was in Chennai, Tamil Nadu. The changed distance of 285 km (instead of 235 km) from the material recover facility to the recycling facility in Erode does not change the conclusion that transport makes up only a minor part of the overall emissions.

a total of 2 096 000 plastic credits were generated through this project, which exceeds the pre-set goal of 1 000 000 credits by over 200%.

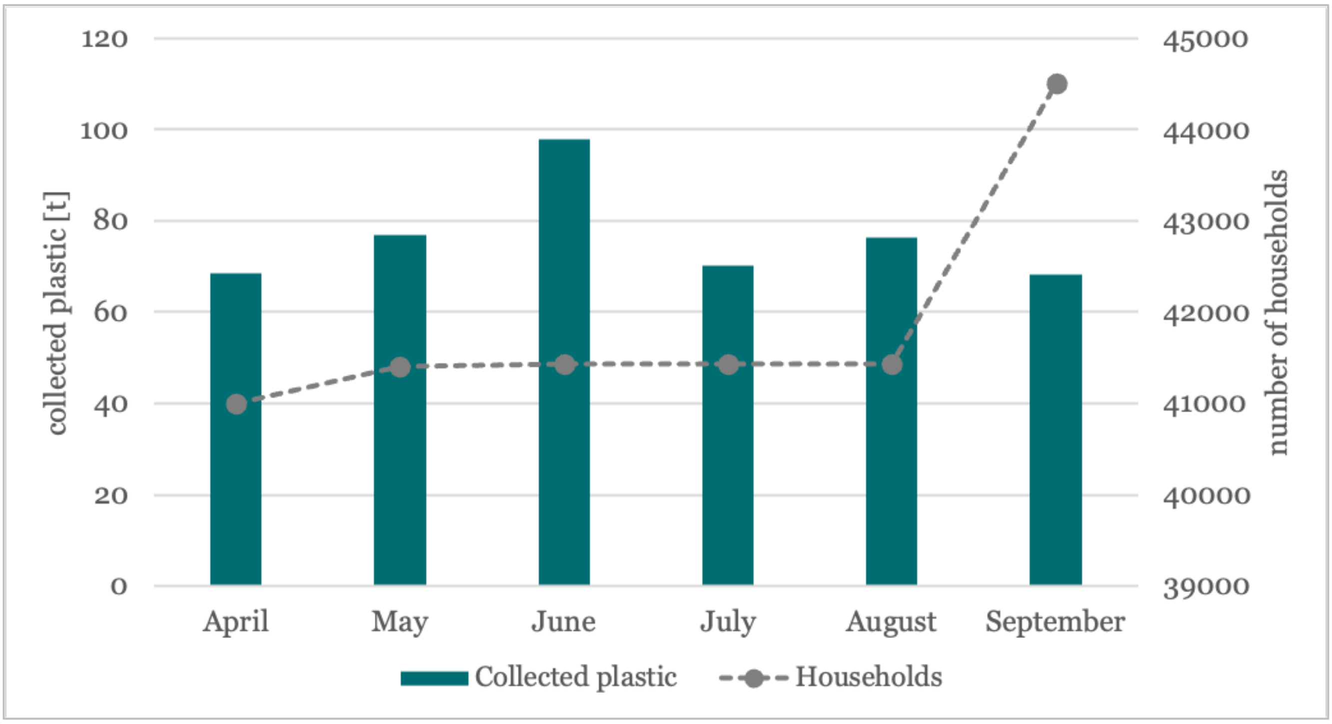

Figure 1 **Amount of collected LVP (includes MLP) and number of households paying a user fee per month in Goa.**

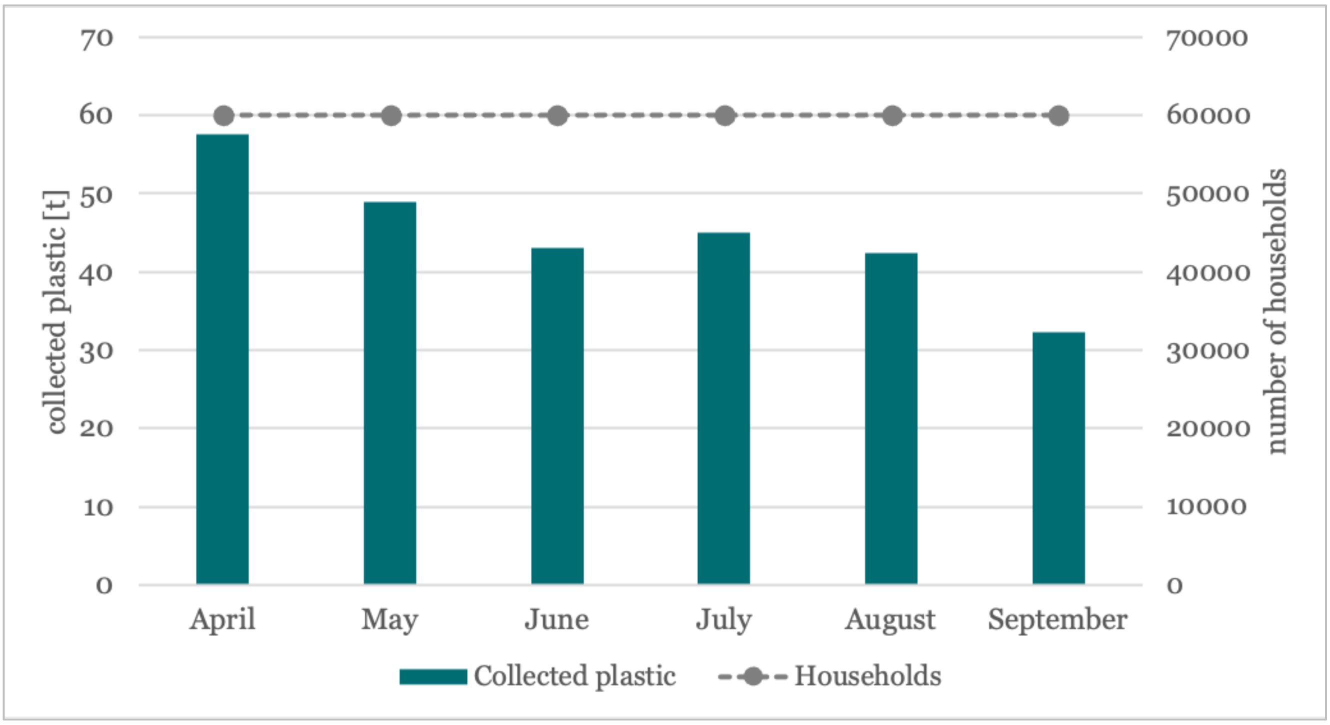

Figure 2 **Amount of collected LVP (includes MLP) and number of households paying a user fee per month in Maharashtra.**

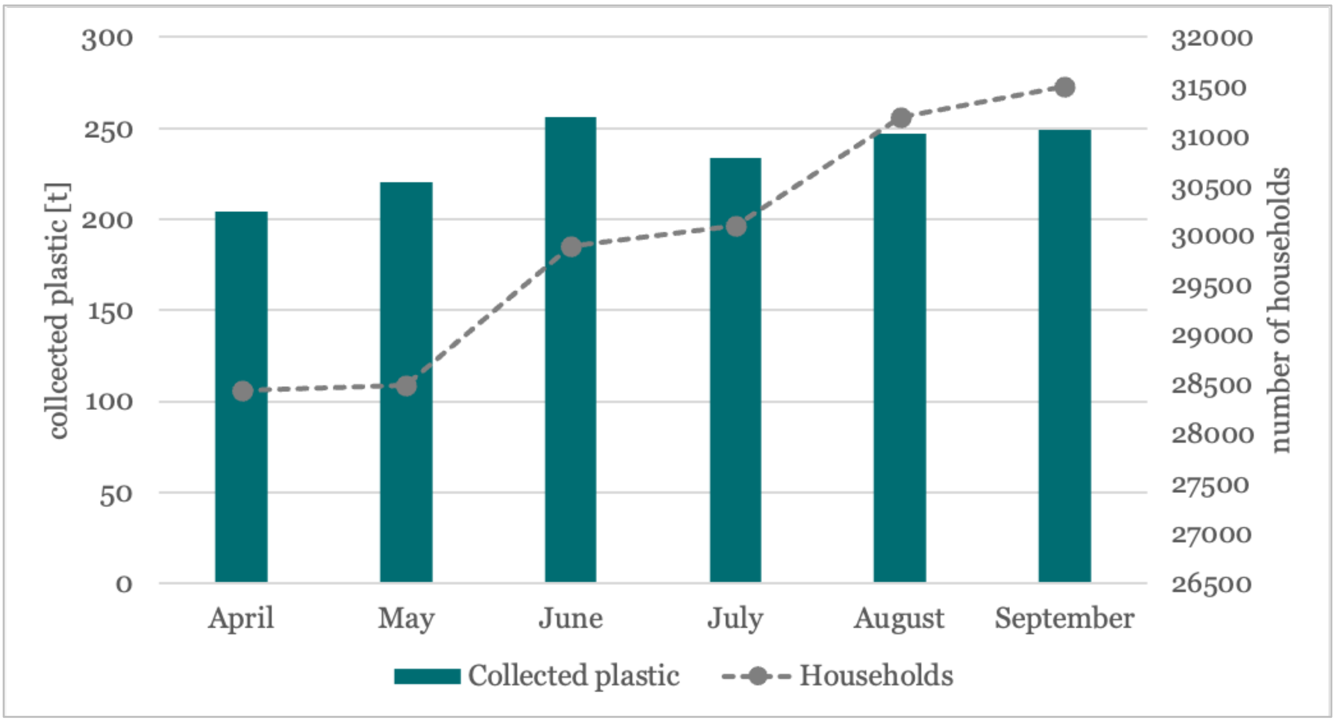

Figure 3 **Amount of collected LVP (MLP + RF) and number of households paying a user fee per month in Kerala.**

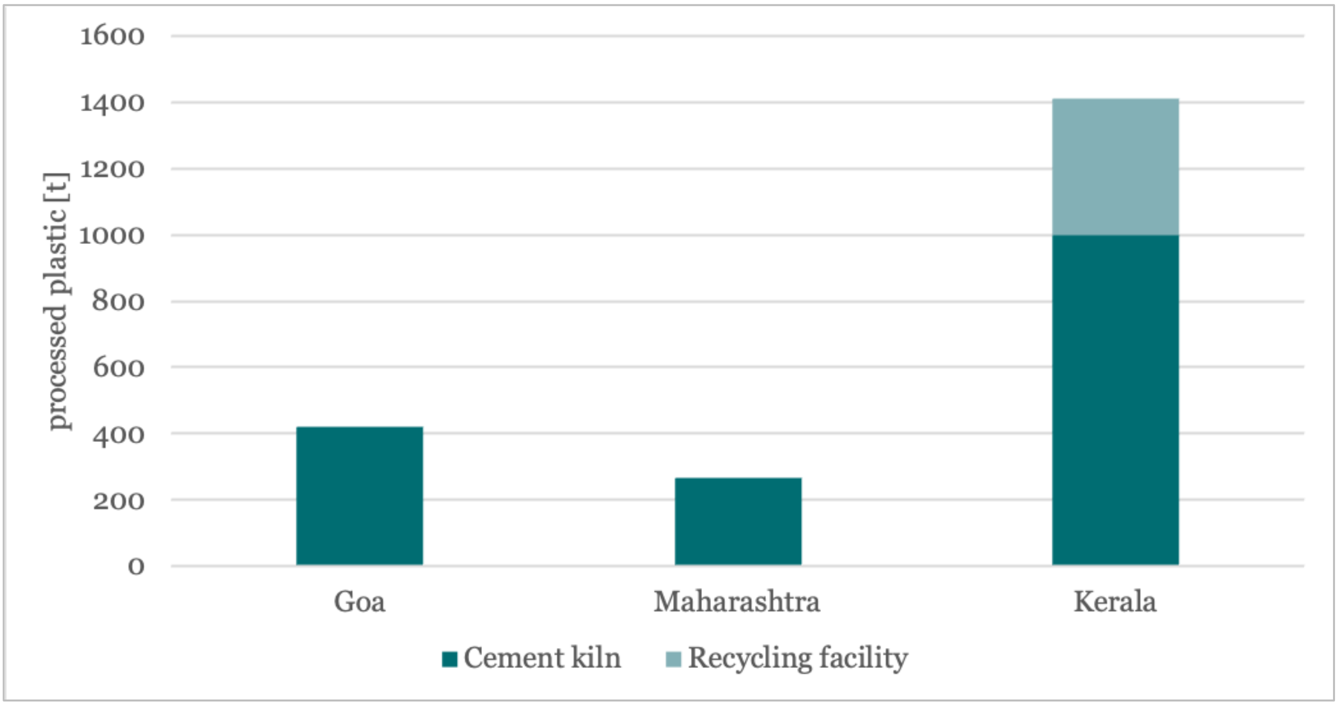

Figure 4 **Total amount of processed plastic per region distinguished by waste treatment.**

3 Environmental Impact Assessment

Although the methodology of the EIA was explained in detail in the Interim Assessment Report (Wuppertal Institute & rePurpose, 2022b), the observations from the site visit, that took place in September 2022, provide further information that are taken into account for the results on the direct social component *Employment*.

Table 1 shows the Environmental Impact Assessment Matrix (presented and explained in the Interim Assessment Report). The matrix provides a structure to the EIA assessment as it shows the linkages between project activities and environmental components.

Table 1 Environmental Impact Assessment Matrix with correlations between the considered project activities and environmental components.

Project activities / Environmental components	Collection of LVP	Segregation and pre-processing of LVP	Co-processing of LVP in cement kilns	Recycling of LVP (only for Kerala)
1| Physical / Chemical				
CO_2 emissions (direct)			✓	✓
Usage of raw materials (direct)			✓	✓
2| Biological / Ecological				
Marine wildlife (indirect)	✓			
Terrestrial wildlife (indirect)	✓		✓	✓
3| Sociological / Cultural				
Employment (direct)	✓	✓		
Health (indirect)	✓		✓	✓
4| Economic / Operational				
Fishing industry (indirect)	✓			
Tourism (indirect)	✓			

In the following, for each of the eight components, results will be outlined following the same structure as the matrix:

1 | Physical and chemical impacts (section 3.1)
2 | Biological and ecological impacts (section 3.2)
3 | Sociological and cultural impacts (section 3.3)
4 | Economic and operational impacts (section 3.4)

At the beginning of each of the four subsections, a short overview of the issue is given. Afterwards, each impact factor is analyzed in detail in a quantitative and/or qualitative way (see also section 3 of the Interim Assessment Report for an explanation of the methodology) and put in reference to the project activities.

3.1 Physical and chemical impacts

In the following two subsections 3.1.1 and 3.1.2, the direct climate and resource related impacts of the project are quantified. The Interim Assessment Report has already shown that emissions from collection, segregation and pre-processing are neglectable in this project. Hence, the changes of CO_2 emissions due to co-processing in cement kilns as well as recycling of the collected LVP are calculated. Furthermore, it is estimated how much raw material is saved by using plastic waste as a substitute for fossil fuels such as coal and gas in the cement factory or for crude oil when the recyclate replaces primary plastics.

3.1.1 CO_2 emissions

In the life cycle of plastic products CO_2 is emitted at various stages. The extraction of crude oil or gas leads to emissions and the refining and polymerization steps require process energy and are therefore linked to emissions. The conversion of plastic granulates into the actual product mainly consumes electric energy and additionally emits CO_2. After the use phase, the collection process contributes further emissions to the footprint through the emissions during collection and sorting, e.g., by collection vehicles. If the plastic is burned, the total carbon content is emitted as CO_2. Depending on the scope these emissions can be (partly) attributed to other products if the burning serves another purpose such as cement or energy production. Overall, the share of emissions from plastics in total global emissions are in the lower single digit percentage realm, but are projected to increase in the future (OECD, 2022). These emissions can be reduced through several approaches. The most promising but least likely approach would be a dramatic decrease in the production of plastic products. Other approaches towards circularity are the switch to renewable energy in the production process, the use of recycled plastic as raw material for new plastic products and the already mentioned “purposeful” burning of plastic waste in cement kilns or other processes. It however needs to be highlighted that in line with the waste hierarchy, the incineration of plastic is to be seen as the last resort for the management of waste.

The activities in this project address two of these approaches: Plastic waste is recycled or - if that is not possible - used as fuel for cement kilns. If the plastic waste substitutes coal as fuel in the cement kilns, the emission savings can be calculated with the contained Energy (E) calculated with the calorific values (H_u) and the mass of the collected plastic ($m_{plastic}$):

$$m_{plastic} \cdot H_u = E$$

This energy content can then be correlated with the amount of greenhouse gasses as CO_2 equivalents emitted through the burning of plastic fuels. A theoretically emitted amount of CO_2 can be calculated that would have been emitted by burning coal. The difference between these two values results in the amount of CO_2 saved.

For the calculation the values presented in the Interim Assessment Report (Wuppertal Institute & rePurpose, 2022b) were used. Plastic waste was assumed to be PE, which results in an upper boundary for the CO_2-savings due to its low specific emission factor of 0.0681 kg_{CO2eq}/MJ and its high calorific value of 46.1 MJ. The values for anthracite coal with a calorific value of 34.361 MJ/kg and an emission factor of 0.0968 kg_{CO2eq}/MJ were used as the fuel to be substituted. The emission saving from the use of MLP instead of coal in cement kilns is shown in Table 2 and Figure 5. In total, an amount of 2.2 kilo tonnes of CO_2eq were saved.

Table 2 Emission savings from the substitution of coal by MLP in cement kilns.

emissions saved [t CO_2eq]	Goa	Maharashtra	Kerala
April	90	75	166
May	86	64	211
June	116	57	224
July	78	59	220
August	100	54	260
September	88	41	241
Sum	**558**	**350**	**1322**

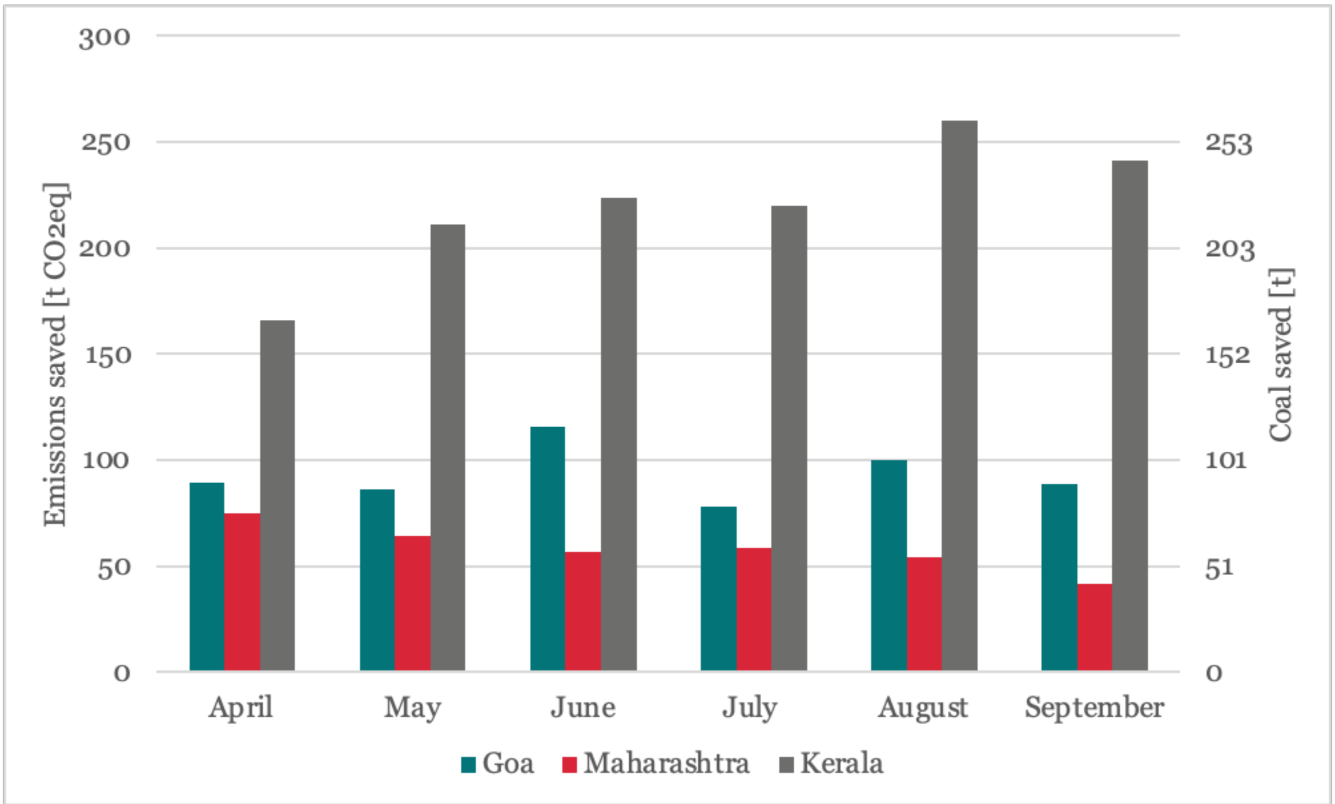

Figure 5 Emissions saved through the collection of plastic waste in this project for the different regions – left axis. Coal saved through the collection of plastic waste in this project for different regions – right axis.

3.1.2 Usage of raw materials

Through the collection of plastic waste, material was regained that otherwise would have been openly burned or leached into the environment. By using this waste as a secondary material, primary material can be substituted. If the plastic is incinerated in a cement kiln, it substitutes coal or gas, if the waste is mechanically recycled, it substitutes virgin plastic.

To calculate the amount of replaced plastic two assumptions have been made:

1| In the produced products the material that is replaced is virgin plastic. The amount of recyclate needed is equal to the amount of virgin plastic.[3]

2| The losses in plastic during sorting and recycling of plastic waste are 5% higher than those for more homogenous fractions plastics.[4] These losses occur through higher reject rates because of material inhomogeneities or when further cleaning steps, like melt-filtration units, are used in the extrusion process. Here a part of the recycled material is screened out together with impurities.

These assumptions lead to a conversion factor of 0.95 of the recyclable plastic to plastic saved. The resulting amount of plastic saved for the different regions and for the duration of the project is shown in the following Table 3.

Table 3 **Savings of the raw materials plastic and coal that were substituted by the LVP and MLP collected in this project.**

Region	Amount of LVP co-processed [5]	Amount of LVP re-processed [6]	Coal replaced by LVP	Plastic replaced by recycling plastic
Goa	421 t	-	565 t	-
Maharashtra	265 t	-	355 t	-
Kerala	999 t	411 t	1340 t	390 t

3.2 Biological and ecological impacts

Next to the direct impacts, the project activities also cause indirect environmental impacts given the fact that the plastic waste, if not collected, would be openly burned, dumped or landfilled in the respective regions. This would lead to plastic pollution on land as well as in the ocean due to the proximity of the pilot regions to the coast. Against this background, the following two subsections 3.2.1 and 3.2.2 present a discussion on the negative impacts of plastic litter on wildlife. This includes marine litter and its impact on marine wildlife, as well as environmental pollution by plastic

3 This replacement-ratio is case specific and can be higher, especially in products like foil, or mechanical components that have demanding mechanical requirements. Since an average makes it not computable, we assume this ratio of 100% as an upper boundary.

4 The losses in conventional plastic manufacturing are about 8% (Conversio, 2020).

5 See section 2.

6 See section 2.

waste on land and its effect on terrestrial wildlife. It is assumed that the health of terrestrial wildlife is potentially harmed in the same way by plastic waste and its treatment as the health of humans which is analyzed in further detail in subsection 3.3.2.

3.2.1 Marine wildlife

Every year, about 330 million tonnes of plastic are produced, which results in about 99 million tonnes of plastic waste and 4.8 - 12.7 million tonnes of this waste is emitted into the oceans (Akhtar et al., 2022, p. 251). In order to assess the different impacts of plastic pollution on marine biotopes, it is important to first categorize plastic litter. In determining the impact on different organisms at the same time, it is useful to classify plastic waste according to the size it appears. Plastic waste can be found in the ocean in all sorts of different sizes. Even though plastic litter is not biodegradable, it is exposed to various environmental processes that cause fragmentation of the materials and break them down into smaller particles (Bhusare et al., 2022, p. 277). The following list shows a rough subdivision of the relevant plastic particle sizes (Barnes et al., 2009, p. 1986; Boyle & Örmeci, 2020, p. 3):

- megaplastic: > 100 mm
- macroplastic: 20-100 mm
- mesoplastic: 5 - 20 mm
- microplastic: < 5 mm
- nanoplastic: < 0. µm

Due to the varying size of plastic particles, they pose different risks to flora and fauna in the marine environment. The most relevant risks posed by marine plastic litter are entanglement, ingestion and the damage to coral beds and seagrass beds (Das et al., 2020, pp. 7–9).

Entanglement

A great danger posed by plastic objects bigger than 20 mm to marine organisms is that they get entangled in them. The occurrence of these plastic objects in the oceans leads to strangulation, suffocation and drowning of some animal species. Also, several animals die due to fatigue when trying to free themselves from the entanglement (Das et al., 2020, p. 7). However, the entanglement of animals in plastic waste does not only result in the death of those affected. A study conducted on the coast of Kerala also found a change in the behavior of various species of seabirds caused by entanglement in plastic waste (Nisanth & Biju Kumar, 2019, p. 118). Nisanth & Biju Kumar (2019) state that in 2019, a Lesser Black-backed Gull was observed to have become entangled in a plastic ring. Due to feeding restrictions caused by the entanglement, the resulting consequences for the animal included a nutrient deficiency which resulted in disturbed plumage. However, entanglement in plastic waste affects almost all marine species. Large marine animals such as turtles and whales, as well as small sea creatures such as crabs, become entangled in plastic. Animals such as seals and sea lions are even attracted to plastic pieces formed into loops (Dar et al., 2022, p. 293). In addition, abandoned or lost fishing nets lead to ghost fishing by drifting through the sea and entangling animals on a large scale (Dar et al., 2022, p. 293).

As the data available to analyze the impact of entanglement is significantly dependent on the number of reports of these incidents, it is difficult to determine the exact dimension of the problem. However, experts interviewed rated the problem of animal entanglement in plastic waste as a greater threat to sea turtles than oil pollution, climate change and direct exploitation. Nevertheless, they rated entanglement as a lower risk than ingestion of plastic waste and bycatch in fisheries (Steer & Thompson, 2020, pp. 53–54).

Ingestion

Another risk that plastic litter poses to marine life is the ingestion of plastic particles, specifically with a size of less than 100 mm. The ingestion of the waste particles occurs either through the false assumption that it is considered food or prey, or by accidentally consuming it during feeding (Das et al., 2020, p. 7). Animals have difficulties distinguishing plastic parts from real food due to the partly close resemblance of the smell and taste to the animals' regular food (Dar et al., 2022, p. 292). The ingestion of plastic litter can cause a variety of negative effects including a reduced growth, a disruption of enzymes and hormones, a delayed ovulation or reproductive failure. In addition, hazardous chemicals such as polychlorinated biphenyls can enter the body through the ingestion of plastic particles, which can have a wide range of negative effects on the health of the animals (Das et al., 2020, p. 8). Also, internal and external injuries, blockage of the digestive tract leading to satiety, hunger and weakness, which may ultimately be lethal, can result from ingestion of plastic waste. Reduced food intake and behavioral impairment in dangerous situations also occur (Dar et al., 2022, p. 294). In this way, along with the consequences of climate change, the distribution of plastic waste in marine ecosystems leads to a major loss of biodiversity if no appropriate action is taken (Kapinga & Chung, 2020, p. 28).

Another negative result of the microplastic pollution of the marine habitat is the impact on the food chain. As micro- and nanoplastic pellets are easily absorbed by organisms due to their small size, they accumulate in various marine species. When humans subsequently consume fish or other marine organisms, the micro- or nanoplastics are transmitted on and deposited in the human body (Das et al., 2020, p. 9).

Concluding review

In conclusion, it can be said that the spread of plastic debris in marine ecosystems leads to many types of damage. The consequences depend on the shape and size of the plastic particles. While larger plastic particles (> 20 mm) are more likely to cause entanglement of animals, smaller plastic particles (< 5 mm) affect organisms through ingestion and subsequent health impairments. In addition to the fauna, however, the flora, i.e., the biotopes, including seagrass meadows and coral reefs, are also negatively affected. Concerning these, plastic debris lowers the distribution and even reduces the population. In addition, the spread of various diseases is promoted leading to the death of the respective organisms in the long term if no actions are taken. In India, 19.4 million tonnes of plastic waste are generated every year (Wuppertal Institute & rePurpose, 2022a). A significant part of that is either not collected or offloaded on open dumpsites. By reducing the amount of plastic in the environment, this project contributes to the cleanliness of the oceans. Therefore, the project activities can have a positive impact on the marine areas neighboring Goa, Maharashtra and Kerala and reduce the negative consequences of plastic debris on marine wildlife.

Excursus: Damage to coral- and seagrass beds caused by plastic debris

Coral reefs are complex underwater habitats that are built up by coral polyps and can take on various forms, such as large, reef-building colonies, but also small, solitary forms. They are connected by calcium carbonate and their solid structure prevents erosion on coasts and protects them from storms (Akhtar et al., 2022, p. 245). In the vulnerable marine ecosystem, all types of plastic waste affect the ecology, geographical distribution and health of coral reefs (Akhtar et al., 2022, p. 244). Coral reefs are irreplaceable marine biotopes with high complexity, biodiversity and productivity, but they are also highly vulnerable and continuously exposed to a combination of natural disturbances and human activities. These include various drivers such as climate change, ocean acidification, marine pollution, disease and ultimately plastic litter pollution. The combination of these factors results in more severe impacts on coral reefs than an individual factor alone. For example, Yang et al. (2020) state that the combination of changed environmental parameters such as CO_2 concentration, temperature and light irradiation together with nanoplastic contamination can affect the growth of microalgae and the toxicity of nanoparticles, which may impact coral biotopes in the long term (Huang et al., 2021, p. 27).

Plastic particle contamination can have various negative effects on coral reefs. One negative consequence is that plastic waste can increase the likelihood of coral reef disease by up to 22 times. Common coral diseases such as white syndrome, skeletal erosion, black band, growth anomalies, atramentous necrosis and brown band can be attributed to plastic waste contamination (Akhtar et al., 2022, p. 247). Infections like these can be further exacerbated by the shortage of light and oxygen caused by plastic build-up on corals. In addition, the reduced light and oxygen supply affects the metabolism of the affected coral structures. External injuries to the coral skin are also possible, enabling the intrusion of various bacteria and promoting infections. Plastic waste thus has a generally destructive effect on coral structures, which in turn has negative consequences for fish populations, as coral reefs are relevant habitats for them (Akhtar et al., 2022, p. 249).

Furthermore, the spread of plastic waste has a negative effect on algae and seagrass. It is suspected that microplastics block algae's access to light. It is also assumed that microplastic particles affect the root growth of various algae species, leading to a decrease in root length (Bhusare et al., 2022, p. 271). Seagrass beds are valuable habitats for many different marine organisms, but they are decreasing due to stress factors such as sediment disturbance and introduced macroalgae. As various plastics modify the structure of certain seagrass species, invasion by invasive macroalgae is possible (Menicagli et al., 2021, p. 10). The spread of plastic litter in the oceans thus leads to a restriction of the growth of marine macrophytes and destroys ecosystems shaped by them.

3.2.2 Terrestrial wildlife

Studies on the impact of microplastics on terrestrial wildlife are limited. The health risks from particulate plastic and low molecular mass substances described in Subsection 3.3.2 apply to humans and, in a similar form, to many vertebrates. The form and extent of exposure are extremely variable, depending on the species, and therefore cannot be addressed in an all-inclusive manner. Instead, possible exposure pathways are outlined using several examples.

Ingestion of (micro)plastic particles

Various studies and case reports confirm that ingestion of plastic is a way of exposition. This holds true for such diverse taxa of animals as mammals, birds, reptiles, amphibians or insects. In the case of ingestion, the particles can trigger various impacts. In addition to those mentioned in the health section, injuries from sharp edges of larger particles have been reported and there are cases where plastic particles clog up the digestive organs or suppress the feeling of hunger.

Trapping

While entrapment and entanglement in plastic waste is a problem that is of great concern to marine wildlife, it can affect larger terrestrial animals as well. There are numerous reports of animals getting stuck in plastic items such as bottles, jars, bags, bottle rings or strings (Blettler & Mitchell, 2021). This can distract the animals, restrict their ability to move, prevent effective foraging and hunting and therefore can have lethal effects.

Material for nesting and shelter

Plastic materials such as threads or containers are used as substitutes for natural materials in nests or shelters. This in itself does not necessarily pose a threat to the animal using it except the increased risk of exposure to plastic. In some instances there have been reports of chicks getting entangled in the threads used as nesting material or animals getting stuck in their plastic shelter (Blettler & Mitchell, 2021).

Concluding review

The collection of LVP carried out in this project reduces the total amount of plastic waste in the area, thus contributing a small part to the improvement of this challenging situation. Due to its low market value, it can be assumed that LVP (and MLP) in particular makes a large contribution to the waste that otherwise would have ended up in the environment.

3.3 Sociological and cultural impacts

The project has a direct social impact in India through the creation of jobs along the value chain, i.e., in the collection, segregation and pre-processing steps. Furthermore, human health is affected by plastic waste pollution and its treatment - and therefore indirectly by the project activities of collection, co-processing and recycling - in different ways. Both aspects are subjected to a qualitative analysis in this chapter (subsections 3.3.1 and 3.3.2).

3.3.1 Employment

Apart from the environmental benefits, this project also assesses the potential impacts on socio-economic aspects including employment, income, working conditions and health insurance. Overall, it has to be mentioned that job opportunities were created that did not exist before. Depending on the region, different numbers of locals are employed. A distinction is made between workers in (1) waste collection and (2) segregation and pre-processing. This separation is relevant as the workers in waste collection in Kerala and Maharashtra are employed by the panchayat and municipality, respectively, and are therefore not recipients of this project funding. Therefore, the activity of waste collection cannot be attributed exclusively to this project. Moreover, it should be noted that the wage level varies by region, as minimum and average wages differ between Indian states.

Wages

In Goa, 11 people were employed in waste collection and transportation in April and May 2022, which was lowered to 8 workers in the period from June to September 2022. A total of 14 workers were responsible for segregation and pre-processing in April 2022 and 15 from May to September 2022. The salary paid amounted to ₹15 000 per month, which is well above the minimum wage. The minimum wage for unskilled workers in the Goa region is ₹307 per day, which amounts to a monthly salary of ₹8596 for 28 working days. For semi-skilled workers, the minimum wage is 368 ₹ per day and about 10 304 ₹ for 28 working days per month (Government of Goa, 2016). Additionally, overtime rates are paid to employees who work past the designated work times or on weekends. The project thus supported the creation of jobs that were paid well above the minimum wage.

In Maharashtra, 78 people were involved in waste collection during the period from April to September 2022. The women employed in the area of waste collection were paid by the local municipality, which is why the exact wage level for this work is not given. In the same period, 31 people worked in segregation and pre-processing, which was paid on a daily wage basis by the project's budget. The salary paid for the second group was ₹10 500 (129€) per month, which is higher than the minimum wage in Maharashtra (Prakash Consultancy Service, 2022). Currently, the workers in segregation and pre-processing are paid according to the amount of waste they sort. The project partner EcoSattva intends to move to a model where they work as a team and earn a general income that is also paid in case of sick leave.

In Kerala, a total of 270 people were employed in waste collection between April and June 2022 and 273 people in the period from July to September 2022. The panchayat organized the employment of this women's self-help group and was therefore responsible for the payment of wages. Previously, the income was dependent on the amount of waste delivered, but meanwhile it is divided according to attendance in order to encourage teamwork. In some cases, there are incentives if more than the targeted quantity is collected. One point of critique is that the women's self-help group is appointed by the municipality for this work, but the workers are not employed by it. In the segregation and pre-processing category, 94 people were employed directly by the project in April and May 2022. This number increased over the months to 106 employed workers in September 2022. The daily salaries paid in the segregation and pre-processing category in April and May were ₹362 per person, which amounts to a monthly salary of ₹10 136 (124€) for 28 workdays per month. In June, July and August, the wages paid were ₹400 per working day leading to a total monthly salary of ₹11 200 (137€). In September, the wages were increased to ₹450 per working day which relates to a monthly salary of ₹12 600 (155€). A total of 7 employees in this field were paid by the project's budget, which is why the income listed exclusively applies to these 7 female workers. The hours worked in segregation and pre-processing per day amounted to approximately 8-10 hours. The minimum wage for work in Kerala which would be comparable to the segregation and pre-processing category is between ₹11 950 (147€) and ₹12 090 (148€) (Government of Kerala, 2021) which means that the salary paid here exceeds the minimum wage in the last month only.

Health insurance

During a visit to the three pilot projects in September 2022, the local partners stated that most of their workers have statutory health insurances. Generally, their workers qualify for health insurance, but in some cases, they face the problem of lacking the required documents. The project partners or NGOs support the workers in obtaining the necessary documents. The local project partner vRecycle in Goa also has a private doctor for these cases, but intends to include all employees in the state health insurance. Currently, none of the local project partners have paid sick leave for their workers.

Worker's perception

In the discussions on site with the female workers and the local project partners, the following points were highlighted as particularly important to them:

- having a stable income, earning their own money,
- earning money they can use for their children's education,
- having a safe space and suitable equipment for work (working outside is difficult, especially for the older women),
- wearing uniforms, resulting in more respectful treatment by others and dignity,
- going to work in a center, which means not picking up waste from the street,
- working together.

Concluding review

Conversations during the site visit revealed that the project causes additional social impacts next to the financing component. In the case of Kerala, these include above all the empowerment that comes with self-determined work and independence for the women involved, which was created and ensured by the project. In addition, the employment in the project offers better working conditions than in municipal waste management companies. The waste workers employed by the municipality often lack appropriate protective equipment, training and education on hazardous materials and risk situations. Therefore, improved occupational safety for the workers involved is also one of the social benefits made possible by the project. One point with room for improvement, however, is that despite health insurance there is no continued payment of wages in case of sick leave.

3.3.2 Health

To begin with, it is important to note that research on the health risks of plastic in general and plastic waste in particular is still in its infancy. This means, above all, that it is to be expected that further findings will be added in the coming years and decades. Until then, the authors believe that the precautionary principle should apply and exposure should be reduced or minimized to the extent that this is possible. The following is an overview of the current state of research, with a focus on plastic waste, but often basic research findings on plastic in general can be applied to both plastic packaging and plastic waste.

The risk posed by plastic to human health can be divided into three subcategories, which are often mixed up in the general debate:

1| **Health risks from particulate plastics:** These are various polymeric substances, but mainly commodity plastics such as polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC) and polystyrene (PS). Exposure occurs either directly during the use of the item made from the plastic or through oral and pulmonary ingestion of tiny particles originating from improperly disposed plastic waste, i.e., through inhalation or ingestion of microplastics from plastic waste (Yee et al., 2021).

2| **Health risks from low molecular mass substances:** For these substances, a distinction must again be made between two cases:

   a. Substances used in the manufacture of the plastic: These are mainly additives added to the plastic during compounding, but also residual monomers or processing aids. These substances can be emitted from the plastic or plastic waste and enter the human body. Many of the substances themselves or their metabolites pose a health risk to humans and other living organisms.
   b. Substances that accumulate in the plastic particle: Plastics that have entered the environment can absorb substances from their surroundings, such as soil or water. Since they are much more hydrophobic compared to their environment, other hydrophobic substances accumulate in these particles. In particular, these are substances of anthropogenic origin that can also pose a risk to humans when released from the particle after entering the human body.

3| **Health risks from climate change caused by greenhouse gas emissions from the production and disposal of plastic waste:** Plastic production currently contributes to about 3% of global greenhouse gas emissions (*Plastic Leakage and Greenhouse Gas Emissions Are Increasing*, n.d.), and all forecasts predict a sharp increase.

In the following, the first two cases are examined in more detail; the hazards from climate change are not considered in further detail here, although they account for a significant share of the overall risk due to the use of plastics.

Particulate plastic

In the manufacture of plastic, the material is usually melted and then shaped into a form in which it is to be used as a product, e.g., films, profiles or finished injection-molded parts. If the plastic product is used normally and then disposed of properly, particles may be released, but the risk of this is relatively low compared to improper disposal or littering. Plastic particles are created by the breakdown or abrasion of plastic products or mismanaged waste. Due to photooxidative processes or the loss of plasticizers, the plastic product becomes brittle and breaks into many small pieces. This process continues and smaller and smaller particles down to the micrometer range are created, the so-called microplastic (Cózar et al., 2014). These microscopic dimensions give the plastic two new properties with regard to the dangers for the human organism. First, the barriers of the human body become much more permeable in this range. Thus, the plastic particle is not excreted again after swallowing, but can be absorbed through the intestine and reaches other parts of the body.[7] On the other hand, the surface area increases dramatically when the plastic is present as a fine particle, and with it the likelihood of interaction and mass transfer with the organism.

The main uptake of plastic particles occurs through ingestion or inhalation. Absorption through the skin is negligible in comparison. The barrier function of the skin makes absorption unlikely; exceptions could be wounds or sweat glands. The particles absorbed by the human body affect it by releasing substances that have effects on the function of the organism. An example are endocrine disruptors. On the other hand, their presence of plastic particles may mechanically cause inflammation-like reactions or affect metabolism (Kannan & Vimalkumar, 2021).

The extent of damage caused by microplastics cannot yet be estimated. However, precautionary mitigation of exposure is possible. This includes, on the one hand, reducing exposure from the use of plastic products, i.e., in particular plastic bottles and other food packaging as well as plastic textiles and interior furnishings made of plastic. Another important measure to reduce exposure is to mitigate the input of plastic into the environment. Measures carried out within the framework of the project also start here. Some of the waste collected through plastic credit funding would otherwise have ended up in the environment, where it would have broken down in microplastic.

Substances with low molar mass

Among the substances with low molecular mass used for plastic production and processing, there are some that have a negative effect on the human body and other organisms. Three examples are presented below (Polcher et al., 2020):

- **DEHP**; may affect fertility, may harm the child in the womb, endocrine disruptor; use: formerly as a plasticizer in PVC.
- **Cadmium compounds**; may cause cancer, damage organs, may affect fertility, may affect the development of the unborn child; use: as a stabilizer.
- **HBCDD**; may probably impair fertility or harm the unborn child, may harm infants through breast milk; use: as flame retardant in polystyrene for electronic products and especially in expanded polystyrene.

As can be seen, some of the additives used pose a risk. The legal situation for use as well as the maximum concentration in plastics varies from country to country. Particularly relevant to the substances escaping from waste are endocrine disruptors, since hormones and these substances have effects on the body even in very low concentrations. The acute toxicity of these substances is often low in the amounts of normal exposure and does not pose an instantaneous health risk. However, the effects of prolonged, low-threshold exposure to multiple substances cannot be studied. This is the case, however, for most substances contained in plastics. The risk posed by these substances can therefore only be estimated to a limited extent.

7 This type of uptake is assumed in many works and could also be shown in vivo. Nevertheless, there are also contradictory results in which an uptake of plastic did not take place (Rawle et al., 2022).

Concluding review

The activities of this project contribute to an improvement of the situation insofar as the collected plastic waste is initially no longer capable of releasing these substances. Accumulation of other toxic hydrophobic substances also does not take place as the waste is not present in the environment as microplastics. During incineration in the cement kiln, the organic substances are largely oxidized due to the high temperatures and lose their toxicity. Heavy metals are either incorporated into the cement clinker or have to be removed from the exhaust gasses of the cement kilns. In the case of mechanical recycling, most of the substances are not broken down, but are transferred to the new product, where they have the same potential for damage. Here it even happens that substances that are already prohibited for use are kept in the material cycle through recycling. However, this problem applies mainly to substances with a long product life, such as building materials or electrical appliances, and less to packaging, which is mainly relevant in this project.

3.4 Economic and operational impacts

Similar to the project activities' impact on wildlife (see section 3.2), the collection - and hence reduction - of plastic waste has an indirect economic impact on the fishing and tourism industry that are both affected by marine plastic litter. These impacts on the fishing and tourism sector are analyzed in the following two subsections 3.4.1 and 3.4.2, respectively. At the beginning of both subsections, the importance of the respective industry for the Indian as well as the region's economies is reported. Furthermore, it is described in which way the industries are affected by plastic litter and which costs are generated through these impacts. In some cases, it is not clearly distinguishable whether the impacts are caused by plastic litter specifically or by marine litter in general. Herein, it should be noted that about 75% of marine litter consists of plastic (Napper & Thompson, 2019).

3.4.1 Fishing industry

India's fishing sector

India plays an important role in the world's fishing industry. In 2018, the country was on the fourth rank of global capture producers and accounted for almost 6% of the global production (FAO, 2020, pp. 10–12). This share refers to a value of about 13.57 million tonnes of fish that were produced in India in the period 2018-19 (Ministry of Fisheries, 2020). More than 28 million people (0.36% of the Indian population) are working in the fishing sector, which is increasing at an annual average growth rate of about 6% (Ministry of Fisheries, 2020). This increase led to the contribution of 1.24% from the fishing industry to India's GVA in 2018-19 (₹212 915 crore[8] (25.5€ billion) at current basic prices) (Ministry of Fisheries, 2020). Of the 13.57 million tonnes of produced fish, 3.85 million tonnes (28.4%) were captured in marine waters. It is worth mentioning that India's marine production increases at a lower annual growth rate than the inland production and in 2010-11 marine production still accounted for almost 40% of the total fish production (in 1950-51 marine fishing contributed even 71%) (Agriculture and Rural Development Sector Unit South Asia Region, 2010).

[8] 1 crore = 10 million

However, marine fisheries still form an important sector of India's economy and in 2019-20 employ 4.9 million people who work as fish farmers, fish workers or fishers (Ministry of Fisheries, 2020). The three occupations will be referred to as fishermen in the following.

Due to the proximity of the pilot regions in Goa and Kerala to the coast and the assumption that a great share of plastic litter that is not collected in these regions will ultimately find its way into the ocean (see also the Interim Assessment Report (Wuppertal Institute & rePurpose, 2022b)), this chapter focuses on the impact of marine plastic litter on the marine fishing sector. It is not discussed how terrestrial plastic pollution impacts the inland fishing sector. However, it should be noted that the inland fishing sector might be impacted by marine plastic pollution in the same way as the marine sector as inland fishing also includes coastal aquaculture.

Figure 6 shows that all three pilot regions (Maharashtra, Goa and Kerala) have a significant share in the national marine fish production. The highest contribution is from Kerala. Its department of fisheries state that "Kerala has a significant marine fisheries sector that has long been an important source of occupation and livelihood for the coastal population of the state" (*Marine Fisheries*, n.d.). The statement is confirmed by the number of 800 000 people that are employed in the marine fishing industry (Ministry of Fisheries, 2020). Thus, 2.25% of Kerala's population work as fishermen which exceeds the Indian average of 0.36% by far. At the same time, the state of Kerala contributes almost 13% to India's marine fish production (475 kilo tonnes in 2019-20, see Figure 6).

Maharashtra has a significant share of India's marine fish production as well (443 kilo tonnes in 2019-20, see Figure 6). Almost 400 000 people are working as marine fishermen in this state (Ministry of Fisheries, 2020). Although the pilot project located in Aurangabad, Maharashtra, is not directly situated at the coast, plastic trash that is littered into the environment can enter the ocean through waterways and therefore potentially impact marine industries like fisheries. In fact, about 80% of marine litter originates from land-based sources (Kapinga & Chung, 2020).

With 101 kilo tonnes, the region of Goa contributes to 2.7% to the national marine fish production (see Figure 6). The marine fishing sector of the state employs about 10 000 people (0.66% of Goa's population) (Ministry of Fisheries, 2020).

Impacts

Plastic waste in the ocean has the potential to impact fisheries in different ways. On the one hand, large plastic debris can damage the fishing equipment or even the vessel if it gets entangled in the propeller of the boat (Das et al., 2020; Kapinga & Chung, 2020). Fishermen will therefore have to pay high repair costs. In some cases, the damage of the boat can even result in a costly rescue mission. At the same time, fishermen are indirectly impacted by the damage caused by plastic litter through the loss of sea time, which in turn results in a reduced catch and therefore a lower revenue. On the other hand, plastic debris can get entangled in fishing nets and thereby reduce the catch. Fishermen will further lose fishing time if they have to spend it unraveling litter from their nets (Das et al., 2020; Napper & Thompson, 2019). Finally, fisheries are impacted by a declining fish stock. This might be caused by lost fishing nets in the ocean that lead to *ghost fishing*, i.e., lost fishing gear captures marine wildlife underwater (Das et al., 2020). Fish populations might further decline by contamination through ingested plastic (Napper & Thompson, 2019) (see also subsection 3.2.1 for the impact of plastic litter on marine wildlife).

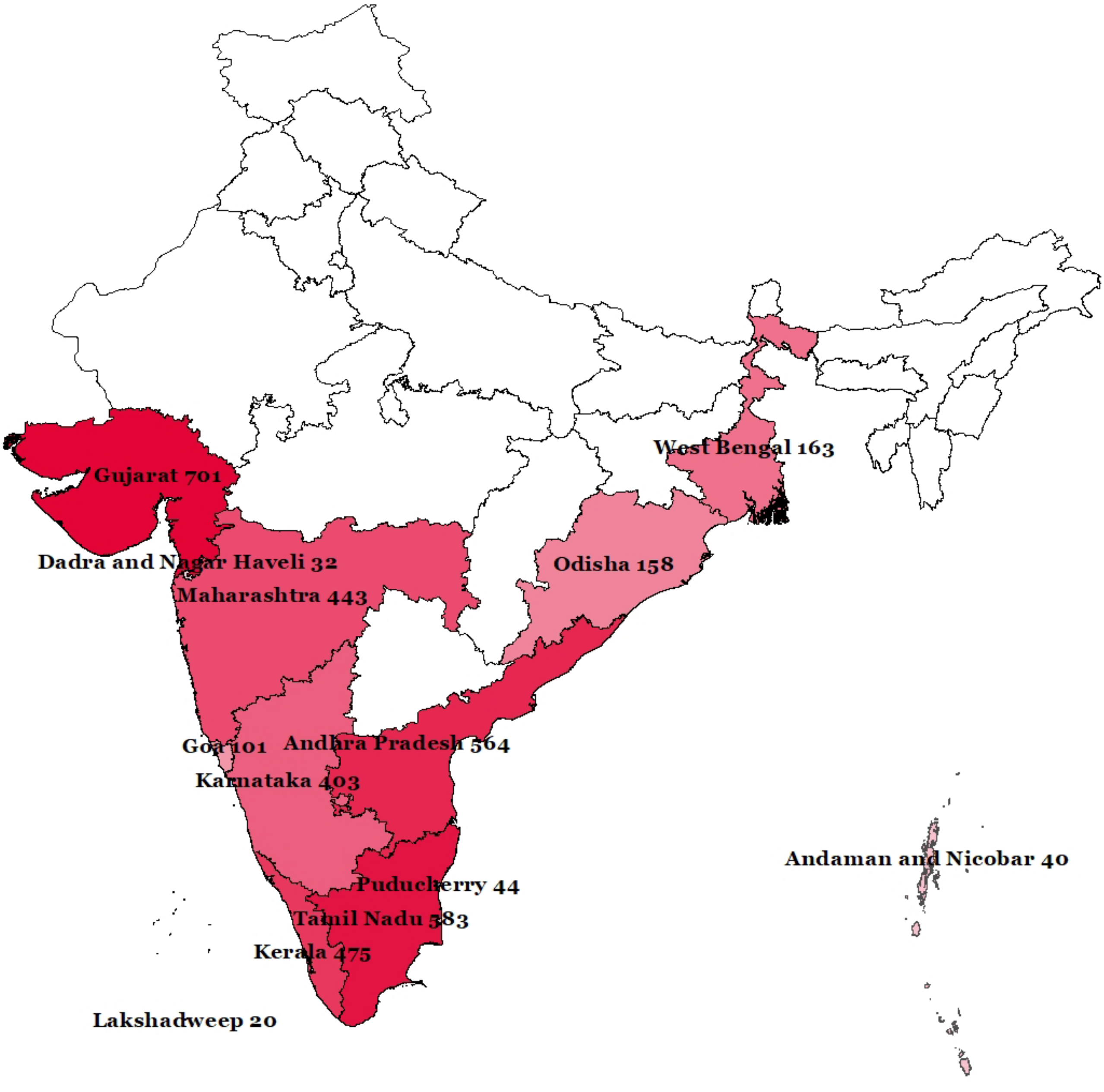

Figure 6 **Indian marine fish production per state in 2019-20 in kilo tonnes. Total marine fish production in 2019-20 was 3.7 million tonnes.**

Source **Own representation, data from Ministry of Fisheries (2020), georeference data from University of Texas (Hijmans, n.d.).**

Economic costs

In this literature review, no study was found that quantifies the impact of plastic pollution on fisheries in India. However, some studies exist that calculate the economic costs that are caused by marine litter on the fishing industry in other countries (Lee, 2015; McIlgorm et al., 2011; Mouat et al., 2010). The results of those studies are not directly transferable to India as the economies of the countries might differ, but are proof that the economic costs caused by plastic litter are enormous. For instance, Mouat et al. (2010) found that marine litter costs every Scottish fishing vessel between 17 000€ and 19 000€ each year. These amounts include direct costs of repairing as well as indirect costs through the loss of fishing time. Every year, the Scottish fishing industry loses between 11.7€ and 13€ million in this way. For the United Kingdom, it was estimated by Lee (2015) that marine plastic waste costs the fishing and aquaculture industry annually between £26.8 and £35.6 million (30.8€ and 40.9€ million). Furthermore, Wallace (1990) conducted a survey in 1989 at the east coast of the United States with commercial fishermen about the impact of marine plastic litter on their vessels. Already 30 years ago, more than 45% of the 161 interviewees answered that they had their propellers caught by plastic debris at some point in time. Almost 40% had their engine cooling system clogged and 30% had their gear fouled. Using the results of a study that was conducted by Takehama (1990), McIlgorm et al. (2011) calculate the damage of marine debris in the Asian Pacific Economic Cooperation as 0.3% of total annual fishery revenue. The GVA of the total Indian fish production in 2018-19 was ₹212 915 crore and the share of marine production in total production was 28.4% (Ministry of Fisheries, 2020). Hence, calculating with a GVA of ₹60 441 crore (= ₹212 915 crore * 0.284) for the marine fishing sector and applying the methodology of McIlgorm et al. (2011) to India, this would imply an annual economic loss of about ₹181 crore (21.8€ million) for the Indian marine fishing industry due to marine litter. By the collection of plastic waste that otherwise would have ended up in the environment this economic loss can be reduced. This impact is specifically important for Kerala as they have a strong marine fishing sector.

3.4.2 Tourism

India’s tourism sector

The tourism industry is an important sector for India’s economy. The direct contribution from tourism to the national GVA was 2.8% in 2019-20. This share converts to a value of ₹514 343 crore (61.7€ billion). The added direct and indirect contribution is almost double as high with a share of 5.4% of India’s total GVA (Ministry of Tourism, 2022, pp. 197–198). The sector directly employs about 35 million people, while indirectly generating workplaces for another 45 million people. This number refers to 6.7% and 15.3% of the total employment of the country, respectively (Ministry of Tourism, 2022, pp. 197–198).

From the three pilot regions, Goa is the most famous one for tourism. The government of Goa calls tourism the “back bone of Goan economy” (Government of Goa, 2020), as it holds a share of about 30% of the region’s total GDP and provides employment for about 40% of Goa’s population (Ranjan, 2020). In 2018, more than 8 million foreign and domestic tourists visited Goa (Ministry of Tourism, 2019).

Even though the number is lower than for Goa, the tourism sector still contributes 10% to the total GDP of Kerala. With 23.5%, almost a quarter of the total employment in the state is created by the tourism industry (Joseph, 2020). In 2018, the Ministry of Tourism registered 16.7 million visitors in Kerala (Ministry of Tourism, 2019).

Being the biggest state by area in comparison to Goa and Kerala, Maharashtra attracted an astonishing number of 124 million visitors in 2018. Almost 19% of foreign tourists that came to visit India, traveled to Maharashtra, which is more than to any other Indian state (Ministry of Tourism, 2019). In 2016, Maharashtra announced the goal of increasing the share of GDP through tourism and tourism related activities to 15%.

Impacts

One of the main impacts of plastic pollution on the tourism industry is through its negative effect on the quality and natural beauty of the environment which reduces its recreational value (Napper & Thompson, 2019). The polluted environment will impact the choice of tourists for their travel destination, which often results in a decline of visitors in those areas (Das et al., 2020; Kapinga & Chung, 2020). Less visitors ultimately lead to a decrease in jobs offers and an economic loss of the region (Abalansa et al., 2020). Moreover, diving or recreational boats can be damaged in the same way as fishing boats by plastic debris in the ocean (see subsection 3.4.1) resulting in repair cost for the operators. Further economic costs are generated by clean-up activities that local municipalities have to organize in order to maintain tourism (Das et al., 2020). At the same time, tourism can increase the amount of waste generated. In Goa, for instance, the local project partner made aware of the pressure of tourism on waste management. Due to the high number of tourists, waste volumes are generated for which the system is not designed for. In addition, the tourists' waste is often not well separated due to two reasons. First, there are often no appropriate in-house separation systems available, and second, raising awareness about waste segregation is a difficult task particularly for temporary guests.

Economic costs

Literature that quantifies the impact of plastic pollution on the tourism industry is scarce. For the case of India, no study was found that calculates the economic loss of the country due to plastic litter. However, there are studies undertaken in other countries. Ballance et al. (2000), for instance, conducted a survey at the Cape Peninsula in South Africa in the years 1994-95 when the topic of marine litter on beaches started to receive more attention. Residents, domestic and foreign tourists were asked to rate the importance of six different beach attributes. By all groups, cleanliness of the beach was ranked as the most important one. The survey further revealed that 85% (97%) of the beach users would not visit beaches if they had more than 2 (10) large items of marine litter per meter. Overall, the authors estimated that over half the tourism income could be lost for the region. More recently, Krelling et al. (2017) found similar results through a survey conducted in Brazil in the years 2015 and 2016. In the questionnaires, 82.4% of the tourists answered they would avoid visiting a beach that had more than 30 items of marine litter per meter. For the same scenario, it was estimated that the municipality could lose between 15% to 39.1% of the total tourism revenue. Furthermore, by a study that was conducted in 2017 at the east coast of China, Qiang et al. (2020) found that plastic litter on beaches not only impacts the choice of travel destination, but also reduces the length of stay by tourists significantly. Accordingly, they estimated that tourist expenditures could increase by up to 32.2%, if dirty beaches were cleaned up from plastic litter. If one compares the results of Ballance et al. (2000) and Krelling et al. (2017), differences in the answers of the survey's respondents can be found. While both studies came to the conclusion that tourists were deterred by plastic litter on beaches, the magnitude of this impact differs. In the survey of Krelling et al. (2017), less than 25% of the participants answered that they would avoid visiting the beach if it had 5 items per meter. The comparable scenario with 2 items per meter in the questionnaire of Ballance et al. (2000) already deterred 85% of the visitors. These differences might occur due to many reasons, for instance the group of respondents and the regions where the surveys were conducted might not be comparable. It is also noticeable that a big time gap lies between the two studies and the general perception of plastic litter might have been changed in that time. In conclusion, one should be cautious in transferring these results to an Indian scenario. However, all three studies show that the choice of tourists for their travel destination is significantly impacted by the cleanliness of the environment. This in turn leads to high economic losses for the tourism industry. On the other hand, it can be concluded that the revenue of the tourism sector might increase, if dirty areas were cleaned up. The collection of plastic waste positively contributes to the reduction of plastic litter in the environment and hence the reduction of economic losses for the tourism industry. As this sector is an important pillar of the Indian economy, this topic should be treated with importance. This is particularly significant to areas like Goa that rely heavily on tourism.

4 Additionality of the project

A definition of the term *Additionality* with regards to the activities of this project can be found in section 4 of the Baseline Assessment Report (Wuppertal Institute & rePurpose, 2022a). Also, two hypotheses (H1 & H2) were developed in order to test the Additionality of the project:

H1) The funding and financial support through plastic credits leads to the additional collection of MLP within the pilot regions Maharashtra, Goa and Kerala, which would not have taken place otherwise.

H2) For each region, the resulting system is different in at least one variable of concern, which is defined by the investigator, from the respective baseline.

As touched upon in the Baseline Assessment Report, the following assumption is made and applied to the additionality test: There is no incentive to collect and/or separate MLP within the pilot regions leading to the fact that such waste would be burned or littered into the environment without economic incentives. This assumption has been confirmed throughout the discussions with the local partners. Additionally, it can be stated that about 1685 tonnes of MLP have been selected and processed through the generation of plastic credits, which otherwise would have been openly burned, dumped or landfilled. This has been confirmed through a site visit, in which the default situation has been witnessed by the researchers of this project. It can therefore be concluded that H1 is true, representing the additionality of plastic credits towards MLP collection and treatment.

Further, H2 can be confirmed as true. The amounts of MLP collected, recycled, and co-processed as presented in section 2 of this report, as well as the other impacts presented throughout section 3 can be considered variables of concern. If these variables of concern change, H2 is true. The impact assessment in the previous chapters shows that the collection of MLP has an impact on these variables in the region of concern. Thus, the condition from H2 is fulfilled.

A quantitative evaluation of additionality is not possible within the scope of this project. Nevertheless, the main findings from the previous chapter indicate a “positive” performance of the project:

- Coal was replaced by plastic waste in the order of 2260 tonnes, this saves CO_2 emissions of about 2230 tonnes.
- Plastic was replaced by recyclate material from waste in the order of 390 tonnes.
- Negative impacts on environment, wildlife, health and industry were prevented.

For more details, please refer to the subsections on direct indicators in the Environmental Impact Assessment Matrix (see section 3).

5 Discussion

The results from the Environmental Impact Assessment have shown the many positive aspects of the collection - and therefore decrease - as well as treatment of plastic litter as it is done in this pilot project. This encompasses a realm of aspects, from human and animal health to industries such as fishing and tourism. Additionally, recycling or co-processing can save a certain amount of raw material and reduce greenhouse gas emissions. While recycling is the preferred option from a sustainability, i.e., circular point of view, this is not possible for all materials and for all locations if the necessary infrastructure is missing. The second-best option is co-processing such as burning in a cement plant as it is carried out by the projects presented in this report. Financing of plastic collection and treatment through plastic credits is one possible way to manifest those positive aspects. In general, however, it needs to be stated that for the quantification of "positive" aspects from plastic credits, the necessary data is scarce and often needs to be substituted or supported with estimations and approximations. Accordingly, the data presented in the EIA should be considered an estimate rather than exact numbers.

Additional insights into this project were brought along by a site visit in September 2022 that allowed two researchers of the Wuppertal Institute to deepen their understanding of the activities on ground and to address questions directly. By doing so, further positive outcomes of plastic credits with regard to the plastic waste management in rural regions of India were revealed and previously reported positive impacts by the project partner rePurpose could been confirmed. Conversations particularly with the workers made the positive implications on social (e.g., employment and health) aspects clear. The observations further highlighted the big differences in handling residual plastic waste between those regions that have a plastic credit partner operating and those that are regulated by the municipality. The latter showed severe littering issues, non-existing sorting activities as well as poor standards on dumpsites. The local partners stated the following crucial aspects for the successful implementation: awareness raising, a transparent and reliable schedule (regular collection of waste), visible separation (providing evidence that separated waste is not mixed-up), knowledge of the needs of workers and households, and the transfer of waste management expertise to the employees. This underlines the importance of a comprehensive waste management solution for India´s regions that is not restricted nor limited to zones. By splitting the regions into different zones that are operated by different waste operators, certain issues emerge. Different ways of waste collection and/or sorting processes are used, which makes the implementation of an infrastructure towards the most efficient management process (i.e., recycling structure) difficult. Consequently, ways need to be paved to upscale best-practice activities as those that have been supported through plastic credits. While revenues generated through plastic credits might not be sufficient for a comprehensive approach, corporations with public authorities that provide financial and infrastructural support remain important. This would not only ensure a comprehensive waste management structure that is safe, prevents littering, and reduces landfilling, it would also help improve the currently existing best practice examples. For instance, it has been observed at the site visit that missing recycling facilities and/or undermaintained roads can hinder the implementation of the most environmentally friendly waste management solution.

In rural regions of India, informal waste pickers still have a core role. The local partners reported a co-existence with informal waste pickers and corresponding structures. In Goa, for instance, informal waste pickers know the formal collection schedule and therefore collect high-value materials and plastics in advance. As a result, the value of the collected plastic arriving at the MRF is lower, but due to the financing structure via the municipality, this is a negligible aspect for the local partner. The local partner in Maharashtra, on the other hand, tried to convince the collectors to sell the collected high-value plastic to them instead of third parties. However, by being able to sell the higher value plastic, collectors have an incentive to ensure more accurate sorting of the waste in any case.

While discussions about an extended producer responsibility (EPR) scheme as a financing instrument of waste management activities are taking more shape, the interrelation of such a framework with plastic credits remains unclear at the moment. India has amended its EPR norm in July 2022, mandating recycling and reusing a certain percentage of plastic produced by manufacturers, importers and brand owners. Challenges regarding the practical implementation of EPR have been stated by city officials during the site visit, raising the issue of motivating companies to register under EPR and difficulties in finding companies that purchase and recycle plastic under the EPR scheme. Plastic credits on non-recyclable plastics (as rePurpose does) such as multilayer plastics, serves so far complementary, as it is in category three of the mandate.

Although the market for plastic credits is growing, the revenue generation is currently strongly based on the demand of foreign (i.e., western) markets and can underlie high fluctuations. The project partner rePurpose aims to create long-term structures and has multi-year contracts with its local partners. However, given the fact that plastic credits represent a rather new financing instrument, globally implemented standards on plastic credit creation, revenue generation, and many more factors, are yet missing. Against this background, more research on plastic credits needs to be conducted, not only to achieve more transparency on the plastic credits market and standards, but also to assess its social, ecological and economic implications with respective data. This report, however, shows how the plastic credit system can kick-start waste management activities in regions where no such activities were in place and thus serve as an innovative and impactful instrument.

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