



INDIAN OCEAN
COMMISSION

CIRCULAR ECONOMY IN THE AFRICAN AND INDIAN OCEAN DEVELOPING ISLAND STATES

EXISTING STRATEGIES AND STATE OF PLAY

Review report





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Foreword

By Dr. Charlotte de Fontaubert, World Bank

We are pleased to be associated with the publication of these reports on the circular economy in the island states of Africa and of the Indian Ocean, which aim at accelerating a development that respects the environment and that is resilient to climate change. These documents, produced by the Indian Ocean Commission (IOC) as part of the implementation of the sub-component AIODIS of the second project on the Governance of fisheries and shared growth in the South-West Indian Ocean (SWIOFish2), deal with three important aspects of circular economy in the AIODIS countries: (i) the state of the circular economy, (ii) the questions of intellectual property with regard to innovative projects and (iii) the prevention, reduction and control measures of marine plastic pollution.

The World Bank has supported, since 2015, the countries of Africa and of the South-West Indian Ocean to meet the Sustainable Development Goals (SDGs) of the United Nations. To this end, we help several countries in their transition to a more sustainable ocean economy (SDG 14). The principle of blue economy is precisely a sustainable use of marine resources to stimulate economic growth, livelihoods and employment, while preserving the health of the ocean ecosystems. In that sense, the World Bank finances regional programmes on fisheries management in the islands of the Pacific, the Caribbean, West Africa and South-West Indian Ocean. It is in this context that lies our SWIOFish2 project in coordination with the IOC.

The first objective of the project is to assist these States to grasp and to increase the economic, social and environmental advantages of blue economy. This can be achieved by improving the management of their marine resources, namely by limiting the depletion of the fish stocks. This is also possible through an increase in alternative livelihood activities for targeted fishermen, and a reinforced regional cooperation in this sector.

With the sustainability of these resources under serious threat, addressing the sources of these multiple and interconnected threats requires us to rethink our entire economy. From the World Bank's perspective, this is why we are committed to supporting these states in their journey towards a circular economy that is best described as a restorative or regenerative industrial system by intent and design.

We are confident that by pooling their experiences and their initiatives through the AIODIS cooperation mechanism, these States will be able to better face their common challenges. Overcoming these challenges will require the use of sufficient technical and financial means coming from institutional frameworks and infrastructure conducive to the development of a circular economy. Thus, it was essential to identify them for each country, so as to set up the foundations of a framework that is adapted to different socio-economic contexts. Endowed with this new knowledge, we can henceforth move forward together towards a circular economy that brings sustainable and inclusive growth opportunities.

Foreword

Plastic: a marker of our times and a responsibility for action

By Prof. Vêlayoudom Marimoutou,
Secretary General of the Indian Ocean Commission

**“The obligation to suffer gives us the right to know.”
Jean Rostand**

Biologist Commoner draws our attention on one of the characteristics of human action: *“its capacity to produce materials that cannot be found in nature”,* and therefore *“to introduce in the system substances that are utterly unknown to it”*. The great circular economy of nature, in which *“nothing is lost, but everything is transformed”*, is more and more upset and disturbed by human manoeuvres.

The Modern world is also a world of pollution and, as Barnosky said in 2014, today *“there are few places on earth that are not affected by man-made environmental pollutants. It is common to find traces of pesticides and industrial pollutants in samples of soil and tree bark of any forest in the world, in whales’ fat, in the body of polar bears, in fishes of most of the rivers and oceans”*. Pollution has become one of the major problems of our times; local or global, of agricultural, industrial or urban origin, it contaminates the lands, the waters and the atmosphere, jeopardising the health of the ecosystems and thereupon that of humans.

Plastic is emblematic of pollution in general

In 2016, J. Zalasiewicz and his colleagues propose to use plastic as an emblematic signature of the general pollution of the Earth’s ecosystem characterising the Anthropocene epoch. Plastics are polymers manufactured from petrochemicals, although some are made from cellulose (8% of petrol extracted on the planet, half as raw material). Adapted to multiples uses, plastic impresses with its theoretical capacity to infinite recycling and to the promise of saving natural resources, and because of its hygienic qualities which led to its adoption in pharmacies and hospitals. From the 1950s onwards, it has grown with mass consumption, on the back of synthetic materials and on the rising production of disposable items. It has rapidly become an essential component of electronics and informatics.

Despite its theoretical infinite recycling capacity, we are far from the mark: it is estimated that 50% is recycled or converted into energy (pyrolysis), the proportion recycled being 15% to 25% in Europe and less than 5% in the USA. We therefore have an idea of the amount of plastic debris dispersed each year, in the form of fragments smaller than 5 mm, or even nano plastics, in the environment. Lightweight, easily transported by wind or water, plastic debris has invaded the entire planet, including the oceans, where it is dispersed from the surface to the bottom of ocean basins. The lightest plastics form areas of highest concentration around the 5 major ocean gyres. They represent a total of 25,000 tonnes of floating debris on the sea surface.

Invasion, resistance and toxicity

The problem posed by this pollution is two-fold.

The first is its resistance. Depending on their composition, the degradation of plastics takes between 50 years and 5 centuries, or even millennia for debris to sink to the deep seabed. If we take into account both this resistance to degradation and the 5 to 13 million tonnes of debris that reach the world's oceans each year, we can see the scale of the problem we are building. And according to B. Montsaignon, 'bioplastics' cannot provide a real solution: their manufacture from plant materials does not guarantee the biodegradability of polymers, and moreover it increases industrial pressure on agricultural land; as for those that are claimed to be compostable or fragmentable, they are still derived from petrochemical products.

Second is its toxicity: 50% of the chemical components of plastics are classified as hazardous by the United Nations classification system for chemicals. Studies have also shown the ability of additives used in PVC to pass into the human bloodstream, as well as the carcinogenic risks of certain components of PVC, polystyrene, polyurethane and polycarbonate. Similarly, biologists have warned of the risks that plastic debris poses to fauna, from micro-organisms to whales or seabirds, which are part of the food chain right up to our plate.

Rethinking the models, blue and circular

So, what should we do?

Regeneration, reinvention and restoration form a new framework for action to (re)think our strategies, to innovate and to provide solutions to this global challenge, which raises significant local issues in island territories. It is not a question of going to war against plastic, which has proved to be a useful, practical and inexpensive material. It is a question of analysing our relationship with this material, of defining new ways of consuming and producing it, and of developing innovative ways of disposing of it and reducing the pollution generated on our coasts and at sea.

To address the multifaceted challenge of marine plastic pollution in the islands of Africa and the Indian Ocean, the IOC and the World Bank, through the AIODIS component of the IOC-SWIOFish2 project, are publishing three studies on i) the state of the art of the circular economy, ii) intellectual property issues on innovative projects and iii) measures to prevent, reduce and control marine plastic pollution. We hope that they will prove useful to policy makers, entrepreneurs, and developers in the blue and circular economy sectors.

Introduction

Natural resources use and material consumptions have exponentially increased in the past 20 years (Schandl et al., 2018; Wiedmann et al., 2015). They have led to various environmental problems such as the biodiversity crisis but also socio-economic issues with the widening of the inequality gap (Marques et al., 2019; Teixidó-Figueras et al., 2016). The global economic system and the capitalist manners of exploiting natural resources have been seen as major contributors to the situation (Seis, 2001). Since the 1960s, alternative systems have been promoted including the need for a circular economy (CE) that is restorative by design (Winans et al., 2017). The concept is now becoming mainstream and has seen its implementation under other concepts such as the green and, more recent, blue economies (D'Amato et al., 2017; Twomey & Washington, 2016).

Among existing definitions of CE, Kirchherr et al. (2017) provided a useful one for the current Indian Ocean Developing Island States project (IODIS): an "economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes.". The CE operates at different level from the micro level (products, companies, consumers), the meso-level (eco-industrial parks) and the macro level (city, region, nation and beyond) (ibid). The CE has also been increasingly associated as a necessary step to achieve sustainable development (Suárez-Eiroa et al., 2019). It has received increasing attention from governments, the private sector and academia (D'Adamo, 2019; Suárez-Eiroa et al., 2019). The European Union (EU), for example, adopted the CE Action plan in 2015 to help stimulate the EU's transition towards a CE (Domenech & Bahn-Walkowiak, 2019). Countries like France or the Netherlands are seen as championing in CE implementation. Global initiatives are also burgeoning, such as the Global Plastic Action Partnership, Circular Electronics Action Partnership or the Global Battery Alliance (WEF, 2020). For the African and Indian Ocean Developing Island States (AIODIS) and African countries in general, excluding Reunion Island, the circular economy is still a nascent concept (Desmond & Asamba, 2019). However, it represents an opportunity to overcome the challenges that the AIODIS face as island states, including the reliance of import for goods and material and the accumulation of waste that degrades the environment (Dussaux & Glachant, 2019; Romero-Hernández & Romero, 2018).

The aim of the report is to look at the level of implementation of CE in AODIS. In the current blue economy agenda that many AIODIS have adopted, it presents the opportunity to build a strong blue economy that could be less reliant on external inputs. It is especially relevant for key areas of blue economy that build on harvesting/extraction, the use of renewable and non-renewable resources, and commerce and trade. Implementing a CE represents the opportunity to achieve sustainable and inclusive blue growth. The CE framework that is used in this report is that of the Ellen MacArthur Foundation, which has been pioneering and promoting the implementation of CE since 2013. The framework is based on three principles: preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows (P1), optimise resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles (P2), and foster system effectiveness by revealing and designing out negative externalities (P3) (EMF 2015).

The report starts with a brief description of the theoretical framework based on the CE system diagram, it then presents the current frameworks and strategies within AOIDIS that can relate to a CE. It continues with a discussion of challenges to achieve a CE in AIODIS. It concludes with the opportunities that can be developed with the AIODIS to boost their CE and contribute to sustainable blue economies.

1 Defining the Circular Economy for the AIODIS

The circular economy as defined in the introduction is a fairly new concept for the majority of the AIODIS. However, under the global framework of sustainable development and more recently the adoption a blue economy agenda, the AIODIS have increasingly adopted sustainable practices in terms of production and consumption. These are, however, dispersed and often siloed under sectoral policies.

In this report, a framework is provided to analyse where the AIODIS are in implementing a circular economy. To address both natural resources extraction and material consumption, the circular economy system diagram of the Ellen MacArthur Foundation is used as a theoretical framework (Figure 1). The diagram puts together the biophysical and technical cycles to address both our use of natural resources and our material production and consumption.

Within the technical cycle that addresses material stock management, the framework of ReX has been integrated. The ReX framework has been designed to cover different strategies of circularity within material stock management. It goes beyond the 3R framework (reduce, reuse, recycle) that is commonly used (Jiao & Boons, 2014) and integrates other concepts within extended frameworks such as 4R or 9R (Table 1). It also provides a straightforward picture of the three main stages of production “Pre-Use, Use and Post-Use” (Figure 2).

Table 1: Different frameworks and strategies within the CE

Strategies	Frameworks			
Reduce	3R	4R	9R	ReX
Reuse				
Recycle				
Recover	4R			
Repair				
Refurbish				
Remanufacture	4R			
Repurpose				
Rethink				
Refuse				

Source: EU (2008), Yoshida (2007), Potting et al. (2017), Sihvonene & Ritola (2015)

Figure 1: Circular economy system diagram adapted from the Ellen MacArthur Foundation and the ReX Framework

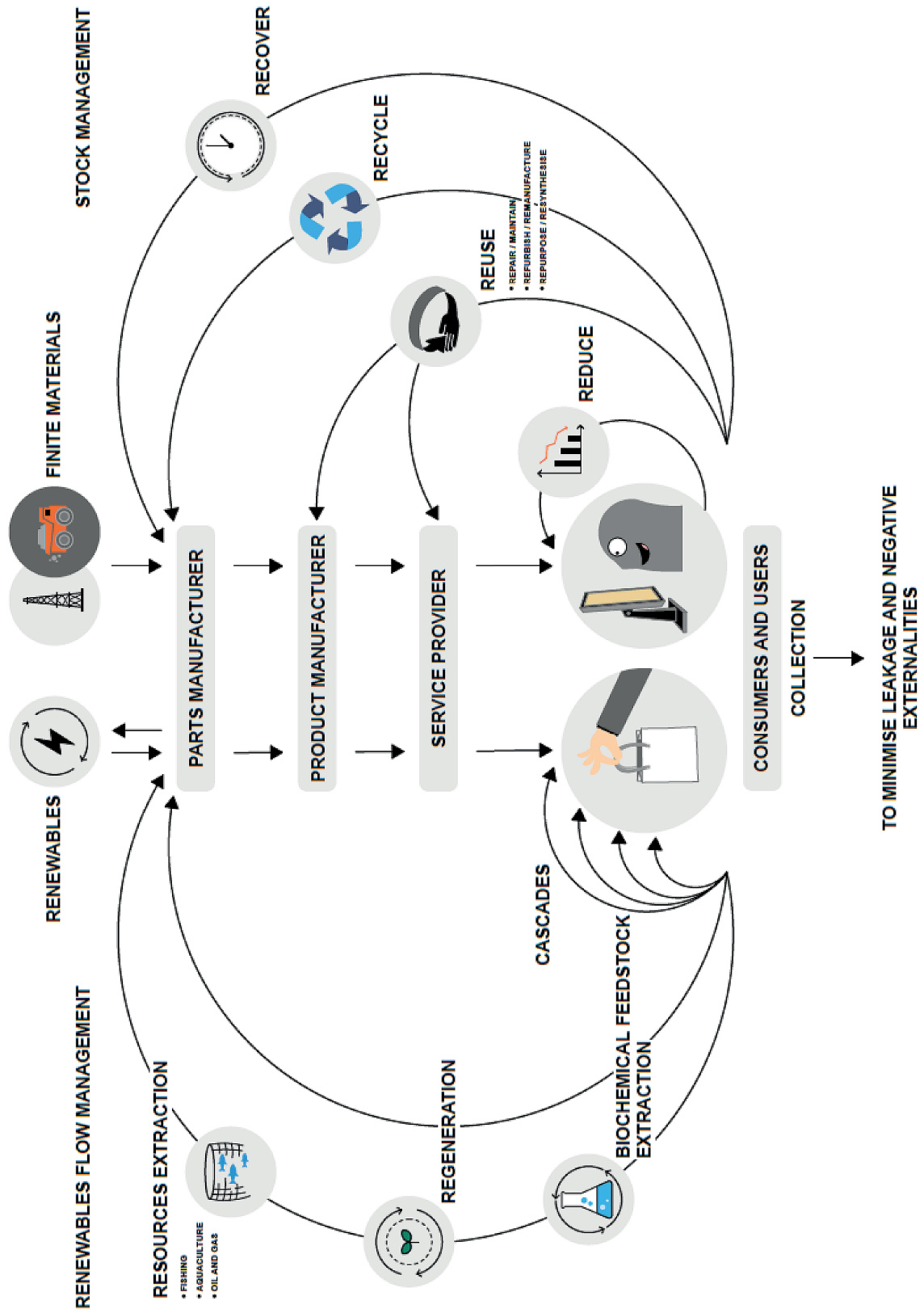


Figure 2: ReX Framework



Source: Sihvonen & Ritola (2015)

To discuss the state of play regarding CE within the AIODIS, three methods have been used:

- Online research on each country regarding initiatives of marine resource use and conservation, waste and plastic management, and specific CE policy and projects
- A gathering of AIODIS presentations during the launch meeting to assess the countries' comprehension of CE nationally
- A compilation of data from global databases that link to the state natural resources and material uses (see Table 2).

Table 2: CE indicators and sources

Indicators	Database/Source
Fisheries production	FAO's Fishery and Aquaculture Statistics (2018)
Marine protected area coverage	Marine Protection Atlas
Material consumption	UN IRP Global Material Flows Database
Resources extraction	
Renewable Energy Consumption	World Bank, Sustainable Energy for All database
Waste generation	World Bank's What a waste Report (2018)
Export and Import	World Bank, WITS
Country profiles	World Bank and FAO databases

Source: Author's conception

2 Circular Economy Strategies within the AIODIS

2.1 Policy and legal frameworks promoting a circular economy within AIODIS

For African countries, including AIODIS, the implementation of the CE concept is still very recent (Desmond & Asamba 2019). However, the AIODIS have different laws and policies that promote the principles of a CE despite not addressing it directly (Table 3). All 9 of the AIODIS have laws and policies that cover the use of natural resources and management of renewable flows (See details in Annex 4). These include texts that regulate forestry and fisheries activities, specific forestry and fisheries codes, environmental laws and biodiversity strategies. They also cover specific texts aimed at protecting ecosystems and species such as protected areas and water codes.

In terms of stock management, all of the countries have developed policies and laws that relate to waste management especially regarding solid waste. The majority of the AIODIS have also addressed the issue of plastic by prohibiting the use of plastic bags or single-use plastics. Countries that have not implemented such prohibition have adopted phasing out policies. Mauritius and Reunion Island in particular have regulations regarding recycling and the activity of recycling.

Table 3: Types of laws and policies available within the AIODIS relating to CE

		CVI	COI	GBS	MDG	MDV	MAU	REU	STP	SEY
Renewable Flow Management	Environmental protection/ Biodiversity Conservation	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Fisheries management	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Forestry management	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Protected Areas	✓			✓	✓	✓	✓	✓	✓
	Water management			✓	✓	✓	✓		✓	
	Renewable Energy						✓	✓		
Stock Management	General waste management	✓	✓	✓	✓	✓	✓	✓	✓	
	Solid waste management	✓	✓	✓					✓	✓
	Recycling						✓	✓		
	Plastic Bag Ban/Phase out	✓			✓	✓	✓	✓		✓

In terms of performance of the countries regarding CE policy development, Reunion Island can be considered the most advanced. In addition to those mentioned above, it has adopted laws on energy transition (2019), a ban on plastic bags and recently a law on the fight against waste and the circular economy (2020). Under the impulsion of France, Reunion Island also adopted a Regional Action Plan for the Circular Economy. The plan has five objectives including coordinating the transition towards a CE, activating the levers of the transition, improving production and consumption, and developing loops.

Most of the AIODIS have also developed Blue Economy laws and strategies that promote the sustainable use of marine resources, protection of marine ecosystems and waste management. That is the case of Cabo Verde (Blue Growth Charter), Comoros (the Strategic Framework for A Policy National on Blue Economy), Mauritius (Ocean Economy Roadmap), Reunion Island (Law on the Blue Economy)

and Seychelles (Blue Economy Strategic Roadmap and Blue Economy Action Plan). Countries that are to develop such Blue Economy policies, including Guinea Bissau, Madagascar and Sao Tomé and Príncipe, have the opportunity to build from the AIODIS region's experience, especially in ensuring that blue growth does not impede on the sustainability of natural resources.

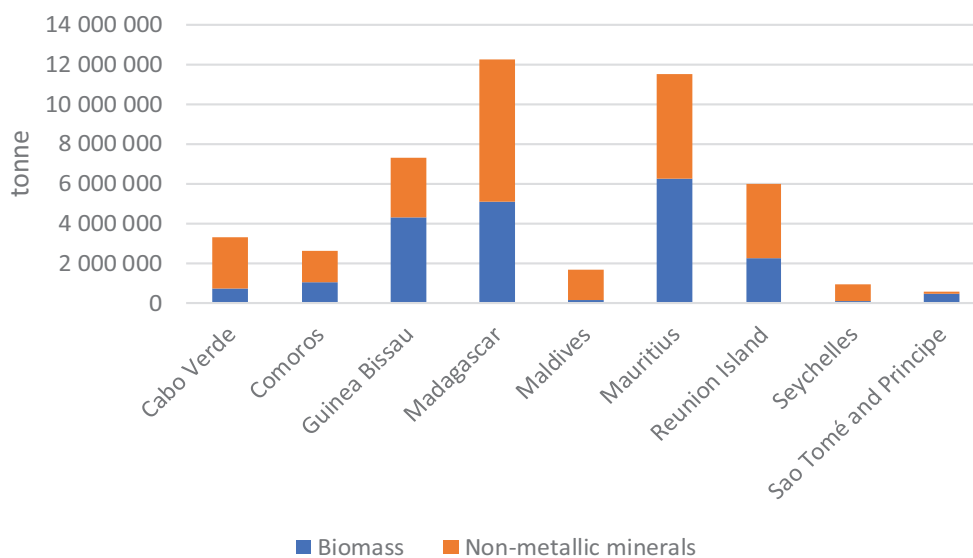
2.2 Renewable flow management: from extraction to regeneration

This section refers to the first part of the CE system diagram on management of renewable flows. Renewable flow management refers to the use of natural resources flows towards multiple cycles, yet in a regenerative way. It allows the rebuilding of natural stocks as well as the re-entering of nutrients into the environment (EMF 2019). In this section, interventions relating to this management will be presented for AIODIS. It is divided into three parts: extraction of natural resources, regeneration of ecosystems and species, and energy recovery and extracting feedstock.

2.2.1 State of natural resources extraction and CE-related interventions

For the AIODIS, the extraction of natural resources is an essential part of economies. Most AIODIS have experienced an increase in their domestic extraction in the past 40 years with countries like Cabo Verde or Comoros with a more than 500% increase of domestic extraction (WU Vienna 2019). Every year, about 45 millions of tonnes of resources are extracted from the AIODIS (Figure 3).

Figure 3: Resources extraction within the AIODIS in 2017



Source: Compilation from WU Vienna (2019) and Cornéllus et al. (2016) for Reunion Island

The extraction of natural resources can be divided into extraction of living resources and non-living resources. In a circular economy, such extraction is aimed at manufacturing products with the aim that products have multiple life cycles. For living resources, the case of fisheries, aquaculture and bio-prospection represent sectors for AIODIS that are integral parts of the CE.

In **fisheries**, the 9 AIODIS have important production levels (Table 4) that are key to the national economies but also for the food security of the countries. The AIODIS have a combined yearly production of around 500,000 tonnes every year (FAO, 2018).

Table 4: Fisheries production of AIODIS (2017)

Countries	Fisheries production (tonne)
Cabo Verde	18,673
Comoros	17,021
Guinea Bissau	6,735
Madagascar	171,724
Maldives	143,258
Mauritius	26,243
Reunion Island	2,259
Seychelles	136,178
Sao Tomé and Príncipe	10,808
Total	532,899

Source: FAO (2018)

In terms of life cycles, fisheries products can have various uses beyond consumption, the production of fishmeal from fish waste is widely practised within the AIODIS. However, the production is low. The entire African production of fishmeal does not exceed 200,000 tonnes (as of 2018) which represents less than 3% of global production. Within the AIODIS, the use of fish parts could also be replicated on other islands. Operating by some private companies (for example, Marine Biotechnology Products, Goa Tuna Oil), Mauritius has produced fish oil from tuna heads un-used in the canning industry. The fish oil is sold as a food supplement.

For **aquaculture**, the production within AIODIS is still very low following the trend in Sub-Saharan Africa. Fish production from aquaculture in Sub-Saharan African still represents less than 1% of the global production. AIODIS countries such as Madagascar, Reunion Island and Mauritius have been involved in aquaculture and mariculture. While the aquaculture sector within the IOC countries alone is estimated at EUR 23,3 million/year, the production is mainly for consumption and exports (Breuil & Yvergnaux, 2017). Activities to improve life cycles for the countries involved in aquaculture would include waste management and water treatment, two aspects that are recognised as requiring improvement in aquaculture practices.

In terms of **bioprospecting**, there is little literature about this topic within the AIODIS. As ocean-based economies, marine products present opportunities for potential diversity of uses. Some countries have developed such initiatives and can serve as a model and lessons learnt for other AIODIS countries. These include:

- Seaweed Aquaculture (in Madagascar). Blue Ventures, an NGO based in Madagascar has developed seaweed aquaculture (red "cottonii" seaweed - *Kappaphycus alvarezii*) with local communities. The products are bought by cosmetic companies outside the country.
- Aquatic algae production (in Madagascar). Private companies and research institutes have grown algae (*Spirulina nei* - *Spirulina spp.*) to be used as a food supplement.

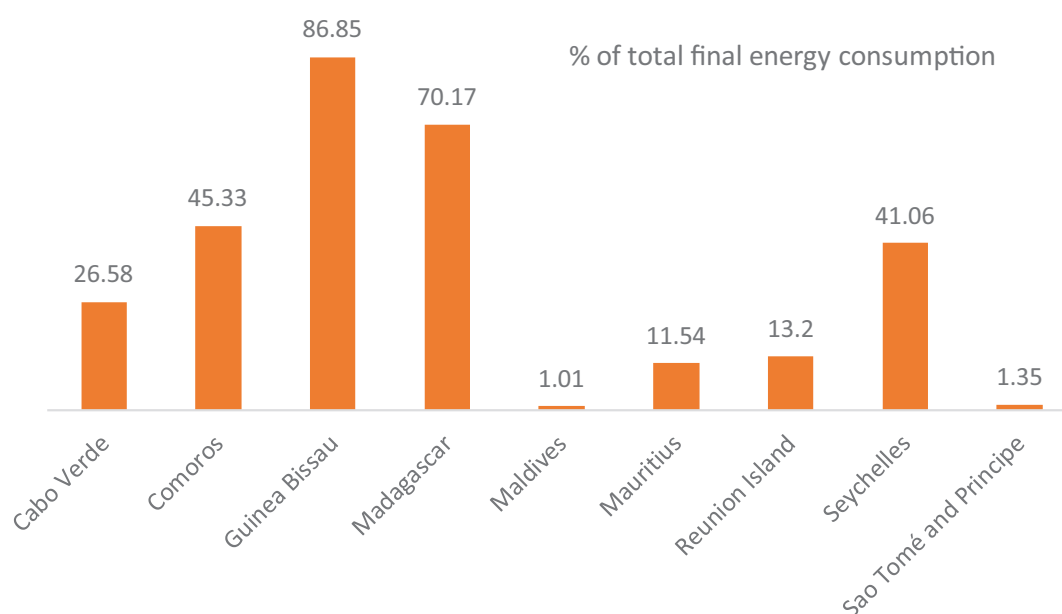
For non-living resources such as **oil and gas** as well as renewable energy and minerals, the AIODIS have not fully developed activities in these areas, despite the substantial potential.

Regarding oil and gas, in 2014 important deposits were discovered within the Mozambique Channel and provide potential of extraction for countries in the region (Richmond, 2016). AIODIS such as Maldives and Guinea Bissau also have existing deposits that present the opportunity of exploitation. Since the discovery of oil and gas deposits within AIODIS, exploration activities have taken place in countries

like Madagascar, Guinea Bissau and Seychelles. Activities pertaining to oil and gas exploration have also started in the Extended Continental Shelf in the Mascarene Plateau region jointly managed by Mauritius and Seychelles. Since extraction itself has not taken place yet, there is an opportunity to build a strong framework integrating circular economy principles within the future of these activities. Water and technical materials of refineries in particular have been recycled and reused in other countries (Alnuaim, n.d.; Kun & Jian, 2011).

For **renewable energy**, the AIODIS have different levels of consumption (Figure 4). Countries like Guinea Bissau and Madagascar strongly rely on renewable energy whereas countries like Maldives, Mauritius or Sao Tome Principe have a very low consumption.

Figure 4: Percentage of renewable energy consumption within total consumption in the AIODIS in 2015



Source: Compilation from Cornéllus et al. (2016); World Bank (2016)

The western Indian Ocean has been assessed presenting the potential for developing energy from ocean-based sources such as deep-ocean temperature, tidal energy, ocean current and wave energy (Richmond, 2016). The technologies for such options are not available yet for the countries of the Indian Ocean although prototypes have been developed (EMR in Réunion and low-cost prototype in Mauritius). Some AIODIS, part of the IOC, however, are taking part in the ENERGIE Project, a 15-million-euro project started in 2015 and funded by the EU to develop renewable energy within the IOC countries. As of 2019, more than 10 projects have been funded covering solar energy, hydroelectricity and biogas (examples in Table 5).

Table 5: Sample of projects funded under the ENERGIE project.

Country	Renewable Energy Projects
Comoros	<ul style="list-style-type: none"> - Production of energy-saving wood-fired cookers - Biogas production from household waste - Reforestation of ylang-ylang to reduce reliance on fuelwood
Madagascar	<ul style="list-style-type: none"> - Social enterprise through solar lamps selling and making (Jito-Ve, Femsolar) - Locally made turbines for a hydroelectric plant (Jiro Meva) - Use of Jatropha grains from Jatropha oil production to generate local fuel (Gemaha) - Biogas production from household waste (Biogaz Diana) - Solar panel centres in remote villages
Mauritius	<ul style="list-style-type: none"> - Desalination of sea water through solar energy (Osmosun) - Biogas production from household waste

Source: IOC (2019)

Finally, a resource that is key for the AIODIS is **freshwater**. Most AIODIS countries have developed desalination plants, and processes seawater into freshwater. Countries like Cabo Verde, Maldives, Madagascar, Mauritius (and Rodrigues) and Seychelles have built desalination plants to improve their input in freshwater. This re-use of seawater can be seen as a key step within the CE principle of increasing life cycles within biological flows.

Overall Diagnostic - Regarding the extraction of natural resources, the AIODIS countries have lessons to share amongst them in terms of fisheries and aquaculture as well as renewable energy. Existing initiatives fit within the CE principles and can be developed further. For other fields such as oil and gas, offshore renewable energy and bioprospection, the AIODIS have not developed these activities yet. This represents an opportunity to build frameworks and policies for these activities that comply with the needs of a circular economy.

2.2.2 Regeneration of ecosystems and protection of species

Another important principle within the CE is regeneration or “the promotion of self-renewal capacity of natural systems with the aim of reactivating ecological processes damaged or over-exploited by human action” (Morseletto, 2020, p7). Within a CE, high priority is given to the natural systems from their use to their flourishing.

For the AIODIS, in addition to terrestrial systems, the marine system plays an essential role in sustaining economies especially considering the large national water and high seas that surround the AIOSIS. Therefore, various biodiversity conservation policies and actions as well as initiatives towards sustainable management of fisheries and marine resources can be included within this regeneration.

The AIODIS share common practices of regeneration that, while not labelled as such, contribute to the reactivation of ecological processes. The following activities are found amongst the AIODIS:

- The establishment of marine protected areas (Table 6). Each AIODIS has established one or more marine protected areas to help species flourish without human action threat.
- The adoption of legislation protecting endangered species such as sharks from being harvested
- Protection and restoration of coral reefs and wetlands

Table 6: Extent of marine areas protected within the AIODIS

Countries	EEZ size (km ²)	Marine surface protected (km ²)	Number of MPAs	Coverage of the EEZ
Cabo Verde ¹	800 561	5	0	<1%
Comoros	163 752	620	0	<1%
Guinea Bissau	123 725	9 197	11	8,6%
Madagascar	1 225 259	54 463	47	3,6%
Maldives	923 322	472	39	<1%
Mauritius	2 203 542	637 909	16	29%
Reunion Island	315 000	35	11	<1%
Sao Tome and Principe	131 397	6	0	<1%
Seychelles	1 336 559	208 618	26	26%
Total		910 690	124	

Source: <https://mpatlas.org/countries/> and <https://www.protectedplanet.net/> (for Cabo Verde and Comoros) Accessed October 8th, 2020.

Specific **regeneration** initiatives that are undertaken by some countries that present some potential of replication are:

- **The setup of fisheries closures** (in Madagascar, Mauritius and Comoros). In the three countries, fisheries such as octopus, crab or lobster are managed under temporary closures of the fishery to ensure that species reach maturity and that juveniles are not caught.
- **The setup of LMMAs - locally managed marine areas** (in Madagascar and soon in the Seychelles) and Voluntary Marine Conservation Areas (in Mauritius). These areas are specific marine areas, often coastal, that are managed by local communities. The management is shaped by a set of rules that prevent destructive use and designates specific areas that cannot be accessed by users in order to protect juvenile species.
- **Marine Spatial Planning (MSP)** (in Seychelles). MSP is a process that allows government and natural resource users to determine together the various use and zoning of national waters. Seychelles has been leading such a process and finalised its MSP in 2019. Through MSP, the Seychelles have been able to designate 30% of its national waters to be protected.
- **Certification of fisheries products** (in Maldives). Certification schemes such as the Marine Stewardship Council for fisheries products like tuna in the Maldives allow the resources to be managed under environmental criteria and rules that the fish stocks can benefit from.
- **Adoption of catch limits** (In the Indian Ocean). To recover the overfished status of yellowfin tuna in the Indian Ocean, member parties to the Indian Ocean Tuna Commission have adopted catch limits on their fishing effort in the region.

Overall Diagnostic - The AIODIS have progressed towards protecting natural systems from degrading. However, efforts are still very limited in terms of protecting marine areas compared to the size of EEZs. Efforts are also not consistent within the region with some countries like Seychelles and Mauritius much more advanced in protection targets. Lessons can be exchanged between countries. Considering the reliance of the AIODIS on the oceans, regeneration is a key component in achieving a CE.

¹ In late October 2020, two islands in Cabo Verde were classified as a UNESCO world biosphere reserve. This new classification is not reflected yet in the mpatlas.org data

2.2.3 Energy recovery and extracting feedstock from island environments

The last component under renewable flow management is energy recovery and feedstock extraction. They can take place at post-harvest as well as post-consuming phases and aim to regenerate nutrients in the biological cycle (EMF 2020). This principle is therefore at the interface between the biological and the technical cycles.

Within the AIODIS, energy recovery in the biological cycle takes place through the use of biological material to generate energy. Some AIODIS, especially those members of the IOC, have developed biogas systems through the use of organic waste and could be replicated across the other countries (IOC 2019). Countries like Madagascar and Mauritius also recover energy from solar panels or from the use of plants like *Jatropha* or sugarcane that can also generate biofuel (Sonnleitner et al., 2013; Sultan & Khoodaruth, 2013; Whitehouse, 2020). Mauritius and Reunion Island have also extracted biomass from mix electronics. They have built infrastructures for such energy recovery, often from external funding, and should be supported in their activities as well as in the promotion of lessons learnt from these initiatives.

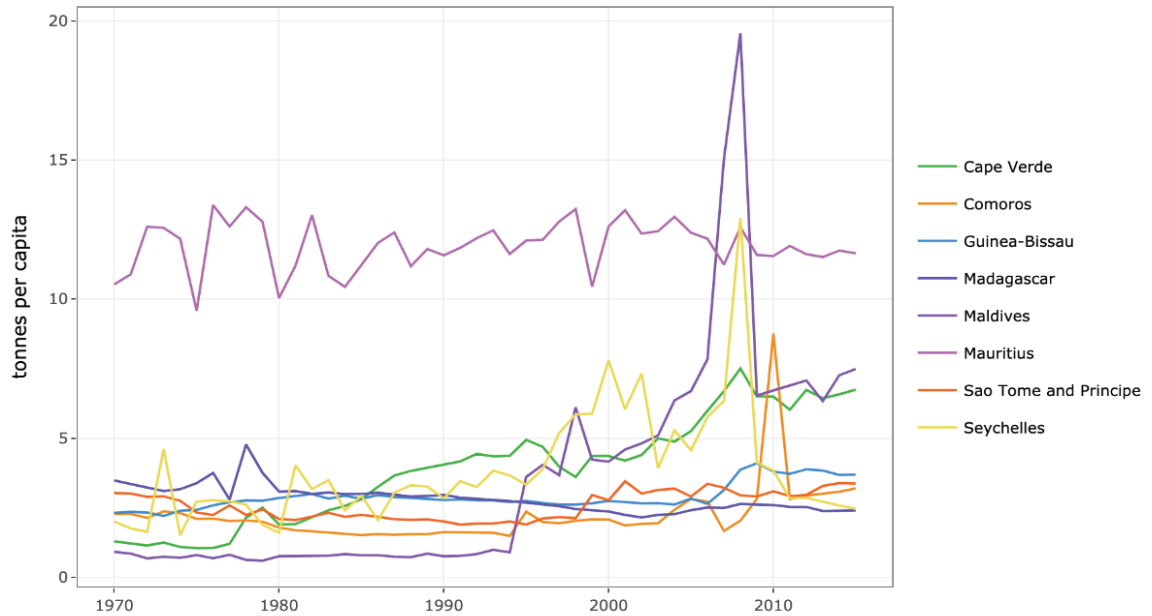
In terms of extracting feedstock, initiatives such as compost making (as it will be developed in the next section) are part of practices that help extract feedstock and regenerate nutrients in soil. As far as the ocean is concerned, such regeneration is possible by inducing less anthropogenic stress in the marine ecosystem (for example through pollution) (Duarte & Krause-Jensen, 2018; McCrackin et al., 2017). Marine conservation-based activities of AIODIS are therefore key in this strategy. The Maldives, for example, is building a sewerage treatment plant with financial support from the World Bank in the capital city to prevent untreated sewage from being released into the ocean.

Overall Diagnostic - While there are initiatives that constitute a good start on energy recovery and feedstock extraction, these are localised and of small scale. Activities that specifically address marine ecosystems are also limited but could be enhanced through ongoing conservation activities.

2.3 Material stock management: implementing ReX strategies for consumption and waste management

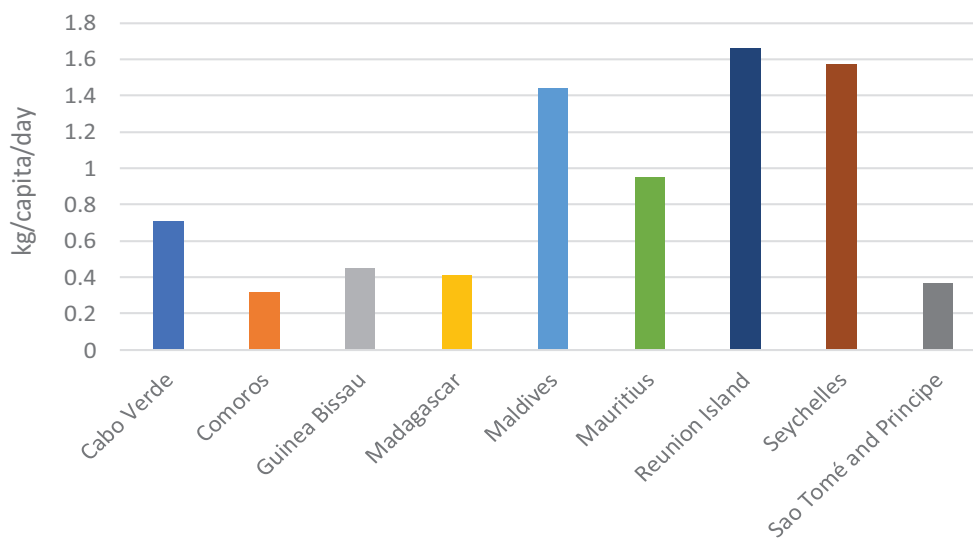
This section refers to the second part of the CE system diagram on material stock management. The management of material stock has the aim to ensure that products have a longer life span. In the context of AIODIS, considering their geographical isolation, the question of material stock management is especially relevant to address issues such as the high consumption of material, including plastic and waste management. In line with their development status, more advanced AIODIS have higher material consumption and waste per capita compared to developing AIODIS (Figures 5 and 6). The issue of plastic in particular represents an important threat to the ecosystems of the AIODIS. With a total plastic consumption of more than 450,000 tonnes in 2010 (Ritchie & Roser, 2018), the AIODIS and especially more developing ones such as Maldives, Mauritius and Seychelles have a high quantity of plastic per capita (Figure 7).

Figure 5: Domestic material consumption per capita within AIODIS (excluding Reunion Island: 10,4 tonnes/capita in 2015)



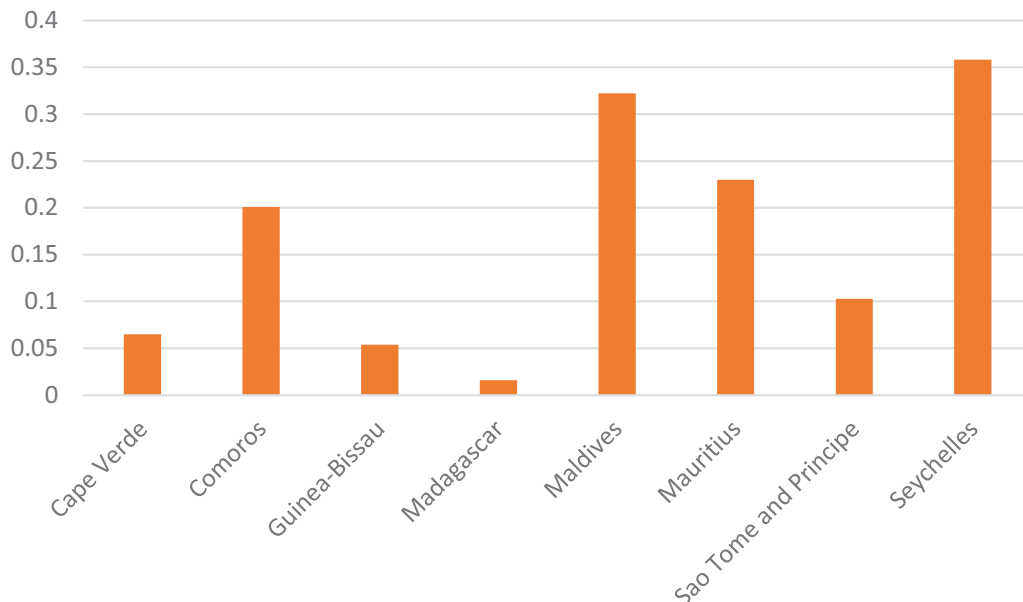
Source: materialflows.net. Accessed October 8th, 2020 and Cornéllus et al. (2016)

Figure 6: Waste Generated within the AIODIS



Source: World Bank (2020); Brink et al. (2017)

Figure 7: Plastic waste generated (in kg) per capita within AIODIS (excluding Reunion Island). Source: Ritchie & Roser (2018)



As material consumption and waste management have increasingly become pressing issues, especially in the AIODIS, we will mobilise the ReX framework (presented in Figure 2) to provide a picture of existing initiatives within the strategies of Reduce, Reuse, Recycle and Recover.

2.3.1 Reducing material consumption and waste generation

The concept of Reduce at the pre-use stage involves various ideas including eco or sustainable design, designing products that last longer or have multiple life cycles, and the use of less material in production or dematerialisation. It also covers the idea of consuming less, using products longer or building more emotional attachments to products to avoid discard.

For the AIODIS, a range of activities and initiatives are in place to promote the reduction of consumption, especially linked to single use plastics. Industries such as tourism and fisheries have been at the forefront of taking part in such initiatives. Common initiatives across the AIODIS include:

- Campaigning against the use plastic bags and bottles (see for example in Table 7)
- Environmental education of the general public regarding reduction of consumption and waste management
- The use of biodegradable fishing aggregating devices (FADs) rather than plastic based FADs in tuna fisheries in the Indian Ocean

Table 7: Sample of projects within AIODIS on Reducing consumption of plastic

Country	Activity	Project/Initiator
Maldives	Promotes source-to-sea solutions to reduce marine littering in tourism	PROMISE PROJECT
	A pledge to reduce plastic use, boost recycling, and support the creation of new materials and methods.	Parley AIR (Avoid, Intercept, Redesign)
Seychelles	Education (online and offline) and action-oriented and policy and research on plastic bags use	SYAH Free from Plastic Bag Campaign

There are also **Reduce** schemes established in specific countries that could be replicated across AIODIS:

- **Deposit-refund scheme on glass bottles (in Mauritius).** The scheme establishes a deposit fee for each 700- and 330 ml glass bottles. The initiative is led by local manufacturers (such as Phoenix Bev, Oxenham, QBL). It helps to ensure that the glass bottles are returned to the retailer and then collected by the beverage manufacturers.
- **Excise Duty on Non-Biodegradable Plastic Food Containers (in Mauritius).** The scheme promotes responsible consumption and production by imposing a tax on single-use plastic food containers, thereby reducing the generation of single-use non-biodegradable plastic food containers and greatly reduced its use.
- **Use of ecological material for construction (in Madagascar and Reunion Island).** The government has supported the structuring of bio-sourced materials sectors in Réunion Island and the creation of ecovillages in Madagascar within which ecological materials found locally are used to build houses.

Overall diagnostic - The main challenge within the Reduce strategy is within the production cycle and promotion of sustainable designs, where there are little recorded initiatives so far. Since AIODIS strongly rely on imports for their goods, production is also often out of the hands of countries. However, local industries have the opportunity to develop innovative designs.

2.3.2 Reusing natural biomass

The concept of reuse covers various strategies within the CE that promotes a sharing economy. According to Sihvonen and Ritola (2015), Reuse includes strategies from direct reuse to remanufacture or resynthesise (Table 8).

Table 8: Six concepts under the Reuse strategy

Reuse concepts	Definition
Resale and direct reuse	Reuse as it is or for another market
Repurpose	Using same product for new purposes without any adjustment
Repair	Restore the product into a 'working order'
Refurbish	Restore product to the extent it is not altered substantially
Remanufacture	Reach the quality of a new product, 'like-new' or 'as new'
Re-synthesise	Creating a new artefact different from original purposes

Source: Author's conception

For the AIODIS, the reuse strategy is key in ensuring circularity and reduce reliance on imports (see figures in Annexe 1). The initiatives that are shared and mainstream amongst the AIODIS include:

- Compost production (Table 9)
- Campaigns against food waste (such as the FOODWISE initiative in Mauritius)

Table 9: Examples of reuse practices through composting within AIODIS

Country	Activity	Project/Initiator
Comoros	Collection of organic waste to produce natural pesticides	Mouniat Compost
	Creation of a national platform for composting	
Madagascar	Collection of organic waste for compost and fuel bricks	Madacompost
	Resale of metal and plastic components to local handcraft businesses	Fakofia Le Relais
	Collection of municipal organic waste for sorting and composting	Fakofia Le Relais
Mauritius	Provision of home compost bins to households to encourage source segregation of wastes and promote the practice of compost production and usage.	Home Composting scheme
Reunion Island	Management of platforms of composting and shredding of farming waste	Green Tropical Circle
	Management and collection of organic waste to alleviate storage issues	ProxiCompost

There are **Reuse** schemes established in specific countries that could be replicated across AIODIS:

- **Ressourceries and Good Shop** (Reunion Island and Mauritius). The structures collect objects considered as waste. By reusing or recovering materials, the collected objects are valorised. The managing associations make products available for a modest price, after being repaired and customised for a second life.
- **Water resource management project** (Cabo Verde): The project aims at solving the problem of water scarcity and makes use of waste water for agriculture. The project targets all existing water, including groundwater for consumption and reuses wastewater for agriculture drop by drop.
- **An online platform of repair artisans** (Reunion Island): The platform allows the public to find individuals or companies that are experts in repairing various products including electronics, furniture, etc.

Overall diagnostic - The AOISIS have developed a vast array of initiatives for the Reuse strategy. One of the challenges of the Reuse strategy for the AIODIS is to build the capacity in the different industries to repair, repurpose and refurbish products. However, in developing AIODIS, the informal sector represents a rich field of exploration as it is where different repair, reuse or resale takes place widely. There is, however, limited data regarding these practices that are key to the CE. This requires more research and investigation on the potentiality presented by such activities.

2.3.3 Recycling organic and plastic waste

Recycling is one of the most mainstream and accepted strategies within the production and consumption cycle. Recycling can be defined as “any recovery operations by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes” (Sihvonen & Ritola, 2015). Recycling involves restoring products through their original or downgraded state so that they can be suitable for different purposes.

For the AIODIS, the strategy of recycling has been adopted at different levels and in different forms. Common initiatives include:

- Integration of recycling within waste management policies, including through the creation of recycling centres
- Establishing collecting points of recyclable waste
- Development of recycling activities at different levels, including within communities (for the case of Maldives and Seychelles), the private sector (for the case of Mauritius, Reunion Island, Madagascar, Guinea Bissau and Comoros) and at the state level (for the case of Cabo Verde)
- Transformation of recycling waste into needed material, including for construction and public infrastructure like streets (Table 10)

Table 10: Samples of recycling activities within the AIODIS

Country	Activity	Project/Initiator
Cabo Verde	Turning Glass bottles into sand for construction	Tinenê factory
	Transforming plastic waste into tile	Santo Antão Island
Comoros	Recycling household waste into tiles and bricks	2Mains initiative
	Recycling discarded clothes material into bags	Yang Creation
Guinea Bissau	Transforming plastic waste into road construction material	Binedou Global Service
Madagascar	Recycling household waste into tiles and bricks	Madacompost
	Transforming plastic waste into tiles and pavement material	Fakofia
Maldives	Regional waste management system	Clean Environment Programme
	Transforming plastic bottles into shoes and clothes through Parley recycling plants	Parley Maldives
Mauritius	Recycling glass bottles into construction and decoration material	Plankton Recycling
Reunion Island	Methanisation of organic waste producing a biogas transformed into green electricity	Biocarbo
	Recycling old tyres into tiles, mats and other construction materials	Solygom
Seychelles	Transforming Glass bottles into construction material	Seychelles Breweries

Source: Author's conception

Within recycling operations, some AIODIS have also developed Recycle strategies and incentives to boost productivity from recycling:

- **Financial incentive for recycling bottles locally** (in Mauritius). The government provides a financial incentive of Rs 15 per kg of PET recycled/exported for recycling. The incentive is higher for recycling done domestically. About 40% of PET bottles are collected annually out of a volume of about 120 million units produced per year. There is also a PET Tax of Rs 2 per bottle on production collected by the government
- **Regional strategy for recycling specific waste** (amongst IOC members). Five countries of the AIODIS, members of the IOC have developed a regional strategy targeting specific types of waste, notably plastic, batteries, oils and tyres. The aim of the strategy is to improve their value after transformation. One of the priorities of the strategy includes reinforcing technical knowledge regarding these specific types of waste and identifying the needs and potentialities of added value, per country.

Overall diagnostic - While recycling exists within the AIODIS, existing operators are not able to respond to the large demand of waste management required. Therefore, in current times, only key products such as PET and glass bottles are widely recycled. There is a need to better investigate the availability of other types of recyclable waste and especially build technical skills at different levels to implement transformation activities. The activities presented above show the diversity of experiences within the AIODIS and from which the replicability could be studied. Countries with similar socio-economic contexts such as Mauritius, Maldives, Reunion Island and the Seychelles could learn from each other and so could less advanced countries such as Comoros, Madagascar, Guinea Bissau and Cabo Verde. Initiatives in this direction have begun, notably the ongoing cooperation between Reunion and Mauritius on the structuring of a circular economy. AFD supports the waste strategy in these countries. The Reunion Region also supports the structuring of the EPR sector with the public and private sectors.

2.3.4 Recovering energy and e-waste parts

Recover is one of the less mainstream strategies with the R framework. Adopted by the European Union (2008) and within the 4R to 9R framework, it is less developed in terms of its implementation globally and especially in developing or coastal countries (World Bank, 2018). Sometimes considered as covering reuse and recycle, the recover strategy in the RX framework involves retrieving valuable or hazardous materials during the post-use phase (Sihvonen & Ritola, 2015). This strategy involves for example energy or metal compound recovery processes (ibid).

For the AIODIS, the strategy of recovery can be embedded within recycling practices. The generation of biogas from household waste, a practice developed in various AIODIS can be considered an energy recovery strategy.

In terms of material recovery countries have had different involvements. A common practice within the AIODIS and especially in less developed AIODIS likes Madagascar, Comoros, Guinea Bissau and Cabo Verde, is the recovery of metal and other components by informal recyclers (Ferrari et al., n.d.; Lazare et al., 2010). These recovery activities target different types of metal as well as e-waste (Lazare et al., 2010). For more advanced countries such as Mauritius and Reunion island, the private sector has been a key player in developing recovery activities:

- **The recovery of energy and metal from old batteries and e-waste** (in Mauritius and Reunion Island). Companies (Wecycle, Recyclage Valorisation Environnement - RVE) have developed processes to collect and recover material from e-waste that can be reused for refurbishment purposes or for an entirely different use.

- **Industrial waste collection and recovery** (in Reunion Island). A private company (Inter'Val) that collects and recovers parts of industrial waste (filter, containers, paints, etc.) to be exported.

Overall diagnostic - There are few records of initiatives that directly refer to the recover strategy. It is however possible that the recovery sector is more developed than what it appears within AIODIS especially considering the informal activities that are taking place in some of the AIODIS. What is therefore missing is a promotion and boosting of these activities to create more value for the countries and also provide more benefits for workers involved in such activities.

3 Challenges and Opportunities

3.1 Challenges around fostering CE in AIODIS

The results in section 3 have shown that the AIODIS are already involved in some CE interventions. However, they are not coordinated under the CE as an overarching concept but more siloed in various sectors of environmental protection and waste management. The novelty of CE for the AIODIS represents the main driver for this lack of harmonisation. Therefore, in addition to existing challenges in implementing sustainable ocean-based activities, implementing a CE also presents additional challenges. These can be gathered under four types: technical, socio-economic, institutional and ecological.

3.1.1 Limited technical capacity

One of the key challenges that AIODIS face in transitioning to a CE is the lack of technical capacity. The low population in most of the AIODIS implies that technical capacities are not always available to implement interventions or to develop a national strategy. Even in Reunion Island, the boosting of the CE² stems from France's advanced CE policy. One of the key challenges for AIODIS is therefore the limited human resources that have the expertise to develop technically advanced CE activities. The AIODIS also lack human resources to implement activities such as those within the ReX framework and especially in waste management. In the latter in particular, recycling and recovering of waste is often not considered an attractive employment for local people and is sometimes associated to a marginalised segment of the population (Lazare et al., 2010; World Bank, 2018). Another important gap is the limited data available as well as the capacity for data collection. Lack of data in the majority of countries³ affects both knowledge on natural flows as well as knowledge on material and waste. Consequently, it can be difficult to adopt the best strategy in the different spheres of the CE where data is scarce for the needs of new initiatives. Furthermore, there is also a limited collection of data that assess the effectiveness of existing projects.

The AIODIS requires capacity building in six key areas:

- the development of a CE national strategy⁴
- technical knowledge in energy recovery and feedstock extraction initiatives
- expertise in expanding recycling beyond plastic and PET bottles
- technical knowledge in material recovery
- data collection regarding natural flows and material use
- data collection assessing existing initiatives and projects

The field of reuse within AIODIS is also one that requires more development. While some skills might be available for small repair of material, and common in developing economies, capacities around refurbishment and remanufacturing are close to non-existent.

² Through the Regional Plan for Waste Prevention and Management - PRPGD or the Regional Action Plan for the Circular Economy

³ Characterisation study of waste in Réunion by ADEME in 2019

⁴ Except in the case of Reunion Island benefiting from the Regional Action Plan for the Circular Economy

In terms of management of natural flows, the AIODIS have succeeded in adopting environmental policies and implementing projects and activities towards the protection of natural ecosystems and marine resources. These, however, still need to be reinforced. A number of lessons learned within the AIODIS (presented in section 3) could guide countries that are less advanced.

In terms of awareness about the CE, more campaigns are also needed at all levels of the population and especially at the production and policy levels. Within the general public, knowledge about the CE economy is extremely limited⁵ if not non-existent. However, the AIODIS population are increasingly aware of the need for environmental protection and waste management, including problems related to consumption and plastic. What is then missing is a broader awareness campaign on how current and future initiatives could contribute to a circular economy that would be beneficial to the AIODIS populations. A stronger effort that is needed is at the production level especially for developing AIODIS. Companies extracting natural resources and producing goods in Africa (including in the AIODIS) have not integrated a CE approach yet (Desmond & Asamba, 2019). This is mainly due to the fact that production and extraction in AIODIS and generally in developing countries are following a linear and accumulative approach that relates to achieving growth (ibid). The benefits of a CE approach is then little known within companies. The experience of Reunion Island in involving companies and promoting the private sector's involvement in building a CE is a key experience for the AIODIS and represents an opportunity for exchanges between similar industries. At the policy level, governments of the AIODIS have only engaged in CE discussions in the past five years, with the exception of Reunion Island. Governments are minimally aware of the requirements and benefits of the CE especially in achieving a sustainable and inclusive blue economy.

Finally, the limitation of funds is a key challenge in developing and implementing activities within the CE. As a common issue that developing AIODIS in particular face, the lack of financial resources available and the reliance on foreign aid to develop projects are an important limitation for the AIODIS. Even within the current blue economy agenda, main initiatives are led by funders such as the World Bank or the IOC. Seychelles is one of the AIODIS that has managed to raise US\$15 million in funds from international investors for "blue bonds" designed to support sustainable marine and fisheries projects (SeyCCAT, 2019). Furthermore, while Reunion Island has raised most of its funds for CE through its state budget, other AIODIS might not have the budget to specifically foster CE interventions.

3.1.2 Differentiated socio-economic contexts

The second set of challenges that the AIODIS face in the context of a CE are inherently linked to their socio-economic contexts. The AIODIS are composed of countries with different levels of development. Some countries are more advanced (such as Reunion Island (France), Maldives, Mauritius or Seychelles) while the rest are at a developing stage (Table 11). Some AIODIS such as Guinea Bissau, Madagascar or Comoros are ranked at the very bottom of the human development index of the UNDP (Table 11).

⁵ Mauritius has the Sign'Natir Pact established by Business Mauritius (<https://www.signenatir.mu/>) which promotes aspects of the circular economy

Table 11: HDI Ranking of AIODIS countries

Countries	HDI ranking
Cabo Verde	126
Comoros	156
Guinea Bissau	178
Madagascar	162
Maldives	104
Mauritius	66
Reunion Island (France)	26
Seychelles	62
Sao Tomé and Príncipe	137

Ranking based on 189 countries assessed. Source: UNDP, 2020

In this context, the AIODIS have very diverse national priorities. The more advanced countries are at the stage where some reflexion of circularity can be undertaken especially in light of increasing consumption and accumulation of waste. The less advanced countries, however, are still aiming at achieving development often relying on more extractive and linear economies. To this is added the issue of waste management that developing countries are increasingly facing. That said, a CE economy represents an opportunity for developing countries to achieve development under a CE framework that is more regenerative for natural resources and address waste issues from the material production stage to post-use. The challenge then lies within changing the paradigm at the highest level for less advanced countries. AIODIS like Comoros have already started this reflexion in its blue economy strategy and could serve as an example for other developing AIODIS.

Another aspect is the engagement of the AIODIS in developing their blue economies. There is a need to align national priorities with circularity rather than growth. Some prospective activities under the blue economy aspirations of countries are strongly related to linear growth. Visions such as increasing seabed mining or further development of fisheries might have contradicting values with the CE principles. It can therefore be a challenge for countries to achieve blue growth within a CE.

Another challenge is to show the relevance of CE for local realities. As the implementation of a CE is emerging in western countries, making such a concept applicable to developing AIODIS is an important issue. In countries like Madagascar or Guinea Bissau, extraction of resources is where wealth resides and consumption of goods is seen as a sign of progress. Applying a CE economy approach in such a context therefore can be seen as a way backward. In countries where the majority of the population rely on day-to-day income and expenditure, concepts such as extracting or consuming less can appear contradictory to development and economic growth. Within the developing AIODIS in particular, CE can be seen as a western concept that will impose limits on individual and national economic growth. On the other hand, in more advanced AIODIS, the implementation of a CE might affect many industries that have strongly relied on extraction such as fisheries. Industrial fishing, for example, is an important source of revenue for AIODIS in the Indian Ocean. Implementing a CE might require a different approach to fisheries that is more geared towards protection of resources and reduce production to a more sustainable level. Economies of countries like Seychelles that are highly reliant on tuna fisheries, for example, might need to adjust their industrial fisheries practices for more circularity and better use of resources.

The diverse socio-economic context within AIODIS can represent a strong obstacle to a harmonised CE strategy. While the principles of CE could be agreed amongst countries as helping to achieve sustainable development, their implementation requires a highly differentiated approach that considers the specificities of each AIODIS.

3.1.3 Institutional and political obstacles

The next set of challenges are closely linked to the socio-economic context of countries. They include the institutional and political obstacles that countries face in order to develop a CE. First, as presented in section 3.1, there is currently no CE framework that is readily available to implement for AIODIS, with the exception of Reunion Island. Countries have different interventions that can be related to implementing a CE without being directly labelled as such. While it shows that there are already opportunities to develop the CE, it also presents the risk of having uncoordinated and potentially contradictory policies that do not comply with the CE principles. Similarly, laws and regulations on specific CE activities are lacking in all the AIODIS, with the exception of Reunion Island.

A second challenge is the limited means that are currently available at the state level especially for implementation of a CE. This includes limited financial means as presented above but also institutional structures and infrastructure that are needed to develop and especially implement circularity. This is evidenced by current initiatives in waste management which is often project-based rather than being long-lasting initiatives. Efforts such as recycling or material recovering require substantial infrastructures and equipment that are not necessarily available within the AIODIS, especially developing ones.

The third challenge is political. While the AIODIS have committed to achieving sustainable development, including by implementing a CE (the mandating of this report being a token of that engagement), political will is not homogenous within each country. Many of the AIODIS are also subject to political instability and crisis. In this context, undertaking a systemic transformation such as the shift towards a CE will be highly dependent on national priorities of political leaders. In countries like Madagascar or Guinea Bissau, recurrent political crises represent a serious threat to enabling a systemic change. Governments that have agreed to a CE agenda today could be replaced tomorrow. The lack of policy continuity will strongly affect the ability of politically unstable AIODIS to fulfil their commitments towards a CE.

In line with this instability, power relations between governments and extractive/exploitative industries often dominate decision-making, especially in developing countries (Childs, 2018; Teixidó-Figueras et al., 2016). Industries such as mining or industrial fishing have strong influence on state actors and on environmental policy making. Often presenting their financial contribution to national economies, they can be reluctant in policy change and influence decision makers through lobbying. Such power dynamics are often overlooked especially in developing countries and require particular attention if any systemic change is to be achieved.

3.1.4 Complex ecological and geographical contexts

While implementing circularity refers to changing the paradigm in the economic system, there are some important ecological factors that can make the implementation of a CE challenging in the AIODIS. The first one is climate change which has serious impacts for island countries. The AIODIS are exposed to sea-level rise and global warming. In such context, implementing new ocean-based activities could be put at risk.

Another ecological challenge that AIODIS face is their geographical isolation and size. Some of the AIODIS such as the Maldives and the Seychelles are constituted by small remote islands that are separated from each other either by lagoons or deep-sea channels. The lack of connection between the islands can make it difficult to implement a national framework of CE. On the other hand, Madagascar has large landmass with a lack of connection between towns. In this context, implementing national policies is also challenging. Connected cities such as capital cities benefit from initiatives and leave

remote areas behind. The AIODIS therefore face both external and internal environmental challenges that can directly affect the implementation of a CE policy.

3.2 Opportunities in adopting a circular economy

The challenges presented above might strongly affect the ability of AIODIS countries in fostering their CEs. However, the CE also presents an array of opportunities that the AIODIS could benefit from.

3.2.1 Safeguarding sustainable blue economies

The first key opportunity that the CE presents to the AIODIS is the potential to achieve sustainable and inclusive blue economies. As most of the AIODIS have now embraced the blue economy agenda, the CE principles could help the AIODIS develop ocean-based activities that are both regenerative and rely on the management of material stock. This is particularly relevant for prospective activities within the blue economy such as seabed mining, bioprospection, or offshore oil and gas extraction. Such activities can have negative impacts on natural flows and could affect the biodiversity and ecosystems in the long term (Allsopp et al., 2013; Cordes et al., 2016).

Another venue for the blue economy to be better implemented through a CE approach is by adopting the system perspective within the CE which looks at implementation at three levels (Sihvonene & Ritola 2015). First is the landscape which represents the external context that actors cannot influence in the short term but since it is highly dynamic, it requires consideration in planning action (such as climate change). The next level is the regime level which is constituted of structures (social, technological, economic, environmental and political) within which institutions and actors shape the system. This is where policies can be adopted to comply with the CE principles. Finally, there is the niche-innovation level where innovation and transformative change take place. This is where actors at the local level and businesses could be involved. Implementing the blue economy agenda with this framework would allow for a consideration of actions needed at all levels from considering environmental conditions to policy and local initiatives.

3.2.2 Job creation within a CE

The second substantial opportunity from the CE is job creation. While technical capacity is currently lacking within AIODIS towards the implementation of a CE, there are, however, areas especially within material stock management that will benefit from job creation. From recycling to reuse and repair frameworks, there are strong opportunities to create jobs and reinforce human resources in these areas. If part of a national strategy, these activities can be promoted by governments as key to sustainability. Waste and material management in particular have notable potential. Reunion Island has started to use the CE framework to promote initiatives and businesses that address circularity. It is an opportunity for the AIODIS to undertake learning exchange⁶.

3.2.3 Tackling plastic and waste issues

Another opportunity for the blue economy agenda is to strongly address the issue of plastic waste that represents a real threat for the coasts and marine ecosystems of the AIODIS. By promoting circularity, the question of waste, and plastic waste in particular, is addressed holistically from reduction of consumption to recycling. Adopting a CE framework would provide AIODIS a strong framework to tackle plastic waste. It can also bring interest and funding to the AIODIS. At the global level, various

⁶ Funding is available for example from INTERREG and the Réunion Region - in particular a cooperation fund of €63 million for the countries of the IOC area

initiatives are now underway to tackle the plastic issue (for example the MARPLASTICCS project and many more). With a CE framework, the AIODIS would be provided with the right policy framework to benefit from various funding that addresses the problem of plastic.

Waste management has been a key area to make progress for different countries that have adopted a CE. It is therefore an important field where the AIODIS would benefit from external experiences but also from support by various entities involved in waste management. African countries like South Africa have recently adopted this approach by establishing a national plan for waste management that are based on the CE principles (IUCN, 2020).

3.2.4 Learning exchanges within the AIODIS

Finally, the CE also presents the opportunity for the AIODIS to build from the experience of more advanced islands such as Reunion Island as well as build its capacity. As presented in section 3.2, different AIODIS are involved in activities that can be integrated within a CE framework. Furthermore, advanced countries like Reunion Island have started the implementation of a CE. The AIODIS therefore can learn from each other and share the challenges and opportunities that they have. The increased interest for the CE offers opportunities of funding to foster these exchanges for the benefit of all the AIODIS.

Learning exchanges can take place at different levels from government level to explore the development of CE policies, to businesses to exchange skills and initiatives. It can also take place at the public level which would require more awareness activities regarding the value of a CE.

From the analysis of challenges and opportunities above, the AIODIS face challenges but are also presented with opportunities in fostering CE. In order to make progress efficiently in the adoption of a CE in AIODIS, governments and concerned stakeholders need to strongly consider the strengths, weaknesses, opportunities and threats in the region (Table 12) and in each country (see Annex 3).

Table 12: SWOT analysis

Strength	Weakness
<ul style="list-style-type: none"> - A vast number of initiatives already ongoing - Interests of governments in sustainability through their blue economy agendas - An array of policies and regulations that can be mobilised and harmonised towards a CE - Each country has advanced in an area or more of the CE that can be a lesson learnt - Existence of regional collaboration already on different initiatives 	<ul style="list-style-type: none"> - No overarching framework for the CE, except for Reunion Island - Limited technical capacities and means of implementation - Limited data regarding informal activities relating to the ReX framework - CE as a novel concept for governments, businesses and the public - Current dependency on external funding to implement innovations
Opportunities	Threat
<ul style="list-style-type: none"> - Promotion and support of existing initiatives and policy - Increase of interests of funders in implementing CEs - Global and regional platforms that promotes CE initiatives - Learning from more advanced islands such as Reunion Island 	<ul style="list-style-type: none"> - Climate change and sea-level rise - Political weight of extractive industries - Potential competing agenda between CE and blue growth - Differentiated socio-economic context amongst AIODIS can lead to different national priorities

To conclude, the AIODIS have initiated various strategies that comply with the CE principles and framework. However, they are implemented under different policies and regulations. This prevents a holistic approach to achieve a CE. The AIODIS need overarching frameworks that link natural resource extraction and material consumption as described by a CE. This will allow a more coordinated approach and will promote regenerative activities that might be marginal at the moment such as marine protected areas or waste recycling.

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Annex 1: Country indicators

	Population (in 2019)	Landmass (km ²)	EEZ (km ²)	2019 GDP (in US\$ Bil)	Exports (in US\$ Mil)	No. Of products	Imports (in US\$ Mil)	No. Of products	Export and Import			Sectors contribution (% of GDP)	
									Agriculture	Industry	Manufacturing	Manufacturing	Services
Cabo Verde	549 935	4 030	800 561	1.982	75	58	815	3 233	5	20	7	61.4	
Comoros	850 886	1 860	163 752	1.186	10	92	115	1 882	33	9	N/A	53.5	
Guinea Bissau	1 920 922	36 130	123 725	1.34	23	32	112	1 315	53	13	10	37.2	
Madagascar	26 996 307	587 290	1 225 259	18.084	3 133	1 761	4 082	3 773	23	17	N/A	52.4	
Maldives	530 953	300	923 322	5.729	182	68	2 961	2 669	6	13	2	67.9	
Mauritius	1 265 711	2 040	2 203 542	14.18	1 988	2 228	5 669	3 915	3	17	11	67.3	
Reunion Island	858 00	2 512	315 000	18.53	294	N/A	4 700	N/A	1.5	6.6	N/A	87	
Sao Tome and Principe	215 056	960	131 397	0.429	12	372	148	2 559	11	15	7	71.8	
Seychelles	96 762	460	1 336 559	1.699	847	325	1 137	3 410	2	11	6	72.1	

Source: Compilation from World bank databases and INSEE reports for Reunion Island

Annex 2: CE profile of each country based on CE intervention samples

	Sample of CE interventions	CVI	COI	GBS	MDG	MDV	MAU	REU	STP	SEY
Regeneration	% of EEZ protected	<1%	<1%	8,6%	3,6%	<1%	29%	<1%	<1%	26%
Renewable energy	% renewable energy consumption (2015)	26,58%	45,33%	86,85%	70,17%	1,01%	11,54%	13,2%	41,06%	1,35%
Feedstock extraction	Biogas production	No	Yes	No	Yes	No	Yes	Yes	No	N/A
Reduce	Policy banning single use plastic	Yes	No	No	Yes	No	Yes	Yes	No	Yes
Reuse	Composting initiatives	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Recycle	Material recycled in country	Glass Plastic	Biomass	Plastic	Biomass Plastic	Plastic	Glass Plastic E-Waste Biomass	Metal Glass Paper Cardboard Biomass E-Waste	Biomass	Can Glass Paper PET
Recover	e-waste recovery	N/A	N/A	N/A	N/A	N/A	Yes	Yes	N/A	N/A

N/A: No data was available

Source: Author's analysis based on online research, literature review and the World Bank database

Annex 3: Individual countries’ SWOT analysis

Country	Strength	Weakness	Opportunities	Threat
Cabo Verde	<ul style="list-style-type: none"> - Low Level of consumption, waste generation per capita and resource extraction - Waste management policy - Start of recycling activities 	<ul style="list-style-type: none"> - Low marine protection to allow regeneration - Limited materials recycled - No recorded activities in recover/reuse/feedstock - Low level of renewable energy consumption 	<ul style="list-style-type: none"> - Supporting and replicating recycling initiatives - Untapped and unrecorded informal sector in waste management 	<ul style="list-style-type: none"> - High level of resources extraction - Strong influence of extractive industries
Comoros	<ul style="list-style-type: none"> - Low Level of consumption, waste generation per capita and resource extraction - Waste management policy 	<ul style="list-style-type: none"> - Low marine protection to allow regeneration - Low implementation of existing policies 	<ul style="list-style-type: none"> - Develop the recycling sector - Untapped and unrecorded informal sector in waste management 	<ul style="list-style-type: none"> - High level of resources extraction - Strong influence of extractive industries
Guinea Bissau	<ul style="list-style-type: none"> - Low Level of consumption, waste generation per capita and resource extraction - Waste management policy 	<ul style="list-style-type: none"> - Low marine protection to allow regeneration - Low implementation of existing policies - No recorded activities in recover/reduce/feedstock 	<ul style="list-style-type: none"> - Develop the recycling sector - Untapped and unrecorded informal sector in waste management 	<ul style="list-style-type: none"> - High level of resources extraction - Strong influence of extractive industries
Madagascar	<ul style="list-style-type: none"> - Low Level of consumption, and waste generation per capita - Waste management policy 	<ul style="list-style-type: none"> - Low marine protection to allow regeneration - High level of resources extraction - Low implementation of existing policies 	<ul style="list-style-type: none"> - Untapped and unrecorded informal sector in waste management - An array of activities in feedstock/composting to support 	<ul style="list-style-type: none"> - High level of resources extraction - Strong influence of extractive industries
Maldives	<ul style="list-style-type: none"> - Low level of resource extraction - Waste management policy 	<ul style="list-style-type: none"> - Low marine protection to allow regeneration - High level of resources extraction - Low level of renewable energy consumption 	<ul style="list-style-type: none"> - Interests of the tourism industry to fight waste generation 	<ul style="list-style-type: none"> - High level of material consumption and waste generation

Annex 3: Individual countries' SWOT analysis (Cont'd)

Country	Strength	Weakness	Opportunities	Threat
Mauritius	<ul style="list-style-type: none"> - Recycling policies - Broad recycling activities - Waste management policy 	<ul style="list-style-type: none"> - Low level of renewable energy consumption 	<ul style="list-style-type: none"> - Favourable business environment to support more recycling in country - A vast array of existing activities to support 	<ul style="list-style-type: none"> - High level of material consumption, waste generation and resources extraction
Reunion Island	<ul style="list-style-type: none"> - Recycling policies - Broad recycling activities - Waste management policy - CE framework 	<ul style="list-style-type: none"> - Low marine protection to allow regeneration - Low level of renewable energy consumption 	<ul style="list-style-type: none"> - Strong state support and funding - A vast array of existing activities to support 	<ul style="list-style-type: none"> - High level of material consumption, waste generation and resources extraction
Sao Tome and Principe	<ul style="list-style-type: none"> - Low Level of consumption, waste generation per capita and resource extraction - Waste management policy 	<ul style="list-style-type: none"> - Low marine protection to allow regeneration - Low level of renewable energy consumption - Low implementation of existing policies - No recorded activities in recover/reduce/feedstock 	<ul style="list-style-type: none"> - Untapped and unrecorded informal sector in waste management 	<ul style="list-style-type: none"> - High level of resources extraction - Strong influence of extractive industries
Seychelles	<ul style="list-style-type: none"> - Low level of resource extraction - Waste management policy - Broad recycling activities 	<ul style="list-style-type: none"> - Low level of renewable energy consumption - No recorded activities in recover/feedstock 	<ul style="list-style-type: none"> - Interests of the tourism industry to fight waste generation - Available funding under blue bonds 	<ul style="list-style-type: none"> - High level of material consumption and waste generation

Annex 4: Legal and policy framework available in AIODIS

Cabo Verde

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Act No. 86/IV/93 defining environmental policy (1993) - Decrees on the management of protected areas (2003, 2006) - Decree-Law 53/2005 defining the Policy on Sustainable Exploitation of Fisheries Resources.
Stock Management	<ul style="list-style-type: none"> - Decree-Law No. 56/2015 establishing the general regime for prevention, production and management of waste. (2015) - Law No. 99/VIII Prohibiting the production, importation, distribution into the market and use of conventional plastic bags for packaging (2015) - Decree-Law No. 26/2020 approving the Legal Regime for Urban Waste Management Services (2020)

Comoros

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Framework Law related to the Environment (1994 and 1995) - Law n° 82-015 relating to the activity of foreign fishing vessels in Comorian maritime zones. (1982) - National Strategy and Action Plan for the Conservation of Biological Diversity (2000)
Stock Management	<ul style="list-style-type: none"> - National policy raising awareness on non-compostable waste - Comoros Emergent Plan 2030 promoting the circular, blue and green economy (2019) - Framework Law related to the Environment (1994 and 1995) – including waste management measures

Guinea Bissau

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Law No. 1/2011 approving the Basic Legislation on Environment (2011) - Decree-Law No. 10/2011 approving the Basic Fishing Legislation (2011) - Decree-Law No. 5/2011 approving the New Forestry Law (2011) - Decree-Law No. 5-A/1992 establishing the Water Code (1992) - National Framework on Biotechnology and Biosafety of Guinea-Bissau (2008)
Stock Management	<ul style="list-style-type: none"> - Environmental Law N.1/2011 defining waste and good practices of waste management - Resolution N.22 of CMB/2010 for the management of Bissau municipal solid waste

Madagascar

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Law 2015-053 on Fisheries and aquaculture Code (2015) - Law 2015-015 on Protected areas code (2015) - Law 97-017 revising forestry regulation (1997) - Law 98-029 on Water code (1999) - National Strategy on the Restoration of Forest Landscapes and Green Infrastructure (2017) - Environmental Programme for Sustainable Development (2016)
Stock Management	<ul style="list-style-type: none"> - Law on the management of industrial pollution (1999) - Law setting fees for urban sanitation (2013) - Decree prohibiting the production, importation, stockpiling and use of plastic bags and sacks on the national territory (2017)

Maldives

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Law No. 4/93 on Environmental Protection and Preservation Act of Maldives (1993) - Law No. 4/93 on Fisheries Act of the Maldives - Protected Areas Regulation (No. 2018/R-78) (2018) - Regulation on the Protection and Conservation of Environment in the Tourism Industry. (2006)
Stock Management	<ul style="list-style-type: none"> - A national waste management policy (2015) with objectives including the introduction and application of the 3R concept - National Water and Sewerage Policy (2017) - Regional Waste Management Strategy and Action Plan - Malé 3R Declaration - Single Use Plastic Phase-out policy for 2020-2023

Mauritius

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Environment Protection Act 2002 (No. 19 of 2002). - Fisheries and Marine Resources Act 2007 (Act No. 27 of 2007) - Forests and Reserves Act 1983 (Act No. 41) National Native Terrestrial Biodiversity and National Parks Act 2015 (No. 14 of 2015) - Biodiversity Strategy and Action Plan 2017 – 2025 (2017) - National Water Policy of 2014
Stock Management	<ul style="list-style-type: none"> - Environment Protection Regulation on sound management of PET bottles (2001) - National Environment Policy – including waste management (2007) - Waste Water Management Authority Act. (2004) - Registration of Recycler and Exporter Regulations (2013) - Environment Protection Regulation on the Banning of Plastic Bags (2015)

Reunion Island

Reunion Island has been strongly involved in developing policies towards the circular economy, notably through impulsion of the French national strategy. Notably the island has a Regional Action Plan for the Circular Economy. The plan has five objectives including coordinating the transition towards a CE, activating the levers of the transition, improving production and consumption, and developing loops.

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Environmental code (2000 and 2018) - Law n° 2006-436 relating to national parks, marine natural parks and regional natural parks (2006) - Rural and Maritime Fisheries Code (2018) - Forestry code (2018) - Law of 20 June 2016 for the blue economy (2016) - Law no. 2019-1147 relating to energy and the climate (2019) - National Strategy for Ecological Transition to Sustainable Development 2015-2020 (2015)
Stock Management	<ul style="list-style-type: none"> - Law on Energy Transition for Green Growth (LTECV) requiring regions to set up Regional Plan for Waste Prevention and Management (2015) - Law on the fight against waste and the circular economy (2020) - Ban on plastic bag policy (2016)

Sao Tomè & Príncipe

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Environmental Law No. 10/99 (1999) - Fisheries Law No. 9/2001 (2001) - Forestry Law No. 5/2001 (2001) - Water Resources Framework Law No. 07/2018 (2018) - Law No. 11/99 on Flora and Fauna conservation and protected areas (1999) - National Biodiversity Strategy and Action Plan 2015-2020 (2015)
Stock Management	<ul style="list-style-type: none"> - Decree No. 36/99 regulating solid waste disposal (1999) - Decree-Law No. 64/2013 creating the Environmental Impact Tax (TIA) (2003 then 2013)

Seychelles

Circular Economy framing	Relevant law and policy
Renewable flow management	<ul style="list-style-type: none"> - Environment Protection Act 2016 (No. 18 of 2016) (2016) - Forest Reserve Act (1976) - Fisheries Act (No. 20 of 2014). (2014) - National Parks and Nature Conservancy Act (1986) - Petroleum Mining (Pollution Control) Act (1976 then 2012) - Wild Animals (Whales Shark) Protection Regulation (2003) - Fisheries Sector Policy and Strategy 2019 (2019) - Seychelles Coastal Management Plan 2019 - 2024 (2019) - Seychelles' National Biodiversity Strategy and Action Plan 2015-2020. (2015) - Seychelles' Protected Areas Policy (2013) - 2012–2020 Seychelles Sustainable Development Strategy
Stock Management	<ul style="list-style-type: none"> - Environmental Protection Act 2016 prohibiting the import, manufacture, distribute, or sell of Plastic bags, plastic utensils, and polystyrene boxes - 2014–2018 Solid Waste Management Policy (SWM Policy)