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Modelling Applications for an Efficient Natural Resources Management and Sustainability Requirements

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ABSTRACT:
Distribution of natural resources are random and heterogeneous over the globe and envelopes regional boundaries. The complex productive features of natural resources could not be studies as a whole rather needs a criteria based interactive categorisation. The need of time is to optimise the human activities to yield maximum, utilising minimum quantum of natural resources. Simultaneously our best possible attempts should aim implementation of comprehensive policies toward conservation and sustainable development. For the near future our aim should be to compensate most of the materialistic requirements of regenerative natural resources by planned sustained resources as well as we must be able to replenish the sustained losses of natural resources in the past centuries.
In order to address societal demand and applicability of natural resources use of modelling process and tools are better choice. Morden computer based modelling techniques can efficiently and precisely describe the envisioned discourses towards resource applicability, demand supply chain and sustainability obligations in various possible temporal and spatial scales. This paper intended to analyse present practices and specified scientific approaches towards better natural resource management and sustainability criteria considering dominant natural and anthropological factors.
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I. INTRODUCTION:

The present time human environment consist of two part natural environment and manmade socio – economic environment. Natural environment envelops all biotic and abiotic features like water bodies, mountains, aquatic lives, mineral, forest, organisms, wind, sunlight etc.; natural forces (like magnetism, gravity etc.) and processes (like thermal, biological etc.); which are developed over the time through process of evolution. Manmade environment developed with the civilisation of human race consist of culture, education, housing, economic system, technological features etc. Development of manmade environment highly dependent upon the consumption of raw or processed (or both) materials from natural environment i.e. natural resources like water, mineral, forest produces, natural fuel etc. [1].

The sustainable gains from an individuals or small communities are a little beside the facts that sustainable living has always been an integral part of the world's most of the civilisation as deducible by studying their believes, culture, tradition, rituals, arts, food practices etc.. A study of ancient history reveals that some conservation laws, reproductive practices, eco-friendly development performs were part of normal human life. Uneven development of civilisation and unequal distribution of resources have turned attitude of many individual and societies intrinsically self-centred and has become the reason for over-exploitation of natural resources. Colonization of the undeveloped territories, industrialisation in technically / socially backward but resourceful region, forced commercialisation and business activities etc. are some reasons for natural resource depletion.

NATURAL RESOURCE AND CHALLENGES:

Natural Resources can be classified as non-renewable (fossil fuels and mineral) whose fast depleting stock has compelled the human race to search an alternate sources else dependent activities will come to an end soon; Continuous (wind, sunlight etc.) the use of which does not lead to a reduction in near future; and renewable those can be harvested but not faster than their own rate of replenishment, through human efforts e.g. forest produces, water, crop, etc. [2]. The Utilisation of natural resources and human societal existence is a complex interaction between natural resources and social- economic services. In mathematical terms the relation between natural resource utilisation (depletion) is inversely proportional to socio-economic growth of human kind. Unplanned and excessive consumption of natural resources for mankind development has led to an unprecedented situation where an easy and comfortable human existence has come to pressure. Ecosystem services (like soil formation for agriculture, deforestation and afforestation, mineral extraction and processing, energy conversion and utilisation for human needs etc.) are the bridge between natural resource utilisation through human socio economic system.

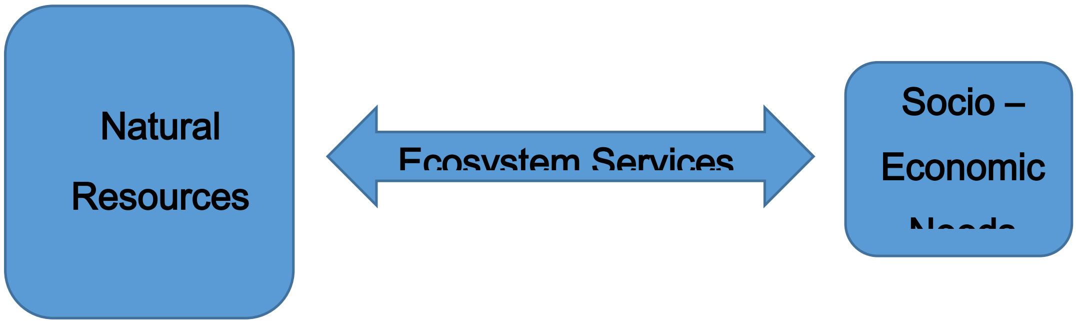

Figure 1: Conceptual Diagram indicating Use of Natural Resources by the Human for their Growth through Activates Developed over the Time

In many regions of the world, either suffering from resource scarcity or having extensive application fields, managing demand of natural resources without damaging the local ecosystem is a challenge (e.g. areas with water scarcity, extensive agricultural fields along the coast, mining in forest area etc.). Around the globe increasing populations, urbanisation, industrialisation, mining etc. have put immense pressure over natural resources pertaining water, agriculture, mining, energy etc. for better health care and improved living conditions.

FIGURE 2: THE TRAJECTORY OF THE ANTHROPOCENE - PRESENT TREND ON ENVIRONMENTAL LOSSES (BOTH NATURAL AND SOCIO ECONOMIC), **REF. – [5]**

Indubitable consequences of natural resource utilisations are pollution in terms of air, water, noise, thermal, soil etc. As a result, 75% of all terrestrial surface has been altered, 85% of all wetlands have been lost and 25% of all species are endangered, close to extinction in coming decades [3]. The word Anthropocene, has been assigned to the new geological age credited to human-driven impacts, where anthropogenic activity has become mightier than geological forces in driving ecologic and planetary change and are continuously increasing [4].

SUSTAINABILITY CONCEPT

Sustainability is the process in support of natural resource conservation and reproduction to sustain ecosystem services in tune to the present and advancing needs of society within the limits of environment. Reduction of the use of natural resources in production and consumption is often referred to as 'dematerialization'. A sustainable development supports both the natural and socio-economic environment. A sustainable system works within the nature's limitations by better knowledge of interacting forces and process with ecosystem services for a justified resource utilisation with present and future generations [6].

The conceptual demand of sustainability is an optimized system with minimum resource requirements, efficient service processes, and maximum applicability for human needs. The concept of sustainability is applicable to renewable and continuous resources, where many concepts are developed to support ecology and environment e.g. the spatial planning for conservation of soil, water, endangered flora and fauna, tribes, by suitable ecosystem services. Design of a sustainable natural resource system requires a deep understanding of dominant interactive parameters and process. The determined complex mix of such factors and relationships; their formulations, analyses, inferences etc. are far too intricate for simple calculations. However, the advances in computer technology, have eased the path towards developing software tools to support our understanding of nature's complex interactions using Mathematical, Statistical, Artificial Intelligence and other reasonable approaches and coherent feedback systems.

The problem of natural resource management and sustainability requirements are often global-level problems and individual perceptions and attempt to tackle them are tedious and hardly to bring any change. There are international laws and regulations, and then there are national laws and acts too for environmental conservation, protection and development. There are also national and international organisations working towards protecting global environment.

SUSTAINABILITY MODELING

In order to develop a strategy on how human activities of natural resource utilisation can be optimised and sustainably utilised attempts are oriented towards modelling processes. The United Nations' Sustainable Development Goals (SDGs) adopted in the year 2015 outlined 17 goals and 169 targets for achieving global sustainability (for a balanced achievement of economic prosperity, social inclusion, and environmental protection) across the local, regional, national and international scales in the year 2030. The global adoption of SDGs has boosted development and use of sustainability planning models [7]. An efficient sustainability model be comprehensive to explain the complexity and uncertainty inherent in natural system and understanding the long-term interactive processes explaining temporal and spatial changes [8]. System dynamics has co-evolved with sustainability research over the past 50 years [9]. In the early 1970s, Forrester's World Model(s) for the Club of Rome has discussed *the Limits to Growth* [10] to analyse global dynamics and predicted the fall of the socio-technological natural system by the mid-21st century. In the past system dynamics and modelling has been used for complex feedback interactions, analysing Inter-linkages between sectors, and understanding non-linearities, radical change, tipping points etc. context to the sustainability applications [11]. Subsequently the sustainability researches have been oriented towards thoughtful explanations of dynamics underlying the life cycle of natural resource and their impact over energy and environment, climate change, and socio-cultural systems etc. [12].

One popular model for sustainability is the three-pillar model which considers an equal contribution of ecology, economy and social matters while developing relevant spatial and functional frameworks for specific applications (13). The model does not acknowledge the ecosystem as the service provider for socio-economy activity (as all three pillars are equally weighted) and give rise to the concept of weak and strong sustainability. Weak sustainability emphasises that "we can purchase Man-Made Capital with infinite and abundant Natural Capital", asserting that "man-made-resources can substitute natural resources" [14]. Whereas strong sustainability considers the natural resources as basis for socio economic development as a non-substitutable factor and loss to the nature is irreversible [15, 16]. Sustainable system dynamics modeling has been further advanced towards *transitions models* [17] whose the feedback-rich structure skilfully explained transformational change in societal system like the destabilisation of an existing regime (e.g. fossil fuels) and the emergence of several competing niches (e.g. renewable energies). Present days sustainability modeling approaches incudes input-output analysis, computational equilibrium, system dynamics, object specific, agent-based modelling, integrated assessment modelling, transitions modelling, exploratory modelling [18, 19] etc..

After adoption of the SDGs, a range of sector-specific models (e.g. water, energy) addressing particular SDG; nexus models that analyse interactions of multiple sectors and inform multiple SDGs (e.g. water-food energy); and integrated assessment models that expresses systemic view of SDG with complex interactions and balancing among socio-economic processes with the natural system dynamics [20] have been developed. Current system dynamics studies of sustainability are diverse in scope, scale, analytical method and feedback, leading to better understanding of its complex system behaviours and offerings in specific sectoral domains (e.g. transportation, supply chain, hydrology) [21].

NEXUS CONCEPT OF SUSTAINABILITY MODELING

Sustainable design to resource scarcity in any region requires different, more sophisticated and adaptive measures. Selection of the proper measures requires understanding the interactions among various environmental parameter affecting resources for example in agricultural sustainability knowledge required is of an individual and / or collective interactive processes among rainfall, runoff, salinity, infiltration, fertility, water sources, soil quality, social response etc. Modeling such a complex systems explicitly requires a comprehensive approach considering historical time line and philosophy across the established theories. This 'Integrated Management Thinking', is known as nexus concept, is used for natural resource (water & hydrological) management. UNU-FLORES is one such web-based, open-access, model developed over the Nexus Tools Platform (NTP) that allows an interactive comparison of water, soil and waste. It can compare different modelling tools based on the resources, regions, processes and technical features using graphical interpretation e.g. curve, histogram, maps etc. [22]

MODELING SOCIO ECONOMIC SUSTAINABILITY

A small amalgamation of population surrounded with particular natural environment generally closer to both the natural and socio-economic sustainability. Urbanisation and Industrialisation are the biggest threats to sustainability. Term 'Urban sustainability' is a doctrine with diverse origins. The alternative models of development in mega cities embody the integration and interlinkage of economic, social, and environmental sustainability. Sustainability attempts in these cities includes an efficient intra-urban bus system, expanding urban green space, and meeting the basic needs of the urban poor. To attain social harmony a sustainable model emphasizes equitable resource distribution rather than consumption, by restraining reproduction, and by attacking divisions of race, caste, religion, and gender. Other dire attempts to attain a balance development with the environment in urban cities includes framing a nature-friendly development plan that protects natural systems, participation of native and local people in the development process, eco-friendly design of infrastructure, conservation of natural resources and historical creations etc. The major challenges in sustainable design includes quantification of problem, interactive process, availability of enable knowledge / expertise, suitable condition for technological applications, coordination among decision makers, field worker and modellers, assertion on prediction efficiency [23]. A sustainability model must be supported by most of the past information, data, latest technical knowledge, precision working platform, impacting variables and other supportive tools for best possible outcome efficiencies consummate with the model objectives. The model's operating procedure, assumptions, boundaries, scales, temporal / spatial resolution, and deficiencies must be clearly defined.

Of course, the relationship between every single natural process and socio-economic factor is much too complex to consider exhaustively with such tools. These software tools create models that represent and simulate reality in a simplified manner and often focus on a specific area of application. In the opening example, water management practices were first analysed solely from the hydrological perspective. However, applying a nexus approach means also looking at the risks for water quality and agricultural soil salinisation, soil processes and waste (i.e., wastewater reuse) as well as institutional processes and socio-economic impacts. As this example illustrates, depending on the overall objective and concerns, researchers and decision makers may need several models to achieve truly sustainable resource management.

LIMITATIONS OF SUSTAINABILITY MODELLING

The basic aim to sustainability model is to predict effects of resource management alternatives without bias, with adequate precision and a correct estimate of prediction uncertainty. The modeling results should be transferable in space and time, and should be easy to understand. However, real models are usually far from ideal. In present days several data and informations necessary for resource modelling are available over e-platforms. However, one need to attempt to know the details and exact application procedures of these models or otherwise go to develop own, new models. It is found that use of (or improve over) existing efficacious and popular models is advantageous in terms of time, cost and acceptability. The information regarding the existing modeling tools and the suitable methods for sustainable design is scattered, distant, incomplete, reserved, static, and simply accessible.

The large diversity of parameters and multifaceted interactive process among natural resources has let to development and availability of various specific models. Absence of general and standard models makes selection of an (or a set of) exact or appropriate model that can deal realistically to a specific problem and requirements. Another struggle towards sustainable design is to development modelling tools able to describe the intricate dependencies among natural and socio-economic systems.

II. CONCLUSIONS

The perpetual decay in natural resource stocks and huge waste generation in the process of technical advancement towards human comfort and safety have rolled the human on the edge catastrophes. The scale of natural resource management is so vast the individual or even community results are not supposed to be enough. A sustainable design requires an integrated analysis of resources, available knowledge, socio-economic goals and spatial extent. The sustainable solution of replenishment of renewable resources demand their regeneration and conservation at a rate faster than geological processes. The technological and economic requirements of a sustainable design and planning requires collaboration and exchange of efforts across the nations. With such a vast investments over a sustainable design assertion of positive results are an essential prerequisite. The discussion over the SDGs and nexus models provides a platform for understanding modeling efforts and model goals. As seen the limits and efficiencies of past sustainability models and ongoing efforts to make a comprehensive sustainable model for a vast spatial extent one can cover some of these gaps. With the latest advancement in computer application use of mathematical and other reasoning module various modeling tools are developed to explain the complex process of resource management and sustainability. Availability of a wide range of interdisciplinary methods and their possible clubbing with system dynamics through advanced computing tools has strengthen the sustainable model for better integration and work beyond the limitations of old specific approaches. With the technological advancement the ruling protocols as well as management and predictive efficiencies too advanced in sustainability models. Now a days internationally collective attempt and knowledge sharing has made efficiencies and usefulness of sustainable model much better than individual and specific models till last decade. The trust areas for sustainability research are improving the relative interactive formulation among resource quantum, environmental factors, governing processes, resulting field etc. and incorporating them in models.

The present and immediate future need is to live in harmony with environment at local as well as global context. Till date the concept of sustainability is actually naïve and it's far enough to gain a global recognised and acceptance due to various limitations, constraints at natural and social grounds. With the technological and materialistic development of human the problem of exploitation (of both the natural and socio-economic resource) has risen to an unsafe state of existence. The need is to make sustainability attempts a part of day to day and total life style to save the nature, earth, and environment to live well.

REFERENCES:

[1]. Web resource 1 - World Forum on Natural Capital: What is natural capital, https://naturalcapitalforum.com/about/ (09.12.2019)
[2]. Reijnders L. 1999. A normative strategy for sustainable resource choice and recycling. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services—IPBES:
[3]. Brondizio, E. S. et al. (Eds): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn: IPBES secretariat, 2019
[4]. Steffen, W.; Broadgate, W.; Deutsch, L.; Gaffney, O.; Ludwig, C.: The trajectory of the Anthropocene: The Great Acceleration, The Anthropocene review, 2 (2015), iss.1, pp 81–98
[5]. https://www.nationalgeographic.org/projects/out-of-eden-walk/ galleries/2015-03-trajectory-anthropocene-great-acceleration/. Accessed 25.02.2020
[6]. Angelsen A. Agriculture expansion and deforestation: Modeling the impact of the population, market forces and property rights. Journal of Development Economics. 1999; 58:182-218.
[7]. UN 2015 Transforming our world: the 2030 agenda for sustainable development Resolution Adopted by the General Assembly on 25 September (The United Nations (UN))
[8]. Neumann K, Anderson C and Denich M 2018 Participatory, explorative, qualitative modeling: application of the iMODELER software to assess trade-offs among the SDGs Economics 25 1–19
[9]. Pedercini M, Arquitt S and Chan D 2020 Integrated simulation for the 2030 agenda† Syst. Dyn. Rev. 36 333–57
[10]. Meadows D H, Meadows D L, Randers J and Behrens W W 1972 The limits to growth vol 102 (New York) p 27
[11]. Eker S, Reese G and Obersteiner M 2019 Modelling the drivers of a widespread shift to sustainable diets Nat. Sustain. 2 725–35
[12]. Saeed K 1991 Towards Sustainable Development: Essays on System Analysis of National Policy (London: Routledge)
[13]. Purvis, B.; Mao, Y., Robinson, D.: Three pillars of sustainability: In search of conceptual origins, Sustainability Science, 14 (2019), iss. 3, pp 681–695, doi https://doi.org/10.1007/s11625-018-0627-5
[14]. Abreu, N.: Pennsylvania State University: Weak sustainability, https://www.e-education.psu.edu/eme504/node/7 (09.12.2019)
[15]. Neumeyer, E.: Weak vs. Strong Sustainability: Exploring the limits of two opposing paradigms, Cheltenham: Edgar Elgar Publishing, 2003
[16]. Pelenc, J.; Dedeurwaerdere, T.: Brief for the Global Sustainable Development Report—GSDR 2015: Weak Sustainability versus Strong Sustainability, https://sustainabledevelopment.un.org (09.12.19)
[17]. Papachristos G 2018 System dynamics modelling and simulation for sociotechnical transitions research Environ. Innov. Soc. Trans. 31 248–61
[18]. Van Beek L, Hajer M, Pelzer P, Van Vuuren D and Cassen C 2020 Anticipating futures through models: the rise of integrated assessment modelling in the climate science-policy interface since 1970 Glob. Environ. Change 65 102191
[19]. Moallemi E A, Kwakkel J, De Haan F and Bryan B A 2020 Exploratory modeling for analyzing coupled human-natural systems under uncertainty Glob. Environ. Change 65 102186
[20]. Randers J, Rockström J, Stoknes P-E, Goluke U, Collste D, Cornell S E and Donges J 2019 Achieving the 17 sustainable development goals within 9 planetary boundaries Glob.
[21]. Sterman J D 2001 System dynamics modeling: tools for learning in a complex World Calif. Manage. Rev. 43 8–25
[22]. Web Resource 2; https://ourworld.unu.edu/en/modelling-tools-for-dealing-with-environmental-complexity assessed 12.9.2022
[23]. Parrott, L., 2017. The modelling spiral for solving 'wicked' environmental problems: guidance for stakeholder involvement and collaborative model development methods Ecol. Evol. 8 (8), 1005–1011. https://doi.org/10.1111/2041-210x.12757.