Why and how to measure the contribution of South Africa's ocean economy

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Abstract

This paper articulates why it is important to measure the contribution to the national economy of South Africa's ocean economy and how such contribution may be measured. It points out much is unknown about the ocean's natural resources. It describes the growing interest of the South African government in the economic development of South Africa's ocean natural resources. It identifies three ways of measuring the national contribution of the ocean economy at a given point in time. The usefulness of each way is considered. All three ways are found to be potentially useful to guiding the efficient and equitable development of the South African ocean economy.

1. Introduction

The size and potential for growing the ocean economy has attracted increasing global interest during the 21st Century because the ocean space is thought to house a vast reservoir of natural resources and ecosystem services. Much remains unknown about the natural resources of the ocean space, especially those on the seafloor.

> *Oceans cover 71% or 361 million square kilometres of the Earth's surface. The average depth of the 20% that has been mapped is about 3.8 kilometres. Maximum depths can exceed 10 kilometres (6.2 miles) in ocean trenches. We know little about what exists on the seafloor, since less that 0.001 percent has been biologically or geologically sampled. The oceans contain 97% of our planet's available water.* (United Nations, 2019: 25)

The natural resources in the ocean space are comprised of abiotic (non-living) and biotic (living) elements. The former consists of minerals and nutrients, water, sunlight, and gasses. When these elements interact, they give rise to waves, currents, temperature and pressure, and a habitat for the biotic elements. The latter consists of ocean plants and animals. The natural

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resource yields of the ocean and terrestrial spaces are products of multiple and complex Earth and Solar systems.

South African's share the global interest in knowing more about the ocean's natural resources and ecosystem services, particularly those that are and can be employed in their ocean economy. The ocean economy is that part of the national economy built on (downstream of) the exploitation or employment of the ocean's natural renewable and non-renewable resources. The contribution of the ocean economy to the national economy may be considered within an aggregate production function framework. It is not the framework of the 'blue economy' or the 'green economy'[2], even though an important avenue of blue economy study is the measurement of the sustainable contribution of the oceans to national and regional economies (Centre for the Blue Economy, United Nations, 2022).

The blue economy is defined by the European Commission of the United Nations as all economic activities related to oceans, seas and coasts aimed at promoting the 'sustainable use of ocean resources for economic growth, improved livelihoods, and jobs' (World Bank, United Nations, 2022). In effect, the blue economy is one where technological choice is constrained to those employing renewable and recycled natural ocean goods and services inputs (not non-renewable inputs) and to those that do not result in a natural environment with higher green house gas, acid, toxic chemical and hazardous solid waste concentrations.

The production activities of the ocean economy are not restricted to ones based on the limited technologies permissible within the blue economy or green economy. They include the mining of ocean fossil fuels and their processing, as does South Africa's interest.

This paper aims to address the dual aims of putting forward reasons why measuring the contribution of the ocean economy to the national economy of South Africa's may be useful to assess the efficiency and equity of development policy making and implementation toward the ocean natural resource inputs at different points in time and how it may be measured at a given point in time.

2. Why the ocean economy has become important to South Africa

2.1 What is known about South Africa's oceans natural resource wealth

Mainland South Africa has extensive known ocean resources, but there is imperfect knowledge

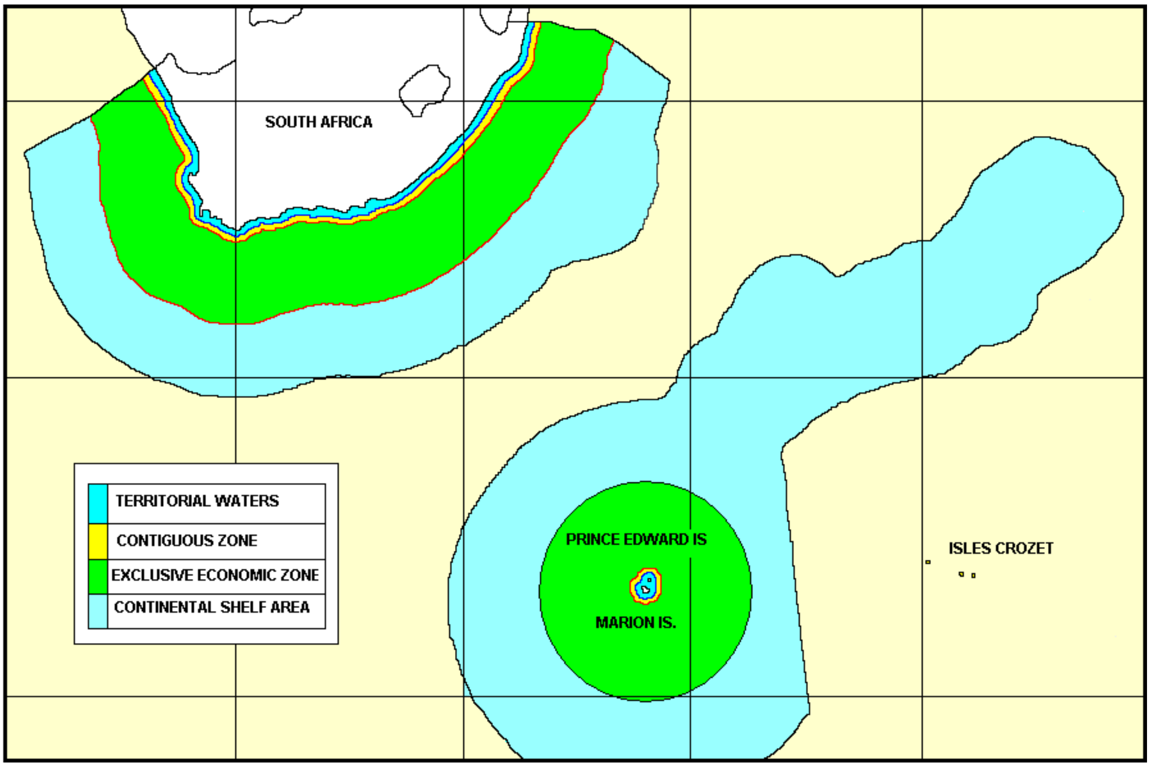
[2] A green economy is an efficient one within the constraints of using of renewable and recycled non-renewable natural resource inputs, not increasing aggregate carbon emissions, preventing the disposal of toxic chemicals into the environment and minimising the volume of waste sent to land-fills (Blue Green Canada, 2022). The blue economy is one relevant to the exploitation of ocean natural resources that has the same constraints as the green economy.

about it. The border of South Africa's mainland area are other states to the north and an approximate 3000 kilometre (km) long coastline to the south (Baird, 2002).[3] The coastline is rich in recreational attractions and has many sites suited to harbour development.

South Africa's mainland's Exclusive Economic Zone (EEZ) is known to be rich in exploitable marine life[4] and moderately endowed with known mineral and fossil fuel deposits. Currently exploited mineral resources within South Africa's mainland's EEZ include sand (for construction), heavy metals, potassium, glauconite, phosphate, oil and gas and diamonds (DEA, 2018). Much of South Africa mainland's EEZ is comprised of ocean with a sea depth in excess of 6000 meters, making it very costly to exploit its seabed natural resources.

South Africa's ocean EEZ, including that of its sovereign Price Edward Island group (Prince Edward and Marion) covers an area of the approximate scale shown in Figure 1.

Figure 1: South Africa's EEZ, **Source:** SANGP100 (2013: 17)



The ocean space adjacent to the South African mainland makes up about 70% of its EEZ.

[3] By way of comparison, the USA's is 10 000 km in length.

[4] 'South Africa is endowed with an exceptionally rich marine environment. Besides the huge diversity of ecosystems, at least 11 130 species of marine animals and numerous species of marine plants and seaweeds have been identified. These many species represent an enormously valuable resource to South Africa. Aside from the great industrial value of several species, there are additional less obvious benefits attributable to many of the other organisms.' (van der Elst, 2018).

The space of the Prince Edward Island group and associated South African ocean EEZ, makes up the remaining 30% of South Africa's EEZ.

The dichotomy of knowledge about the natural resource inventory lying within land and ocean spaces is in part brought about the high potential costs of exploiting such natural resources relative to those on land not covered by water, given the prevailing levels of technological development. It is also a situation that is changing globally because the expectation of rising future prices of natural resources have given rise to sufficient incentive to South African (and other nation) firms to invest more in increasing their knowledge about South Africa's national ocean natural resource inventory and the technologies to exploit it.[5] These prospects logically motivate for a South African government economic growth policy (strategy) to expedite increased investment into the investigation and potential for technologies based on a future of increased employment of South African ocean natural resources.

It follows logically, that there is social and strategic advantage for an analysis of the scope for government interventions to promote economic growth in South Africa through increased employment of its ocean's natural resources. South Africa's natural resources occur in three geographical spaces: land not covered by ocean, ocean that covers land which falls within the sovereign control of South Africa and ocean that falls outside of the sovereign control of South Africa but to which South Africa has access. In these spaces, the natural resources of reference include those occurring on the surface, below the surface and above the surface, irrespective of whether they occur within water or within solid earth materials such as soil and rocks on the seabed.

[5] *A priori*:

- natural resource limits on land will decrease the cost advantage (at the margin) of extracting minerals and fossil fuels on dry land as against under the sea, resulting in an increase in the proportion of mining subsector being derived from under the oceans (within the Exclusive Economic Zone (EEZ)),
- diminished availability of suitable agricultural land and undermining of wild fish habitats and stocks will decrease the cost advantage (at the margin) of food farm produced on dry land relative to in the sea, resulting in an increase in the relative contribution of the aquaculture sub-sector,
- improved transport and communication technologies will decrease the costs of recreation and living on and in the oceans and increased incomes will increase demand for ocean dependent recreation and lifestyle, and thereby result in a relative increase in construction activity along the coastline to access the oceans, utilisation of sea water for production (of potable water and salt, inter alia), wholesale and retail trade and financial services activity,
- increased economy of scale in the transport of goods, improved cargo management technology and decreased trade barriers will increase the volume of goods transported over the sea, resulting in a relative increase in transport and communication services sector activity utilising the ocean medium and the manufacture of the boats and cables for ocean transport and communication, and
- increased social and national recognition of the economic importance of the ocean sector, will induce increased government and community support and interest in sustainable ocean sector development (including but not limited to the conservation and governance of ocean natural resources and the environment), resulting in a relative increase in community and government sector ocean sector activity.

The geographical distinction drawn between ocean and land space resources is blurred at the borders of some of the spaces (where some land is covered by ocean during some periods of the day but not others and where there is a mixing of ocean and fresh water, such as at estuaries). From a scientific perspective, a distinction between land space and ocean space natural resources is artificial in the sense that natural resources are not separable at the eco-and Earth systems levels. The natural resources occurring in the land and ocean spaces are inter- dependent.

2.2 Why there is a growing government interest in knowing more about the feasibility of employing more of South Africa's natural ocean resources

Against a backdrop of almost overwhelming domestic development needs, emerging clarity on the natural resources accessible to South African exploitation and a growing appreciation the role the exploitation of natural resources had historically played in the economic development of South Africa (Houghton, 1973), a South African national economic growth strategy makes sense that seeks to take full advantage of all its natural resources and ecosystem services, i.e., that 'unlocks' its ocean natural resources and ecosystem services to South African economic development (Odeku, 2020).

> *The South African Government's starting point was that South Africa is surrounded by a vast ocean which has not fully taken advantage of the immense potential of this untapped resource. The oceans have the potential to contribute up to 177 billion rand to the gross domestic product (GDP) and create just over one million jobs by 2033.* (DEA, 2017)

The challenge facing the South African government in 2012 was how to 'unlock' (exploit) its ocean natural resources. In order to exploit its ocean natural resources, the government needed to better understand what they are, the potential for them to make an economic contribution and the market or government forces (and failures) curtailing economic development based on their exploitation. Between 2012 and 2017 the government responded to this need.[6] In order to identify what it could do (through the public good of government facilitation and coordination), the South African government initiated two strategies. One strategy related to potentials for the exploitation of the natural resources within the South African EEZ ocean space adjacent to the South African mainland, as well as the exploitation of the service opportunities to support transport and trade within this EEZ and in ocean space outside of it. This strategy was implemented under the auspices (name) of *Operation Phakisa.*

> *'Operation Phakisa is a results-driven approach, involving setting clear plans and targets, on-going*

[6] The lead author was recruited to assist in this matter by the Department of Environmental Affairs.

monitoring of progress and making these results public. The methodology … focusses on bringing key stakeholders from the public and private sectors, academia as well as civil society organisations together to collaborate in detailed problem analysis, priority setting, intervention planning and delivery.' (DPME, 2022)

The other strategy related to potentials to exploit the oceans space adjacent to the Prince Edward Island group, to which South Africa was entitled to exploit, as well as southern oceans space and Antarctic territory in which South Africa had both a long history of activity and a relatively low transport cost advantage in accessing. That strategy was known by various names until 2020, when it was settled at the *Antarctic and Southern Oceans Strategy.*

These two strategies were implemented under the leadership of the Presidency and co-ordinated by the Department of Environmental Affairs (now Department of Forestry, Fisheries and the Environment), the Department of Public Enterprises, the Department of Transport and selected other departments.

From the outset (2012) the key government role players understood that good information was required both to support:

- the policy formulation flowing from these strategies
- the efficiency and equity of any government interventions proposed to unlock the ocean economy potential and to facilitate economic development (that is, to enable efficient and equitably shared economic growth).

It was with these dual purposes in mind that the Oceans Economy Secretariat of the Department of Environmental Affairs set about researching information on the past and potential future economic contributions of selected ocean sector activities within the ocean spaces of South African economic interest. Its initial objective was to develop pathways to ocean economy led development through the growth of six selected 'promising' (identified as having the potential for economic growth) industrial sectors (*work streams*), namely Marine Transport and Manufacturing, Offshore Oil and Gas Exploration, Aquaculture, Marine Protection Services and Ocean Governance, Small Harbours and Coastal and Marine Tourism.

'By focusing on six priority growth areas, the Oceans Economy will unlock the economic potential of South Africa's oceans, providing significant GDP growth and job creation potential'. (DFFE, 2022)

Once the South African government had decided to implement an ocean economy promoting strategy this way and had declared targets for it, a requirement emerged for it to measure in more detail the economic contribution of the natural resource inputs of the ocean. The declared government targets (over-riding objectives) were referenced to economic aggregate measures (achievements) for 2033 relative to 2010.

> *The first implementation of Operation Phakisa will be led by the Department of Environmental Affairs. It will focus on unlocking the economic potential of South Africa's oceans, which are estimated to have the potential to contribute up to one hundred and seventy-seven billion rand to GDP by 2033 compared to fifty-four billion rand in 2010.* (Public Address, President J.G. Zuma, July 2014, DFFE, 2022).

Published estimates put the contribution of the ocean economy to the national economy (GDP) in 2010 at about 4,5% (Hosking, Du Preez, Kaczynsky, Hosking, Du Preez and Haines, 2014). To this contribution could be linked output, income and exports at the national level, and investment and employment at a microeconomic (firm and household) level.

The underlying intent (purpose) of measuring the contribution of the ocean economy to the national economy was therefore to inform the efficiency of government interventions into the ocean economy (to address market and or government failures) and improve government understanding of the effects on equity of their interventions in the ocean economy. The need to regularly measure the contribution of the ocean economy arose because comparative market advantage changes over time between regions.

There is a gap in published estimates of the contribution subsequent to 2010.[7] This information gap has limited the capacity of government at all levels to target efficient and equity promoting interventions during the period 2010-2027, i.e., ones that would enable the realization of the development potential of the South African ocean economy with improved equity.

3. The contribution of the ocean economy to the South African national economy

3.1 The theoretic framework

The theory of the contribution of the ocean economy to the national economy is sensibly approached from an aggregate production function perspective. Production is a process whereby technologies that combine human and capital are applied to transform inputs (natural resources or intermediate goods derived from them) into final goods and services over time. The process is described in Figure 2 (overleaf).

Intermediate goods are ones that have been processed by a firm through the application of

[7] SAIMI have declared their intention is to address this gap during 2022 and 2023.

some technology. Intermediate goods serve as an input to another firm's application of technology. The functional objective of the firm is to increase the market (selling) value of the natural resource or intermediate good through its production process. Final goods are ones that are ready for consumption by the end user. Final goods do not enter a further production process by a firm, but they may enter a home production process.

Figure 2: The aggregate production process

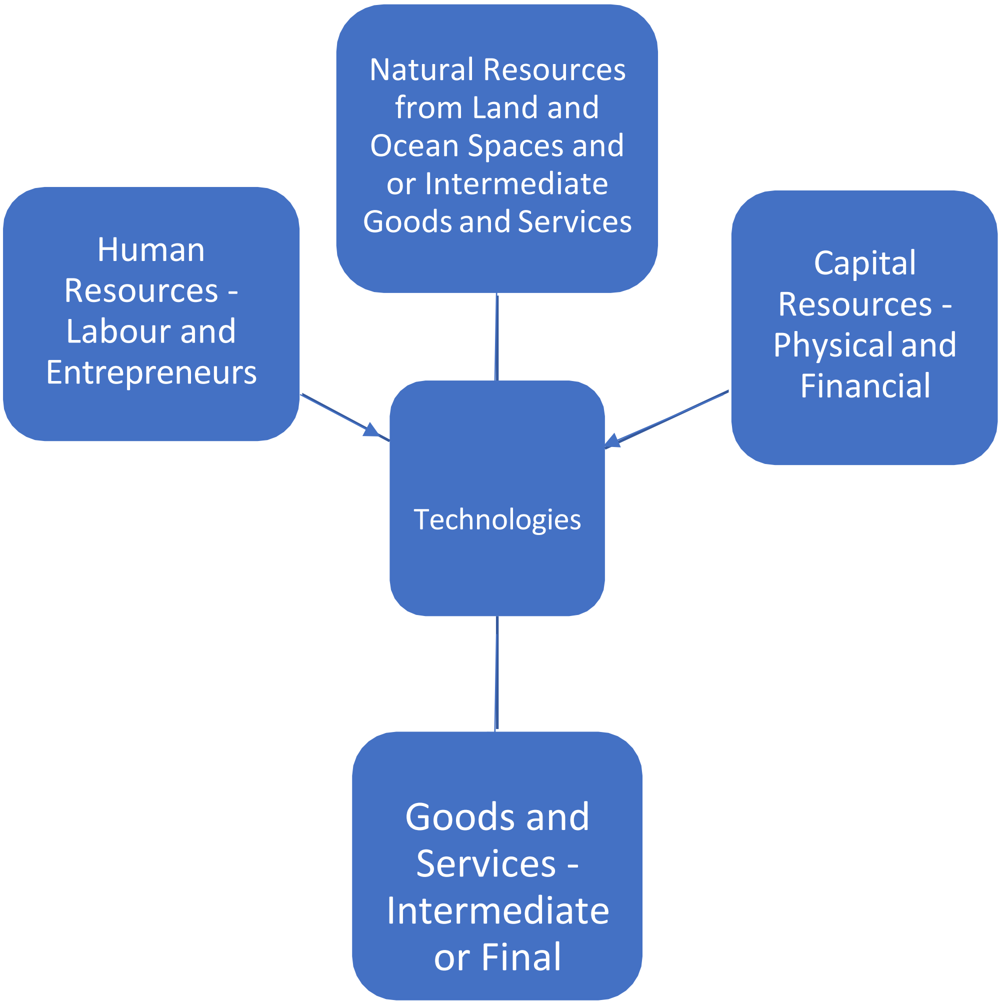


Figure 2 shows how Natural Resources from Land and Ocean Spaces and or Intermediate Goods and Services, are transformed in the production process into intermediate or final goods and services through the application of technologies that combines capital and human resource inputs.

Equation 1 shows an aggregate production function that reflects the production transformation process represented in Figure 2.

$$Y - R = Af(HR, K, NR, t) \qquad (1)$$

The natural resources (NR) that South African firms can employ are those yielded from three spaces: the South African mainland and Prince Edward Islands, the space covered by ocean making up South Africa's Exclusive Economic Zone (EEZ) and the space covered by international waters:

$$NR = NR_{ML} + NR_{OSA} + NR_{OI} \qquad (2)$$

The aggregate production function of Equation 3 incorporates the distinct natural resource contributions from these three spaces, two of which are ocean spaces:

$$Y - R = Af(HR, K, NR_{ML} + NR_{OSA} + NR_{OI}, t) \qquad (3)$$

where, Y is aggregate output as measured by the Gross Domestic Product (*GDP*), R is the total negative residual returned to the environment, $R = f(Y)$, *a priori* $dR/dY > 0$, A is the productivity input of technological progress taken into production, HR is the human resource employed, K is the physical capital employed, NR_{ML} is the natural resource employed in production from the mainland space, NR_{OSA} is the natural resource exploited in production from the space covered by the ocean making up South Africa's EEZ,[8] NR_{OI} is the ocean surface and seabed natural resource falling within international waters that is employed in the production of South African transport and communication services and living marine resources in international waters South Africa has negotiated internationally for access to in order to produce other goods, t is the time period measured in years.

3.2 Growth theory

The theory motivating the South African government's increased interest in the contribution of the ocean economy, is that marginal contributions of the employment of the natural resources of the ocean spaces to the national economy are positive and will grow relative to the employment of natural resources of the land spaces, as reflected the Equations 4 and 5:

$$d(Y-R)/d(NR_{OSA}) > 0 \text{ and } d[d(Y-R)/d(NR_{OSA})]/dt > d[d(Y-R)/d(NR_{ML})]/dt \qquad (4)$$

$$d(Y-R)/d(NR_{OI}) > 0 \qquad (5)$$

If the trend is towards:

[8] The United Nations Convention on the Law of the Sea (UNCLOS, Part V) defines the EEZ as: '*a zone beyond and adjacent to the territorial sea in which a coastal state has: sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents, and winds; jurisdiction with regard to the establishment and use of artificial islands, installations, and structures; marine scientific research; the protection and preservation of the marine environment; the outer limit of the exclusive economic zone shall not exceed 200 nautical miles from the baselines from which the breadth of the territorial sea is measured'*.

$$\Delta NR = \Delta NR_{OSA},$$[9]

it follows:

$$\Delta Y = MP_{HR}\,\Delta HR + MP_K\,\Delta K + MP_{NR}\,\Delta NR + f(N,K,NR).\Delta A \qquad (6)$$

where MP_{HR}, MP_K, and MP_{NR} respectively are the marginal products of human resources, capital and natural resources and ΔY, ΔHR, ΔK, ΔNR and ΔA respectively are changes in aggregate output resulting from changes in human resources, capital, ocean natural resources and technical progress, so:

$$\Delta Y/Y = (MP_{HR}.HR/Y)(\Delta HR/HR) + (MP_K.K/Y)(\Delta K/K) + (MP_{NR}.NR/Y)(\Delta NR/NR) + \Delta A/A = \alpha(\Delta HR/HR) + \beta(\Delta K/K) + (1-\alpha-\beta)(\Delta NR/NR) + \Delta A/A \qquad (7)$$

where $\alpha = MP_{HR}.HR/Y$ = labour's share of aggregate output growth $\beta = MP_K.\ K/Y$ = capital's share of aggregate output growth $(1-\alpha-\beta) = MP_{NR}.\ NR/Y$ = natural resource's share of aggregate output growth (Dornbusch, Fisher and Startz, 2008: 59).

3.3 The implications of growth theory for the contribution of the ocean economy

Under this government strategy motivating theory of South African economic growth (2010-2027), the total contributions of the employment of the natural resources of the ocean spaces to the national economy can be expected to increase relative to those of the natural resources of the land spaces.

These respective contributions may be determined (measured) in terms of the dependency requirement on the employment of ocean natural resources in production. The dependency requirement on the employment of ocean natural resources in production may be deduced from the feasibility of substituting ocean natural resource inputs in production. The ocean natural resource economic contribution is deduced as the difference between in net aggregate output produced with and without the ocean natural resource inputs, as per Equations 8 and 9:

$$(Y-R)_O = (Y-R) - (Y-R)_L = Af(HR,K,NR_{ML} + NR_{OSA} + NR_{OI},t) - Af(HR,K,NR_{ML},t) \qquad (8)$$

$$(Y-R)_O/(Y-R) = 1 - (Y-R)_L/(Y-R) \qquad (9)$$

where $(Y-R)_O$ is the Ocean Natural Resource Contribution to aggregate output, $(Y-R)_L$ is the Land Natural Resource Contribution to aggregate output, that is, what the aggregate output would be without the ocean natural resource inputs.

A priori:

$$d\,[1-(Y-R)_L/(Y-R)]/dt > 0 \qquad (10)$$

[9] The ΔNR_{ML} may tend towards *0* because South Africa's mainland natural resources entering production are not increasing, as may the ΔNR_{OI} because the international ocean services entering production are not increasing.

4. Three approaches to estimating the South African ocean economy contribution to aggregate output at a given point in time and the ways they can guide efficiency

The theory that Ocean Natural Resource Contribution to aggregate output is increasing (Equation 10) may be tested by measuring (estimating) the contribution of ocean natural resources to the South African economy at different points in time. This contribution may be measured by a number of methods; three of which are described below. The estimated contributions may be made more useful to government policy determination and implementation by linking them to efficiency and equity objectives.

4.1 The GGP method of measuring an ocean economy

It is feasible to define a Gross Geographic Product (GGP) for a land area where production processes mostly depend on ocean (maritime) natural goods and services and another GGP for a land area where production processes mostly do not. The GGP for a land area where production processes mostly depend ocean (maritime) natural goods and services may be taken as a measure of the ocean economy.

A priori, the probability of ocean natural resource (maritime input) dependence in production is related to the closeness of that land to the ocean. If D_O is the distance of the land area from the ocean, D_H is the distance from nearest harbour and D_1 and D_2 are the distances at which ocean natural resource dependence becomes unlikely, then a maritime input dominated area is one where $D_O < D_1$ and/or $D_H < D_2$, and a non-maritime input dominated area is one where $D_O > D_1$ and/or $D_H > D_2$.

Under reasonable propositions for D_1 and D_2, the economic contribution of the ocean economy may be measured by the proportion:

$$\Sigma M_j / (\Sigma M_j + \Sigma NM_k) \qquad (11)$$

where:

$$Y = GDP = GGP_M + GGP_{NM} = \Sigma M_j + \Sigma NM_k \qquad (12)$$

and Y is the sum of the value of output produced in maritime dominated land area and non-maritime dominated land area, GGP_M is the gross geographic product of $j = 1, \dots n$ geographically defined (demarcated) maritime areas, GGP_{NM} is the gross geographic product of $k = 1, \dots m$ geographically defined (demarcated) non-maritime areas, M_j is a set of outputs of $j = 1, \dots. n$ geographically defined (demarcated) maritime areas that make up the total national maritime area, NM_k is a set of outputs of $k = 1, \dots m$ geographically defined (demarcated) non-maritime areas that make up the total national non-maritime area.

The weakness of the geographic method of estimating the contribution of the ocean economy to the national economy is that the determination of D_1 and D_2 is necessarily made by 'blunt' methods of division[10].

If $\Sigma M_j /(\Sigma M_j + \Sigma NM_k)$ increases over time (Equation 11), the theory of Equation 10 is empirically supported. The usefulness of the geographic method of estimating the contribution of the ocean economy to the national economy may be enhanced by:

- linking it to microeconomic assessments of the efficiency of regional stimulatory or retarding government interventions such as providing specific regions or locations with supporting infrastructure, market access information or market opportunity
- generating information of relevance to the government's pursuit of the equity objective. The equity of opportunity between people living in different regions may be considered in terms of a maritime area dividend per capita contribution to GDP. That dividend may be estimated by dividing the respective output values by the populations residing in those areas:

$$Maritime\ area\ per\ capita\ dividend\ = \Sigma Mj\ /(pop\ in\ region\ j) - \Sigma NMk/(pop\ in\ region\ k) \qquad (13)$$

4.2 The downstream industry value added GDP methods for measuring the ocean economy

There are two feasible downstream value added GDP methods by which to measure the ocean economy – a Social Environmental-Economic Accounting (SEEA) satellite accounting approach and a downstream dependency on ocean inputs method.

4.2.1 The SEEA satellite accounting approach (ocean attributable value added per sector)

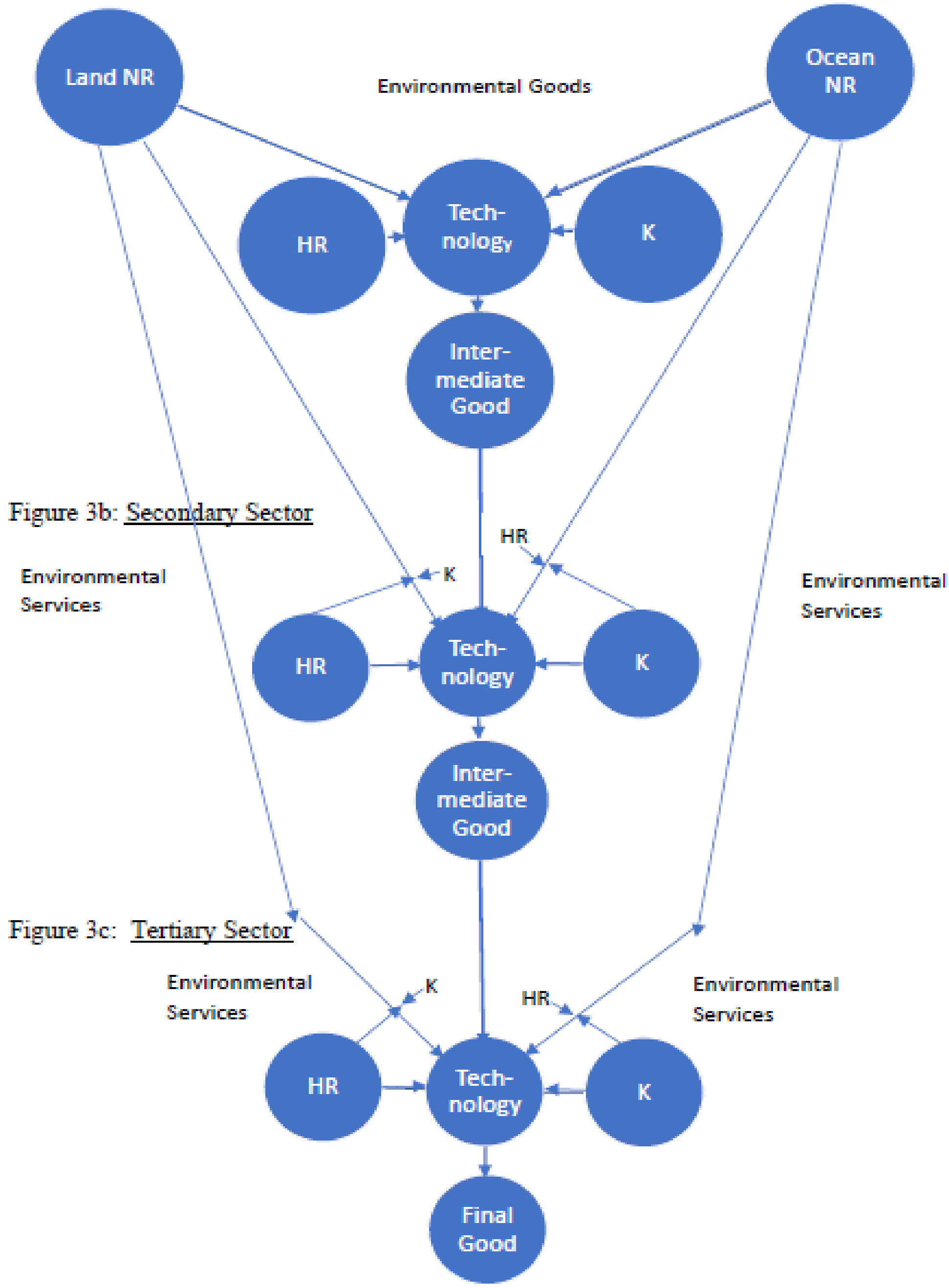
An internationally popular approach to measuring the contribution of the ocean economy to GDP is through ocean economy satellite accounts (United Nations, 2019). These accounts are an element of a SEEA framework, which has the aim of extending the scope of the System of National Accounts (SNA) to include measures the contribution of nature to the economy (United Nations, 2019). Satellite Accounts within the SEEA framework provide guidance on the physical quantities and monetary values of natural inputs (land, water, timber, minerals, energy) in the country (assets), their flows into to the economy (supply), their use in the economy (use), residuals produced from their use and expenditures to mitigate impacts on the environment (United Nations, 2019: 24). The satellite accounts report the contribution of the ocean resources with reference to the value added to GDP downstream of the exploitation (employment) of ocean natural resources – as the sum of value added in the secondary and tertiary industrial sectors (Figures 3b and 3c overleaf) to the ocean natural resource exploited (Figure 3a overleaf).

[10] In the absence of specific knowledge of production for a given area, it is speculated, that (reasonable) approximations for D1 and D2 respectively, could be about 1 kilometre and 10 kilometres.

Within the Satellite accounting framework, the sum value of ocean economy activity is the downstream GDP value added across all industrial sectors that may be attributed to ocean natural resource inputs. The method for attributing the value added may be estimated in several ways. One way is by expert opinion (as done for South Africa by Hosking, Du Preez, Kaczynsky, Hosking, Du Preez and Haines, 2014).

Figure 3: The downstream value generated by ocean natural resource exploitations

Figure 3a: Primary Sector



The problem with this application of the method is it is necessarily ‘once off’. The constancy of the 'expert opinion (assessment)' across time cannot be assured. Changes of the estimate across time can just as easily be due to the change in the 'expert opinion' as to the change in the 'actual value added' by the ocean economy industries.

Equation 14 defines the ocean economy as a summed valued added per industrial sector attributable to the ocean sector natural resource:

$$GDP_O = \Sigma A_i - \Sigma(1 - V_i)A_i = \Sigma V_i A_i \quad (14)$$

[11]

where A_i is a set of the value added of industrial sector $i = 1,.....o$, or the GDP value added by industrial sector (or sub-sector) i, so $\Sigma A_i = GDP$ and $\Sigma(1 - V_i)A_i = GDP_L$, GDP_O is the specific Ocean Natural Resource Contribution to GDP summed over all industrial sectors , GDP_L is the specific Land Natural Resource Contribution to GDP summed over all industrial sectors, what the GDP would be without ocean natural resource inputs, V_i is a set of the proportion of valued added of industrial sector i attributed to the ocean sector, i.e.

$$V_i = \text{(Ocean Sector Natural Resource Input employed per industrial sector i)/(Total Natural Resource Input employed per industrial sector i)}, \; V_i \leq 1 \quad (15)$$

The general problem with this measurement method is that an attributable V_i has to be estimated for every single industrial sector – an almost overwhelming task. The idea underpinning the concept of the SEEA "ocean economy satellite account" is that of deriving a consensus international standard by which the importance of the ocean to the national economy may be demonstrated and a consensus on the evaluation of cross impacts on the ocean economy of inland development orientated policies. Unsurprisingly, given the almost overwhelming problems of objectively determining the respective proportions of value across all industrial sectors (for which the V_i has to be attributed), there is no generally agreed way (currently) of measuring the ocean economy contribution to the national economy per industrial sector (United Nations, 2019), so in practice a variety of non-comparable criteria are used to apply the (SEEA advocated) satellite account approach to attributing the V_i.

The SEEA and related frameworks identify three sets of natural ocean resource inputs for the purpose of reporting in Satellite Accounts:

– *Materials: including minerals and energy resources, soil, timber, aquatic resources, and other biological resources;*
– *Energy: including inputs of energy from fossil fuels, solar, hydro, wind, wave and tidal,*

[11] *A priori,* if over time the primary sectors with high V_i coefficients grow relative to ones with low V_i coefficients or the V_i coefficients increase on average, the ocean sector contribution will increase

geothermal, and other electricity and heat;

- *Water: including surface water, groundwater, soil water and seawater* (United Nations, 2019: 48).

For Satellite accounts the SEEA and related frameworks identify ecosystem provisioning services as:

- *Biomass for nutrition (cultivated and wild animals, plants, algae or fungi)*
- *Biomass for materials (cultivated and wild animals, plants, algae or fungi)*
- *Genetic materials from plants and animals (pharmaceutical products, genetic inventorying and conservation)*
- *Abiotic materials and energy (offshore oil and gas, minerals; wind, wave, solar energy)*
- *Abiotic: substrate for transportation*
- *Abiotic: seawater for drinking (desalination) or non-drinking (industrial cleaning and cooling)* (United Nations,2019: 49).

In addition, there are 'regulating and maintenance' and 'cultural' ecosystem services to consider.

Table 1 provides an indication of the industrial sectors that have been cited in one or other study as ones where ocean natural resources make a value added contribution to the GDP (United Nations, 2019).

Table 1: International guidelines on the ocean share of the national economy per industrial sector

Ocean-related ISIC codes Sector	ISIC Code	Description	Ocean share
Ocean-related hunting and trapping (walrus, seals)	0170	Hunting, trapping and related service activities	Partial
Fishing/aquaculture	0311	Marine fishing	Full
	0321	Marine aquaculture	Full
Offshore oil and gas	0610	Extraction of crude petroleum	Partial
	0620	Extraction of natural gas	Partial
Marine mining and quarrying	0810	Quarrying of stone, sand and clay	Partial
	0890	Mining and quarrying n.e.c.	Partial
	0893	Extraction of salt	Full
Mining support service activities	0910	Support activities for petroleum and natural gas extraction	Partial
	0990	Support activities for other mining and quarrying	Partial
Marine manufacturing	1020	Processing and preserving of fish, crustaceans and mollusks	Full
	1394	Manufacture of cordage, rope, twine and netting	Partial
Marine chemical industry	2011	Manufacture of basic chemicals	Partial
	2029	Manufacture of other chemical products n.e.c.	Partial
	2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products	Partial

Ocean-related ISIC codes Sector	ISIC Code	Description	Ocean share
Boat and Ship Building, Maintenance and Repair	3011	Building of ships and floating structures	Partial
	3012	Building of pleasure and sporting boats	Partial
Repair and installation of marine equipment	3315	Repair of transport equipment, except motor vehicles	Partial
Marine renewable energy and distribution	3510	Electric power generation, transmission and distribution	Partial
Salt water supply	3600	Water collection, treatment and supply	Partial
Waste management services	3700	Sewage	Partial
Marine construction	4290	Construction of other civil engineering projects	Partial
	4311	Demolition	Partial
	4312	Site preparation	Partial
	4321	Electrical installation	Partial
	4322	Plumbing, heat and air-conditioning Installation	Partial
	4329	Other construction installation	Partial
	4390	Other specialized construction activities	Partial
Marine equipment wholesale	4659	Wholesale of other machinery and equipment	Partial
Marine equipment retail	4773	Other retail sale of new goods in specialized stores	Partial
Transport via marine pipeline	4930	Transport via pipeline	Partial
Marine transportation	5011	Sea and coastal passenger water transport	Full
	5012	Sea and coastal freight water transport	Full
Warehousing and support activities for transportation	5210	Warehousing and storage	Partial
	5222	Service activities incidental to water transportation	Partial
	5224	Cargo handling	Partial
	5229	Other transportation support activities	Partial
Marine tourism	5510	Short term accommodation activities	Partial
	5520	Camping grounds, recreational vehicle parks and trailer parks	Partial
	5590	Other accommodation	Partial
Food and beverage service activities	5610	Restaurants and mobile food service activities	Partial
	5621	Event catering	Partial
	5629	Other food service activities	Partial
	5630	Beverage serving activities	Partial
Marine information services	6311	Data processing, hosting and related activities	Partial
Marine insurance	6512	Non-life insurance	Partial
Marine geologic exploration	7110	Architectural and engineering activities and related technical consultancy	Partial
Marine research and education	7210	Research and experimental development on natural sciences and engineering	Partial
Marine/Environmental Consulting	7490	Other professional, scientific and technical activities n.e.c.	Partial
Travel agency, tour operator, reservation service and related activities	7911	Travel agency activities	Partial

Ocean-related ISIC codes Sector	ISIC Code	Description	Ocean share
	7912	Tour operator activities	Partial
	7990	Other reservation service and related activities	Partial
Ports (maintenance)	8130	Landscape care and maintenance service activities	Partial
Public administration and defence	8411	General public administration	Partial
	8422	Defence activities	Partial
Education	8521	General secondary education	Partial
	8522	Technical and vocational secondary education	Partial
	8530	Higher education	Partial
	8541	Sports and physical education	Partial
	8549	Other education n.e.c.	Partial
Libraries, archives, museums and other cultural activities	9102	Museums activities and operation of historical sites and buildings	Partial
	9103	Botanical and zoological gardens and nature reserves activities	Partial
Sports activities and amusement and recreation activities	9312	Activities of sports clubs	Partial
	9321	Other sports activities	Partial
	9329	Other amusement and recreation activities n.e.c.	Partial

Reference: United nations (2019: 62)
Note: ISIC = International Standard Industrial Classifications

4.2.2 The downstream dependency on ocean inputs method

One way of addressing the problems of the SEEA satellite accounts approach is to assume a constancy of the dependency proportion across downstream industrial value added. The constancy assumption is that the V_i dependency in the primary sector is carried through into the secondary and tertiary value adding industrial sectors:

$$GDP_O = GDP - GDP_L \qquad (16)$$

or

$$(GDP_O/GDP) = 1 - (GDP_L/\ GDP) \qquad (17)$$

$$(GDP_O/GDP) = 1 - (GDP_{PL}/GDP_P) - (GDP_{TL}/GDP_T) = 1 - [\Sigma(1 - V_i)A_i/\Sigma A_i], \qquad (18)$$

where GDP_P is the primary sector value added by all natural resource inputs (land and ocean), GDP_{PL} is the primary sector value added by land natural resource inputs only (without ocean natural resources), and $i = 1,...p$, or the GDP value added per primary industrial sub-sector.

The assumption that the downstream value adding process in aggregate production is linear across the primary, secondary and tertiary sectors is motivated by an *a priori* proposition. It is that a subtraction of ocean natural resources would eliminate the same proportion of output in the secondary and tertiary sectors as it would in the primary sector, because the value adding of production of the secondary and tertiary sectors is dependent on the input from the primary sector.

It is a less than perfect solution to reducing the number of industrial sectors for which the

Vi dependency has to be determined, because many of the major ocean natural resource service inputs are not made in the first instance at the primary sector level of the production process. They only enter the production process in the first instance at the secondary and tertiary industrial sector levels. Production at these later stages in the process may still depend on ocean natural resource inputs. In order to capture the ocean environmental services entering the production process in the first instance at the secondary and tertiary industrial sector levels, Equation 18 may be adjusted (as done in Equation 19):

$$(GDP_O/GDP) = 1 - [\Sigma(1 - V_i)A_i/\Sigma A_i + \Sigma(T_jA_j)/\Sigma A_j], \quad (19)$$

where $\Sigma(1 - T_jA_j)/\Sigma A_j$ is a proportional adjustment to secondary and tertiary industrial sectors $j = 1,..r,$ for the additional ocean environmental services employed (over and above that embodied in the intermediate good input into production),

Tj is the increased proportion of total output in the secondary and tertiary industrial sectors dependent on the employment of these additional ocean environmental services. This may be a constant because it mostly relates to long-standing uses of the ocean.

Ocean natural resource inputs that only enter the production process in the first instance at the secondary and tertiary industrial sector levels respectively are:

- the ocean as a sink (for residuals from manufacturing and potable water production) and cooling services of the ocean (exploited in nuclear electricity production), as indicated in Figure 3b
- the ocean service (space) as a transport cost reducer and recreational and quality of life improver, as indicated in Figure 3c.

If $\{1 - [\Sigma(1 - V_i)A_i/\Sigma A_i + \Sigma(T_jA_j)/\Sigma A_j]\Sigma M_j /(\Sigma M_j + \Sigma NM_k)\}$ increases over time (Equation 19), the theory of Equation 10 is empirically supported. The usefulness of the value added per industry method of estimating the contribution of the ocean economy to the national economy may be enhanced by:

- linking it to microeconomic assessments of the efficiency of regional stimulatory or retarding government interventions such as, such as providing industry specific supporting infrastructure, market access information or market opportunity
- generating information of relevance to the government's pursuit of the equity objective.

The equity of employment rents for workers and natural resource controllers in different industries may be considered in terms of a wage dividend per worker per maritime industry. That dividend may be estimated by dividing the respective income contribution by the number of workers employed in those industries (say industries *j* and *k*):

Maritime industry per worker dividend = $\Sigma Mj/(no.\ workers\ in\ industry\ j) - \Sigma NMk/(no.\ workers\ in\ industry\ k)$ (20)

4.3 The method of disaggregating expenditures on final goods and services

A third methodological approach to measuring the contribution of the ocean economy is to disaggregate the expenditure on all final goods and services into those dependent for their production on South African ocean natural resource inputs, those dependent on South African land natural resource inputs and those dependent on foreign inputs (imports). The disaggregated expenditure on final goods and services dependent for their production on South African ocean natural resource inputs is reflected in the bottom 'balloon' of Figure 3c. It is the sum of expenditure on retail products dependent on ocean natural resource inputs, e.g., final marine living animal products of the ocean, desalinated potable water sold, gas and liquid fuels sold that were processed from fossil fuel resources in the sea bed, and products sold processed from other minerals abstracted in the ocean space, recreational and quality of life improvement expenditure dependent on the ocean's environmental services, waste water disposal service sold that depends upon the use of the ocean as a sink and the all other final goods and services whose production depends on their transport by ship over the ocean (there is no other feasible alternative).

In principle, the calculation of the sum of consumption, government, investment and export less import expenditure on South African ocean input dependent final goods and services yields the same estimate to that of the summed industrial value added method. The method may be applied by disaggregating a domestic expenditure 'basket' of final goods and services into its expenditure parts and adding to it the export part.

If the disaggregated expenditure on final goods and services dependent in the production for South African ocean natural resource inputs increases over time, the theory of Equation 10 is empirically supported. The usefulness of the disaggregated expenditure on final goods and services method of estimating the contribution of the ocean economy to the national economy may be enhanced by:

- linking it to microeconomic assessments of the efficiency of market information access and market opportunity generating government interventions[1212]
- generating information of relevance to the government's pursuit of the equity objective.

The equity of consumer surplus appropriation across different domestic consumer groups may be considered in terms of a consumer surplus dividend per consumer per ocean sector product purchased. The equity of that dividend may be inferred by dividing the respective

[12] Such government interventions may include initiating special trading partnerships and or facilitating access to international supply chains and or facilitating improved price and other attribute competitiveness within this international supply chain by providing supporting infrastructure and market access information or opportunity.

consumer group expenditure by the number of consumers in that group buying those final products:

$$Maritime\ consumer\ surplus\ dividend\ per\ product\ per\ consumer\ group\ j\ =$$
$$(domestic\ expenditure\ by\ consumer\ type\ j)/(no.consumers\ of\ type\ j) \qquad (21)$$

$$Maritime\ consumer\ surplus\ dividend\ per\ product\ per\ consumer\ group\ k\ =$$
$$(domestic\ expenditure\ by\ consumer\ type\ k)/(\ no.consumers\ of\ type\ k) \ldots\ldots (22)$$

5 The difficulty of measuring progress toward the employment, investment and capacity building objectives resulting from growing the oceans economy

There are many variables or indices of economic (and human) development that may be linked to growing the ocean economy. A particularly important one to the South African government is generating additional employment opportunity and ways it can facilitate an increase in this employment (DFFE, 2022).

For this reason, from the outset there was a commitment by the South African government to measure the employment created by the ocean economy (DFFE, 2022). It is a difficult task. The variability of employment within and between periods is a complicating measurement factor. In ocean economy industries, such as fishing and tourism, there can be very high levels of seasonality and very different hiring and firing practices to formal employment ones. A common feature of fisheries in many parts of the world (South Africa included) is self-employment and subsistence or non-market employment. In parts of the ocean economy such as marine transportation, the employment is recorded in one country (the flag country), but takes place in other countries or in international waters, and the wages generated may be sent to yet another country (United Nations 2019:95-96).

Three possible ways to measure ocean economy employment at different points in time include:

- through an assumed fixed coefficients link between the ocean economy gross value added (GDP_O), so deduce aggregate employment created from the relevant GDP element (*aggregate employment* = *b*. GDP, where *b* is a constant over time and GDP)
- through unemployment insurance (or other administrative) records from a sample of all the ocean economy enterprises, or
- through the inclusion of an appropriate question in Statistics South Africa's Quarterly Labour Force Surveys.

Two important government intervention measures to plan the growth of the South African ocean economy and the numbers employed in it, are investment expenditure in capacity to enable trade in ocean natural resource dependent goods and services and investment in developing maritime sector skill capacity within the South African population (human capital).

6 Conclusion on linking methods of estimation with policy usefulness

At the very latest, since 2012 the growing of the ocean economy has been an important South African objective. The aims were to diversify the structure of the economy and to support long-term economic growth. Since the 2014 launching of Operation Phakisa, so too has it been important to continuously measure the national and regional GDP and employment benefits of policies and interventions put in place for this purpose, such as in encouraging ocean economy investment and a growth in ocean economy skill capacity. But that measurement has not occurred. This paper is motivated by SAIMI's intent to support this measurement, with the aim of facilitating an improved understanding of the Oceans Economy, and the provision of data to facilitate improved decision making by government and industry.

There are a number of methods by which the growth of GDP and employment, consequent to the implementation of ocean economy promoting policies and interventions, can be measured at a given point in time. A geographic method to measure the ocean economy, is to apportion the GDP into that generated within a part of the country where the majority of value created within that area is dependent on ocean inputs (GGP_M) and that generated in other areas, where the majority of value created within all industrial sectors is not dependent on (or influenced by) ocean inputs (GGP_{NM}). The determination of the physical border of these two areas of the country is necessarily approximate. Some activity within the GGP_M zone will not be dependent on ocean inputs, but equally some activity in the GGP_{NM} zone will. The dividing line between the two areas should be determined with the aim of balancing out these effects, but it may well be difficult to obtain enough information to enable precise balancing.

The satellite accounting approach within the Social Environmental-Economic Accounting (SEEA) framework (United Nations 2019) is another method by which to measure the ocean economy. It is based on attributing value added per industrial sector across all industrial sectors of the economy. It has previously been applied to South Africa using an expert opinion approach (Hosking, Du Preez, Kaczynsky, Hosking, Du Preez and Haines 2014). The problem with this approach is the potential subjectivity of the experts in attributing downstream values to ocean space natural resource inputs and land space natural resource inputs across every defined industrial sub-sector of the economy. It is concluded that modifications of the satellite accounting approach may be made to reduce this problem and so generate measures more objectively comparable over time.

A third method to measure the ocean economy (that should yield the same measure as the downstream value added method) is to sum the expenditure value of all final goods and services that are dependent for their production on ocean natural resources (ocean environmental goods and services). It requires the expenditure on final goods and services domestic and international markets to be disaggregated into South African ocean natural resource dependent, South African non-ocean natural resource dependent and import input dependent types.

The conclusion drawn is that all three methods by which the size of the ocean may be measured have the potential to form part of the baseline information by which the progress of the economy toward greater dependence on the South African ocean natural resources may be monitored and efficiencies and equities assessed of various types of government interventions. As such, there exists an adequate economic rationale for measuring the contribution of the ocean economy to the South African economy in combination with a marginal microeconomic contribution analysis for the period 2010 to 2022; the case being to assist (together with other analyses) government policy design and implementation to realise the potential of the South African ocean economy for the period 2022-2027 and beyond.

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