

The economic impact of marine plastic debris in South Africa: A preliminary estimate

Summary presentation
March 2023



science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA



CSIR

Touching lives through innovation



RHODES UNIVERSITY

Where leaders learn

Background

- Leakage of plastic waste into the environment an issue of increasing global concern
- SA: 15 000 – 40 000 tonnes of plastic enters marine environment from land-based sources each year (Verster and Bouwman, 2020).



Image credit: Steve Cohen

Ecosystem services

PROVISIONING SERVICES

Products obtained from ecosystems

- SeaFood (wild, farmed)
- Fish Feed
- Fertiliser
- Medicines

REGULATING SERVICES

Benefits obtained from the regulation of ecosystem processes

- Climate regulation
- Waste removal

CULTURAL SERVICES

Nonmaterial benefits obtained from ecosystems

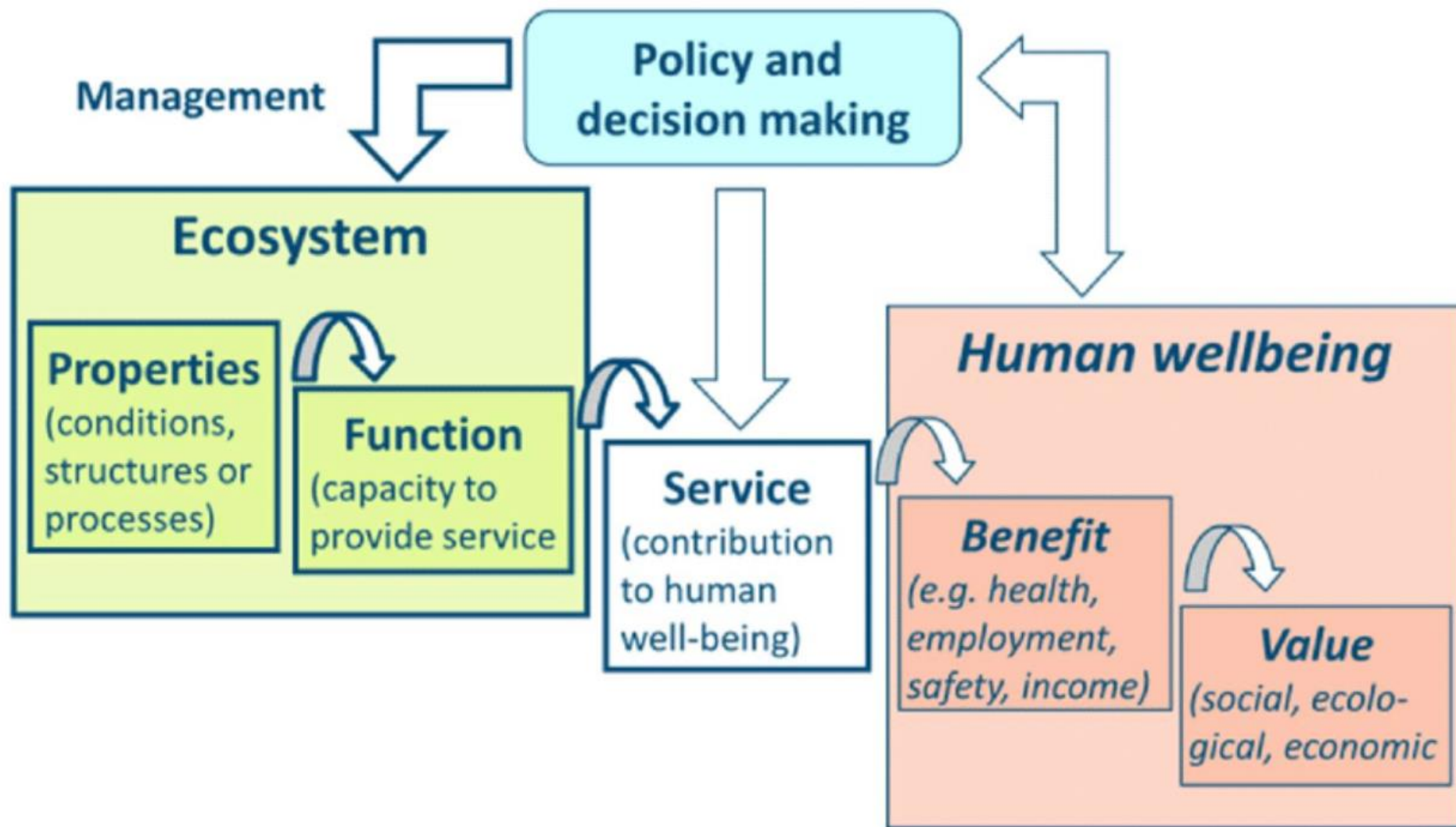
- Tourism
- Aesthetic benefits

SUPPORTING/INTERMEDIATE SERVICES

Services necessary for the production of other services

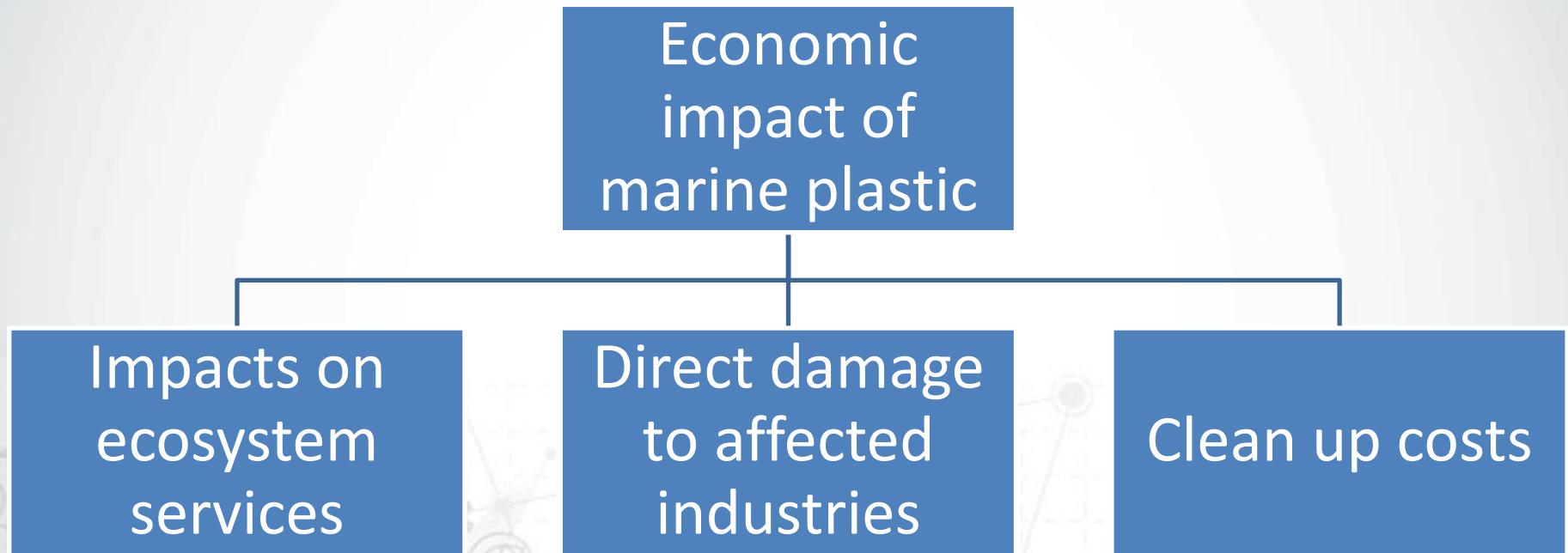
- Species habitat
- Nutrient cycling

Economic value of ecosystem services



Category	Sub-category	Impacts	South African research
Impacts on ecosystem services	Provisioning services	Impacts on fisheries and aquaculture	–
	Cultural services	Impacts on recreation and aesthetics	Some research on the impacts on tourism
		Impacts on heritage	–
	Supporting services	Impacts on habitat provision	–
		Impacts on biodiversity	–
		Invasive species transport	Some studies on plastic as a vector for transport of species, but not for invasive alien species specifically
	Regulating services	Nutrient cycles	–
Economic impacts	Direct costs	Impacts on the tourism industry	Some research conducted on the impacts on tourism and on beach clean-up costs, although fairly dated and largely confined to Cape Town
		Impacts on the transport/shipping industry	Information on harbour clean-up costs in Durban obtained through personal communication; no published information could be found
		Impacts on fisheries industry	–
	Indirect and non-market costs	Health costs	–
		Non-market costs	–

Framework: Components of the total economic impact of marine plastic



Approach for quantifying each component: Benefits transfer method

Identify best available estimates of impacts in relevant units (e.g. % reduction in ES delivery; % reduction in revenues, clean up costs per capita)

Workshop the range of unit impact values to identify most relevant estimate for SA

Calculate impact per tonne & per annum, based on refined unit impact values & relevant local variables

Ground-truth the resulting estimates

Report on the resulting impact per tonne of plastic, and per annum

Framework: Components of the total economic impact of marine plastic

Economic impact
of marine plastic

```
graph TD; A[Economic impact of marine plastic] --> B[Impacts on marine ecosystem services]; A --> C[Direct damage to affected industries]; A --> D[Clean up costs];
```

Impacts on
marine ecosystem
services

Direct damage to
affected industries

Clean up costs

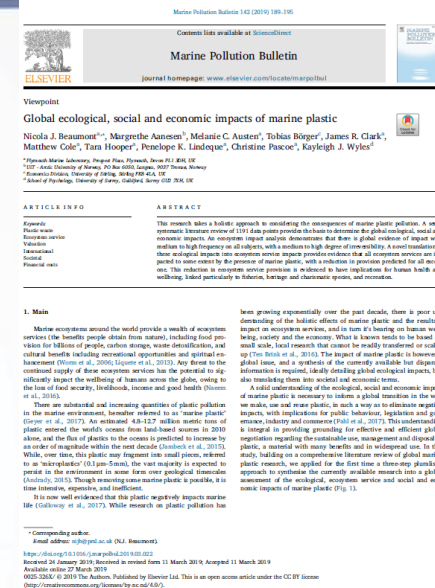
A. Estimating impacts on marine ecosystem services – the Beaumont et al. 2019 / WWF 2021 approach

- **Beaumont et al. 2019**

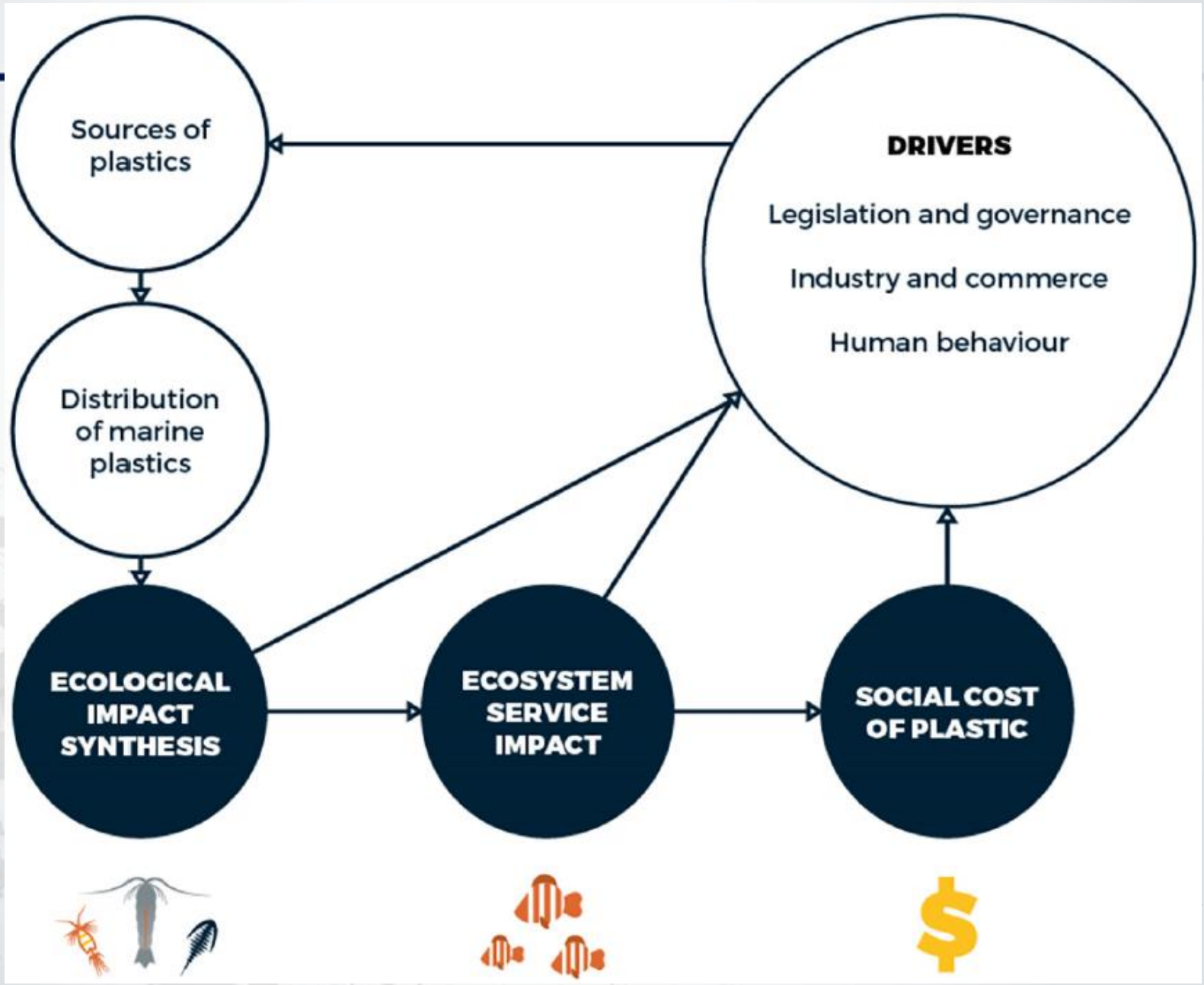
- Estimate a **1–5% reduction in marine ecosystem service delivery (per year) due to marine plastic**
- Based on current value of global marine ecosystem services, and the stock of plastic in the ocean, they calculate a **cost per tonne of plastic in the ocean**

- **WWF 2021**

- Apply the low end of the Beaumont et al. range (**1%**)
- Extend on Beaumont et al. by looking at costs imposed by each tonne of plastic in the ocean **over the lifetime of the plastic**



Beaumont et al 2019 approach



1. Assessment of ecological impacts



CONFIDENCE:



BACTERIA 

ALGAE 

ZOOPLANKTON 

INVERTEBRATES 

FISH - Entanglement 

FISH - Ingestion 

TURTLES - Entanglement 

TURTLES - Ingestion 

BIRDS - Entanglement 

BIRDS - Ingestion 

MAMMALS - Entanglement 

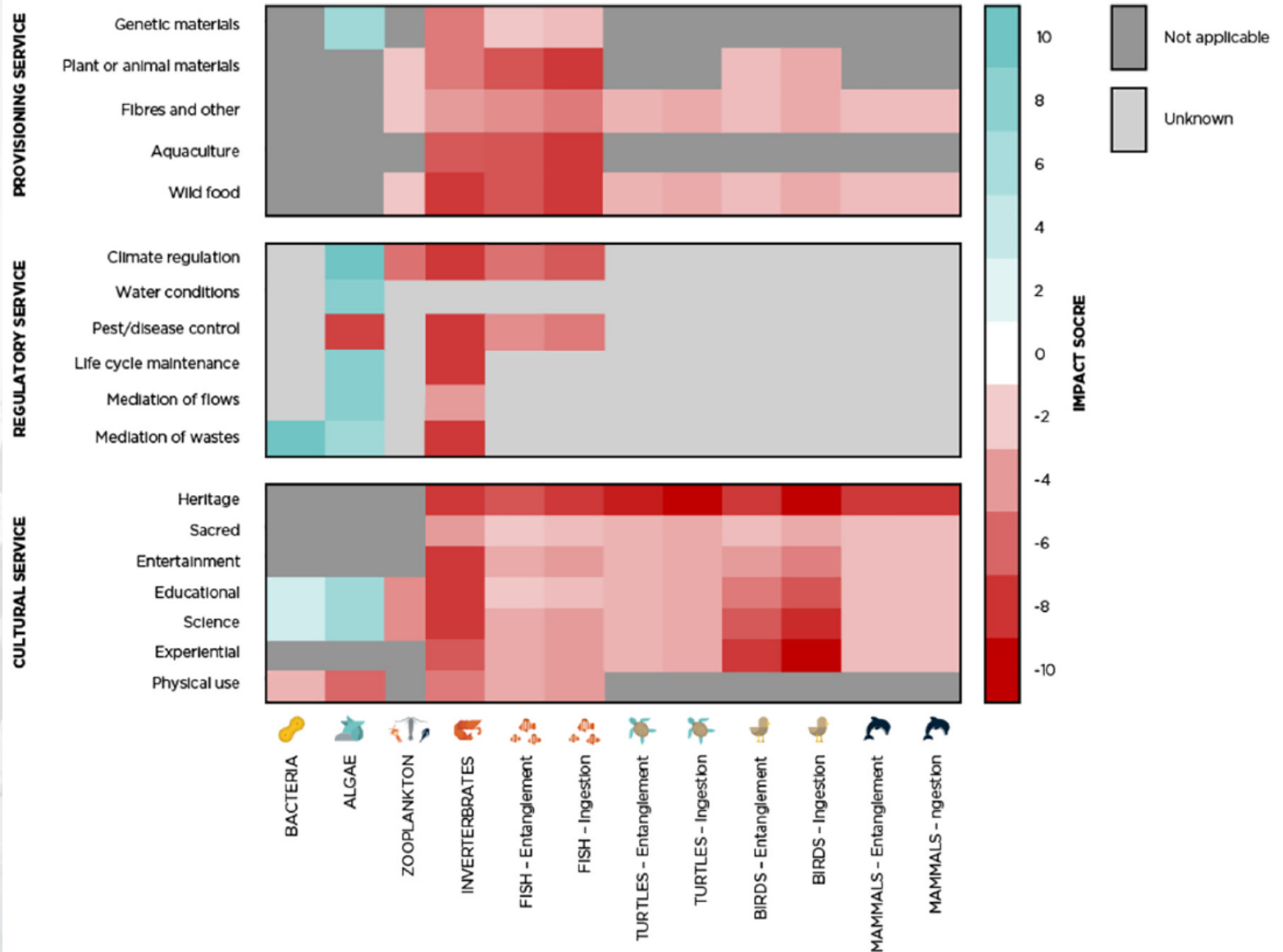
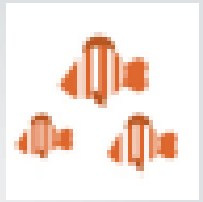
MAMMALS - Ingestion 



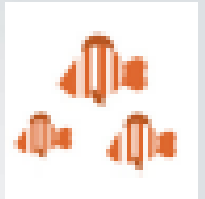
NEGATIVE IMPACT

POSITIVE IMPACT

2. Translation to ecosystem service impacts



2. Translation to ES impacts (continued)



- “the evidence... suggests substantial negative impacts on almost all ecosystem services at a global scale...”
- “In light of this evidence, it is considered reasonable* to postulate a **1–5% reduction in marine ecosystem service delivery as a result of the stock of marine plastic in the oceans in 2011**”

1–5%
reduction in
marine
ecosystem
service
delivery due
to plastic



CSIR

Touching lives through innovation

3. Translating to economic impacts



- “On a global scale, it has been estimated that for 2011, **marine ecosystem services provided benefits to society approximating \$49.7 trillion per year** (Constanza et al., 2014)” (in 2007 USD).
- WWF (2021) have since adjusted this to **\$61.3 trillion per year** in 2019 USD.



Contents lists available at [ScienceDirect](#)

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha



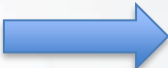
Changes in the global value of ecosystem services

Robert Costanza^{a,*}, Rudolf de Groot^b, Paul Sutton^{c,d}, Sander van der Ploeg^b,
Sharolyn J. Anderson^d, Ida Kubiszewski^a, Stephen Farber^e, R. Kerry Turner^f



3. Translating to economic impacts - continued



- 1–5% decline in marine ecosystem service delivery  **annual loss of \$613 billion –\$3.1 trillion** in the value of benefits derived from marine ecosystem services:
 - 1% of \$61.3 trillion = \$613 billion
 - 5% of \$61.3 trillion = \$3.1 trillion
- With 75 - 150 million tonnes of plastic in the ocean; **each tonne of has an annual cost in terms of reduced marine natural capital of between \$4087 and \$40 867:**
 - \$613 billion loss per year / 150 MT plastic = \$4087 per ton
 - \$3.1 trillion loss per year / 75 MT plastic = \$40 867 per ton

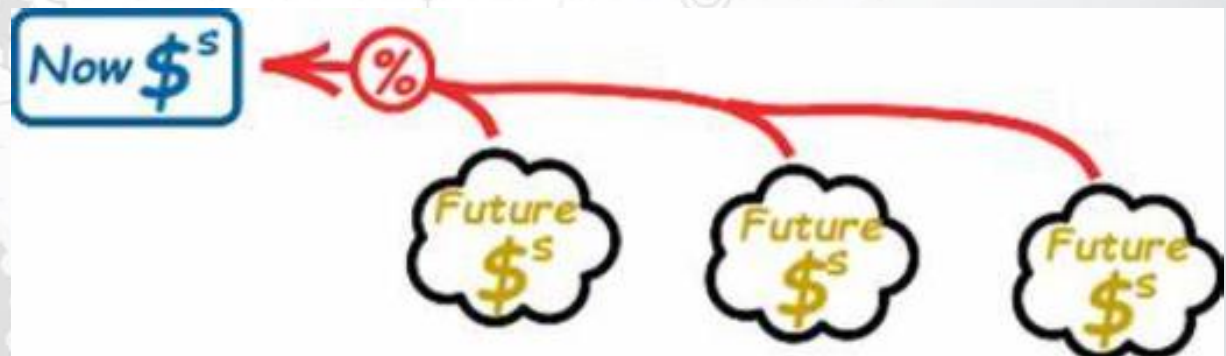
WWF 2021

- Beaumont et al. estimates are based on the ANNUAL reduction in marine ES due to each tonne of plastic in the ocean.
- But each tonne of plastic reaching the ocean will remain there for hundreds to thousands of years – so plastic will accumulate and will continue to impact ecosystems
- WWF extend on Beaumont et al's analysis by calculating the **lifetime cost of each tonne of plastic in the ocean**



WWF 2021 continued

- This is done by applying a **Net Present Value (NPV) formula** – i.e. aggregating the annual costs into the future; and applying a discount rate (2%)
- They apply the **low end** of Beaumont et al's range for reduction in marine ES delivery due to plastic (1%)
- This results in a more conservative range of \$4087 - \$8173 for the annual cost per tonne of plastic
- Applying the NPV formula results in a lifetime cost of **\$204 270 to \$408 541 per tonne of plastic**



How much plastic enters SA's marine environment each year?

Source	Jambeck et al. (2015)	Verster & Bouwman (2020)	IUCN-EA-QUANTIS (2020; 2021)	Stafford et al. (2022)
Assumption regarding the % of mismanaged plastic waste	56%	29%	40%	29%
Assumptions regarding the proportion of mismanaged waste entering the ocean	15-40% of mismanaged waste from coastal populations (within 50km of coast) will enter the ocean	15-40% of mismanaged waste from coastal populations (within 50km of coast) will enter the ocean	Mismanaged waste from inland populations is also included. Estimates 79 000 tonnes of plastic leakage to waterways and oceans annually (107 000 in the updated report); but doesn't apportion freshwater vs. marine	Estimates 68 000 tonnes of aquatic plastic pollution (freshwater and marine) per annum; based on mismanaged plastic waste from all populations within 1km of a waterway; but doesn't apportion freshwater vs. marine
Plastic entering marine environment from land-based sources (tonnes per annum)	90 000 – 250 000	15 000 – 40 000		

Seen by participants as most relevant estimate; but episodic flooding and marine sources still to be added. Propose adding 10 000 tpa, as literature suggests 80:20 ratio of land-based to marine. Therefore **total plastic entering marine environment estimated at 50 000 tonnes per year**

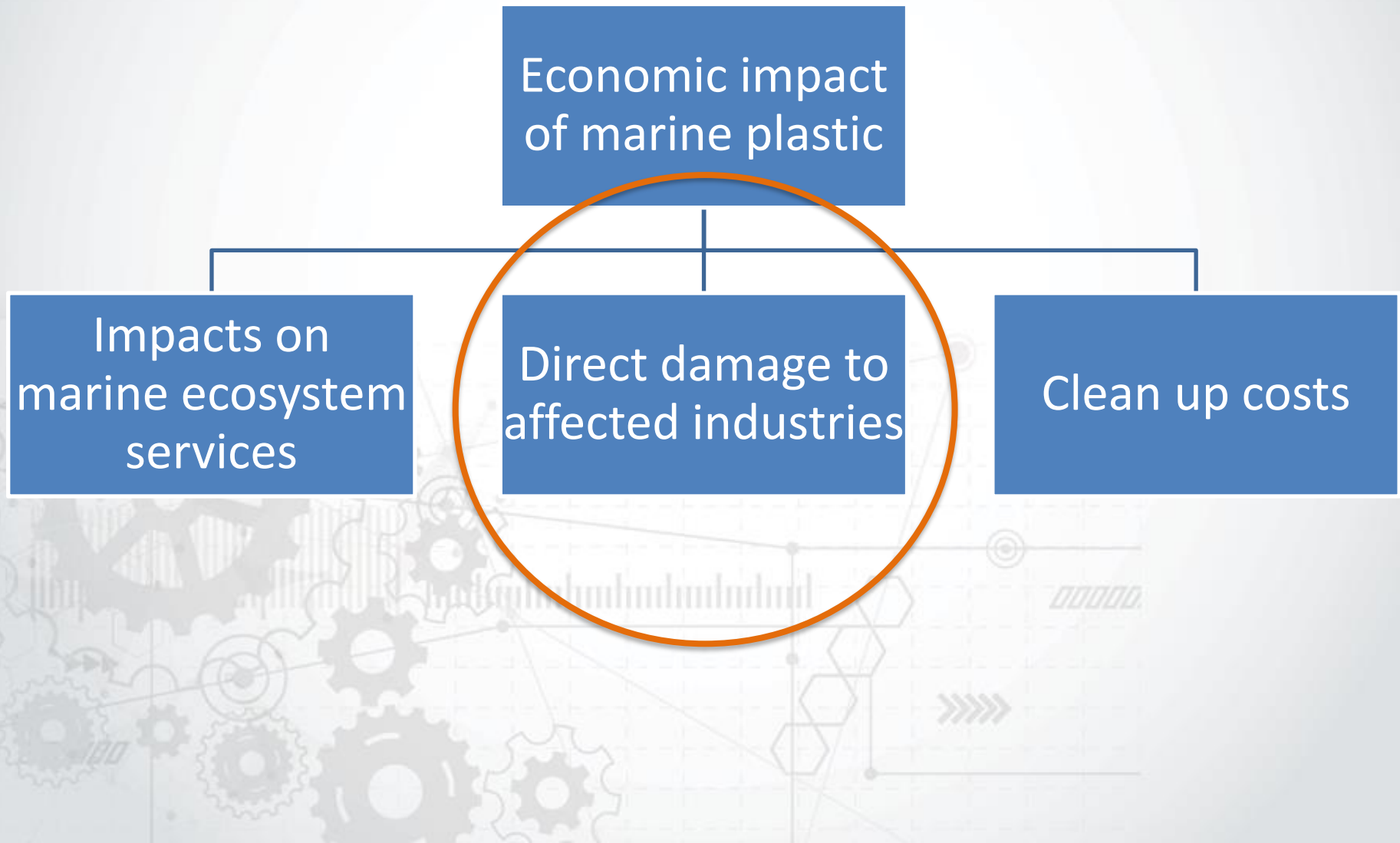
Results: Impacts of marine plastic on ecosystem services (per year)

	Low estimate	Mid-range estimate	High estimate
% reduction in annual marine ecosystem service delivery	1%	3%	5%
Cost per tonne of plastic, per year (Rands)	68 142	272 569	681 423
Annual cost for plastic entering marine environment each year* (R millions)	3 407	13 628	34 071

Results: Impacts of marine plastic on ecosystem services (lifetime costs)

	Low estimate	Mid-range estimate	High estimate
% reduction in marine ecosystem service delivery	1%	3%	5%
Lifetime cost per tonne of plastic (R millions)	3.4	13.5	33.8
Lifetime cost imposed by plastic entering marine environment each year (R billions)	169	677	1 691

Framework: Components of the total economic impact of marine plastic



B. Direct damage to affected industries

Industry	% reduction in revenues due to marine plastic	Source
Fisheries and aquaculture	1% - 5%	Takehama (1990), Ten Brink et al. (2009), Deloitte (2019), McIlgorm et al. (2020).
Shipping (marine transport and related services)	1%	McIlgorm et al. (2020)
Marine & coastal tourism	1.5% - 5%	Ten Brink et al. (2009), Mouat (2010), Trucost (2016), Deloitte (2019), McIlgorm et al. (2020).

Participants suggested adopting conservative estimates.

Initial estimates based on high-end %'s were far too high relative to other sources (e.g. Benn et al. 2022)

B. Direct damage to affected industries – current annual revenues for each industry in SA

Industry	Annual revenues (SA) (inflated to 2022 R billions based on CPI)	Source
Fisheries	17.82	Statistics South Africa (2020)
Shipping (transport & related services)	4.62	Statistics South Africa (2019)
Marine & coastal tourism	16.73	Department of Tourism (2017)

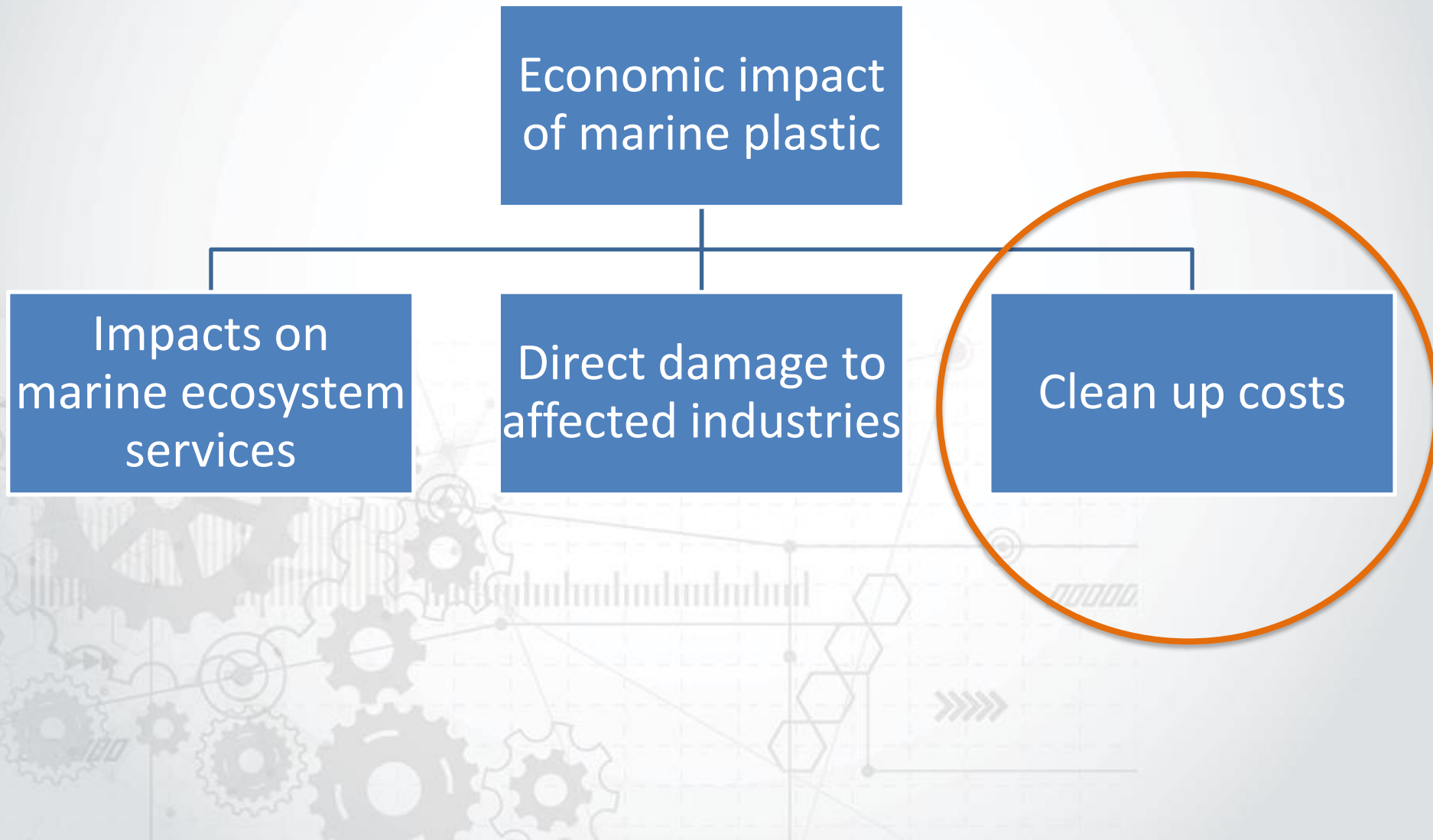
Results: Direct damage to affected industries

	Low estimate (total)	Mid-range estimate (total)	High estimate (per sector)		
			Industry	Reduction in value of output	High estimate
Cost per year (R Millions)	R63.6 million; based on Benn et al. (2022) estimate of \$ 4 million in 2018 USD	R269.4 million, calculated as an average between the low-end and high-end estimates	Fisheries*	% loss / year	1%
				Cost per year (R Millions)	178.2
			Shipping	% loss / year	1%
				Cost per year (R Millions)	46.2
			Marine & coastal tourism	% loss / year	1.5%
				Cost per year (R Millions)	251.0
Total	Total	475.3			
Cost per tonne of plastic** (Rands)	1 272	5 390			9 507

* Marine fisheries only, excluding mariculture

** Cost per tonne of plastic is estimated by dividing the total cost per year by the tonnages of plastic entering the marine environment each year (estimated at 50 000 tonnes per year)

Framework: Components of the total economic impact of marine plastic



C. Clean up costs



C. Clean up costs

Region	Cleanup cost
Asia	2.51
Europe	0.29
North America	0.24
Latin America	0.54
Oceania	0.06
Middle East	0.01
Africa	0.06
Global avg.	1.61

Average clean-up costs per region, in USD per capita (Deloitte, 2019)

Resulting estimate for SA (R61 per annum) viewed by stakeholders as much too low.

Results: Clean-up costs

	Low estimate	Mid-range estimate	High estimate
Cost per capita (2019 USD)	0.06	0.20	0.36
Cost per capita (2022 Rands)	1.00	3.33	5.95
Cost per year* (R millions)	61	203	363
Cost per tonne of plastic entering the marine environment annually** (Rands)	1 221	4 069	7 256

* Based on an estimated population of 61 million in 2023.

** Note this is cost per tonne of plastic entering marine environment; not cost per tonne cleared. Estimated by dividing the total cost per year by the tonnages of plastic entering the marine environment each year (estimated at 50 000 tonnes per year)

Summary: Total (annual) economic impact of marine plastic

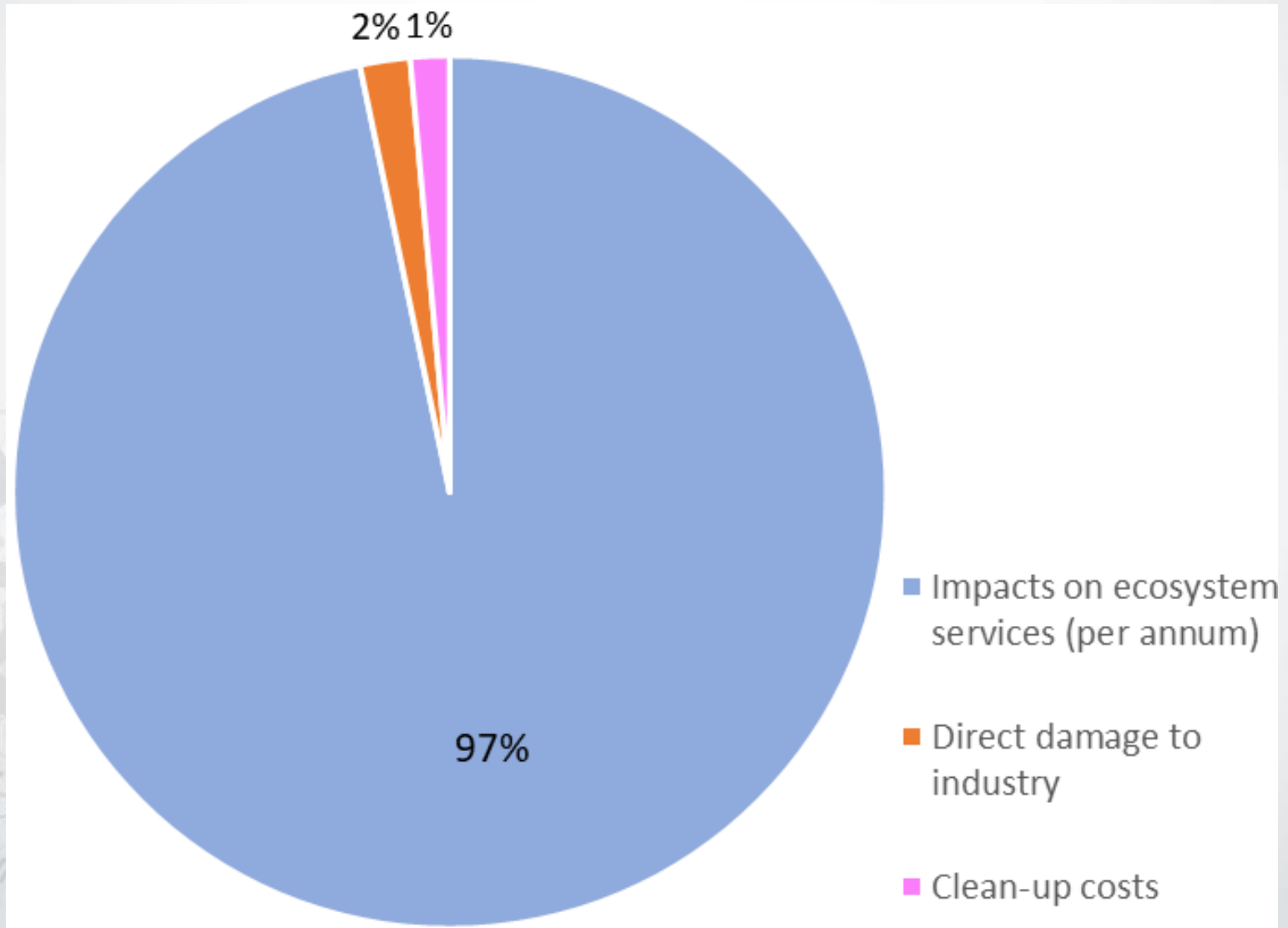
	Costs arising from plastic entering marine environment in one year, per annum (R millions)			Costs per tonne of plastic, per annum (Rands per tonne)		
	Low	Mid	High	Low	Mid	High
Impacts on ecosystem services (per yr)	3 407	13 628	34 071	68 142	272 569	681 423
Direct damage to industry	64	269	475	1 272	5 390	9 507
Clean-up costs	61	203	363	1 221	4 069	7 256
Total	3 532	14 101	34 909	70 635	282 028	698 186

Comparing the total economic impact of marine plastic vs. national & sectoral GDP

	Total revenues or GDP as at 2022 (R billions)	Total economic cost as a % of revenues / GDP		
		Low estimate (R3.5 bn)	Mid-range estimate (14.1 bn)	High estimate (R34.9 bn)
SA annual GDP ¹	6 640	0.05%	0.21%	0.53%
Plastics ²	76	4.65%	18.57%	45.97%
Fisheries ³	18	19.82%	79.14%	195.92%
Shipping ⁴	5	76.52%	305.51%	756.31%
Marine & coastal tourism ⁵	17	21.11%	84.27%	208.61%

1. Nominal Gross Domestic Product at market prices in 2022 (Statistics South Africa, 2022).
2. Direct contribution of the plastics industry to GDP in 2020 (Plastics SA, 2022); inflated to 2022 values based on CPI
3. Total income for ocean fisheries and related services in 2020 (StatsSA, 2020); inflated to 2022 values based on CPI. Excludes mariculture
4. Total income for "water transport" & "supporting services to water transport" in 2019 (StatsSA, 2019); inflated to 2022 values based on CPI
5. Direct contribution to GDP of the coastal & marine tourism sub-sector in 2015 (Dept of Tourism, 2017); inflated to 2022 values based on CPI


Percentage contribution of each component to the total impact



Lifetime costs

	Low estimate	Mid-range estimate	High estimate
% reduction in marine ecosystem service delivery	1%	3%	5%
Lifetime cost per tonne of plastic (R millions)	3.4	13.5	33.8
Lifetime cost imposed by plastic entering marine environment each year (R billions)	169	677	1 691
% of annual GDP	2.5%	10.2%	25.5%

Conclusions and recommendations

- This study provides a preliminary, order of magnitude estimate (range) of the economic impact of marine plastic debris in SA
 - Lack of relevant SA data, and numerous uncertainties
 - Estimates from this study should therefore be used with caution
- 
- A faint background graphic featuring several interlocking gears of various sizes on the left side. On the right side, there are technical-style lines, including a horizontal line with a circular end, a vertical line with a dot, and a series of four right-pointing chevrons. The entire graphic is overlaid on a light gray grid.

Conclusions continued

- Exclusions:
 1. Focus only on impacts of plastic at end of life; other impacts across the lifecycle are excluded (WWF, 2021)
 2. Focus only on marine plastic. Majority of plastic waste in SA remains in the terrestrial or freshwater environment (Verster & Bouwman, 2020); or is subject to open burning (Stafford et al., 2022)
 3. Only quantifies impacts in terms of reduction in marine ecosystem service delivery, direct damage to industry, and clean-up costs; impacts on human health and on non-use values are excluded
 4. Estimates are based on current rates of plastic waste generation (estimated at 50 000 tonnes of plastic reaching the marine environment per year). In the absence of significant intervention strategies, plastic production and leakage are projected to increase in future (Stafford et al., 2022).

Recommendations

- No single intervention strategy implemented in isolation will effectively reduce plastic pollution (Stafford et al., 2022).
- System-wide change is required, incorporating a broad range of upstream and downstream interventions; in line with the principles of a circular plastics economy (World Bank and CSIR, 2022).
- Benefits of plastic should also be taken into account. Transitioning away from plastics toward alternative materials is not necessarily the solution
- Need for further research to assess full set of environmental, social and economic costs and benefits of plastics, of alternatives to plastic, and of various types of intervention strategies; to inform the most suitable strategies for reducing leakage

THANK YOU!

Anton Nahman

Principal Environmental Economist

Research Group Leader: Sustainability, Economics and Waste, CSIR

anahman@csir.co.za

<https://www.csir.co.za/sustainability-economics-and-waste>