Chapter

Evolving a Sustainable Paradigm for Harnessing Intellectual Resources in the Nigerian Space Industry

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Abstract

Over the years, one of the ways that have been identified as pivotal in building sustainable organisations is the manpower development component of any organisation. Such manpower development through capacity building can be gained by training and retraining to retool the workforce into having the relevant and up to date skill set that spurs competitiveness and growth. For the Nigerian space industry, this human capacity development component has been embraced, encouraged and adopted into a working model for sustainability. The Nigerian Space Industry has leveraged on its potential to harness its intellectual capital through a collaborative culture with national and international partners to provide sustainable growth in attaining technological competence in Space Science and Technology (SST). In this chapter, we present a capacity building context as a model by which Nigeria's Space Industry mobilises its intellectual resources and collaborative efforts towards achieving sustainable development.

Keywords: sustainable organisations, collaboration, capacity building, sustainable development

1. Introduction

1.1 Sustainability

Sustainability is a system level property which describes the ability of a system to operate in its present state indefinitely [1]. In answer to the question "what is to be sustained - consumption, income levels or the ecosystem"? Chopra and Kadekodi, [2], state that eco-fundamentalist will solicit for resource sustainability, which will eventually force the acceptance of a level of well-being that will ensure sustainability. The ideal situation that may ensure sustainability will be a judicious balance between meeting the needs and expectations of this generation without endangering the environment or the ability to meet the needs of future generations [3]. Such an approach assumes that the society has a coping mechanism for any unforeseen

challenges that may severely inhibit resource requirements. These challenges therefore ensure sustainability not just in the use of resources but of improvement in the resource base so that future challenges are tackled with ease. The capacity to achieve this depends on the ability to monitor and assess resource requirements and effectively respond without undue environmental or social restrain [3]. It lays emphasis on the long-term aspect of the concept of sustainability, introducing the ethical principle of achieving equity between the present and future generations [4].

The term sustainability is a concept that evokes diverse viewpoints that continue to be debated on. However, these different views raise a fundamental question – what is to be sustained and how can organisations implement it? To maintain a broad domain for discussion there is a necessity to describe the concept.

The concept of sustainability is therefore treated in this paper as a target or end result of a process called 'Sustainable Development'.

Luqmani [1] defines sustainable development as "a global development paradigm describing human, social and economic transformations which contribute to an enlargement of people's choices to lead a long, healthy life, are able to be maintained, supported and intensified indefinitely for current and future generations".

Diesendorf [4] proposes that a broad definition of sustainability should convey three principal components explicitly – social, ecological and economic. A socially sustainable system is one that achieves fairness in opportunity, distribution and adequate provision of social services; an ecologically sustainable system maintains a stable resource base avoiding over exploitation of renewable resource systems and depletion of non –renewable systems without investment in adequate substitutes; an economically sustainable system is one that maintains and augments its different kinds of capital for continual economic production of goods and services.

1.2 Intellectual capacity

Capital theory distinguished human capital only in the last 50 years, although there has been interest since the 17th century [5]. From 1900, knowledge as a means of production was no longer contestable, therefore predicating the statement made by Charles Hardy, "*Karl Marx would be amused. He longed for the day when the workers would own the means of production. Now they do*" [5]. According to Bontis [6], intellectual capital (IC) encompasses all intangible assets of an organisation, including its operations, innovation capability, as well as the tacit knowledge possessed by its employees and their network partners. Cavicchi [7], refers to IC as knowledge that can be transformed to value. It covers the competitive assets of creativity and innovation-based development. Serrat [5], proposes that IC has become the one indispensable asset of organisations; he defined management of the three components of IC as the essence of business; as follows:

Human Capital: the cumulative capabilities and engagement of an organisation's personnel, rooted in tacit and explicit knowledge, that can be invested to serve the joint purpose; Relationship Capital: This refers to the organisation's formal and informal relationships with suppliers, customers and partners to co-create products and services, expressed in terms of width (coverage), channels (distribution), depth (penetration), and attachment (loyalty); and Structural Capital: these are the collective capabilities of an organisation including its governance, values, culture and management.

IC embodies the imperative assets of an organisation critical for long term value creation which is necessary for sustainability, sustainable growth and competitiveness. In today's highly dynamic and competitive world, IC offers organisations and

countries a sustainable competitive advantage through utilisation of technology and IC management to create value and spur innovation.

1.3 Overview of the Nigerian space industry

The National Space Research and Development Agency (NASRDA) Act, 2010 is Nigeria's primary law regulating the operation of space related activities. The Act set up the National Space Research and Development Agency and the National Space Council which is the country's highest policy-making body for space science and technology development [8].

NASRDA is a major player in Africa's space development. With a total of five (5) satellites launched between 2003 and 2012, the nation has established sustainable national growth and demonstrated peaceful utilisation of outer space by economic, educational, humanitarian and governmental applications [9]. The three remote sensing satellites; NigeriaSat-1, NigeriaSat-X and NigeriaSat-2 and two communications satellites; NIGCOMSAT-1 and NIGCOMSAT-1R highlighted the status of space operations and adhered to globally agreed practice of the peaceful use of outer space treaty [10].

As a testament to the competence of the highly trained scientists and engineers who make up the nation's space programme, NigeriaSat-1 was the first satellite to send back images of the Hurricane Katrina in the east coast of the US in 2005. Joining other nations in space operations; the Nigerian Earth Observation satellites are part of the Surrey Satellite Technology Limited (SSTL)–coordinated Disaster Monitoring Constellation (DMC). This network of satellites includes spacecrafts from Algeria, China, Spain, Turkey, and the UK, they provide rapid imagery from space when environmental disasters occur [10, 11].

NigeriaEduSat-1 is a part of BIRDS-1 constellation of five cubesats with membership of the following countries: Japan, Nigeria, Ghana, Mongolia, Bangladesh and Thailand (5). The Nanosat project was launched on June 3, 2017 aboard SpaceX rocket at Cape Canaveral, Florida, USA and deployed in orbit on July 7, 2017 at the International Space Station (ISS) [12, 13].

NIGCOMSAT-1 and NIGCOMSAT-1R have been used for tele-medicine, teleconferencing, data transfer, internet services, e-library etc. [10].

NASRDA is made up of seven (7) activity centres to implement research and development programmes and foster local and international collaboration in order to provide solutions for sustainable national socio-economic development and help achieve the Sustainable Development Goals (SDGs) [10].

One of the mandates of the Nigerian Space Agency, through its centres, is to strengthen capacity building and human resources development in the various specialisations that can be found in the entire space sector value chain. This is in line with NASRDA's 2030 road map – to develop and launch a satellite locally – encouraging capacity building and strengthening the Agency's intellectual resources [8].

Since inception, NASRDA has focused on intellectual capital, training engineers and scientists in all areas of satellite technology in Know How Transfer Training (KHTT) programmes in UK, China and Ukraine. NASRDA has also recorded training of over a hundred and twenty staff (120) at Masters Level and over seventy (70) staff at PhD level [10, 14].

Continuous research and development through capacity building and sustained funding will be a veritable asset and resource towards placing the Nigerian space journey on surer footing for sustainability. In this paper, we review and share our operational experiences and present a collaborative context as a model by which

Nigeria's Space Industry mobilises its intellectual resources and collaborative efforts towards achieving sustainable development.

2. The evolution of sustainability models

The work of the Club of Rome and The Limits to Growth in 1972 is a good starting point in the evolution of sustainability models [15]. Its central proposition is humanity's waking up to the limits of its natural environment and the negative impacts that population and its "development" have been having on it [16]. This concept missed out the dynamic potential for technology development and resource discovery which was unimaginable at the time. It is evident now however that the transformative and disruptive potential of technology is crucial to meeting our sustainability and development goals [17].

A powerful first step towards the modern concept of sustainability was the Stockholm Declaration (1972) [18]. It describes key environmental goals as connected to economic development drivers and the integrated nature of the solution path it describes. It's concept of sustainability ticked most of the boxes from a broad and holistic viewpoint but considerably underestimated the effects of technology and the associated effects of how changing economic markets, policy and culture drives beneficial technologies. A considerable part of the Stockholm Declaration's understanding of the main challenges of economic production, development and consumption to achieving sustainability, access to technology and the need to bridge gaps of cooperation and financial resources for a more global implementation of sustainable solutions is included in the framework of the Brundtland Report [19]. It roughly provided steps for transition on a large scale to a low- carbon global economy and how industries could efficiently "produce more for less" by deploying and developing new technologies.

A natural extension of the Brundtland *Report* was the Triple Bottom Line Framework. It powerfully describes sustainability's primary objectives and potential [20]. It highlighted significantly some of the key relationships between cultural, social and economic institutions in relation to environmental goals; bringing us to the realisation that we need more, not less intelligent, analytical thinking about economics and markets, if we are to achieve global sustainability.

Climate Change was the bolt from the blue that changed the focus and discussion on global sustainability. While the scientific research and evidence regarding anthropogenic climate change had been growing since the 1960s [21], the first Intergovernmental Panel on Climate Change (IPCC) [22] impact assessment report marked the beginning of a much broader and significant outlook on climate change and highlighted exactly how interdisciplinary and integrated our efforts would need to become.

In the early to mid-1990s, Michael Porter and Stephan Schmidheiny opened us up to the possibility that sustainable development was not just a cost but an opportunity for business, and therefore a necessity for modern business strategy. Schmidheiny [23] in *Changing Course*, spoke in broader strategic terms, which certainly was a precursor to Creating Shared Value (CSV), another more modern strategic sustainability paradigm [24].

A major milestone was the notion that major stakeholders could actually transform the paradigm and playing field through economic markets. It was no longer economy versus environment, but the potential that business and economic market development would no longer be a liability to sustainability, but could become one of its most powerful drivers and foundations.

A positive reaction to the Brundtland Report in the early 1990s was the creation of the World Business Council for Sustainable Development (WBCSD), and the 1992 United Nations Conference on Environment and Development (UNCED), also known as the Rio Earth Summit, which certainly changed the dynamics in favour of implementing sustainability solutions that are fully integrated, involve all stakeholders working cooperatively, engage economic markets and incentive systems, on a global scale. WBCSD's comprehensive corporate representation and membership, is as significant as the perspectives it develops and endorses. In terms of models, WBCSD's Circular Economy projects are an evolution from earlier versions of the factor approaches at the Wuppertal Institute in Germany [25]. Without dismissing the relevance of Environmental, Social and Governance (ESG) standards or Socially Responsible Investing (SRI) criteria developed and earnestly utilised in the early 2000s, these rather general guidelines have significantly repackaged the triple bottom line approach [26]. However, on the other hand, the general ideas and flexible roadmaps of the ESG's may help trigger changes in thinking and practices of the financial sector's process, which have always been somewhat conservative [18].

More recently the evolution of sustainability approaches and thinking is influenced greatly by urbanisation- rapid global urbanisation, a fact that will have major impact on how most people live, and with big implications and opportunities for sustainable economic development.

In the twenty-first century, Creating Shared Value (CSV) takes a fully modern and proactive approach with market actors and corporations creating positive, sustainability opportunities, social impacts and new green markets consistent with long-term profitability and survival strategies [24].

The UN's Sustainable Development Goals (SDGs) are a set of universal objectives developed within a process that included government, the private sector, academia, and civil society [27]. The SDGs are now without question the leading organisational and planning prototype across many sectors and projects, and one supported in a complementary manner by the more solutions-oriented focus of the three pillars of sustainability framework [18]. The three pillars of sustainability framework are based upon the key and connected roles of: technology and innovation; laws and governance; economics and financial incentives [28].

The Brundtland's Report defines sustainable development as *"development that meets the need of the present without compromising the ability of future generations to meet their own needs. It is in essence a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are in harmony and enhance both current and future potential to meet human needs and aspirations"* [29].

Diesendorf [4] states that the ecological and social equity are primary of the tripartite components of sustainability. He believes that any social or economic development is sustainable, if it protects and enhances the environmental and social equity. His definition is: *"Sustainable development comprises types of economic and social development which protect and enhance the natural environment and social equity"* [4].

Social equity here is used as a sense of equal opportunity for all rather than equality.

Development here may or may not involve economic growth, its focus is on 'qualitative improvement of human well-being' or 'unleashing of human potential' as opposed to quantitative growth in economic activity.

The significance of the ecological aspect of sustainability follows from the fact that the society and economy depend ultimately on the integrity of the biosphere and ecological processes within it. Unfortunately, a vast majority of humans are oblivious of their impact on their life support system. Scientists and scholars over

the last four decades have written extensively about these adverse effects of human beings and their activities on the environment [11, 30, 31] and large groups of eminent scientists [32].

A synopsis of the evolutionary trends identified and discussed Club of Rome, the first documented effort to identify the need for sustainability models; Stockholm Declaration was the first real attempt at understanding the linkages between environmental goals and economic development. The Triple Bottom Line Framework clearly identified the key objectives needed for setting sound sustainability models while IPCC traced the deleterious impacts of climate change to more of anthropogenic factors and recommended an integrated and interdisciplinary effort to tackle the causes and effects of climate change. Michael Porter and Stephan Schmidheiny advocated that the environment wasn't a hindrance to economic growth and development but benefitted from new economic models which utilised technology to its advantage and preservation. The CSV unique in its total embrace of the identification of symbiotic linkages between economy and ecology was designed to lessen the possibility of disenchantment and disillusionment with economic growth and wealth distribution.

Evolutionary trends in the development of the outlined sustainability models are mostly underpinned by the need to create a world that is in harmony with the competing needs and demands of production and consumption. As with all measures to satisfy the needs of mankind, inevitable constraints and drawbacks can arise in the form of disenchantment or disillusionment occasioned by inequalities stemming from the resulting imbalances in earths' ecosystem caused by man's cultural, social and economic practices and activities. These facts have been instrumental in the search and development of sustainability models at different times and by different individuals or groups.

3. Existing sustainability models

There exist various sustainability models, developed and or adopted by organisations and institutions. In this section, we have selected an independent and two organisational sustainability models for review.

3.1 Diesendorf's model of sustainability

This model of sustainability and sustainable development explicitly sets out the underlying ethical assumptions, measurable objectives (sustainability indicators), broad goals and actions measured for implantation, integrating the ecological, social and economic aspects without requiring trade-offs. It makes the ecological aspect a constraint on economic and social development types. It offers both a comprehensive theoretical framework and a six-step implementation action plan. This action plan involves facilitating community participation and empowerment to create a vision, develop sustainability policy and implement Ecological Sustainable Development (ESD) by changing the system [33] (**Figure 1**; **Table 1**).

The model has four logical levels:

- Level 0, comprising the broad ethical principles
- Level 1, comprising broad goals arising from these principles
- Level 2, comprising measurable objectives and indicators
- Level 3, comprising the action plan for implementation of Ecological Sustainable Development (ESD)

The sustainability model illustrated below answers the fundamental question: "What is the scope of sustainability and how can we present it in a systematic way, making distinctions between ethical principles, broad goals and objectives which are measurable and actionable. This is illustrated in Levels 0–2. Level 3 is the six-step systematic implementation process itemised below.

Sustainability indicators or measurable objectives are necessary for monitoring progress and motivating action. These indicators however do not produce good policies or implementable actions in themselves. To create appropriate indicators, one must ask the question "What behaviour am I seeking?" to develop policy and then create indicators to serve the policy [33].

The Diesendorf model's systematic process of implementation and assessing progress is a six – step plan which utilises the combined approach drawing the most appropriate components from the Ottawa Charter and the Bellagio Principles [4] as follows:

- Present a guiding vision, goals and scenario
- Develop sustainability policy in all sectors, at all levels, with all types of instrument

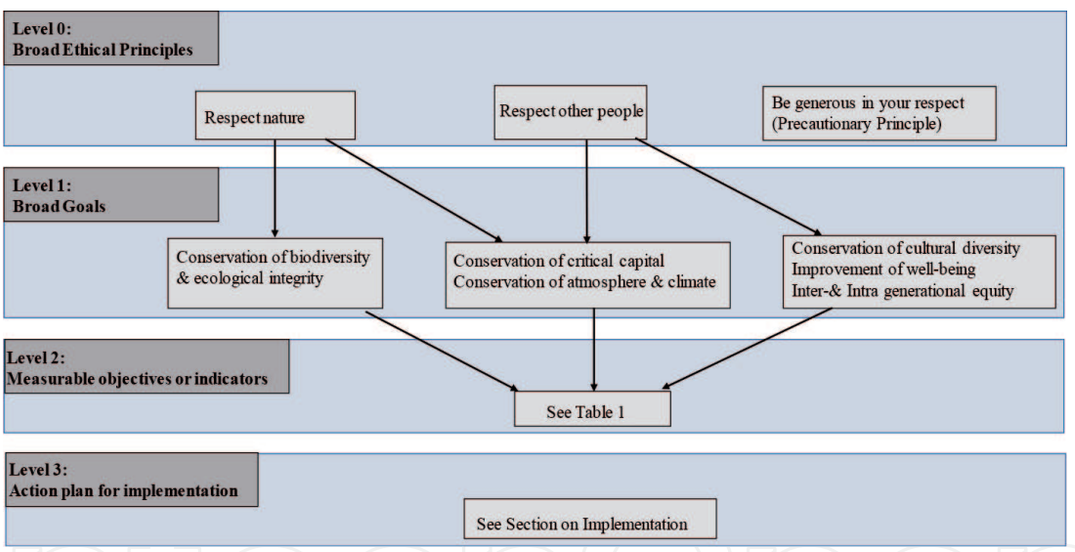

Figure 1.
Sustainability model or framework [33].

Ecological	Economic	Social
Rate of materials 'flow; Rate of energy use; Total and per capita rate of greenhouse gas emissions; Vehicle kilometres travelled per capita; Human population and growth rate; Area of land degraded and polluted; Water pollution; Air pollution.	'Genuine Progress Indicator'; Distribution of household and personal income; Percent of income needed to pay for basic 'needs' of a person; Percent of children living in households with no adult earner; Mortgage repayments and rents relative to median income in region; Employment by top five companies in the region.	Basic services within walking and cycling distances of dwellings; Availability of day care for under 5 s Levels of education, including literacy and numeracy; Life expectancies at birth and at age 20; Morbidity rates; Crime rates; Homelessness; Teaching of indigenous languages in schools.

Table 1.
Examples of some measurable objectives [4].

- Create supportive environment
- Strengthen community action
- Develop personal and organisational skills
- Reorient the system

3.2 The natural step

3.2.1 Organisation background

The Natural Step (TNS) is a non-profit, non-governmental, environmental organisation dedicated to achieving ecological, social and economic sustainability; opening and maintaining communication pathways between stakeholders; and building consensus. Founded in 1989 by Dr. Karl-Henrik Robert, a Swedish cancer physician and scientist with a keen interest in nature. In the course of his work Dr. Roberts was touched by the compassion and resources that were mobilised by families, society and caregivers in response to children with cancer at his clinic. He found their approach swift, comprehensive and co-ordinated, an absolute contrast to the commotion between government, businesses and environmental movements over our rapidly deteriorating planet. Dr. Robert soon realised that the crux of the matter was that environmental debates were focused sparingly on systemic causes of problems and more on downstream issues. The solution required a holistic approach, a new way of looking upstream to understand the underlying systemic causes and walk away from them. Dr. Roberts then decided to find a comprehensive, rigorous and concrete way to tackle these systemic causes; working with more than 50 Swedish scientists, they developed a consensus document that was adopted by the Swedish government. The document described the basic functions of the biosphere, how societies influence the natural system, how humans are a part of the natural systems, how humans threaten themselves by degrading natural systems and functions and lastly how there are great opportunities to change the situation into an attractive sustainable society [34] (**Figure 2**).

Dr. Robert has since then worked with an increasing number of international scientists to develop a framework or model for strategic decision making, enabling a systematic step by step approach towards sustainability while reducing risk and promoting design and innovative decisions in government and business. This framework is the intellectual foundation of The Natural Step. Several major Swedish companies like IKEA and Electrolux have incorporated this framework into their business practices. The TNS framework has gained grounds internationally, recognising the unique challenges businesses and governments face locally, TNS decided to licence the framework to local non for-profit partners while TNS International is steward of the framework. The organisation is established in the US, UK, New Zealand, Australia, Israel, Canada, Japan, Brazil, South Africa, France and Italy.

3.2.2 TNS sustainability model

The Natural Step sustainability model or framework is embedded in four system conditions which have slightly evolved through the 1990s. The rationale

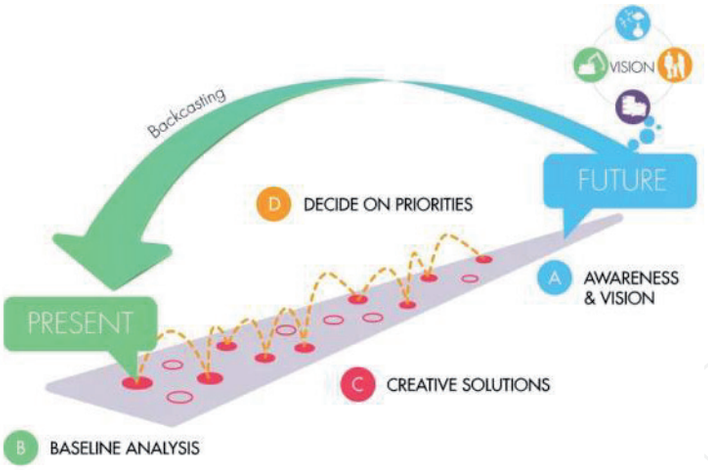

Figure 2.
The ABCD process [36].

behind the system conditions is that since the number of possible designs of sustainable societies is probably without limit, the definition must be principle based such that any sustainable society would be able to adopt such principles [4]. The system conditions are stated as not allowing the destruction of the ecosphere:

"*In order for society to be sustainable, nature's functions and diversity are not subject to systemically increasing:*

- *concentrations of substances extracted from the earth's crust*
- *concentrations of substances produced by society*
- *impoverishment by overharvesting or other forms of ecosystem manipulation*

Together these first three conditions provide a framework for ecological sustainability, implying a set of constraints within which the sustainable societal activities must be incorporated. It is on this basis that a first order principle for the society's internal turnover of resources is formulated as follows:

- *resources are used fairly and efficiently in other to meet basic human needs worldwide*" [35].

3.2.3 TNS implementation strategy

TNS Implementation Strategy enables the application of the system conditions to an organisation's daily operations and implementing sustainability through the ABCD process.

These principles are at the core of TNS sustainability framework and aim at the efficient and fair utilisation of resources; the substitution of rare and toxic materials for environmentally friendly and abundant materials; developing new technologies and protecting ecosystems. TNS model offers a strong focus on businesses and governments in the control of flow of materials released into the environment by humans and human activities, thus it establishes a structure for the creation of measurable indicators in the area of ecological sustainability for decision making; it is limiting however, in its treatment of the social and economic aspect of sustainability [4].

3.3 Interface

3.3.1 Company background

Interface, an innovative company founded in 1973 by Ray Anderson, with radical sustainability goals is a global manufacturer of modular carpet tiles with an annual revenue of approximately $1bn. Boasting a sizable employee base and expansive geographical spread and manufacturing operations in North America, Europe and Asia-Pacific; Interface has been recognised as the pioneer of sustainable business practices in the carpet and flooring industry and one of the global leaders particularly in the area of sustainability, for more than 10 years.

3.3.2 Interface sustainability oriented innovation (SOI) model

Interface SOI model posits that, innovation is critical for long term business; successful innovation promotes growth, profit and access to new markets. SOI, a term first used by Hansen *et al.* [37] to describe innovation that produces improved sustainability. *"SOI is the production, assimilation or exploitation of a product, process, service, method, structure or social institution that is novel in its application, and which improves economic, environmental and social outcomes throughout the life cycle of the application, compared to relevant alternatives"* [38]. Discussions bordering on SOI are a bit complicated in literature as it is defined in several different ways [39]. Eco-innovation is debated as a related concept. Another area of debate is intent; Kemp and Pearson [40] and Machiba [41] discuss whether improvements that are financially driven and lead to environmental and social well- being as a by-product can be considered SOI. Innovation can be classified as incremental (minor or radical) e.g. minor efficient improvements or dramatically increased performance or reduced cost [42]. Bessant and Tidd [43] suggest that radical innovations sometimes result in entirely new products or markets; these may be classified as disruptive or discontinuous. However, Machiba [41] suggests that the most radical forms of SOI lead to a fundamental change in the business model and the wider system. Hansen *et al*. [37] defined SOI as innovation with a positive net effect on the overall capital stock. A well-rounded definition of SOI should achieve several criteria - encompass new ideas, production of ideas from internal sources and assimilation of ideas from external sources [40]. It should include old ideas that have found a new purpose and describe a full range of innovation products (incremental, radical and or disruptive) [43]. To ensure sustainability, the definition of SOI should describe innovations that result in improvement of the environmental, social and financial outcome or those that reduce the negative impact on these outcomes in comparison with other options.

Interface implements SOI with its co-innovation and other related innovation processes to achieve the company's ambitious environmental goals. Co-innovation is a global process within Interface designed to accelerate and systematise innovation projects within the company towards its Mission Zero Goals [38]. Interface's environmental programme is called Mission Zero, illustrated in **Table 2** with its sub goals.

Mission Zero, a priority objective for the company and the company's reputation as a leader in sustainability are its key market differentiators that endear its customers especially the architectural and design community [44].

Interface through innovative activities between 1994 to 2014 was able to cut waste, reduce greenhouse emissions and reliance on fossil-derived energy a remarkable progress towards goals 1, 2,3 and 5 which formed the basis of their claim of a "cumulative sum of $480m savings and avoided costs since 1994" [1]. The Mission

Mission Zero Goals	Goal Description
1. Eliminate Waste	Eliminating waste in all forms- material waste, wasted time and wasted effort
2. Benign Emissions	Eliminating waste streams that have negative or toxic effects on natural systems
3. Renewable Energy	Reducing energy demand and substituting fossil fuels with renewable ones
4. Closing the Loop	Redesigning processes and products so that all resources can be recovered at the end of life and reused, closing the technical and natural loop
5. Resource Efficient Transport	Transporting people with minimal waste and emissions. This includes consideration of plant location, logistics and commuting
6. Sensitising Stakeholders	Creating a community within and around Interface that understands the functioning of natural systems and our impact on them
7. Redesign Commerce	Redesigning commerce to focus on delivery of service and value instead of material
	Encouraging external organisations to create policies and market incentives

Table 2.
Mission zero goals and Interface description [38].

zero goals 4, 6 and 7 were achieved through various standalone innovation projects and research and development activities; the use of the principle of biomimicry [45] to develop a non-directional carpet tile with good material saving properties and strong aesthetics. This design brought about an affinity towards non directional tiles in the industry [46]. The company made commendable progress with Mission goal 4 in 2013 as it launched its first product line with post-consumer recycled nylon; they partnered with Universal Fibres [47] using a novel process. Net-works, a socially-oriented recycling programme which progressed goal 7 significantly and less so goals 1, 4 and 6.

InterfaceRAISE was an attempt in 2011 to create a consultancy arm that leveraged on the company's global sustainability leadership to deliver on its promise of becoming a restorative enterprise in line with its Mission goal 7; and FairWorks, initiated by the co-innovation team in 2008 attempted to create a tangible social benefitting product that used local skilled artisans in India to weave handmade products from grass [48] providing them access to the global market through an inclusive business model. It made no market impact and failed after 4 years due to high cost, lack of scale, variable quality and poor integration into the company's core product range.

3.4 Interface net-works

Fairworks failure between 2011 and 2012 led the co-innovation team to seek the use of their existing core product range to address the social dimension of sustainability. Interface's European Sustainability Director met Hill a researcher from Imperial College who had recently completed his PhD in livelihood approaches to marine conservation at the Zoological Society of London (ZSL) at a conference and made a connection between his work and the Aquafil recycling technology (ECONYL). Aquafil, a fibre manufacturer and yarn supplier to Interface at the time launched ECONYL to convert postconsumer nylon waste mainly from the fishing industry into premium quality recycled yarn.

Interface launched Net-Works in 2013 a disruptive, cross-sector, ongoing partnership between Interface, Aquafil and ZSL. The core concept was to partner with fishing communities to recover discarded fishing nets in the Philippines through an "inclusive business" social enterprise model using ECONYL to recycle the waste

into high quality nylon to be used in manufactured goods and integrate them into part of the Interface core product range such as yarn for their carpet tiles. Net-Works has had significant impact and gained unexpected global recognition for its sustainability component. Networks' prominent characteristic is its integrated and tangible approach to addressing, social, economic and environmental sustainability. Socially, Net-Works is self–supporting and integrates with the existing livelihood of the community based partners. Economically, it has been a powerful, differentiation tool that has resonated with customers; at a local level it has benefitted the partnering communities as a steady source of supplementary income. Environmentally, it has reduced pollution and improved local marine stocks and biodiversity at the partnering sites and created awareness of waste and recycling among the partnering communities [38], on a wider scale, it has lowered CO_2 emissions per kilogramme [49]. Currently, Net-works is its own organisation supported by the original project partners with the primary objective of creating a social enterprise model which could be adapted to other contexts, inspiring similar activities by other companies.

3.5 Comparison of sustainability models

This section compares and presents a process classification of the three sustainability models discussed above. Time related criterion forecasts the state of sustainability; place related criterion models the state of sustainability with respect to their spatial scale and or localisation while scale related criterion models sustainability of systems according to composition and structure [16] (**Table 3**).

Drawing inference from the three sustainability models compared above, it can be observed that the models share similar indices, therefore, the three aspects of sustainability: ecology, social and economic are adopted as specific metrics, to further analyse the various points of departure of one model from the other.

The first two models are ecologically centric, however, while Dissendorf's model proposes that social and economic development is sustainable if it protects and enhances ecological development; the TNS model seeks to address the role of businesses and governments in the control of materials from human beings and their activities into the environment and create measurable indicators for decision making in the area of ecological sustainability.

The Interface model places greater emphasis on the social aspect of sustainability through a shared network system of collaboration, assistance and biodiversity management. It creates a veritable platform of contributory efforts that lead to sustainable and inclusive outcomes for all.

In summary therefore, it has been established that all three models place particular importance to varying degrees on an aspect of sustainability. Overall, what is sought after are model types that have capacity to present the co-evolution of the global system and charge humanity to realise and fulfil its stewardship obligation as sustainability Guardians. These models can be described as "Dynamic, Global and General" [16].

Sustainability Model	*Time Related*		*Place Related*		*Scale Related*	
	Static	*Dynamic*	*Global*	*Regional*	*General*	*Specific*
Diesendorf		√	√	√	√	√
The Natural Step		√	√	√	√	√
Interface		√	√	√	√	√

Table 3.
Process classification of the reviewed sustainability models.

4. Research design

4.1 Method

This research uses a descriptive case study paradigm in order to analyse NASRDA's sustainability capacity building process and context, while being guided by literature. The case study method was adopted for its suitability to address the key questions of "How" and "Why". It has been established that a case study research methodology approach provides a rich contextual analysis of the unit of study, at a level of qualitative detail which can be obtained using quantitative or experimental methodologies [50].

In this instance, the research examines "how and why NASRDA implements its own sustainability capacity building process", in view of extenuating circumstances and peculiar environmental factors. This is done with the ultimate aim of highlighting how these all come together and intervene to form a generalised view and central idea of its core processes and systems that have kept it going for more than twenty years. The unit or analytical baseline selected is the human capacity development model that ties the individual staff skills and knowledge base with the organisational core strengths, competencies and projected or forecasted goals.

To expatiate on the peculiarities of NASRDA's model, a multi-entity study is proposed and adopted for this work. Such multi-dimensional approach is to serve as a foundation for generalisations in claims and conclusions which can be broadly adopted and further improved upon as per our recommendations and contributions by others. Overall, the human capacity building approach as a component in engendering sustainable organisations is proposed in this work drawing from the inherent experience of NASRDA as a holistic whole.

4.2 Data collection

Most of the data used for this work was drawn from literature as the case study approach earlier mentioned in Section 4.1 bears out. This work has drawn from the long and varied experiences of different governmental and non-governmental actors working at regional and global levels to present a case for the utility of a mixed CCT-RBV model that is human capacity development centric in its central theme, ethos and workings.

Strength: 1. Human capital 2. Collaboration and linkages 3. Space and ground assets 4. Service and product regulation	Weaknesses: 1. Inadequate working facilities 2. Inadequate funding 3. Low products and or service sensitization and awareness 4. Accountability and transparency
Opportunities: 1. Rising global space market 2. Space based solutions and innovation for socio-economic development 3. Private sector participation in space technology	Threats: 1. Declined Government funding 2. Public sector/ individual interest 3. Insurgency 4. Brain drain and loss of competent hands

Table 4.
SWOT analysis.

4.3 The NARSDA SWOT analysis

This section presents a SWOT analysis, a strategic tool to review and evaluate the Nigerian Space Industry's internal and external environment reflecting specifically on its organisational strengths and opportunities that reinforce the development of future strategic options and its weaknesses and threats which can be further developed for sustainability. This analysis will aid the development of an effective sustainable model by identifying critical areas to leverage on and develop within the organisation (**Table 4**).

5. The NASRDA sustainability model

Organisations adopt and implement sustainable models based on peculiarities in their operations and unique set of challenges faced. At NASRDA, we have implemented a sustainable capacity building approach with technology transfer as its starting point. As noted by [51], the best measure of development by any nation is the quality of products and services produced by its people. Therefore, capacity building through quality formal education and other capacity building mechanisms provides the needed solution for a sustained growth in our nascent space industry.

NASRDA has over the years adopted the concept of Core Competence Theory (CCT) and Resource-Based View (RBV) theory. CCT was first developed in 1990 by Garry Hamel and C. K Prahalad while RBV was developed by E.T. Penrose in 1959 [52]. Core competency can be defined as a unique capability acquired by a firm over a period of time in form of a resource, operations facility, specially skilled manpower, technology know-how or delivery of service which gives the firm sustainable competitive advantage in the future, in quality, design, production or distribution of a product/service or in cost of the product and is viewed as a relative value addition by a prospective customer"; RBV focuses on the human resources and the way they are deployed by management in the organisations, and how they contribute to the creation and development of value within the firm [52].

Being the premier space industry in Sub-Saharan Africa, it was paramount to invest heavily in capacity building to ensure sustainability of its space programme. From the design, build and launch of NigeriaSat-1 – Nigeria's first satellite in 2003; the Nigerian space programme witnessed its pioneer KHTT training programme of 15 young engineers and scientists at SSTL, UK. During this KHTT programme, we were able to deduce that technology cannot be transferred but could be acquired. This was possible through capacity building by applied research, hands on training, retraining and experimental development. Like other emerging sectors in developing economies, brain-drain poses a huge challenge to the Nigerian space industry especially when working conditions are not at par (or close) with counterparts in developed countries.

Over the years, acquisition of space technologies training has led to innovation through research and development and strengthened our indigenous capacity development and competency in satellite design, development and launch as well as ground facility management, operations and maintenance. It has also enhanced the optimal use of each satellite to fully derive its benefits and exploit its potential. Furthermore, it has promoted educational qualifications up to PhD in most areas of space science and technology and in a collaborative context, nano and small satellites for education and operational applications. The services and technologies developed for nano and small satellite programmes create opportunities for the establishment of commercial businesses [53], and this in turn promotes Public-Private Partnership (PPP).

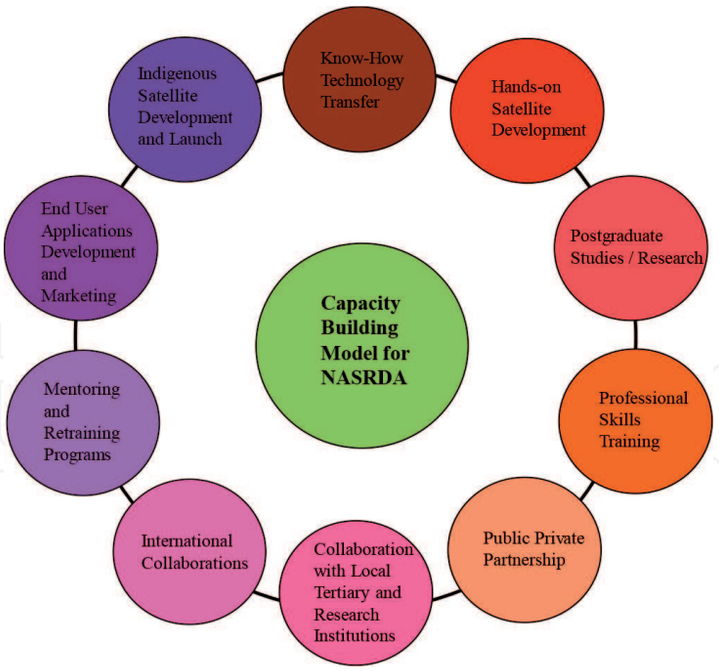

Figure 3.
NASRDA's sustainability model for capacity building development.

As the nation aims at diversification of its economy from oil and gas dependency, the space sector is strategically positioned to contribute to the economy sustainably by harnessing space technologies for innovation.

The figure below depicts NASRDA's sustainability model for capacity building development (**Figure 3**).

5.1 Know-how technology transfer (KHTT) training programme

From inception of her journey into Space Research and Development, NASRDA has adopted the Know-How Technology Transfer (KHTT) training approach for ensuring sustainability in the sector. This has been a major component for the satellite projects done so far for Nigerian capacity building in space science, engineering and technology. These satellite projects KHTT programmes included: 15 engineers and scientists for NigeriaSat-1 (2001–2003) at SSTL, UK; 55 engineers and scientists for NigComSat-1 (2005–2006) at China Great Wall Industry Corporation (CGWIC) China and 26 engineers and scientists for NigeriaSat-2/X (2006–2009) at SSTL UK. Of emphasis to the success of these programmes is the preparedness of transfer of proprietary knowledge and skills that have been protected by intellectual property rights and patents to the trainees [51]. The knowledge and specialised skills have been of tremendous impact towards a sustained space industry. Most of the efforts which have been significant in this regard include the development of spin-off projects from the various aspects of satellite technology development.

As discussed in [10], NigeriaSat-1 was indigenously operated and managed from its Mission Control Ground Station (MCGS) in Abuja, Nigeria. Similarly, NigeriaSat-2, NigeriaSat-X and NigComSat-1R (a replacement of NigComSat-1) MCGSs in Abuja were also operated and managed indigenously.

The takeaway from the foregoing therefore is that the KHTT trainees have since put their training to good use through the advancement in space research that has brought about numerous home-grown projects and innovations that have impacted positively in solving various challenges. This in turn has contributed towards the socio-economic development of Nigerians.

5.2 Hands-on satellite development

One of the successes recorded in each of the KHTT programmes was the provision of hands-on experience in satellite engineering and technology. Apart from participating in the design, build and launch of the satellites, the KHTT trainees had to design and build their own Training Model (TM). The NigeriaSat-1 TM for instance, had similar features and components like NigeriaSat-1 satellite apart from the solar panels and a substitute for the 32 m Multi-Spectral Imager Payload. This was a proto-flight model and was not intended for flight. However, during the NigeriaSat-2 programme, NigerriaSat-X – X represents eXperimental, was the TM and was designed for flight and thus, had to be space qualified. This practical hands-on experience was a giant milestone recorded by NASRDA with the capability of designing a 22 m high-resolution imager. The hands-on experiences for Nigeria Sat-1, NigeriaSat-2 and NigComSat-1 KHTT included ground-station modules, operations and maintenance.

5.3 Post-graduate studies/research

Formal education and other capacity building mechanisms are most needed in order to ensure technology acquisition and utilisation [51]. As a result, NASRDA has over the years encouraged advancement in formal education for its staff. This was one of the reasons NigeriaSat-2 satellite programme was designed to run concurrently with a Master's programme in their areas of specialisation. On completion of the program, outstanding staffs were further sponsored to pursue their PhDs. Currently; NASRDA's teeming experts are supporting various tertiary institutions across the country in teaching and research activities. NASRDA has also established an educational arm for post graduate research called the Institute of Space Science and Engineering (ISSE). It provides advance research in space science and technology and is an affiliate of the African University of Science and Technology (AUST). The lecturers of the Institute comprise mainly staff of NASRDA who specialise and have been trained in various aspects of space exploration.

5.4 Professional skills training

The routine professional skills training in NASRDA which is designed to facilitate career competencies can be regarded as value-added skills. Training areas include but are not limited to software package development, IT, space applications, administrative and project management courses have been highly beneficial to staff of the Agency.

5.5 Public-private partnership

Public-Private Partnership (PPP) is an important institutional innovation in infrastructure and public service and can be considered as a long-term partnership through contracts between members of the public and private sectors [54]. Through PPP, government and businesses cooperate to provide goods and services to the populace. This innovative initiative brings about real economic potential and sustainable development of the space industry.

There has been a consistent effort by certain key technology innovators to partner with NASRDA. To contribute towards the fight against the COVID 19 pandemic, NASRDA initiated PPPs in the area of its tele-medicine programme.

5.6 Collaborations

NASRDA has imbibed the culture of collaboration at both local and international levels in its model. This has yielded fruitful results in technological advancement. With its accomplishment in capacity building, opportunities in collaborative capacity building becomes essential as nations partner together to achieve common goals in space technology. To this end, NASRDA has signed working Memorandum of Understandings (MoUs) with several tertiary institutions, such support spans the gamut from teaching to developing high end research activities that are capable of gaining patent status and commercial traction due to the innovative component within such projects. NASRDA is also collaborating within the educational framework, through its activity Centre, the African Regional Centre for Space Science and Technology Education (ARCSSTE) in Ile Ife, and ISSE which is affiliated to the AUST, Abuja Nigeria.

Reiterating some of the collaborations already mentioned, we have the KHTT framework with SSTL UK and CGWIC China; space training collaboration with Indian Space Research Organisation (ISRO) India and Korea Aerospace Research Institute (KARI) South Korea to mention a few. Some of the products of these collaborations include Nigeria's inclusion in the Disaster Monitoring Constellation International Imaging (DMCii).

Furthermore, Nigeria through NASRDA is a member of the Committee on Peaceful Uses of Outer Space (COPUOS), the International Telecommunications Union (ITU) and several other local, regional and international bodies working in space related endeavours.

5.7 Mentoring

As one of the building blocks of capacity building for NASRDA, mentoring plays a key role. Mentoring is essential for developing skills to take on more responsibilities and guide the progress of mentees on the acquired knowledge. This could be through a formal education setting such as the ISSE, Abuja, or informal settings by supervising and coordinating departments, divisions, projects etc. All these avenues provide a platform for knowledge transfer and channelling the next generation of space scientists and engineers towards technological advancement.

5.8 End-user applications development and marketing

According to Adams, [55] the three dimensions of core mainstream of sustainability adopted by the World Conservation Union are environmental, social and economic sustainability. The effectiveness of NASRDA's sustainability model is its capacity for effective application of acquired space technologies to impact positively on the quality of lives and socio –economic development of Nigerians. This is achievable through provision of valuable information to end-users in areas of agriculture, disaster monitoring, land cover/land use change, environmental monitoring, health and wellbeing etc. The application of the space resources and data into meaningful information and services is therefore essential in making the populace and global community reap the benefits of space science and technology.

5.9 Indigenous satellite development and launch

With the accomplishment demonstrated in the design, build and launch of NigeriaSat-X, and the existing sounding rocket launch activities at NASRDA's Centre for Space Transport and Propulsion Epe. The Agency is poised to achieve

one of the milestones on its roadmap which is to indigenously develop and launch a satellite; this giant milestone is achievable through the effective harnessing of its intellectual resources. Such an achievement strengthens the space Agency and the Nigerian economy, offering potential benefits such as sustainable revenue, infrastructural development, science and technology advancement, space and global competitiveness.

6. Conclusion

In summary therefore, the strategic and operational goals of the Nigerian Space Agency has followed a model and trajectory that subscribed to the hybrid concept of CCT and RBV. This has proven to be invaluable in its pursuit of space technology mastery with the inadvertent result of leaning heavily towards technology acquisition as a first step in its chosen hybrid sustainability model. On closer analysis, however, it can be seen that CCT and RBV are just two sides of the same coin, with one being unable to do without the other for effective functioning of the described model. CCT requires a critical mass of manpower resource that is well trained and up to-date in the various fields of space science and satellite technology. Conversely, the possession of such expertise in human resource creates a fertile ground for the incubation and enculturation of a technology culture that is driven by a common underlying thread of scientific method and sustainable technological model in the conceptualization and development of various space science and technology related products and services.

Drawing inspiration from the discussed sustainability models, NASRDA has adopted a little bit of each of the three principal models. While not specifically applying the underlying strategies in these models to ecology in the Dissendorf's case, natural resource exploitation and allocation in the TNS model or social responsibility (CSR) in the Interface model. The core of NASRDA's sustainability model makes the continuity and unmitigated improvement of manpower resource its raison d'etre. As has been well documented, all the sustainability model types ultimately have the benefit of mankind as the central aim of their workings. These models have also gone to sufficiently show that organisations do not have to walk a fine line between meeting their goals and balancing the needs of lives versus livelihoods. In anchoring NASRDA's sustainability thrust on its manpower, it underscores the identification of human capacity as the fundamental component of any organisation just like the upstream factor component addressed by the TNS model. This fact captures the logic that a satisfied workforce means good and efficient deliverables or products downstream that satisfies both workers and consumer's needs.

It is therefore seen that the inadvertent adoption of a hybrid, mixed, collaborative sustainability model which has underpinned NASRDA's successes so far was quite logical for fledgling organisational coming into the heavily regulated and tightly controlled space science and technology sector. Projecting its strength into the future with such applications that are targeted indigenously and driven from Nigerian technology space and the African continent remains one of the most salient ways to prove the ultimate workability of this sustainability model.

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