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POLICY BRIEF

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PLANETARY HEALTH AND SUSTAINABLE SOCIO-ECONOMIC DEVELOPMENT: AN ECOSYSTEM APPROACH

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ABSTRACT:

The industrial revolution of the 19th century greatly increased the wealth of the global community, but much of this development was dependent on technology that relied on fossil fuels. Unfortunately, the use of fossil fuels, deforestation for industrialisation, and the erosion of biodiversity have had major effects on the Earth's natural systems. These changes have contributed to global warming, unstable climate conditions, the emergence of harmful microbes, the loss of many biological species, disruption in food systems, an increase in contagious diseases, and other natural disasters that adversely impact the quality of life for all species on Earth. The consequences of these changes have also affected worker productivity, increased the cost of resources for firms, disrupted global supply chains, and adversely impacted the health of economies. This paper proposes a new values-based socio-economic development framework that aims to transition economies from a "zero-sum" development model to a "nature-centric" sustainable development framework. This new framework is critical for ensuring the health of the planet and the survival of the human species.

1. INTRODUCTION

"*If we do not re-boot our economic ecosystems; nature will boot us out of the natural ecosystem."*

The Earth is estimated to be 4.54 billion years old, while modern humans (homo-sapiens) have only been around for about 300,000 years (Howells, 2023; Hare and Woods, 2020). Despite this, humans have had the greatest impact on the planet's health, compared to any other species. This impact has been most profound in the last three hundred years, starting from the post-industrial

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revolution period. Humans are now considered a force of nature that is powerful enough to influence the Earth's natural biosystems and the fate of all other life on the planet. The relationship between human activity and planetary systems is becoming increasingly strong, and this is beginning to have consequences for the health of the planet, life on Earth, and the global economy.

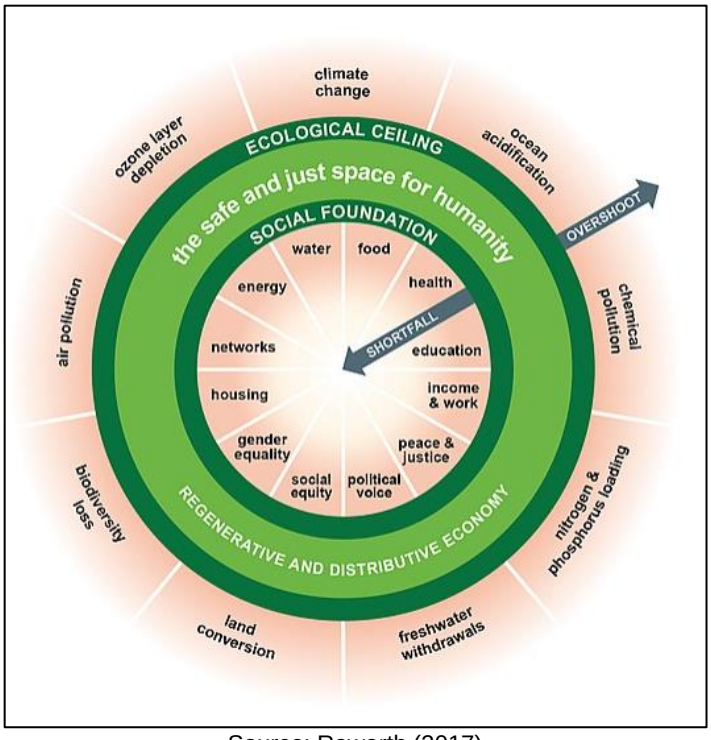
Studies have shown that socio-economic development has had a major impact on the health of the planet and has had an adverse impact on the climate systems across the globe (Dasgupta, 2021; Fanning et al. 2022; O'Neill, 2018; Myers, 2017). Humans have been a dominant force in initiating a new epoch called *Anthropocene*, characterised by the impact of a single biological species on the transformation of biophysical and climate systems (Rockstrom, et al. 2009).

The start of Anthropocene is attributed to the 19th century industrial revolution (around AD 1800) in Great Britain; and this process intensified after World War II (as is known as the *Great Acceleration* period) (Steffen et al., 2011). The Great Acceleration period (1945 to present) saw countries across the globe pursuing economic growth to meet the needs of the increasing global population. Massive investments were channelled to provide homes, food, water, education, employment, energy, and other basic human needs. Rapid development to meet social needs was at the expense of the natural ecosystem. The scale and speed of socio-economic development during the Great Acceleration period has placed significant pressure on the Earth's natural systems and, in some cases, surpassed the threshold of damage to these natural systems (Steffen et al., 2015a and 2015b). These changes to the natural systems are starting to adversely impact the health and well-being of all species on Earth. Changes to the global climate over the years have had an impact on rising sea levels and increasing intensity of cyclones, drought, forest fires, landslides, flooding, and other climate-related disasters (Oxfam International, 2022).

Since the industrial revolution, humans have made significant progress in enhancing socio-economic development through the use of advanced technology and newly found energy sources. However, a significant proportion of this development has been driven by the use of fossil fuels, which have had a major impact on Earth's biosystems. The expansion of industrial development to meet the socio-economic needs of the growing global population has also led to the clearance of natural forests, resulting in a loss of biodiversity and the extinction of many biological species. Such extinctions contribute to the disruption of the delicate balance of biological systems in nature.

Several studies have attempted to incorporate both human development and sustainable development using more integrated development frameworks. One such approach is the "Doughnut of Social and Planetary Health Boundaries (DSPHB) framework (Raworth, 2017; O'Neill et al., 2018), which consists of twelve basic human development needs (social conditions); and nine ecological ceiling metrics[2], as shown in Figure 1 (also referred as the *Doughnut Economic Model*). Within the Doughnut Economic Model, an ideal development pathway is for economic activities to operate within the "safe and just space for humanity". The model proposes to move away from the traditional neoclassical economic model of profit maximisation (using available resources) to a more regenerative and redistributive framework. This framework ensures that human development needs are met (minimising shortfalls in meeting social conditions – socio-economic factors) while simultaneously ensuring that developmental activities have no or minimal impact on the environment (not overshooting the ecological measures – biophysical boundaries).

Figure 1: Doughnut Economic Model

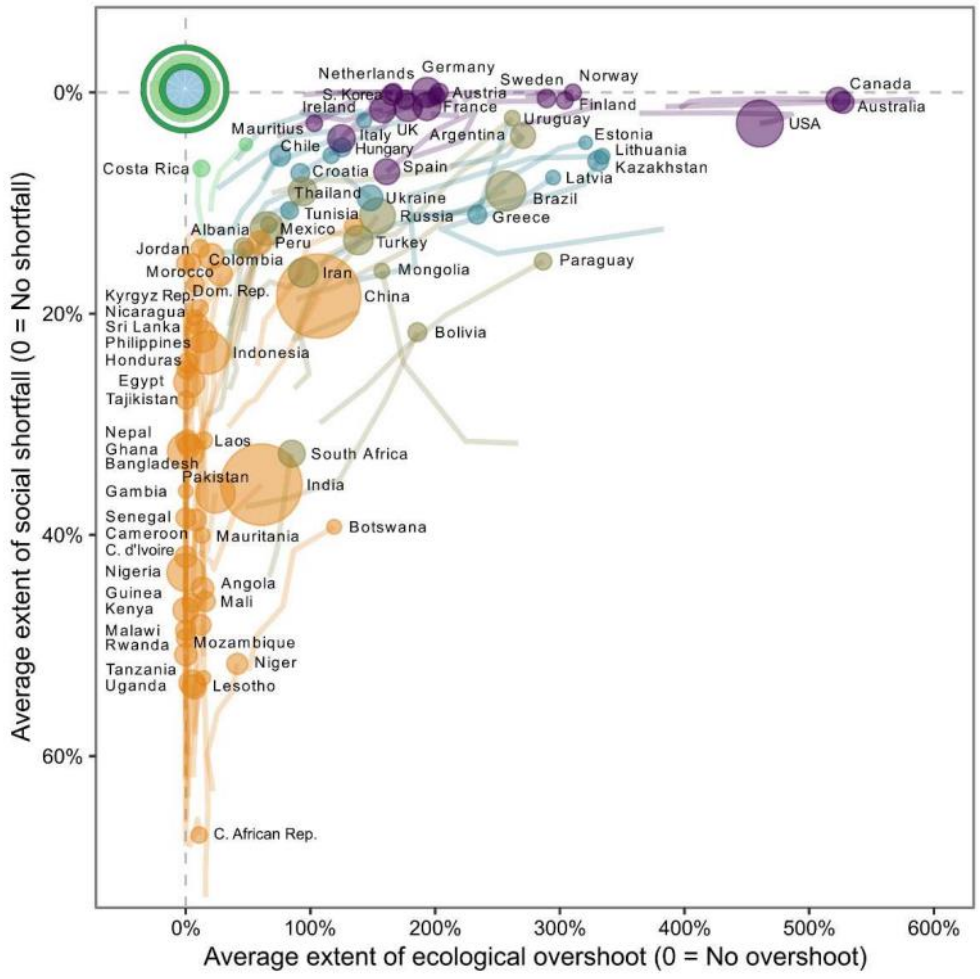


Source: Raworth (2017)

[2] The nine planetary ecological ceiling metrics (biophysical measures) include (i) climate change; (ii) ocean acidification; (iii) chemical pollution; (iv) nitrogen & phosphorus loading; (v) freshwater withdrawals; (vi) land conversion; (vii) biodiversity loss; (viii) air pollution; (ix) ozone layer depletion. Also refer to Rockstrom et al. (2009).

Fanning et al. (2022), using the Doughnut Economic Model, provide an empirical analysis of 140 countries based on 11 indicators for social conditions and 6 indicators that characterise the ecological ceiling measures from 1992 to 2015. Figure 2 shows the correlation between breaches of ecological thresholds and improvements in social conditions in developed and developing countries. The figure shows that improvements in economic conditions have been at the expense of the degradation of ecological conditions. In fact, most developed countries with higher quality of life (higher social conditions) have higher ecological overshoot, contributing to the degradation of several ecological ceiling measures. The study shows that over the sample period, the ecological ceiling metrics for several countries have surpassed the threshold by 32%-55% to 50%-66%.

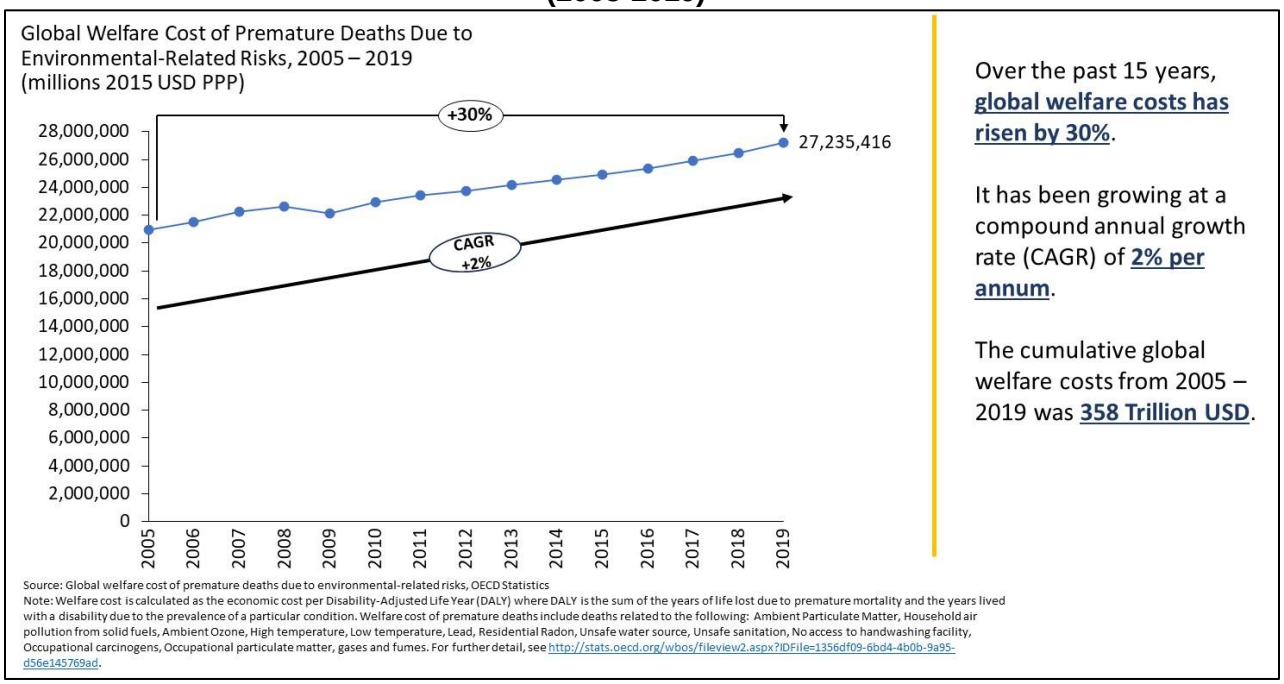
Figure 2: Shortfall of Social Foundation Measures and Overshoot in Ecological Ceiling Metrics for Countries, 1992-2015.



Source: Fanning et al. (2022).
Notes: The ideal state for countries is at the top-left corner, (0, 0), where the countries meet all the social indicators and does not overshoot the ecological metrics used in the study.

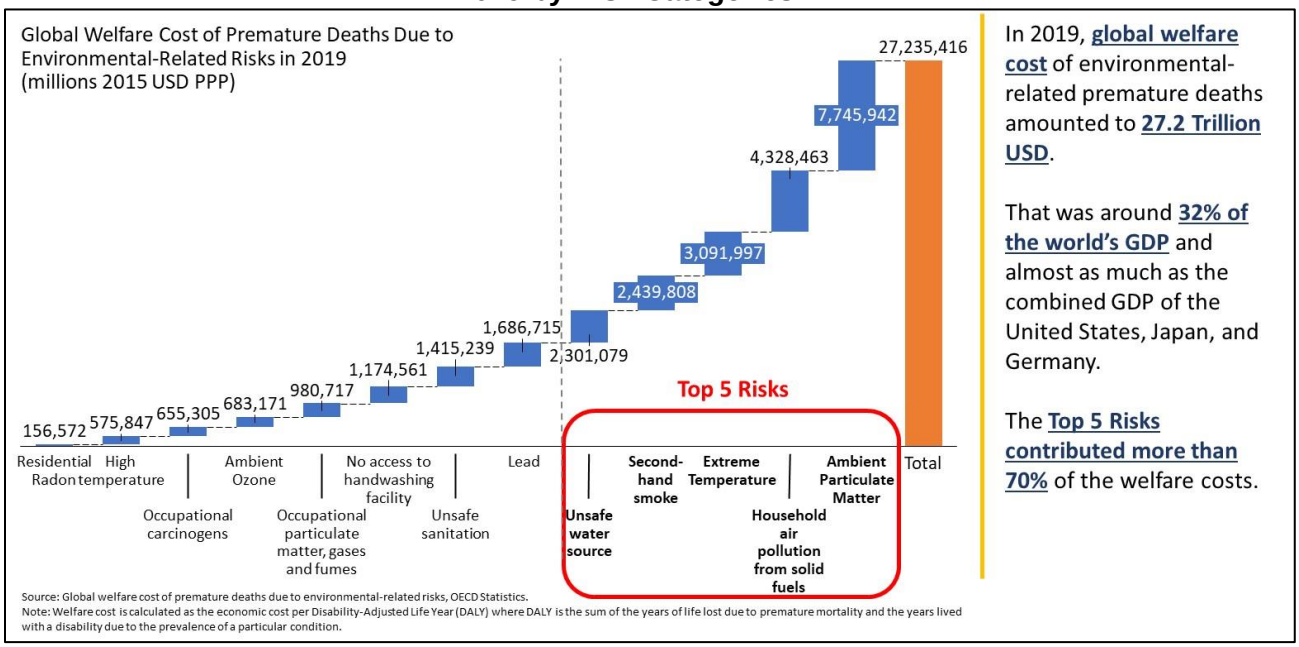
The breach in ecological ceiling metrics due to unfettered socio-economic development has incurred a significant welfare cost for people across the globe. Figure 3 shows that the global welfare cost of premature deaths due to environmental-related risks has risen by 30% from 2005 to 2019. The cumulative welfare cost during this period is approximately USD 358 trillion. A more granular analysis of the data for 2019 in Figure 4 shows that the global welfare cost due to environmentally related premature deaths cost USD27.2 trillion. This cost is 32% of the world's gross domestic product (GDP), which is almost as much as the combined GDP of the United States, Japan, and Germany. The top five risks contributing to this welfare cost are ambient particulate matter, air pollution in homes from solid fuels, extreme temperature, second-hand smoke, and unsafe water sources. These top five risks account for 70% of the welfare cost due to environmentally related premature deaths.

Figure 3: Global Welfare Cost of Premature Deaths due to Environmental-related risks (2005-2019)



Analytics by Sunway Institute for Global Strategy & Competitiveness, SUNWAY University

Figure 4: Global Welfare Cost of Premature Deaths due to Environmental-related risks in 2019 by Risk Categories



Analytics by Sunway Institute for Global Strategy & Competitiveness, SUNWAY University

The discussion above sheds light on the fact that the prevailing socio-economic development model has been detrimental to the health of our planet, and it is not sustainable in the long run. The continuous degradation of the planet's health will have adverse impacts on human health, which, in turn, will undermine the global economy. This is because the current economic system relies heavily on exploiting natural resources and disrupting the balance of the natural ecosystem. To address this issue, a new socio-economic framework based on a nature-based ecosystem approach is proposed. This framework aims to strike a balance between the health of our planet and socio-economic sustainability.

This paper is organised as follows. In Section 2, the current "Zero-Sum" Socio-economic Development Model is presented. Here, we discuss how the traditional neo-classical economic model, driven by the pursuit of return on investment (ROI), often results in a trade-off between meeting the social conditions and breaching ecological thresholds. In Section 3, a new economic development model based on a nature-based philosophy of planetary health is presented. In this context, a nature-centric economic ecosystem is proposed, which will enhance strong collaborative partnerships among multiple stakeholders in the ecosystem to help nurture strong *dynamic capabilities* (absorptive, adaptive, and innovative capabilities) among the players and produce better return on values (ROV) for all the stakeholders in the ecosystem. A planetary health impact model showing the relationship between the ecosystem enablers, dynamic

capabilities and sustainable development are discussed in detailed in this section. Sustainable development in this context is the balanced development that takes into consideration both the social conditions and ecological boundaries in all development plans. In Section 4, key lessons are discussed to ensure humanity is able to pursue balanced development agenda of ensuring the holy trinity of health of the planet, people, and the economy.

2. "ZERO-SUM" SOCIO-ECONOMIC DEVELOPMENT MODEL

There is increasing scientific evidence showing that human activities are adversely impacting the climate of the Earth (IPCC, 2007). These human activities are primarily linked to the intensification of economic and industrial activities to support the increasing global population. The increased demand for nature's resources is exerting significant pressure on Earth's natural habitat and biophysical system, all of which will have an irreversible impact on the health of the planet, people, and the economy. How did we end up in this deleterious situation? The current predicament can be attributed to two major drivers:

- **Biotic drivers**[3]
    - Population growth and increasing population density that increase the demand for homes, employment and other amenities;
    - Deforestation and its impact on endemic organisms in the forest ecosystems;
    - Expansion of agriculture and plantations, coupled with widespread use of pesticides and unsustainable agriculture practices that contaminate the water system, rivers and other natural ecosystems;
    - Illegal hunting and trade of wildlife and wildlife products – extinction of species has had a major disruption on food-chains and life-systems of other species in the ecosystem; and
    - Deliberate or accidental introduction of invasive alien species into the ecosystem that adversely impacts natural species in the ecosystem.
- **Abiotic drivers**[4]
    - Expansion of extractive and mining industries to meet the unfettered demand of industrialisation of the global economic system;

[3] Biotic drivers are living organisms such as plants, insects, animal, including humans and bacteria that impact the ecosystem.

[4] Abiotic drivers are non-living components in nature such as soil, atmosphere and water systems that make-up the natural ecosystem.

- Widespread use of fossil-fuels across the globe has increased CO_2 and other heavy metals in the atmosphere;
- Rapid urbanisation that places major demand on nature's biophysical systems; and
- Major infrastructure projects such as major highways, transportation systems, housing development, construction of dams and others that disrupt the natural habitat and biophysical systems.

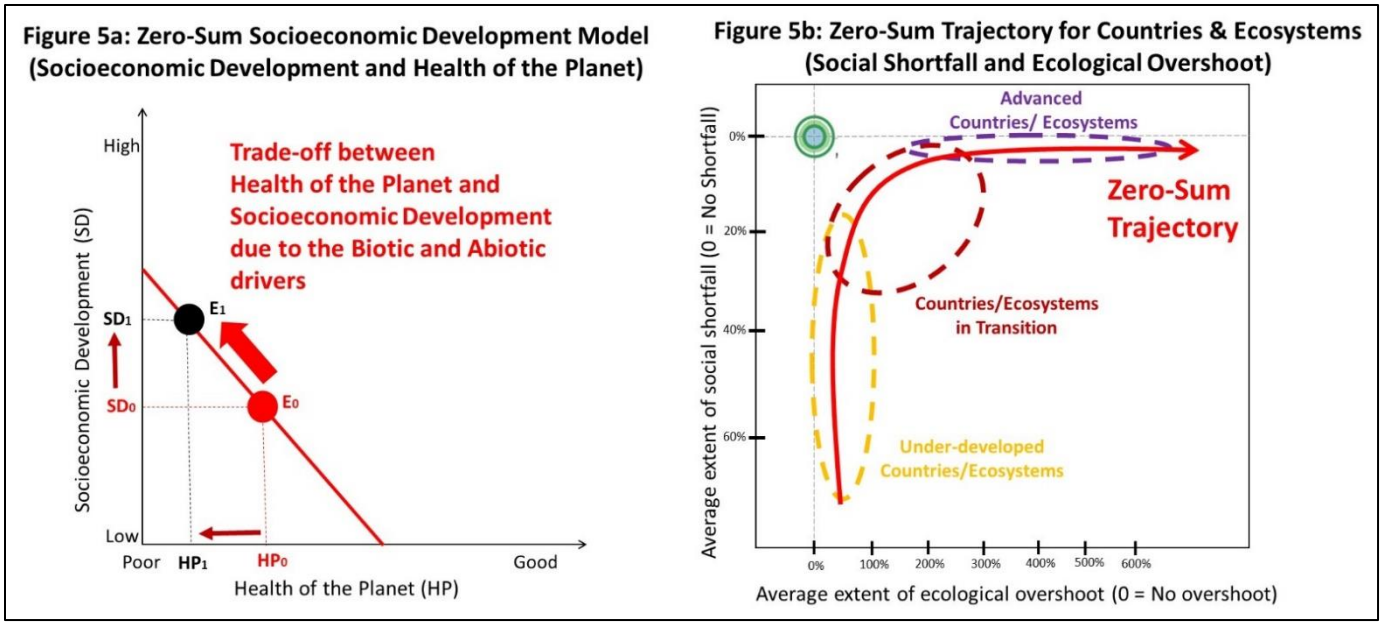
Increasing population and demand to meet the needs of people in terms of food, shelter and other basic amenities have contributed to the trade-off between environmental sustainability and socio-economic development. Figure 5a shows that over the past three centuries, humanity has been climbing-up the wrong curve, pursuing rapid economic growth at the expense of the environment. A majority of countries and ecosystems across the globe are pursuing development growth models that are breaching ecological thresholds. This "Zero-Sum" trajectory, as shown in Figure 5b, has adversely impacted the Earth's biosystems such that it is unleashing a fury of natural disasters and health pandemics. These are undermining the health, wellbeing, and livelihood of people across the globe.

So, the question is, can humanity change the current course of the planet that is heading towards a major calamity that would make the environment uninhabitable in the new future?

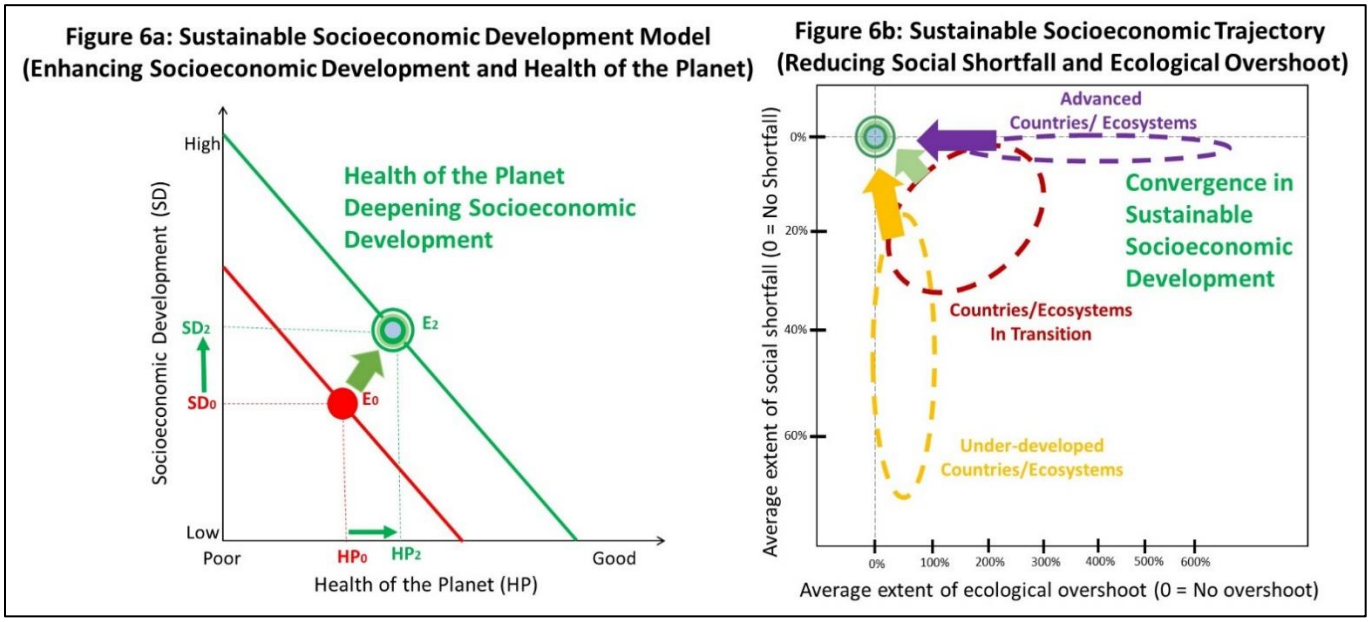
This paper addresses two important questions:

1. Can humanity re-set its economic development towards a more sustainable socio-economic development, where all socio-economic development initiatives incorporate planetary health considerations?
2. Can the new development model ensure that the health of the planet becomes a major contributor to sustainable prosperity for current and future generations, as shown in Figure 6a and Figure 6b?

In the next section of the paper, we will describe a new planetary health sustainable economic development model that addresses the above-mentioned questions.



Notes: In Figure 5a, assume that the economy/ecosystem is operating at an initial equilibrium state of E_0. The economy/ecosystem operating at the status-quo level will transition the economy/ecosystem to a new equilibrium E_1. At the new equilibrium, while there is an increase in socio-economic development from SD_0 to SD_1; the health of the planet had declined from HP_0 to HP_1. Figure 5b shows the trade-off (Zero-Sum Trajectory) between a shortfall in meeting the socio-economic needs of society and ecological overshoot under the traditional economic model. The framework described in Figure 5b was adapted from Fanning et al. (2022)



Notes: In Figure 6a, assume that the economy/ecosystem is operating at an initial equilibrium state of E_0. The economy/ecosystem that incorporates more effective management of the environment (biodiversity and conservation efforts) will transition the economy to a new equilibrium E_2. At the new equilibrium, while there is an increase in socio-economic development from SD_0 to SD_2; the health of the planet had increased from HP_0 to HP_2. Figure 6b shows a sustainable economic development model that reduces the shortfall in meeting the socio-economic needs of society and minimises ecological overshoot. The framework described in Figure 6b was adapted from Fanning et al. (2022)

3. NATURE-CENTRIC DEVELOPMENT MODEL

The Earth is entering a new epoch called the Anthropocene, where human activities, in particular socio-economic development initiatives, are changing Earth's biophysical systems. These changes have major ramifications for the health of the planet and have triggered many global catastrophic incidences such as severe drought, floods, health pandemics and major natural disasters. If more sustainable approaches to managing the needs of society are not given serious attention, the changes in the Earth's biophysical system can be irreversible, and this has the potential of jeopardising the health of all living beings on Earth. There is a growing call by scientists, economists, and policymakers across the globe to address the need for a new economic development model that is anchored on better management of the Earth's resources. More importantly, it will be necessary to ensure that the socio-economic development and future industries reverse some of the changes that have taken place on the Earth's biosystems – they must contribute to restoring, replenishing, and revitalising the natural ecosystem. In this context, we propose a new values-based planetary health economic development model that balances socio-economic development with environmental sustainability.

This section is organised as follows: We commence the discussion by describing the planetary health values, which is a nature-centric philosophy necessary to guide the proposed new socio-economic development framework. We then describe a socio-economic ecosystem aligned to the nature-centric philosophy. In this context, we discuss how the ecosystem will enable the development of *dynamic capabilities* aligned with the nature-centric philosophy – the ability to learn from nature and develop new economic models that spawn nature-centric industries and economic activities. This section will also show a new approach to capture return on values (ROVs) from a nature-centric economic development model. Finally, we show that this new framework has the potential to lead to multiple positive externalities to create better socio-economic development for countries and communities across the globe.

3.1 Nature-Centric Philosophy

Humans are regarded as the single most impactful species on Earth, as their actions have shaped the course of changes in the natural biosystems over the last three hundred years. Hence, humans bear a moral responsibility to ensure that Earth and its resources are used in a sustainable way for future generations, ensuring that their actions do not adversely impact the

quality of the natural ecosystem and lives of all other biological species on Earth[5]. Major religions and spiritual philosophies of the world highlight the sacred "custodian" role of humans in ensuring that Earth remains a pristine and vibrant ecosystem for all species on Earth to thrive[6]. These religions also warn us about the calamities that can adversely impact biological life, including human life if nature (the environment) is taken for granted and human activities disrupt the natural systems of the Earth. All these religions and spiritual value systems promote greater harmony between the human way of life and nature. This is to ensure the rich biodiversity of Earth is maintained and the Earth's natural systems are in a steady state to create a vibrant, rich, and quality experience for current and future inhabitants of this small blue planet in our solar system.

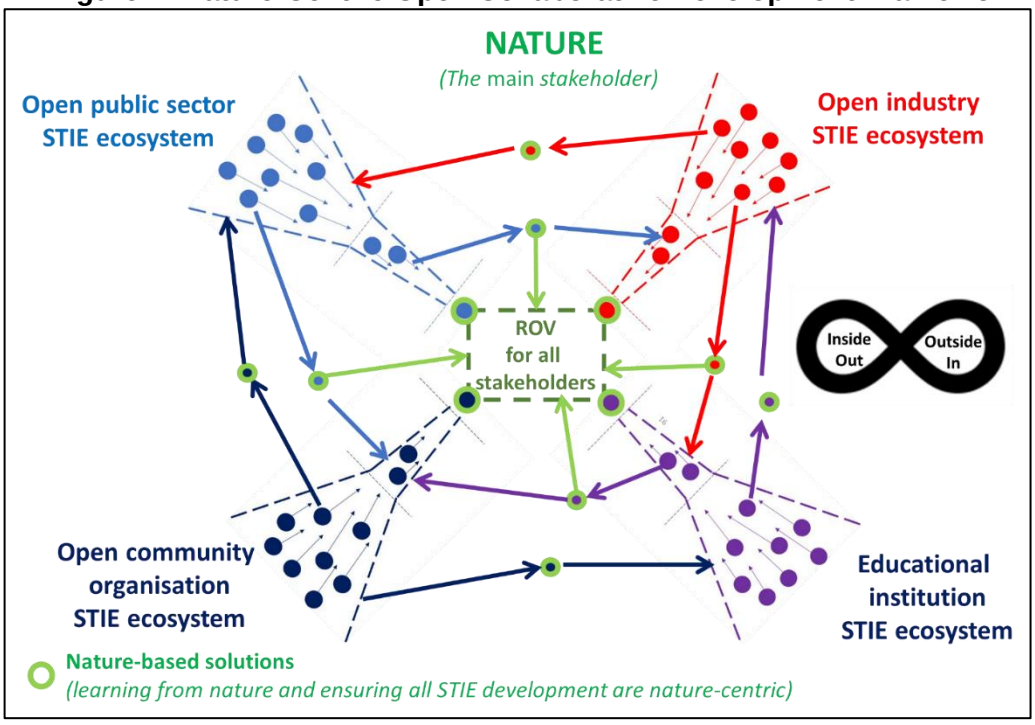
The Rockefeller Foundation-Lancet Commission on Planetary Health also highlights the close link between the health of the planet, people, and all other biological species on Earth[7]. Planetary health is the inter-relationships between Earth's natural systems and economic and social systems that impact the quality of life for all biological species, including Homo sapiens. A vibrant and flourishing Earth system will require better stewardship of the environment and good management of natural resources, which is the source of sustenance of all biological species on Earth. Stewardship is critical at this juncture, as many of the Earth's biosystems are experiencing significant pressures from unfettered socio-economic development since post-World War 2. Decoupling from the balance between environmental sustainability and socio-economic development will threaten the health of the planet and the survival of all species on Earth.

To ensure Earth does not transition towards a doomsday trajectory, we must transition away from the traditional socio-economic development model of extracting nature's natural resources and maximising profits/returns for shareholders. Economies need to transition towards a more nature-centric development model that derives value from the sustainable management and use of resources within nature[8]. When nature is vibrant, and the natural systems of the Earth operate in harmony, all biological species can thrive, and economic systems can generate sustainable wealth for all segments of the population. The nature-centric socio-economic development model is anchored on an Open-Innovation framework that ensures cooperation and collaboration among

[5] Scholars such as Nasr (1997) highlight the need for the inclusion of spiritual values pertaining to nature to ensure the sacred quality of nature is revived back to its original state, prior to the industrial state of development.
[6] In the Appendix, Table 1 provides a summary of planetary health philosophy summarised by ten major religions and spiritual philosophies of the world.
[7] Whitmee et al. (2015)
[8] Nair, Ahmed and Vaithilingam (2022).

all stakeholders in the ecosystem. These include nature, public sector, industry, institutions of learning and community organisations (as shown in Figure 7).

Figure 7: Nature-Centric Open Collaborative Development Framework



Source: Nair et al. (2022). Note that the ecosystems for the public sector, industry, education institutions and community organisations are porous, allowing them to learn, cooperate and collaborate to enhance greater value for all. Knowledge flows for each one of them come from within their own organisations and from across the organisation – both horizonal and vertical knowledge and innovation flows. The proposed framework presented above is consistent with the proposed organisational open innovation model proposed by Chesbrough (2009). Here, we contextualise to include the environment as an important stakeholder in the ecosystem.

In this context, we propose a socio-economic development model anchored on the following nature-centric philosophy, which consists of the 8R-Nature-Centric philosophy (as shown in Figure 8) [9]:

- **Respect:** Inculcate appreciation for natural ecosystems and earth's resources are managed and utilised effectively to protect the biodiversity of the ecosystems.
- **Rethink:** Shift the mind-set of "what can we exploit from the natural ecosystem" ("Profit Maximisation") to a "Purpose Maximisation" mindset ("Value Creation" for all stakeholders) – that is, the transition from unsustainable practices to a regenerative framework, which

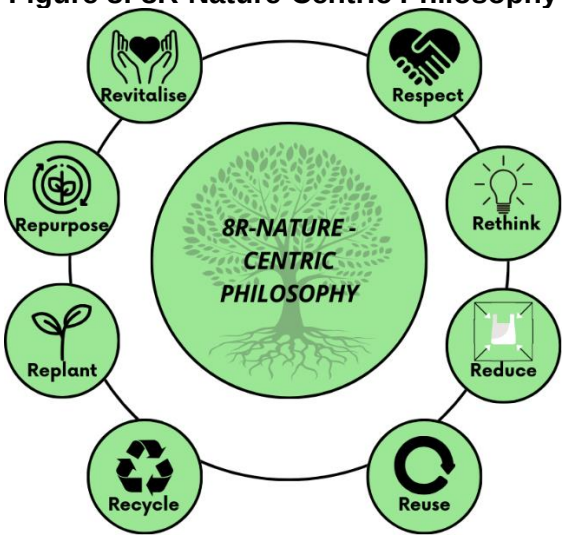
[9] This philosophy, originally from Sibaud and Gaia Foundation (2013), was modified by the authors into a values-based development framework (Nair et al., 2022), that aligns to the UN-SDGs. The 8Rs were refined to characterise the 8R-Nature-Centric philosophy and they are aligned to the values highlighted in the major religions and spiritual philosophies of the world.

ensures biodiversity and conservation from all human activities. This includes rethinking, not undertaking or refusing to undertake any development initiatives if the long-term costs to the environment and society are very high.

- **Reduce:** Reduce human footprint by minimising human encroachment into natural habitats to protect the biodiversity of the ecosystems and prevent the extinction of endangered species. This requires a significant reduction in the carbon footprint and the emission of harmful gasses and waste products that can harm the environment.
- **Reuse:** Create products and materials which can be used for multiple purposes, reducing the demand for natural resources. This practice prevents their depletion at rates exceeding the earth's ability for regeneration. This also reduces the quantum of waste disposed of in landfills, rivers, and oceans consequently mitigating adverse impacts on the environment, people, and other biological life.
- **Recycle:** Implement comprehensive waste management systems to ensure that all forms of waste, including bio-degradable and non-biodegradable materials, are recycled to support a *Circular Economy*[10].
- **Replant:** Foster initiatives aimed at increasing the 'green' (forest) cover to ensure adequate 'carbon sink' to mitigate human activities that contribute to carbon emission.
- **Repurpose:** Create innovative approaches to enhance the ROV from the natural ecosystem. This involves creating nature-centric technologies, socio-economic sectors, business models and employment opportunities.
- **Revitalise:** Increase investments for the revitalisation, rejuvenation, and preservation of biodiversity of the natural habitats, especially the ones that have been degraded due to human activities.

[10] A Circular Economy (CE) is a nature-centric development framework that minimises and mitigates risks associated with the adverse impacts of socio-economic activities, by incorporating the 8R-Nature-Centric philosophy. The adoption of the 8R-Nature-Centric philosophy is from the conception, design, implementation and management of all resources used from nature; so as to create the highest value for all stakeholders in the ecosystem, including nature itself. This definition is consistent with the characterisation in existing literature, for example Scarpellini et al. (2019). A comprehensive survey of CE is given in Kirchherr et al. (2017).

Figure 8: 8R-Nature-Centric Philosophy



Adapted from Nair et al. (2022)

3.2 Characterising Planetary Health Return on Value (ROV)

In this paper, we envisage that the 8R-Nature-Centric philosophy if implemented effectively will generate an appropriate ROV for all stakeholders in the ecosystem. The notion of ROV is new in the literature[11]. It is not widely used as compared to the return on investment (ROI) concept. One of the weaknesses of the ROI measurement is that it does not capture key intangible factors such as social, environment, and people in the measurement. This underestimates the benefits of a project, program, or organisational endeavour.

In this paper, ROV is defined as the ***values gained for all stakeholders (from environmental, economic, social, and political empowerment perspectives) resulting from the adoption of nature-centric development frameworks (technologies, systems, processes, business models, circular economic models, and value chains) that are aligned to global environmental and planetary health best practices***[12].

[11] The notion of return on value (ROV) has not been widely used in the literature, compared to Return on Investment (ROI). Akem (2017) characterises ROV (Return on Value) as the value an organisation generates by including factors such as improvements of their talent, technology, and service quality delivery. Jha and Kumar (2017) also characterise ROV capturing the tangible and intangible outcomes of an organisation. More recent industry experts have explored the ROV notion. For example, Stancil (2023) and Beck Technology (2023) attempt to capture broader firm level outcomes such as employee & customer satisfaction, social & environmental impact, innovation and long-term sustainability of the firm.

[12] ROV characterisation for this paper was adapted from Nair et al. (2022); but, modified to address the planetary health development agenda. The environmental and planetary health development agenda anchors on the 8R-Nature-Centric philosophy outlined in this paper.

Here, four broad categories of ROV are characterised that are also aligned to the United Nation's Sustainable Development Goals (UN-SDGs):

- ***Environment*** — Adoption of environmental best practices for the preservation of biodiversity aligned to the 8R-Nature-Centric philosophy. This is to alleviate risks associated with pollution, biodiversity loss, climate change, and the extinction of endangered species. These efforts are critical to enhance the aesthetic value of the natural ecosystem for current and future generations. This dimension is aligned with six of the UN-SDGs shown below.

- ***Economic*** — Generating new nature-centric science, technology, innovation and economic (STIE) development initiatives that harness the full economic value of nature in a sustainable way. These include adopting circular economic development models, spawning nature-centric industries, jobs, and wealth-creating opportunities and nurturing economically vibrant and sustainable cities and communities. This dimension covers three of the UN-SDGs given below.

- ***Social*** — Ensuring human activities do not harm the environment, which have a knock-on impact on the quality of life, health & wellbeing, livelihood, and lifestyles of people. Vibrant and thriving ecosystems will open new wealth-creating opportunities for communities living in these localities, with the potential to reduce poverty and hunger and provide access to vital social services such as education and healthcare. All of which will reduce inequalities in these localities, creating more peaceful and harmonious communities. This dimension is aligned with seven of the UN-SDGs shown below.

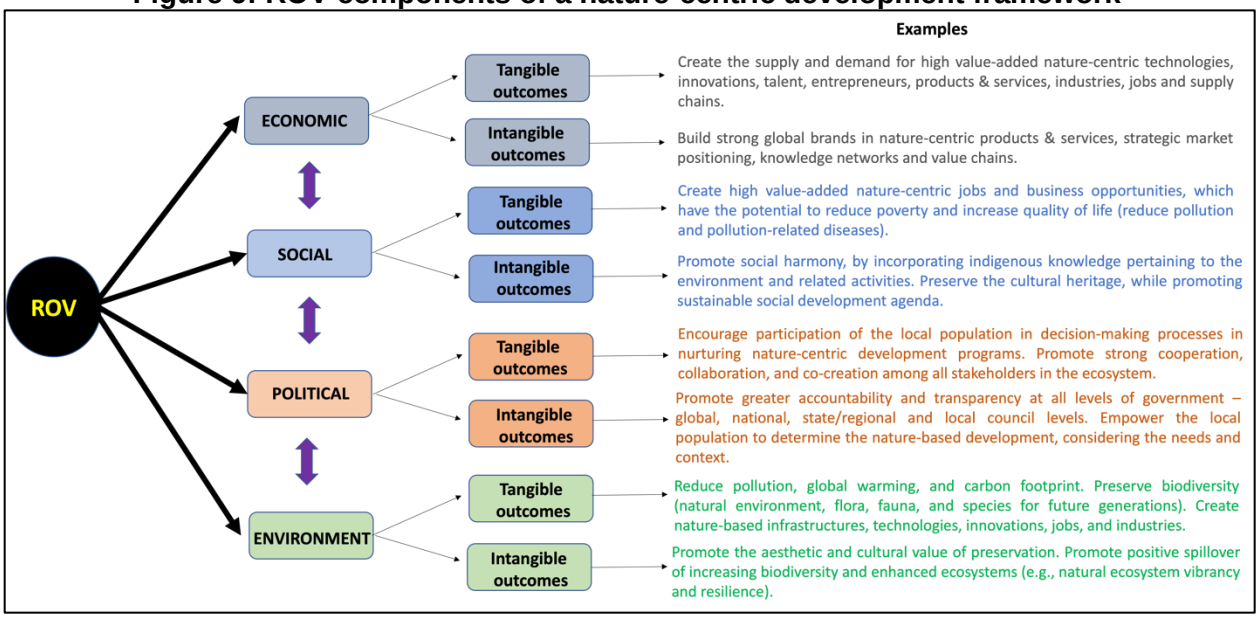
SOCIAL

- ***Political (Will, Stewardship and Empowerment)* —** Political will to ensure active planetary health initiatives, even if the ROV may only be realised in the long-term. This dimension also captures the stewardship needed to guide organisations, communities, and nations towards sustainable practices. A key feature includes the empowerment of the local community and indigenous populations in the design and implementation of nature-centric technologies, innovations, business models, and social systems to create social harmony within their communities and with nature. To achieve this optimal ROV, strong partnerships are required among all stakeholders in the ecosystem. This dimension is aligned to the UN-SDG 17 (partnerships for the goals).

POLITICAL (WILL, STEWARDSHIP AND EMPOWERMENT)

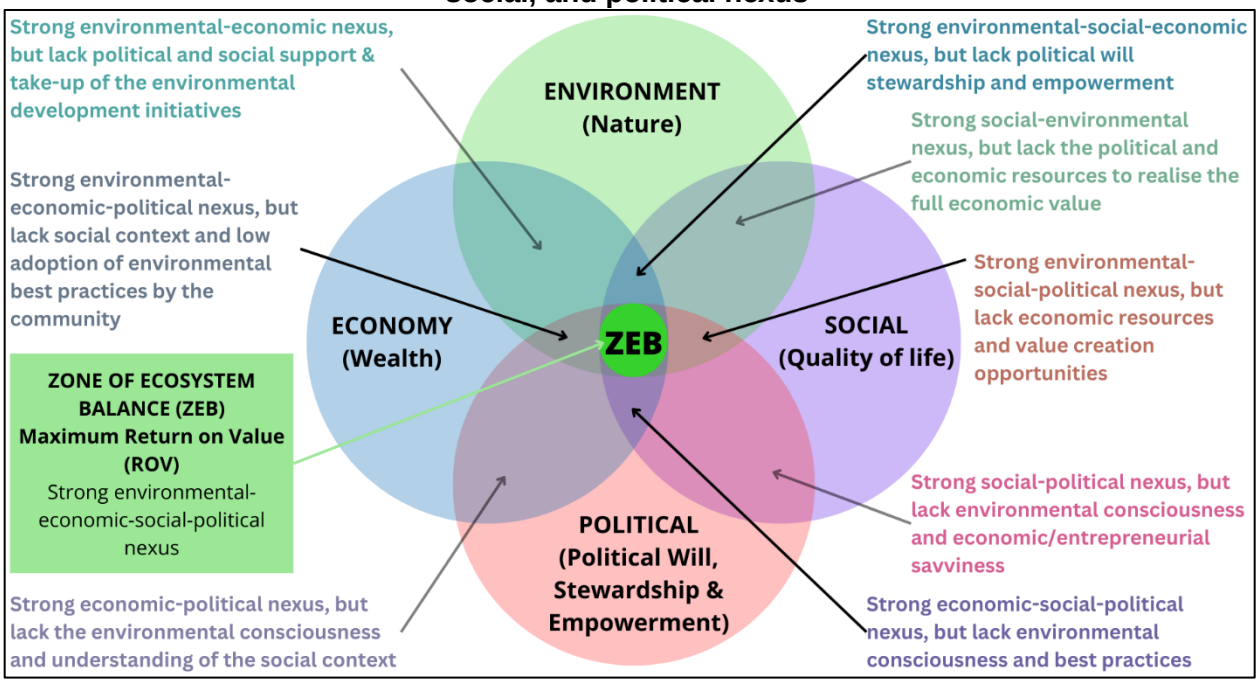
In many of the traditional development models, economic prosperity was the primary focus, with little consideration for environmental, social, and political empowerment dimensions. In the nature-centric development model, all four components (environment, economic, social, and political) are critical in creating ROV for all stakeholders in the economy. Examples of tangible and intangible ROV derived for the four components are summarised in Figure 9. Convergence of all four components will lead to the formulation of nature-centric development initiatives that empower local communities to take stewardship to initiate and lead various value-creating socio-economic programs for all stakeholders in the economy (as shown in Figure 10).

Figure 9: ROV components of a nature-centric development framework



Adapted from: Nair et al. (2022). The examples were modified to suit for a nature-centric development framework.

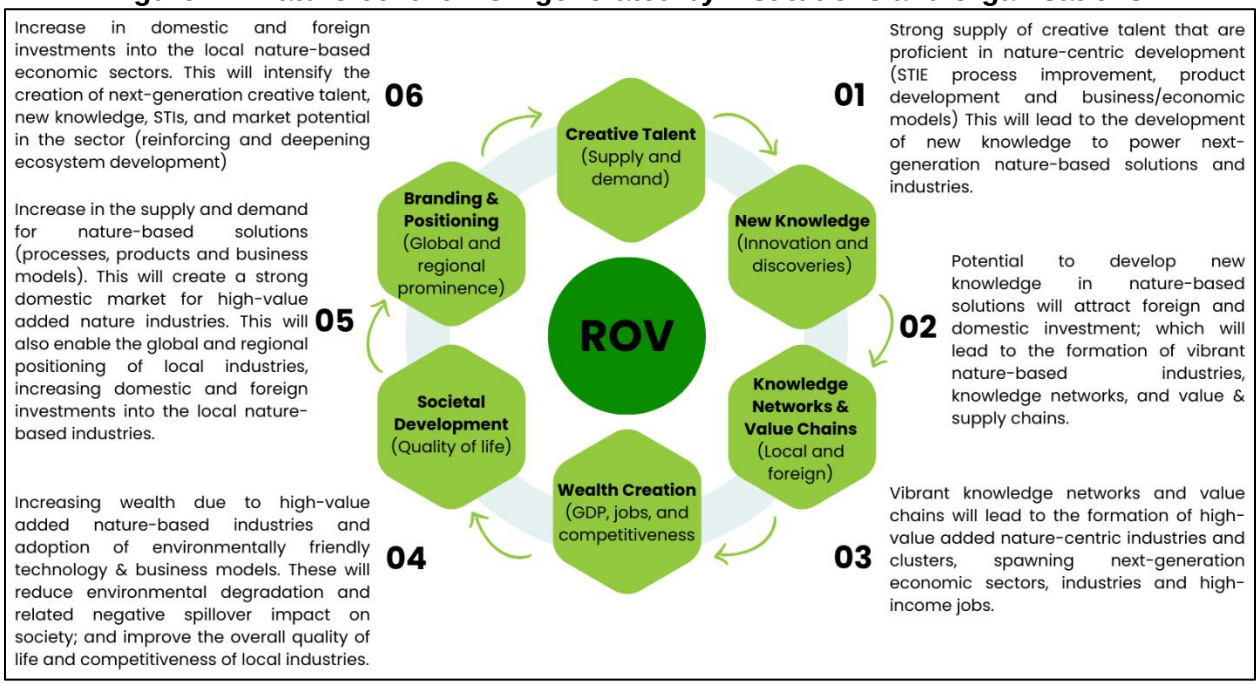
Figure 10: Nature-Centric Development Framework – Strong environmental, economic, social, and political nexus



As key stakeholders (institutions and organisations) in the ecosystem incorporate the 8R-Nature-Centric philosophy, they pave the way for the development of ROVs. This philosophy aims to (i) cultivate creative talent that meets the needs of nature-centric industries; (ii) develop new knowledge (frugal innovation and discoveries) that are environmentally friendly; (iii) foster knowledge networks and build robust sustainable value chains; (iv) create new value-added jobs,

nature-centric industries and increase the contribution of wealth to the country; (v) mitigate risks associated with degradation of the environment, which will have a knock-on impact on the health of the planet, people and the economy; (vi) strengthen nature-based industries, enhancing the global and regional competitiveness positioning and branding of the countries and ecosystem – leading to an inflow of domestic and foreign investments. All of which, will enable the countries and ecosystems to continue to attract talent and other resources to reinforce the development of the nature-based ecosystem (as shown in Figure 11).

Figure 11: Nature-centric ROV generated by institutions and organisations

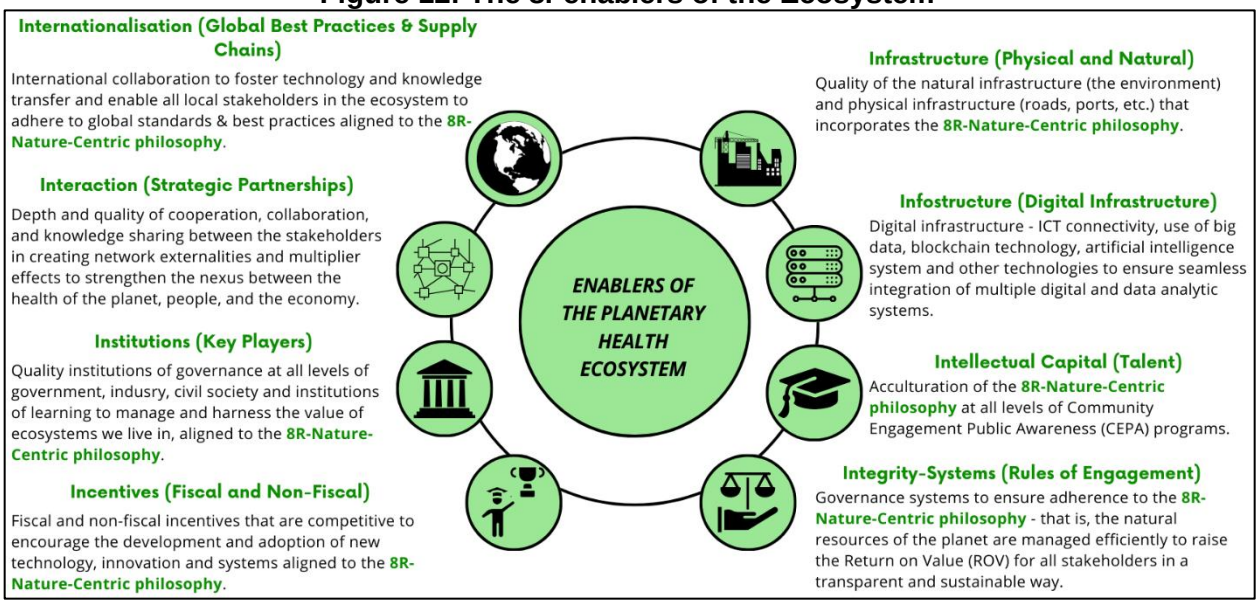


Adapted from Nair et al. (2022)

3.3 Ecosystem Analysis – Characterising the Enablers of the Ecosystem

In this section, we characterise the natural ecosystem using the 8i-ecosystem analysis outlined in Nair et al. (2022). The natural ecosystem is characterised by 8i-enablers that are aligned with the 8R-Nature-Centric philosophy, as summarised in Figure 12.

Figure 12: The 8i-enablers of the Ecosystem

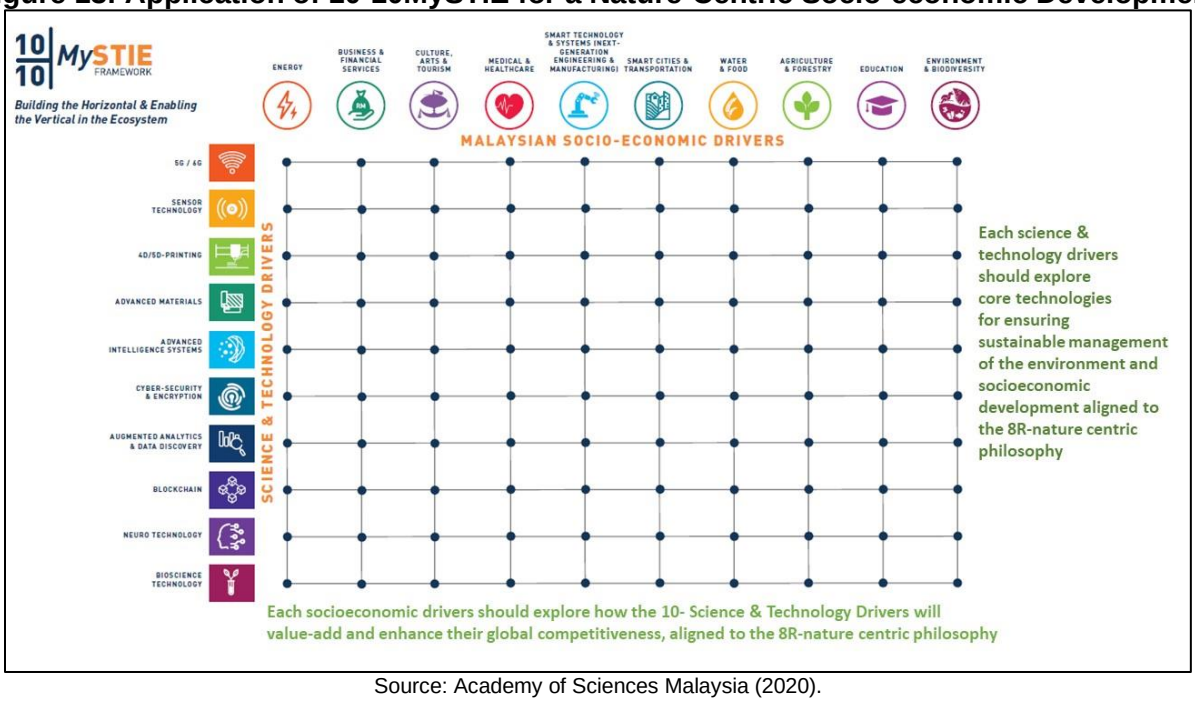


Detailed description of the eight enablers of the ecosystem is given as follows (Nair et al ,2022):

- ***Infrastructure*** – Quality of the natural (environment) and physical (roads, ports, etc.) infrastructure that integrates the 8R-Nature-Centric philosophy. These include the use of advanced technology to manage the natural infrastructure to ensure adherence to global best practices in biodiversity conservation efforts. Further, all socio-economic infrastructure development projects adopt the best technology to mitigate risks associated to environmental degradation and pollution impact on the natural ecosystem.

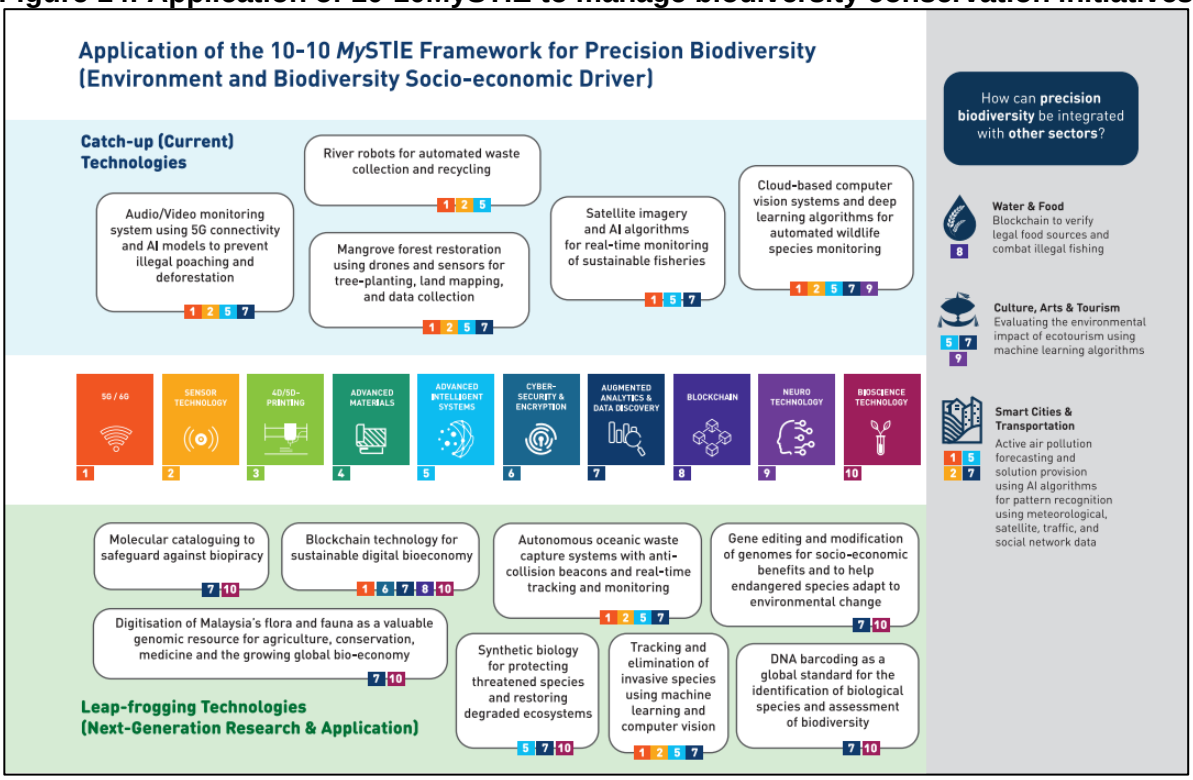
  For example, the 10-10MySTIE framework (Malaysian Science, Technology, Innovation, and Economic Framework) (Academy of Sciences Malaysia, 2020) is an example of how firms and other stakeholders use the 10 global technologies across all the 10 socio-economic sectors to create better ROV for all stakeholders, including the environment (refer to Figure 13). These technologies can be used to develop next-generation environmental technologies and tools to mitigate risks associated with activities that will harm the environment and biodiversity of the ecosystem (refer to Figure 14 for the application of the 10-10MySTIE for developing precision biodiversity technologies). Application of these technologies has a positive spill-over impact on the other economic sectors, such as water & food sectors, culture, arts & tourism, and smart cities & transportation. The new technologies reduce pollution, increase sustainable economic activities, and create high income jobs. All of which, contribute to the wealth of the country.

Figure 13: Application of 10-10MySTIE for a Nature-Centric Socio-economic Development



Source: Academy of Sciences Malaysia (2020).

Figure 14: Application of 10-10MySTIE to manage biodiversity conservation initiatives



Source: Academy of Sciences Malaysia (2020). Analytics by Nair, M., Ahmed, P., and Vaithilingam, S. & Sunway University and ASM team.

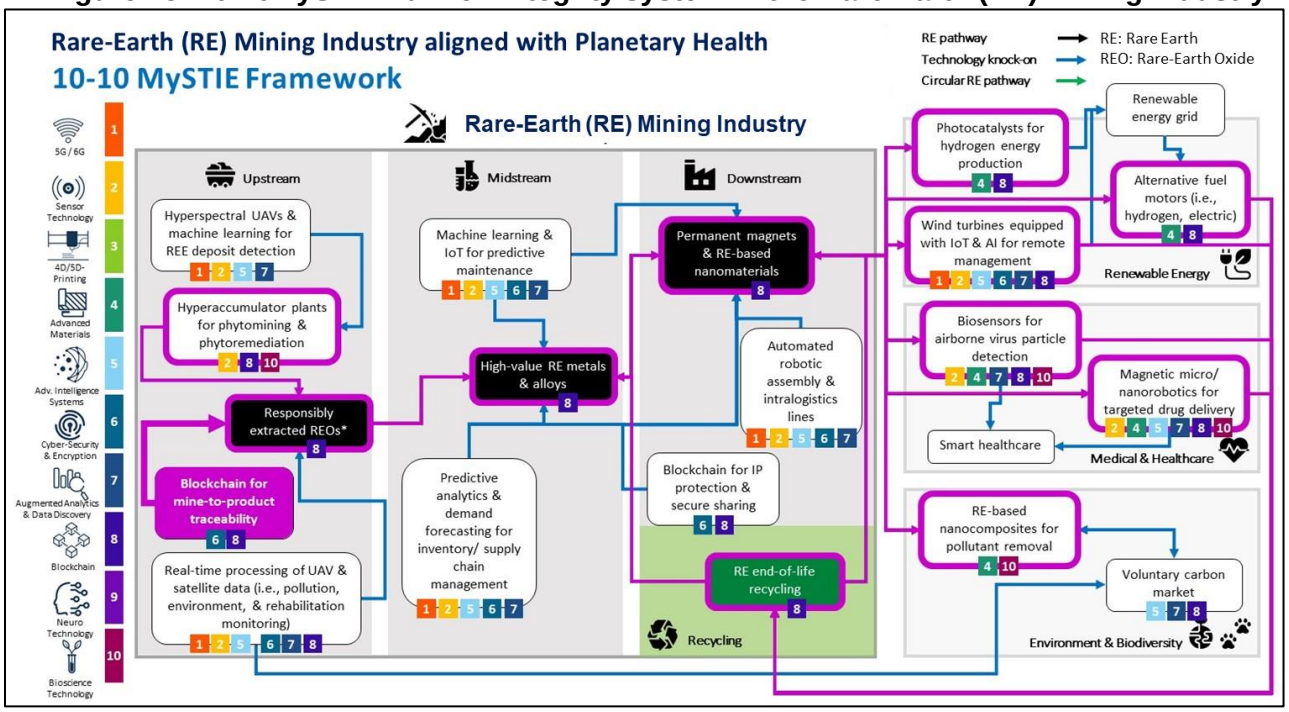
- ***Infostructure*** – Digital infrastructure facilitating seamless integration of multiple digital and data analytic systems, empowering strategic decision making, in-line with the 8R-Nature-Centric philosophy in managing the quality of the environment, biodiversity, and conservation efforts. These include the use of digital technologies such as artificial intelligence (AI), big data & advanced data analytics, sensors technology, and autonomous systems to create higher ROVs from nature-based industries. These technologies are critical for ensuring seamless integration of the upstream, midstream, and downstream industries and operations to ensure environmental sustainability, allocative and productive-efficiency of nature-based industries. Based on the 10-10MySTIE shown above (Figure 13), the first seven out of the ten global STI drivers are digital technologies. These technologies are important for supporting the development of the remaining three STI drivers and the ten socio-economic drivers to be more environmentally friendly.
- ***Intellectual Capital*** – The awareness and understanding of the 8R-Nature-Centric philosophy at all levels within stakeholders. This includes ensuring well-curated Community Education and Public Awareness (CEPA) programs aligned to planetary health and the nature-centric philosophy. There is a need to harness the knowledge of the local ecosystem from the indigenous communities that have been living in the various localities for many centuries. There is also a need to invest in talent with specialised knowledge, technical, entrepreneurial, and leadership skills for nature-based industries, sustainable conservation, and biodiversity initiatives. These include nurturing next-generation engineers, bio-scientist, financiers, and other experts that can create vibrant and sustainable environmental-friendly industries aligned to the 8R-Nature-Centric philosophy. A combination of local indigenous knowledge and modern expertise in next-generation environmentally friendly ‘know-how’ will go a long way to create better ROV for all stakeholders in the ecosystem.
- ***Integrity systems*** – Governance systems that ensure all human activities and economic development initiatives are aligned to the 8R-Nature-Centric philosophy. These include having effective regulations, enforcement mechanisms, incentives, business & community-friendly policies, and best practices in place to ensure the nurturance of planetary health practices among all segments of the population. Key initiatives include the expansion of sustainable supply chains that incorporate planetary health requirements (8R-Nature-Centric philosophy) and Environmental, Social, and Governance (ESG)

standards across different supply chains. This is achieved by putting in place effective management practices standards, and financial incentives.

One of the major supply chains worldwide is the ‘Halal Supply Chain’, where the global market potential is envisaged to increase significantly. Integrating planetary health and ESG requirements into the halal certification process will be a crucial “game-changer” for planetary health efforts in regions with large Muslim populations and the wider global market.

Other key sectors that are critical for the reduction of carbon emissions are the electric vehicle (EV) and solar panel industry. These industries are highly dependent on key minerals and Rare-Earth (RE) materials. An example of a planetary health integrity system is the *Chain of Custody* of managing the mining of precious metals industry so that it adheres to planetary health. This is shown in Figure 15, where 10-10MySTIE technologies are deployed to ensure responsible mining practices are in place at all levels – upstream, midstream, and downstream of the RE industry. This also includes developing effective market mechanisms for recycling minerals. This circular economic framework (recycling) is incorporated in the business value chain. This is to reduce the extraction of these key minerals for supporting the increasing demand by downstream industries.

Figure 15: 10-10MySTIE - driven integrity system in the Rare-Earth (RE) mining industry



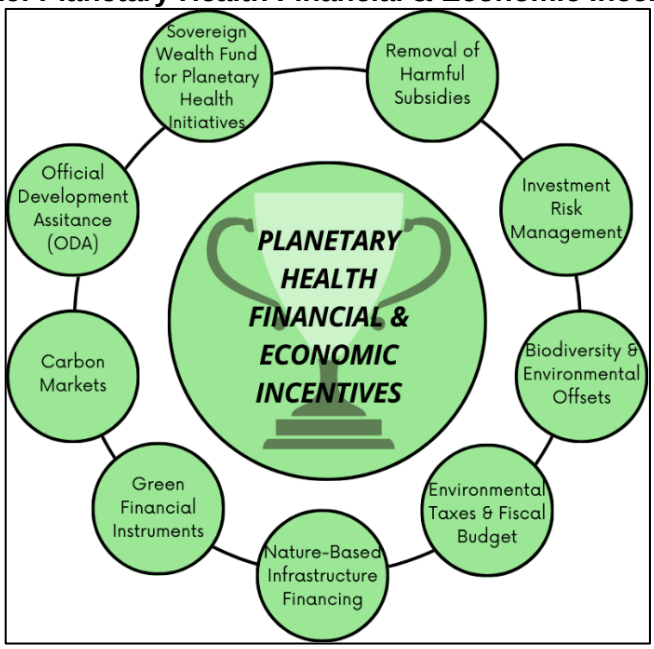
Analytics by Sunway Institute for Global Strategy and Competitiveness – Sunway University.

- ***Incentives*** – Comprehensive fiscal and non-fiscal incentives that encourage planetary health and environmental best practices among the corporate sector and all segments of the population. The economic and financial incentives include the following (refer to Figure 16):
    - Removal of subsidies that harm the environment and adversely impact biodiversity and conservation effort;
    - Introduction of investment risk management of all development initiatives so as to mitigate any adverse risks to the environment;
    - Introduction of biodiversity and environmental offsets for firms that put in place effective environmental management practices and invest in eco-friendly R&D, innovation, and technology development;
    - Ensure that the environmental taxes and appropriate fiscal budgets are provided to support people and firms to transition towards nature-based solutions, environmentally friendly technology, products, and services;
    - Intensification of natural infrastructure financing to ensure preservation and rejuvenation of the biodiversity of the natural ecosystem, including mitigating risks against natural disasters. For example, effective management of the coastal mangrove forest can mitigate the adverse impact on coastal communities and ensure livelihood of the indigenous population that depend on the local ecosystem.
    - Green financial instruments - debt and equity-based instruments that can contribute to biodiversity, conservation, and sustainable development initiatives. These include green bonds, sukuk, and loans, which are important instruments to promote good environmental management practices and investments to address climate change mitigation, resilience, and adaptation initiatives.
    - Intensification of nature-based solutions and carbon markets to transition countries towards reducing carbon emissions – hybrid policy measures of carbon taxes, regulated carbon-cap traded markets and carbon offset markets will enable countries to transition to net-zero carbon pathways. The latter is linked to forest cover and will give countries the impetus to manage their forests more effectively and provide a sustainable livelihood to the indigenous population that resides in the forest reserves.
    - Planetary health and biodiversity conservation initiatives that are linked to Official Development Assistance (ODA) programs for less developed regions with rich biodiverse ecosystems. The funding can be from the government budgets,

international institutions, and donor countries to support biodiversity and conservation initiatives in less developed regions. These include backing significant nature-based infrastructure projects, implementing capability development programmes, and establishing robust institutions and support systems for local communities to manage the local ecosystems aligned to the 8R-Nature-Centric philosophy.

- Sovereign wealth funds that are aligned to planetary health – sovereign funds are state-owned investment funds that can be a crucial financial instrument in unlocking the value of environmental assets to create sustainable wealth creation for the current and future generations. The funds include pension funds, fiscal stabilisation funds, savings funds, and other global development funds. Increasingly, many are divesting from investments that are damaging the environment[13]. This fund can play a key role in investing in appropriate technology and technology companies that enhance the ROV from the natural ecosystem for the current and future generations.

Figure 16: Planetary Health Financial & Economic Incentives



[13] Refer to Capape & Santivanez (2017), which highlights how institutional investors in New Zealand and France are withdrawing investments from companies with significant GHG emissions.

- ***Institutions*** – The calibre of the institutional leadership and institutions (government, industry associations, tertiary institutions, and community organisations) is pivotal in transitioning economic, social, political, and environmental systems towards greater knowledge and technology intensive, aligned to the 8R-Nature-Centric philosophy. There are many institutions that are involved in the management of the ecosystem. Hence, there is a need for "Champions with Clout" to oversee the planning and implementation of planetary health initiatives in the development of the ecosystem. A "Whole of Nation and Community" plan is needed to ensure the effective implementation of the planetary health action plan. There is a need to recognise that the health of the environment is a national security issue that impacts humans, other biological species, and the economic health of the country. As such, planetary health should be core to all development agenda of countries and communities. This will require sound stewardship of managing the environmental assets of the country to enable the country to move up the innovation, economic, and competitive value chain sustainably.
- ***Interaction (smart partnerships)*** – Evaluate the extent of collaboration, cooperation, knowledge, and technology sharing among key stakeholders within the ecosystem to ensure sustainable utilisation of natural environmental assets, thereby enhancing the quality of life and livelihoods of people living in the ecosystem. A key feature of the partnership is the engagement of the local indigenous community and local organisations in understanding local knowledge of the ecosystem and measures to prevent market failures such as illegal logging, pollution, hunting of endangered wildlife, and other illegal activities that harm the biodiversity of the local ecosystem. Strong cooperation among all stakeholders is crucial for sharing valuable insights about the local ecosystem, sharing best practices, and adopting innovative systems and processes. This collaboration aims to generate multiple socio-economic benefits to the ecosystems and communities living in within them, in alignment with 8R-Nature-Centric values.
- ***Internationalisation (building global network and partnership)*** – Characterise the depth of international collaborations with other countries, knowledge networks, and value chains. The internationalisation strategy is important to ensure local players in the ecosystem gain access to state-of-the-art technology and knowledge on planetary health and sustainable management practices from pace-setter countries and leading institutions in the field. A strong presence of local institutions and firms in international knowledge networks will also enable them to contribute to regulations, trade policies, and environmental management practices that improve the health of the planet, livelihood, and

quality of life of the global community. It also helps local institutions, firms, and other stakeholders to extend their global reach for local innovation, technology, products, services, and global best practices. Continuous effort to move up the global value chain has the potential to increase nature-centric and environmentally friendly foreign direct investments into local ecosystems and economic sectors.

3.4 Planetary Health Dynamic Capabilities

Dynamic capability in the context of planetary health is defined as the ability of the various stakeholders in the ecosystem to mobilise and allocate resources to build strong *absorptive*, *adaptive,* and *innovative capabilities* to create better ROV for all stakeholders in the ecosystem:[14]

- ***Absorptive capability*** - The ability of ecosystem players[15] to recognise the importance of understanding nature, forces of nature, and other players in the ecosystem and their impact on the well-being of all stakeholders in the ecosystem. Sound understanding and sustainable use of the resources provided by nature will go a long way to creating better ROV for everyone in the ecosystem, including nature. Key activities that entail absorptive capabilities include the following activities:
    - Undertake regular scanning of the external environment to obtain valuable insights into the inter-relationships and the impact of the various forces of nature and its impact on the various stakeholders in the ecosystem;
    - Translate the above insights and discoveries from nature and external stakeholders to their strategic decision-making process at the individual, corporate and national policies;
    - Put in place capability development programs to transfer new knowledge aligned to the 8R-Nature-Centric philosophy to all stakeholders in the ecosystem;
    - Systematically acquire and store vital knowledge from nature and other stakeholders in the ecosystem for future strategic decision-making processes; and
    - Acquire knowledge and disseminate it across multiple stakeholders in the ecosystem value chain.
- ***Adaptive capability*** - The ability of stakeholders to respond to the changes taking place in the ecosystem by investing in vital resources to improve their decision-making process, management of the ecosystem, reconfigure economic development initiatives, business

[14] Refer to Wang and Ahmed (2007) for a comprehensive discussion of dynamic capabilities of firms and organisations.

[15] 'Ecosystem players' here refers to firms, organisations, and other institutions in the ecosystem.

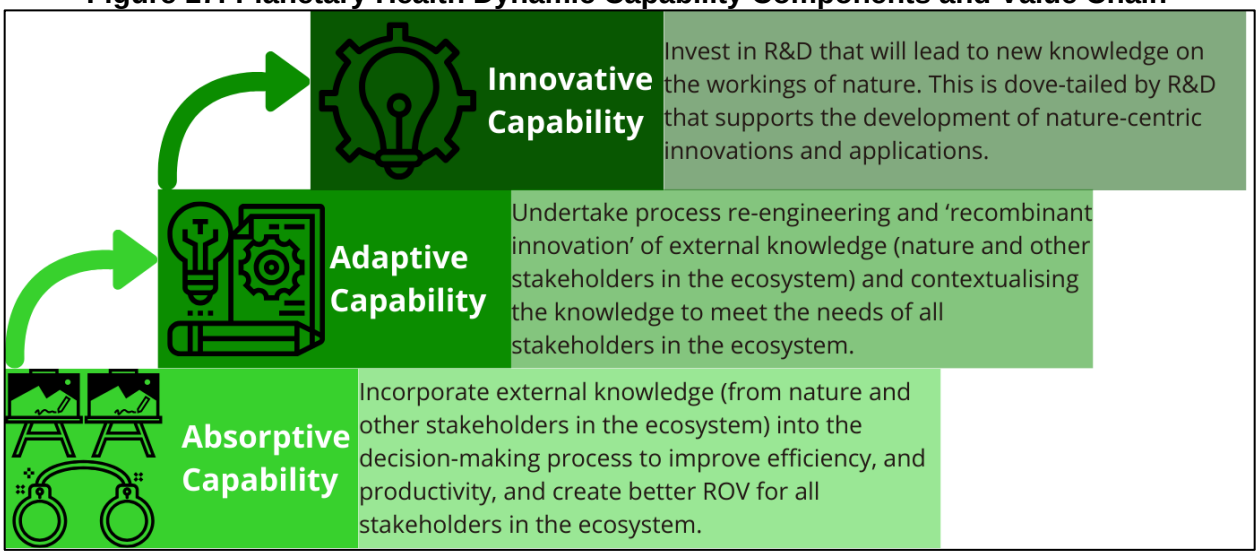
models & value chains, and capability development programs to meet the needs of all stakeholders in the ecosystem. These initiatives are to be aligned with the 8R-Nature-Centric philosophy. Key initiatives include:

- Invest in R&D and capabilities that will enable stakeholders to modify and adapt external knowledge to meet the needs of the stakeholders and effectively manage the local ecosystem, aligned to the 8R-Nature-Centric philosophy;
- Enable stakeholders in the ecosystem to respond to shocks from the external environment and mitigate any risks to the health of the environment, people, and economy; and
- Intensify investment in nature-based solutions and develop internal structures and processes that enable all stakeholders to create new opportunities from the changes taking place in the external environment.

- ***Innovative capability*** - The ability of the stakeholders in the ecosystem to create new solutions, products, services, methods of production, markets, and business models that meet the needs of all stakeholders. These new innovations have the potential of initiating significant improvement in current practices, processes, and products. These will require the following:
  - Investment in basic R&D that understand the workings of nature and the impact of human activity on nature;
  - Increase investment in the development of new nature-centric innovations and applications that create better ROV for all stakeholders in the ecosystem; and,
  - Increase financial, regulatory architecture, and institutional governance systems to expedite nature-centric innovations and the adoption of these new applications.

A summary of the components of the dynamic capabilities is shown in Figure 17. Strong absorptive capabilities are envisaged to build the adaptive capabilities of the local players in the ecosystem. This will have a knock-on impact on the innovative capabilities of the various stakeholders in the ecosystem.

Figure 17: Planetary Health Dynamic Capability Components and Value Chain



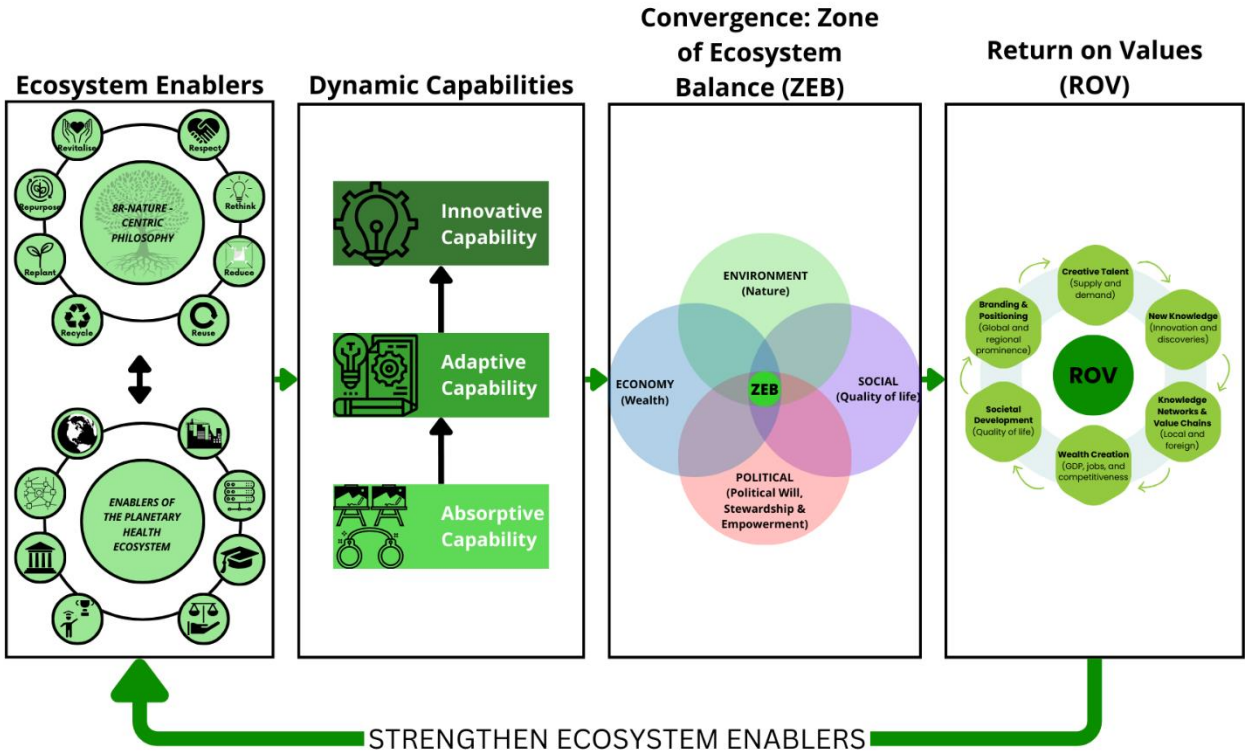
3.5 Integrated Planetary Health Ecosystem Value Chain

In the previous sections, we outlined the components of the planetary health value chain. In this section, we discuss the integration of these components within the planetary health ecosystem value chain (as shown in Figure 18). The enablers of the ecosystem are characterised by the 8R-8i enablers. As communities, organisations and countries invest in the development of ecosystem enablers, the capacity to build dynamic capabilities aligned to planetary health will increase. This will lead to greater alignment of economic and societal needs, balancing the impact of the development activities on nature. This involves ensuring increased empowerment of local communities and indigenous populations in the design, implementation, and monitoring of development initiatives. This will nurture next-generation leaders who become "Champions" for ensuring convergence of economic, social, environmental, and political empowerment of communities in the ecosystem. In other words, all development activities and initiative operate in the Zone of Ecosystem Balance (ZEB). Any veering away from the ZEB will be detected early on and measures will be put in place to correct any overshooting of planetary ecological ceiling metrics and socio-economic development measures.

Greater alignment of the development initiatives to ensure ecosystem balance will lead to increasing the ROV of stakeholders to nature and vice-versa. Increasing ROV will enable players in the ecosystem to continuously improve both the enablers of the ecosystem and themselves, as shown in Figure 18. This circular development framework is critical to ensure the sustainability of the ecosystem in delivering services and enhancing the quality of life for stakeholders. It also

ensures that human and economic activities do not breach planetary boundaries. These improvements enable ecosystems to break away from the “Zero-Sum Economic Development Model” to a more sustainable socio-economic trajectory, as shown in Figure 6a and Figure 6b.

Figure 18: Integrated Planetary Health Value Chain



4 KEY LESSONS AND CONCLUSIONS

The discussion in the previous section of the paper highlights that the current economic development model of extracting natural resources and the negative externalities from pollution and other by-products of industrial development is untenable. Humanity is at a critical juncture. If development activities remain status-quo, the probability of climate change, pollution, and other man-made disasters will not be reversible. The “Zero-Sum Development Model” that is prevalent at present, will disrupt the Earth’s natural systems. This will have a negative impact on all biological life on Earth, as shown in Figure 19. It is envisaged the current status-quo development model will see the Earth under-going nine phases of evolution (dystopian pathway), as discussed below.

PHASE 1: Pre-Industrial Age - a thriving and vibrant natural ecosystem due to low population and the use of environmentally friendly energy sources. In 1750, prior to the industrial revolution the global population was 814 million (O'Neill, 2024). The economies were primarily agrarian based economies and key energy sources were muscular energy (manual labour and animals) and biomass (primarily firewood) (Wrigley, 2023; Smil, 2004).

PHASE 2. 18th Century Industrial Revolution – a significant shift characterised by a rapid population increase, encroachment of industrial and housing lands onto natural habitats, and the exploitation of new energy sources like steam, coal, and fossil fuels to drive mechanisation of industrial development (Wrigley, 2013; Smil, 2004).

PHASE 3. 1970 – Present: "Zero-Sum Development" – characterised by widespread reliance on extractive industries, leading to elevated levels of greenhouse gases, atmospheric contamination, and rising sea levels (Lindwall, 2022; NOAA, 2021; Shivanna, 2022). This phase witnesses unprecedented environmental degradation, global warming, including irregular weather patterns, biodiversity loss, and the emergence of environmental diseases and pandemics (Lindwall, 2022; NOAA, 2021; Shivanna, 2022; Cahill et al., 2013).

PHASE 4. Environmental Stress on Natural Systems – escalation of environmental stress on natural systems leads to precipitating consequences such as temperature threshold breaches, intensified land, air, and water contamination, extinction of critical biological species responsible for ecosystem stability, resulting in knock-on impacts on food systems, and acidification of marine life. The latter would lead to shortages of food from the oceans. The negative spillover impact on environmental degradation is highlighted in Lindwall, 2022; NOAA, 2021; Krol, 2023; Kemp et al., 2022; Shivanna, 2022; Cahill et al., 2013.

PHASE 5. Ecosystemic Collapse: Uninhabitable Planet – continuing on the same path would subsequently lead to the collapse of the natural ecosystem. Thus, leading to disruptions in the climate, forest, ocean, water, and food systems, along with the collapse of healthcare and economic systems. Such a collapse would cause widespread starvation, water shortages, and conflicts among nations due to shortages of food and water. The consequences would further include a high incidence of mutation of viruses and bacteria, low fertility rates, a rise in non-communicable diseases (NCDs) due to changes in diet and increasing pollutants in the environment (Carneiro, 2022; Segal & Giudice, 2022; Rice et al., 2014; Leddin, 2024). All these factors contribute to premature deaths and escalating welfare and healthcare costs, making the Earth increasingly uninhabitable for biological life.

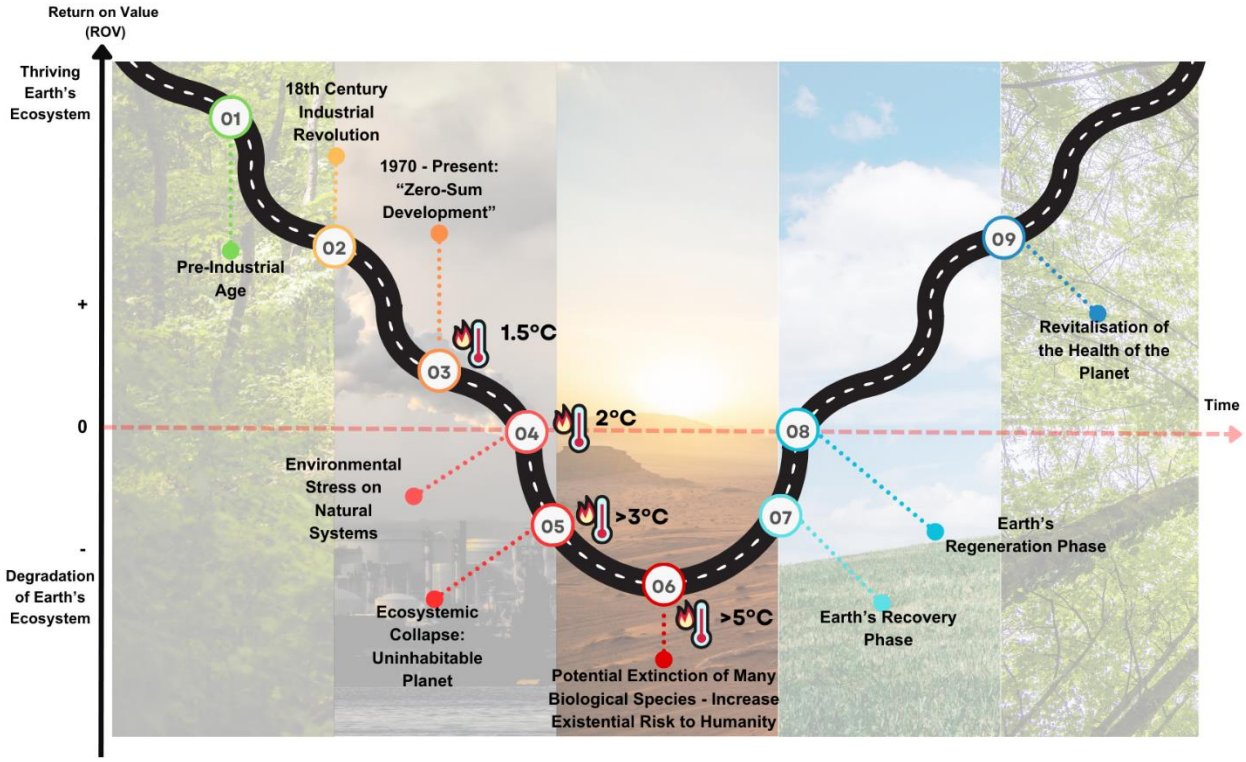
PHASE 6. Potential Extinction of Biological Species – increase existential risk to humanity – some studies assert the potential for the extinction of many biological species is very high. This poses an existential risk to humanity, resulting in food and water shortages, prevalence of infectious diseases, low immunity levels, low fertility rates, and high mortality rates leading to significant reduction in many biological species. Studies show that close to 90% of biological species are in danger of extinction, posing a major existential threat to the human species (Xu & Ramanathan, 2017; Leddin, 2024). Alternative viewpoints emphasise the resilience of human populations amidst substantial challenges and regional upheavals, despite the potential for human extinction and the near collapse of biological ecosystems under extreme climate scenarios (Krol, 2023). Despite divergent assessments, all perspectives underscore the urgent need for comprehensive plans and strategies to mitigate the adverse impacts of climate change and safeguard the health of the planet.

PHASE 7. Earth's Recovery Phase – low fertility rates coupled with high mortality rates will lead to a significant reduction in the human populations, potentially even resulting in human extinction. This drastic decline or extinction of humans would consequently lead to a decrease in industrial and economic activities on Earth. Consequently, the outcomes of this phase could see a reduction of pollution and contamination. This could also result in a decrease in greenhouse gases, reduction in encroachment of the natural habitat by humans, and the recalibration of Earth's natural systems.

PHASE 8. Earth's Regeneration Phase – reduced levels of pollution and greenhouse gases will allow Earth to recover from unchecked industrial development and economic growth. This will lead to improved climatic conditions, the resurgence of biodiversity, and the flourishing of vibrant biological life on Earth.

PHASE 9. Revitalisation of the Health of the Planet – over the long term, Earth's natural systems will revert to their pre-industrial state, characterised by increased green cover and a thriving marine ecosystem.

Figure 19: Dystopian Pathway - "Zero-Sum" Development Model



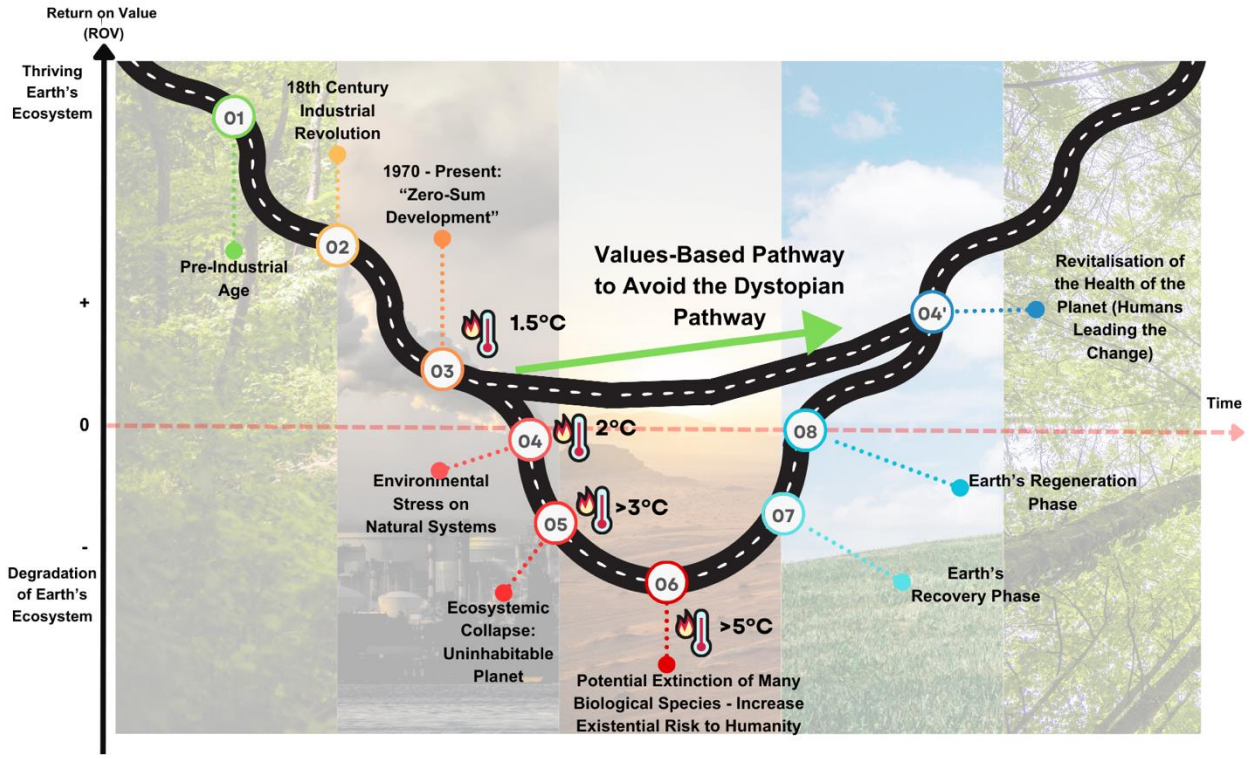
Notes: The temperatures for phases 5 and 6 were adopted from Xu and Ramanathan (2017).

To ensure the sustainable development of the human species, a paradigm shift towards a more values-based development model is needed. This new agenda must take into consideration nature as an important stakeholder in the development agenda. To achieve sustainable development, there is a need to transition from the "Zero-sum Development Model" to a "Values-based Development Model" that gives importance to the following (as summarised in Figure 20):

- All human activities must take into consideration the state of development of the ecosystem enablers (8i dimensions) and alignment of the development to the planetary health mindset (8R-Nature-Centric philosophy);
- Improve and enhance the dynamic capability of all stakeholders in the ecosystem to learn from nature, and create new solutions that will improve the ROV for all stakeholders in the ecosystem – this includes creating environmentally-friendly industries and high-income jobs;
- Development initiatives must transition from capturing ROI for shareholders to ROV for stakeholders; and from corporate profit maximisation to shareholder value optimisation; and,

- Develop clear metrics for measuring the state of ecosystem enablers, dynamic capabilities, and ROV; and continuously track them to ensure sustainability and value creation for the current and future generations.

Figure 20: Planetary Health Pathway - Values-Based Development Model



Notes: The temperatures for phases 5 and 6 were adopted from Xu and Ramanathan (2017).

The discussions in the previous sections have highlighted the strong endogenous relationship between human activities and the health of the planet. Humans through their scientific and technological development over the last three hundred years have transformed their industrial ecosystem and way of life. These changes have resulted in major transformations to the Earth's biophysical and climate systems, adversely impacting the biodiversity of the natural ecosystems, and the health and well-being of all biological species on Earth. This study proposes that to ensure sustainable development of the human species, there is a need to recalibrate the current Zero-Sum economic development that hinges on an ROI-driven model to a more values-based development framework that captures the full ROV for all stakeholders in the ecosystem.

The main stakeholder in the ecosystem is Earth itself. When Earth is healthy and vibrant; it provides all the necessary resources for all biological species (including humans) to thrive and attain a high quality of life. When Earth's biophysical systems are adversely impacted by human activities; it

destabilises the climate, health, economic systems, and value-chains. The complex relationships between the various systems require a more holistic ecosystem approach. In this context, the 8R-8i ecosystem approach provides a systematic way to capture the state of the ecosystem enablers on the dynamic capabilities of all stakeholders and generating greater ROV for the players in the ecosystem. Future research in this area will focus on applying this framework to study biodiversity conservation, marine life ecosystems, the blue economy, and other planetary health development initiatives.

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APPENDIX

Table 1: Spiritual and Planetary Health Values

Schools of Thought	Relationship between the Earth and Man (Anthropocene and Planetary Health Perspectives)	Key Sources
Judaism	The creation of the universe was in the image of God. While human beings are given a pre-eminent role in this creation, they do not have the right to exploit them. *Midrash Ecclesiastes Rabba 7:13* states "*See My creations, how beautiful and exemplary they are. Everything I created, I created for you. Make certain that you do not ruin or destroy My World, as you destroy it, there will be no one after you to mend it. Moreover, you will cause the death to the righteous one*." (Kohelet Rabbah, 7:13)	Tirosh-Samuelson (2001) The Sefaria Midrash Rabbah, 2022
Christianity	Humans must have respect and reverence for Earth and its sentient beings therein. This is clearly stated in the following: "*the Earth is the Lord's and all the fullness thereof, the world and those who dwell therein*." *Psalm 24.1* "*The Earth mourns and withers; the world languishes and withers; the highest people of the Earth languish. The Earth lies defiled under its inhabitants; for they have transgressed the laws, violated the statutes, broken the everlasting covenant. Therefore a curse devours the Earth, and its inhabitants suffer for their guilt; therefore the inhabitants of the Earth are scorched, and few men are left*". *Isaiah 24:4-6*	Mc Fague (2001) (Smith, 2022)

Islam	In Islamic thought, humans are seen as stewards (*Khalifa*) of the natural world. As such, Islam emphasises the environmental care as an important obligation of mankind to ensure ecological balance in all human activities and deliberations. "*He is the One Who has placed you as successors on Earth and elevated some of you in rank over others, so He may test you with what He has given you*." *Surah Al-An'am 6:165* Environmental care is integrated into core Islamic values through Islamic law (*Shariah*) and the *Sunnah* (the spoken words and practices by Prophet Muhammad, PBUH). The care for the Earth and creations therein is prescribed at individual (*fard ain*) and societal (*fard kifaya*) levels. Islamic teaching prohibits excessive use of natural assets provided by the natural world; and the consequences of the exploitation of nature. **"*O children of Adam! … eat and drink: but waste not by excess, for Allah loves not the wasters*."** *Surah Al-A'raf 7:31* "*Corruption has spread on land and sea as a result of what people's hands have done, so that Allah may cause them to taste [the consequences of] some of their deeds and perhaps they might return to the Right Path*." *Surah Al-An'am 30:4*	Haq (2001) Nasir et al. (2021 and 2022) Bsoul et al. (2022) Islam Channel (2022)

Hinduism	Hinduism is anchored on the concept of *Dharma*, which is defined as righteousness, duty, justice, and sustainability. A key feature of the Dharma is the notion of *Ahimsa* – the practice of non-violence or non-injuriousness to nature and other creations within nature. The practice of Ahimsa is congruent with the call for ensuring the biodiversity of the Earth and the conservation efforts of all species on Earth. In many of the Hindu scriptures, the Earth is revered as being a divine goddess with many names - Bhu, Bhumi-Matha (Mother Earth), Prithvi, Vasuda, Vasudhara and Avni, Here is the dialogue between Sri Krishna (the Supreme Lord) and Arjuna (mortal king) who is preparing the battle against injustice and corruption. "*For whatever forms are born of the individual wombs, O Kaunteya (Arjuna), the one great womb is Brahma (in its active aspect, meaning Nature). And I am the Father who casts the seed*." *Bhagavad Gita, Chapter 14, Verse 04.* "*The Asura people (demonic qualities) know not what should be done (dharma) and what should not be done (adharma). Such people have neither cleanliness (outer and inner) nor good conduct. They are not given to truthfulness*". *Bhagavad Gita, Chapter 16, Verse 07* "*Fostering this kind of vision, lost to their own distorted intellect, they emerge as enemies of the world, and take to fierce, violent acts that meant to bring about large-*	Narayanan (2001). Tirtha (2019)

	scale degeneration". ***Bhagavad Gita, Chapter 16, Verse 09***	
Jainism	The Jainism school of thought gives reverence to the sanctity of the various sentient life forms and to mother nature. Mahavira, the twenty-fourth teacher of the Jains, established a way of life for mankind for the attainment of harmonious living and liberation from the vagaries of life in the text called *Acaranga Sutra*. The Acaranga Sutra speaks about the symbiotic relationship between man, the environment, and all other species living on Earth. These rules set in this scripture are anchored on the observance of *Ahimsa* (non-violence of non-injuriousness) to nature and the creations of nature. The notion of Ahimsa includes not disturbing or harming the natural habitat (water, land, and air) of sentient beings and not causing distress to them. Mahavira states that neglect and harm to the Earth and the biological species will lead to severe consequences for mankind. He states that the beauty of the trees should be left in the forests and not as ornaments in man's homes. He warns that the destruction of the forest and the extinction of living beings will also lead to the extinction of man. In this context, Jainism is considered one of the most biodiversity-friendly schools of thought.	Chapple (2001) Mitra (2019)
Sikhism	The main scripture of the Sikh community is the Sri Guru Grand Sahib (SGGS), which emphasise the strong inter-	

	dependent relationship between man and the material world ("Japu Ji"). The teaching sees the importance of human life is conducted in harmony with nature; and that dismisses the notion that human domination of all other creation and nature. This inter-relationship is captured in the SGGS. "*Air, water, Earth and sky are God's home and temple – sacred places which need to be protected and looked after*" SGGS:723 (obtained from Singh, 2010, p.17). The teachings of Sikhism take an integrated approach to planetary health in the context of preservation of Earth's biodiversity, balance of the natural ecosystems, social justice, sustainable development, equity, equality, human and animal rights. The latter include upholding the rights of humans and other biological beings to decent living conditions, quality of life and dignity. For this, human actions must minimise their impact on the Earth's natural ecosystems	Singh (2010 and 2021) Gelaw and Sharma (2019) Prill (2015)
Buddhism	Gautama Buddha revealed to the world the doctrine of *Paticca-Samuppada* (the Law of Dependent Origination or Dependent Co-arising or Interdependence). This doctrine explains the process of repeated existences due to chains of interconnectedness due to laws of karma (cause and effect) powered by unfettered desires and cravings. This Patticca-Samuppada doctrine explains the *Four Noble Truths* about human life. And they are: suffering are part and parcel of life; suffering are a result of human	Swearer (2001 and 2006) Lin (2022)

	cravings; suffering can come to an end; and practicing the Noble Eightfold Path will end all suffering. The *Noble Eightfold Paths* are as follows: correct view; correct intention; correct speech; correct action; correct livelihood; correct effort; correct mindfulness; and correct concentration (Lopez, 2024). The Buddhist environmental ethics rejects the notion of man's dominion over Earth and living beings. It highlights that the exploitation of nature's resources and other living beings to meet unfettered human cravings is the source of sufferings for mankind and other sentient beings. To ensure sustainable living, the Noble Eightfold Path highlights the importance of understanding the relationship between man and nature. And, putting in place nature-centric human development agenda that hinges on the values of respect for nature and all creations in nature; moderation, restraint, non-violence (Ahimsa), compassion, and generosity.	
Confucianism	Confucianism contributes to planetary health discourse based on the doctrine of *Ren-Ben-Zhu* (Humanism) *Tian-ren-heyi* (Unity of Heaven and Humanity). There are three schools of thought that have been identified – they include the traditional Confucianism, New Confucianism and Neo Confucianism schools of thought. The schools of thought are predicated on the doctrine of *Dahua* (Great Transformation), where humans are seen as integral to nature, instead of humans dominating and exploiting nature.	Weiming (2001) Xu et al. (2019) Li et al. (2022)

	In this context, forces of nature are regarded as harmoniously weaving across lands, seas, air, all sentient beings, and everything in nature. These forces of production and reproduction are the source of vitalism and dynamism of life on Earth. Core to a vibrant and thriving human life is the attainment of individual, family, and community harmony. To achieve this harmony, scholars of this school of thought opine that the vitality of the natural system must be respected and preserved. This is critical for sustainability of the Earth, and all sentient species, including mankind.	
Daoism	This School of thought's principle is based on the *Dao* (Nature's Way) of harmonious living. In this context, all sentient beings are inextricably tied to the natural environment. It is said the serene and pristine places in nature are resided by deities; hence, these places needed to be respected and protected. Any changes to the environment and climate will impact the sanctity of these divine abodes, all biological species on Earth, and the human species. The Daoist School of Thought called *Shangqing* (Highest Clarity) uses the theory of inter-relationships between the energy systems in the macrocosm (the natural world) and microcosm (human body). The human body is seen as a network of energy systems called *Qi* (also known as vital energy). There are two subsystems called the: *Yin* systems (stores potential energy for maintaining dynamic homeostasis in the biological entity); and *Yang* systems	Miller (2001) Schonfeld and Chen (2019)

	the utilisation of the stored energy. The concept of Qi (the flow of Yin-Yang) is used widely in Chinese medicine to ascertain the health of the human body. It is believed the Qi (Yin-Yang systems) in the biological systems are strongly connected to the macrocosmic environmental systems. Any degradation of the environmental conditions will adversely impact the Qi (the flow of Yin-Yang systems) in all biological and human health.	
Indigenous Population (Native Americans)	This school of thought is regarded as “Animism,” where everything in the universe (animate, inanimate, and natural) has a living soul. The Earth, rivers, the Sun, the moon, and other natural elements are regarded as living beings and sacred. There is a strong kinship between the natural elements, the ancestors, the family, and all living beings. They regard the Earth and the natural elements therein as Parents and Grandparents. Hence, they all should be treated as sacred and with great respect and care. This is clearly articulated by one of the native writers Black Elk (1953) on the divine relationship between man and nature. In his book, he narrates a story from the Lakota tribe, who was visited by the White Buffalo Calf Woman (Wakan/holy woman) with gifts of a sacred pipe; a round rock and a message from Wakan-Tanka (The Great Spirit). The message is as follows (Black Elk, 1953, pages 6 and 7):	Forbes (2001) Deer, Fire and Erdoes (1972) Elk (1953)

	"*Earth is your grandmother and mother, and She is sacred. Every step that is taken upon Her should be a prayer. … All these peoples, and all the things in the universe, are joined to you … all send their voices to Wakan-Tanka, the Great Spirit. … It is the Earth, your Grandmother and Mother, and it is where you will live and increase. All this is sacred and so do not forget*!" "*Every dawn as it comes is a holy event, and every day is holy, for the light comes from your Father Wakan-Tanka; and also you must remember that the two-leggeds and all other peoples who stand upon this Earth are sacred and should be treated as such.*" The native communities also recognises the symbiotic relationship between man and the Earth; and warns that any harm to the Earth will have an adverse impact on human life too. This is clearly articulated by the 20th Century Lakota Holyman, John Fire Lame Deer: "…*being a living part of the Earth, we cannot harm any part of her without hurting ourselves*" (Lame, Fire and Erdoes, 1972, p265-266, obtained from Forbes, 2001, p.284)	

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