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Engineering Topology of Construction Ecology for Dynamic Integration of Sustainability Outcomes to Functions in Urban Environments: Spatial Modeling

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***Abstract*—**Integration sustainability outcomes give attention to construction ecology in the design review of urban environments to comply with Earth's System that is composed of integral parts of the (i.e., physical, chemical and biological components). Naturally, exchange patterns of industrial ecology have consistent and periodic cycles to preserve energy flows and materials in Earth's System. When engineering topology is affecting internal and external processes in system networks, it postulated the valence of the first-level spatial outcome (i.e., project compatibility success). These instrumentalities are dependent on relating the second-level outcome (i.e., participant security satisfaction). The construction ecology-based topology (i.e., as feedback energy system) flows from biotic and abiotic resources in the entire Earth's ecosystems. These spatial outcomes are providing an innovation, as entails a wide range of interactions to state, regulate and feedback "topology" to flow as "interdisciplinary equilibrium" of ecosystems. The interrelation dynamics of ecosystems are performing a process in a certain location within an appropriate time for characterizing their unique structure in "equilibrium patterns", such as biosphere and collecting a composite structure of many distributed feedback flows. These interdisciplinary systems regulate their dynamics within complex structures. These dynamic mechanisms of the ecosystem regulate physical and chemical properties to enable a gradual and prolonged incremental pattern to develop a stable structure. The engineering topology of construction ecology for integration sustainability outcomes offers an interesting tool for ecologists and engineers in the simulation paradigm as an initial form of development structure within compatible computer software. This approach argues from ecology, resource savings, static load design, financial other pragmatic reasons, while an artistic/architectural perspective, these are not decisive. The paper described an attempt to unify analytic and analogical spatial modeling in developing urban environments as a relational setting, using optimization software and applied as an example of integrated industrial ecology where the construction process is based on a topology optimization approach.

***Keywords*—**Construction ecology, industrial ecology, urban topology, environmental planning.

I. Introduction

SPATIAL modeling represents the ecological experience in prediction the fate of pollution from a perspective of systems ecology. The architecture of resources (i.e., natural or man-made) without depletion is a focus part of integration sustainability outcomes [1] and emphasize on all dimensions of various terms that invest to culturally cover all three dynamic functions of sustainable communities: Economy, Ecology, and Equity for social security in industrial projects [2]-[5]. The construction ecology (i.e., conservation energy, material as resources of land, water, and air) [6]-[12] is often a complex incentive between financial, aesthetics, technology and systems ecology. The successful outcomes of such a spatial model requires design input from the point of view of ecologists and engineers at the early process stage of design in which computers have an important role in simulation of the detail applications [13]. In urban environments, engineers provide detailed review with healthy and appropriate space for efficient land-use in natural harmony of construction to reduce emissions and solid waste. Ecologists and engineers both employ iterative multi-stage design procedures, starting with conceptual design to progress to the final product. There are, however, essential differences in approaches to these disciplines. The proposed terms of geophysical object, in which anthropogenic insertions are integrated industries, have a rapid cause of planetary change of object-orientation systems 14]. The name object Anthroposcene is a combination of anthropos (Ancient Greek: ἄνθρωπος) meaning "human", and -scene from kainos (Ancient Greek: καινός) meaning "new", or "recent". The tendency of a system responds and maintains changes or perturbations of dynamic-service-orientation systems that are described in a certain function (i.e., regulate temperature, balance acidity and alkalinity, preserve carbon dioxide and oxygen concentration, etc.). On the micro level this process is often done through centralized regulatory systems such as the hypothalamus in the human body [15]-[20]. The basic description of human behavior is integrated sustainability outcomes as classified into categories that indicate considerable points to social security, spatial economy and urban environments as in Fig. 1 [21]-[23]:

1. Spatial Economy (Resources Economy)
2. Social life (Social Security Systems)
3. Urban Environments (Environmental Topology)
4. Legislation and Governance (Services-Oriented)

Besides conceptual design of sustainability outcomes, construction ecology tends to be pragmatic in nature, (i.e., the choice between an arch and a composite structure, between chemical and physical properties with a proper structure). These different approaches are typified by problem of expressing psycho-physiological spatial concern in the mathematical of computers [24]. Yet these differences tend to vanish in some of the most successful examples of integrated process and pattern design, exemplified as in "algebraic

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topology" [25]-[27].

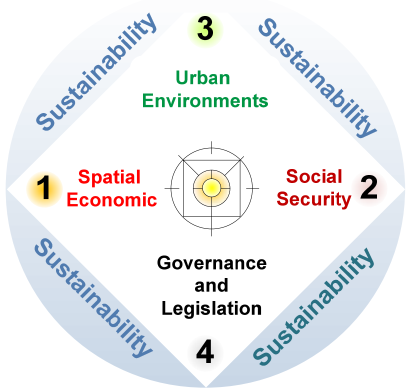

Fig. 1 Essential elements of Sustainability [21]

The sustainability is also known in urban environments as resources flow (i.e., energy and materials in a protective structure) that designed in an executive manner and operated, or reused in an ecological resource-efficient manner. The stand point of spatial economics represents both the rate of investment and transport network in which influence the market. The spatial economy reflects the relative age of people who form the managerial elites [28], [29], across the distributed centers of production or interaction consumption that acquire complex knowledge to analyze [30]. In reality, sustainability has "spatial organization" [31, p.69] as materialized by the advances in these two networks. The spatial distribution of these facilitators might be reflected in the agglomeration of specific-global-economic activities [32].

Integration of sustainability outcomes and construction ecology to function in urban environments are relatively innovating disciplines within systems ecology. When the infrastructure supports our energy flow to share natural resources with social security in a much higher level of efficiency, there will be a much lower level of pollution and waste. Recently, industrial ecology has emerged as a systems approach for design, development, and operation of human systems, for both levels of governorate and private sectors. Their objective is focusing on transition between social system and sustainability outcomes in which spatial economic activities respect the limits of global and local service-orientation [33].

II. Procedure for Orientation Impact

The service-orientation is an optimal form obtained using topology and shape optimization tools developed during the last decades with the finite element method [34]. The finite element method is used to predict and compare biomechanical performance implicated as selective factors in the evolution of morphological structures. Such methods are given data results or optimization techniques that imply a predetermined load scenario, obtained structure with the minimum relation of weight-space process [35]. Service-orientation does not need the technology, but it has a wide philosophy or paradigm to include feedback-end scenarios like road network topology, high level scenarios like business process and web services [36], [37]. The service-orientation topology is designed to provide the possibility of changing parts of a system without change in physical configurations. These properties forward the researcher to shift the pervasive system from an object-oriented system to services-orientation that configured system's middleware platform is used in different urban environments [38]. The physical components of midpoint abiotic and biotic variables are described in ecological systems to predict what is beyond "efficiency measures" and indicate systems deviation to control emissions, releases and volumes of solid waste. The improvement system predicts construction ecology as variable design aspect of the classified between biotic and abiotic variables in three main categories influence flux motion [39]:

- Generic of physical static and dynamic variables
- Mitigation to human behavior and systems ecology,
- Religion protective systems.

Several industrial projects have addressed products directly to services in the urban pervasive system [40]-[43], for example in [36] is explored a service-oriented middleware that posed an engineering topology to the incentive process between the product-market and the population-density in the urban environments. These eco-feedback chain systems revealed that there are three main trends in this spatial data of service-oriented industrial projects: first systems focusing on indicators of the location, second systems focusing on social contexts and third systems focusing on spatial economic [44]-[47].

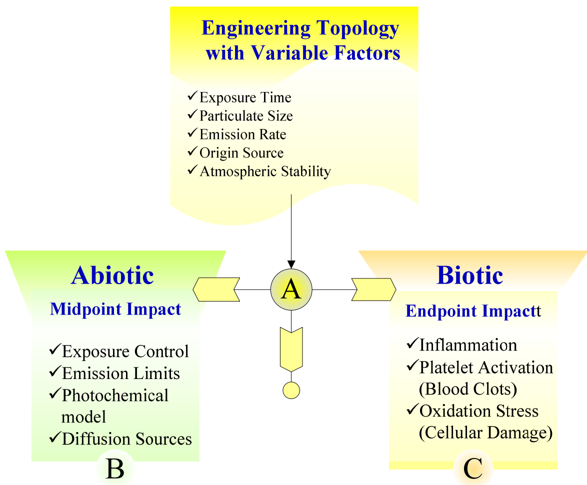

Fig. 2 The EIA has the central orientation of impact [48]

Based on systems topology, the proposed relations between design orientation and impact are a pervasive system directly to the urban environments. These relations are providing location-based services and interaction with indicators within a social context (i.e., directly to the individual). In industrial ecology, potential integration of a service-orientation topology with the urban environments developed a new service that provides equilibrium to clarify the service processes. These processes are integrated with physical configuration, influence different services and reused in multiple applications depending on the social context. The definition of these services is considered the adjustment and the interaction of the individual with the pervasive system. The conceptual results are derived from the ethnographic analysis and the Precinct Structure Planning (PSP) guidelines to identify framework indicators in urban environments as quantified by life-cycle analysis models to predict a service-orientation topology [49].

A. Feedback Mechanism

The eco-feedbacks flow is the mechanism that enables the ecosystem to keep its natural stability of resources and regularly maintains the environment. The term "feedback services" is used to denote functional components, which are viewed as dependent on their location. Instead, the program entity and spatial modeling is defining the molecular-platform mechanism that forms the core abstraction of service. Its interaction with environment manifests is exploring behavioral semantics in manipulation a global context [50]-[52]. In other words, negative feedback forwards the systems to orientation with its principals in equilibrium position. In recent objective, engineering topology has seen a rapid evolution of feedback paradigms aiming towards increasingly modular, hierarchical, and compositional approaches. Orientation as middle components of the impact assessment is a product-line of service–orientation functions. Continuously, ecology emphasizes on service-orientation that promotes a particular concept and is associated with the term "service". These positive feedback mechanisms–forcing systems forward to renovate its conditions to state equilibrium position. This environmental resilience has both natural and human behavior-orientation by feedback mechanisms to preserve the urban environments within their original state, so negative feeedback is usually influenced by positive feedback. This service-orientation linkage developed relations, which can be characterized as [53], [54]:

– resource-oriented vs. process-oriented
– architectural vs. behavioral
– static vs. dynamic

In the following paragraphs, we investigate these standpoints of potential support as truly service-oriented development. The initial comparison between spatial modeling and conventional ones involves considering properties, structures, topology of the urban environment [55], [56] and semantics, using some examples to illustrate the different viewpoints of feedback mechanisms.

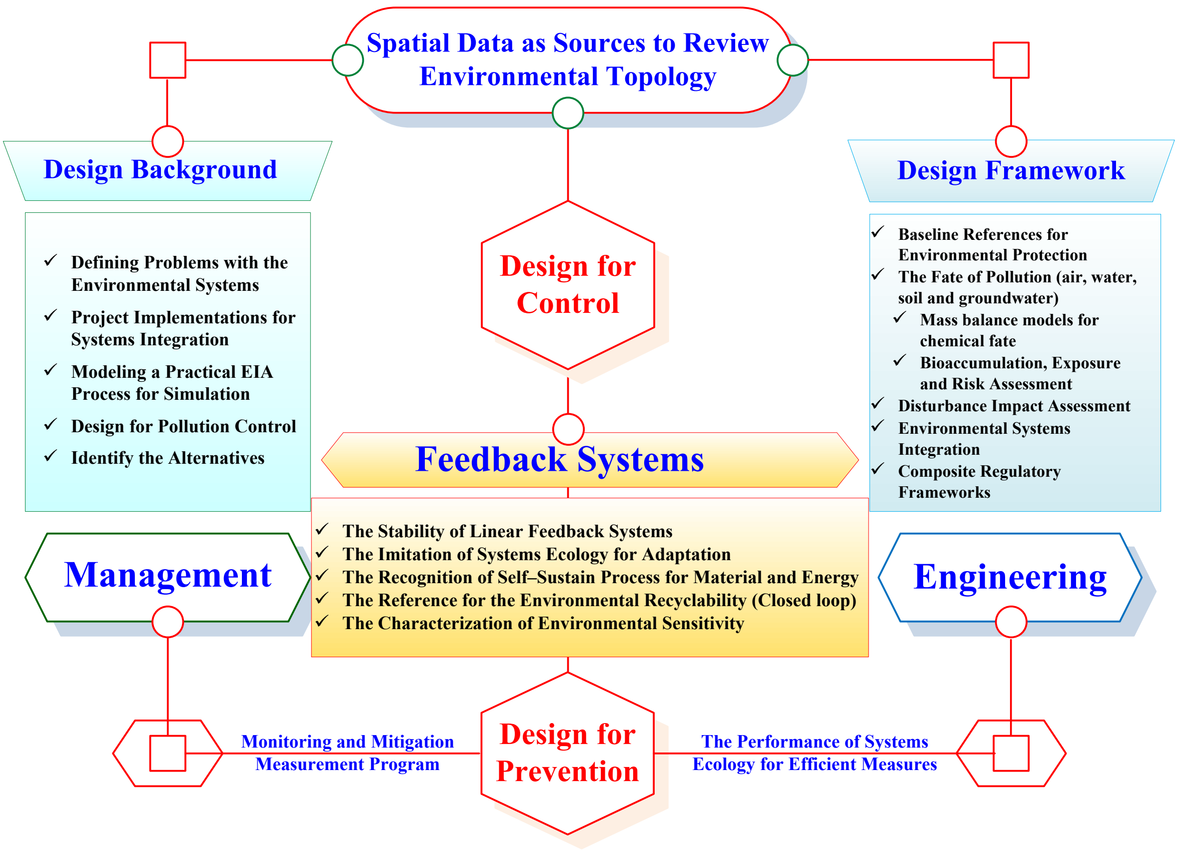

Fig. 3 The main element of monitoring feedback control system [57], [58]

Feedbacks are relevant to many biological systems and essential to systems ecology for evolutionary biology [59]. While the points of systems ecology are the interactions between an individual's behavior and their environment, evolution refers to changes in all frequencies over time. In the past, both fields have been investigated in an isolation empirical layer for spatial simulation processes. Evolutionary ecology [60] is a notable exception, where links between ecology and evolution tend to be a theoretical research. Theoretical simulation is pertaining to feedback between ecological and evolutionary processes that prevalent selection of multiple biological fields. The spatial data are highlighting eco-evolutionary feedbacks to be incorporated in theoretical analysis for nearly a century. Yet, this analysis does not include the notion of rapid evolution or concurrent ecological and evolutionary time scales. The spatial data explored the importance of density- and frequency-dependent selection for feedback, as well as the importance of dispersal as a central linking attribute between ecology and evolution in a spatial context [61], [62].

In recognition evolution concept, the dynamics extreme is rapidly occurred on similar time scales as ecology [63], [64] has prompted interface between the two disciplines (i.e., often termed “eco-evolutionary dynamics”, [65]) and feedbacks between ecological and evolutionary processes “eco-evolutionary performance”. Eco-evolutionary feedbacks involve situations where an ecological property influences evolutionary change, which then forwards to an ecological property, or vice versa. Classical empirical examples include ecological property lead selection of defense in evolutionary change that in turn feedbacks dynamics shifts the phase of action oscillations (i.e., feedback on ecological property reviewed in [66]).

Despite the various investigated techniques exploring feedback procedures, most spatial data are not explicitly used to improve knowledge on the complex behavior of land systems. Investigations of the relationship between feedback simulation and linear modeling did not receive substantial attention in the majority of the reviewed articles [67]. Time series has limited utilities in aiding management and policy intervention, as in energy-response relations revealed. The comparisons between sustainable outcomes and a reference served either to validate spatial modeling or compare different approaches. The comparisons between sustainable outcomes, derived by turning feedbacks in active and passive conditions, quantified the difference of implemented feedbacks, are made to influence land-use applications. The integrated sustainability outcomes did not provide information about linear behaviors in landscape but system policy recommendations such linearity in providing spatial data for modeling systems [68].

B. Invasive Species

This section discusses the invasive species or elements as they are not native to specific locations, it is introduced from some foreign ecology and thus may have influenced consumers for broken feedback flow within that environment to unbalance cycles as food web. Human interventions have been introduced as invasive species when broken feedback flows in different ecologies around the world. Disturbance is the major changes in the biological functions of the ecosystems. It is the temporary change in external parameters that break the passive feedback flows in the linear systems (e.g., fire, wind storms, earthquakes, floods, or human behavior impacts on the environment such as acid rains) [69].

The Anthropocene has become an environmentally known since the atmospheric chemist and Nobel laureate Paul Crutzen popularized it in 2000 and is not limited to anthropogenic climate change. It is a more specific term used to define our current geological epoch, in which biodiversity is diminishing and biogeography and ecosystems around the globe seem more and more similar to one another mainly due to invasive species that have been introduced around the globe either on purpose (i.e., crops, livestock) or accidentally [70].

C. Succession

A phenomenon or process, that an ecological community undergoes orderly and predictable changes, as an initial disturbance. The environmental resilience has arrived at an equilibrium or steady state conditions with the physical biotic environment (i.e., Eruption in Krakatoa Island) [71]. The linear regressions predict the stable equilibrium when climax is state balanced energy with ecological development.

According to classical ecological theory, succession stops when the full series have arrived at an equilibrium or steady state with the physical and biotic environment. Barring major disturbances, it will persist indefinitely. This end point of succession is called climax [35]. Climax is the point of highest tension in a narrative work of self-perpetuating through balanced energy production and material consumption (i.e., biological culture has reached a balanced conditions because of adaptation to the area). In negative feedback, flows with the physical habitat mean no net annual accumulation of organic matter [72], [73].

Successional dynamics beginning with establishment of an area that has not been previously occupied by an ecological community, such as newly exposed rock or sand surfaces, lava flows, newly exposed glacial tills, etc., are referred to as primary succession. Successional dynamics following severe disturbance or removal of a pre-existing community are called secondary succession. Autogenic succession can be brought by changes in the soil caused by the organisms there. These changes include accumulation of organic matter in litter layer, alteration of soil nutrients, or change in the pH of soil due to the plants growing there. The possible range of these datasets and the concomitant joint force of each individual organism are determined by a mathematical model for describing static equilibrium conditions in the sagittal plane. All mathematical models in biomechanical simulations are portrayed unilateral bites using homogeneous and isotropic material property models, solved through linear static analysis [74], [75].

III. Main Procedures of Industrial Ecology

Topology optimization methods offer a spatial simulation model for ecologists and engineers as a regular basis for the selection structure’s initial form, particularly in developments of simulation software of this approach. It is a branch of systems science or operational framework design of industrial systems to be sustainable and interdependent with the natural ecosystem. It is emerging production with spatial factors to

balance anthropogenic insertion and ecological systems. Industrial ecology is applied for [76]:
– Conservation energy and material.
– Optimization product life cycle and process.
– Control ecological impact on the natural system.
– Improvement of system performance.
– Short term innovation for product quality.

The industrial ecology has emerged in in the last few years as a system approach to design and control pollution as waste. These fields approach the transition sustainability outcomes in which our spatial system respects the limits and constrains of social security. The industrial ecologists can predict dynamics of anthropogenic insertions from ecosystem behavior [77].

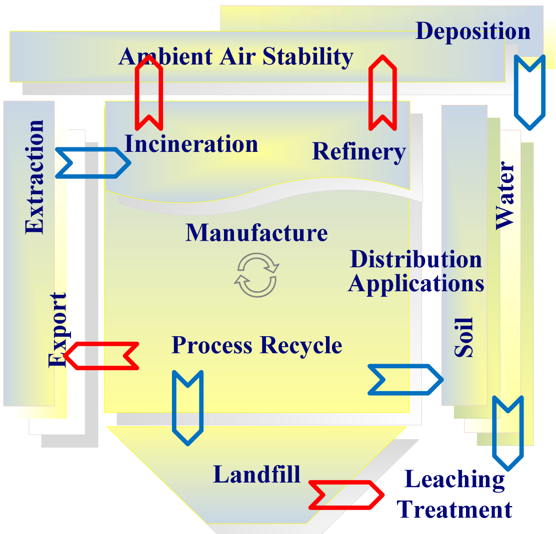

Fig. 4 The elementary process in Industrial Ecology [76]

The feedback mechanism is improving spatial organization from traditions and historical configurations of society to mobility patterns and leading to equilibrium of anthropogenic structure change. The nature mitigation is describing linear and nonlinear processes for engineering conservation energy and resources through 3'R (i.e., Recycle, Reuse, and Reduce) with biomimicry ecosystems in design and management systems. The religion is the holistic anchor lingers to preserve nature resources and environment from inadvertently behavior [75], [78]-[81].

A. Life Cycle Assessment

In order to attain the defined objectives, the Life Cycle Assessment (LCA) methodology is selected to quantify the impact through various methods. Those methods are available to estimate the environmental impacts, in spite of being adequate to an extent for a particular purpose with various notes about outcomes. LCA is a structured approach and it is performed based on ISO 14040 – 43 standards [82]-[88]. The LCA modeling has influenced the impact of construction ecology [89]. According to ISO 14040, LCA method consists of four distinct analytical stages [90], [91]:
1. LCA is defining the goal and scope of the systems.
2. The inventory of life-cycles is predicting the materials and their associated environmental impacts.
3. The impact assessment of the ecosystems is predicting life time with the Life Cycle Inventory (LCI) datasets.
4. The interpretation model is defined from the results to predict LCA using quantitative methods.

Basically, the first stage of LCA methods is to state the purpose, scope, and system boundaries. The goal of design conditions is to evaluate the project life cycle energy use and environmental impact of typical types of construction ecology in the economic model and to inspect whether the obtained results are significantly deviated by the type of integration outcomes. These methods then are used to evaluate the overall energy flow and environmental impacts from the industrial sector with the aim of identifying the best alternative. The functional unit is considered as 1 kg of CO_2 equivalent per capita over its lifetime. A 50-year lifespan is assumed for this project, which is commonly used by researchers in LCA analysis of construction. Also, this allows for a significant time period for repair, and replacement of industrial production materials. The framework for system boundaries and outputs of this LCA study are shown in Fig. 5 [92].

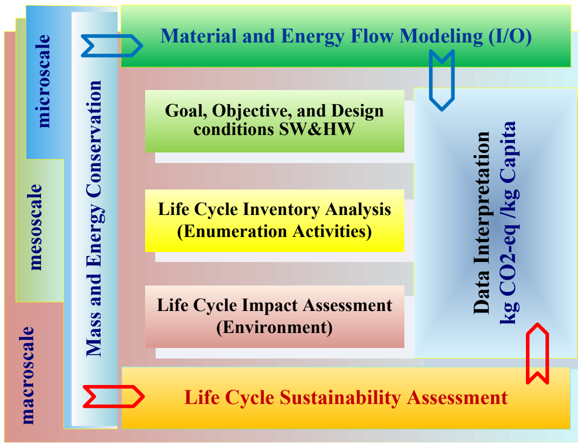

Fig. 5 The main flow of LCA [92]

The second stage of LCA is Life Cycle Inventory (LCI), starts with making a process tree or a flow-chart classifying the events in a process's life-cycle which are to be considered in the LCA, plus their interrelations. This procedure is followed by data collection, where quantitative and qualitative data for all inflows and outflows, such as raw materials, energy, ancillary products, land use and emissions are gathered. The next step in LCI is to calculate the amount of energy used and emissions of the studied system in relation to its functional unit [93], [94].

The third stage of LCA study is Life Cycle Impact Assessment (LCIA), which calculates the potential environmental impact and estimates the energy flow in the project system or process. Finally, the last stage of LCA study is interpretation, which is an iterative process present during all phases of the study. The findings of the LCI and LCIA are combined here in order to achieve the recommendations and conclusions for the study. Management of an environmental system is proportionality related to common perception of cause–effect model; large scale stimuli cause large effects, whereas small stimuli cause only small effects. Management energy and resources from input–output stream are interpreted in physical parameters that function in various scales of ecosystems: Microscale systems, Mesoscale systems, and Macroscale systems [95]-[101].

The environmental aspects are increasingly more significant in sustainability. Therefore, environmental assessment of construction ecology is a significant approach to attain the goal of sustainability. In general, LCA technique is employed in urban environments to quantify and evaluate the environmental impact during its stable condition lifetime, which includes construction inventory of extraction raw materials, utilization, end of life, and beyond building life [102], [103].

B. Composite Structure

Composite structure can be simulated from the point of ecology, resource savings, static load design, financial and a number of other pragmatic reasons from a prospective of the spatial modeling of decisive materials. Analogical design structures include metaphoric interpretation of intention and considerations of context. The composite structure describes an attempt to unify analytic and analogical approaches in a management tools setting, using simulation software. Based on the surveyed dataset, diagnostic treat has been used in a composite FE model to predict biomechanical performance by the combination of molecular recognition and small taxonomic sample for quantitative assessment. Feeding variations in systems ecology generates artificially elevated correlations as a bias to introduce positives response into interpretations of clade-level trends. These are considering potential pitfall, recommendations and providing to consider the ways FE analyses to address quantitative both taxon-specific and clade-level evolutionary questions. These methods are applied in recent model where the ecological design process is based on optimization topology as investigated in [104].

The system's analysis is breaking down structures and properties of individual component's parts into a composite structure between linear and nonlinear processes at microscopic level. The simple trajectory of molecules is dialogue with nature features in atomic mechanics to exchange natural energy and resources for equilibrium in a stable mechanism at a specific period of time. The building protocol is applied to quantitative model across all recent models used in this study except for the elastic moduli values (20 GPa for models from [105], 18 GPa for models from [106] and this model), which were standardized using a secondary linear regression analysis. In brief analysis, the adjustment occurs through composite finite elements simulation protocol include capturing the 3D geometry of each skull specimen using CT scanning (i.e., dataset of the constructed models is downloaded from scans uploaded to MorphoSource.org by [107]). There is emerging mathematical modeling to systems ecology and establishing environmental real-time monitoring systems within probability datasets of random interaction between biotic and abiotic variables in ecosystems [108].

C. Industrial Anthropocene

The proposed term of current geophysical force is applied to assess the impact in which indicators of anthropogenic insertions have the rapid cause of planetary changes. The name Anthropocene is inferred to a combination of anthropos (Ancient Greek: ἄνθρωπος) meaning "human" and -scene from kainos (Ancient Greek: καινός) meaning "new" or "recent" [109]-[111].

IV. Construction Ecology

The question is how construction ecology is applied for modeling system diversity within the biotic and abiotic variables as autocatalytic [112]. The natural optimization of energy, natural resources and the environment is providing stability in rectification failure of generic systems contributing in the state of anthropogenic insertions. In order to mitigate the impact of construction components along their life cycle, composite structure has emerged for encouraging the use of environmentally friendly materials. These techniques are saving resources and reducing waste consumption. The indoor conditions, [113], [114], are predicted energy flow of construction materials as domestic (vernacular) that provided in those modeling theories. These types of materials do not have any harmful effect on the environment, because when buildings are demolished, there is confidence in quick resumption of material to nature unlike current construction. For instance, Sialk hills are the good example of sustainable outcomes that were made about 7000 years ago. It can be named as a sustainable complex. Although it is being demolishing these days, it never pollutes the environment due to the use of the proper material [115]. Recently, when the current buildings are demolished, it reveals different types of pollution. It can be named as a sustainable complex. The recognition of the need to attain sustainable development in urban environments has led to increased interest in the discourse of sustainability considerations as one of the important roles of outcomes. The concept sustainability outcomes are situated in the expansive skeleton of knowledge of construction ecology performance or project eco-feedbacks. In literature, the terms project eco-feedback, project outcomes and project objectives are inextricably linked. Reference [116] defines project outcome as the extent to which an operation's major relevant objectives have been achieved. Reference [117] equates project success as a favorable outcome. According to [118], project outcome is often referred to loosely as project success (or failure). Thus, the analysis of random parameters is perceived and aligned to project objective as the project has a favorable outcome to orientation [119].

It is important to note that the quantitative analysis is described above to make biomechanical simulation about the nature of the spatial data collected from datasets defined as:

(1) The standard FE simulation outcomes are recognized from results without error,
(2) The dataset is feeding variables of predicting systems ecology for examining the composite structure,

(3) The error is predicted with generated phylogenetic topology to evaluate systems in accurate relationship to structure performance.

Extensive literatures are efficiency examining these issues behind each of these assumptions and demonstrates the complexity of each of these issues in comparative analysis. In recent biomechanical points of view, the outline data are characteristic finite elements model building protocol for calculation of all elected taxa in the full dataset included adjusted canine mechanical efficiency, adjusted fourth premolar mechanical efficiency, adjusted strain energy value in canine bite scenario, and adjusted strain energy value in fourth premolar bite scenario [120]. These data models served as the functional performance variables used to characterize a given taxon. The biomechanical performance is feeding ecological systems with variables used for correlation to include dietary breadth and trophic level. The levels in each variable and the coding of each of the taxon are included in the dataset from the PanTHERIA database [121]. Feeding ecological grouping in this model is characterized by the combination of these two categories.

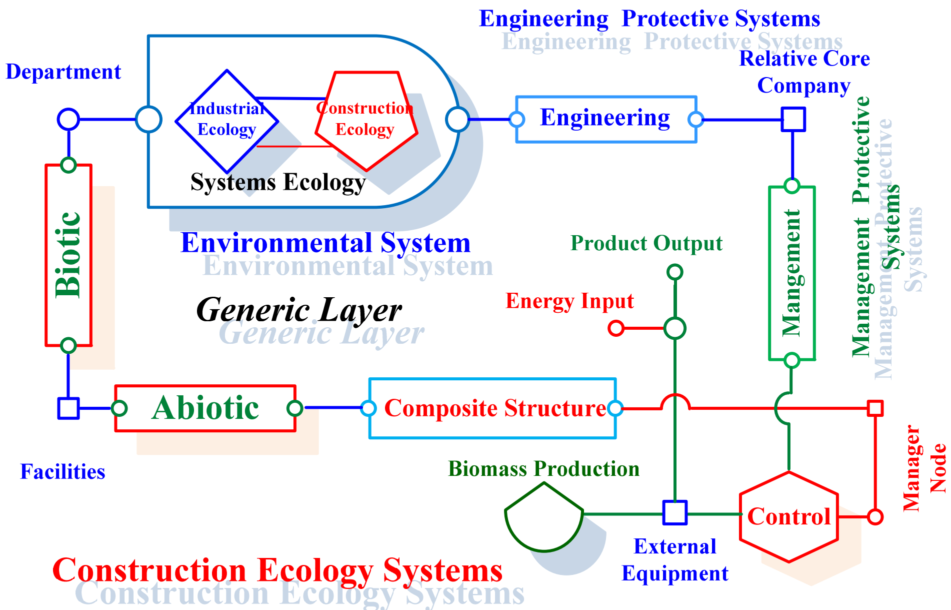

Fig. 6 Main relations to construction ecology systems [122]

The general concept of relations between construction ecology and other Earth's Systems reset on the importance of maintaining or improving conditions of the natural life cycle and human health via the urban environments. Fig. 6 [122] contains a grounding of fact-based knowledge in construction materials (i.e., classification, production, qualities and uses) with the development of design frameworks that enable environmental and health criteria to be set project components. These components are providing the knowledge to enable ecologist and engineer to select or collect a number of building materials for any project, in any location, culture or date for resources conservation [123].

B. Case Studies

Social, economic and environmental unity is the core state of urban environments development. It is a high degree of harmony between human behavior and urban environments. Integration of sustainable urban environments and morphology in the model parameters are reducing the energy consumption and carbon emissions in an industrial region, which is mainly reflected in two aspects: the moderately cities compact and the ecological corridor [124]. Compact cities are useful to promote land mixed-use, reduce the travel distance, and also bring the sustainable multiplier effect [125]. These travel distance data have been located in eastern boundary of Suez Canal as a tourist attractive place considering it as a gateway between Cairo (current capital of Egypt) and Suez (Industrial areas and harbors). It is at the end of both sides and at the beginning of Sinai (latitude 33° 59'E and longitude 29°27' N).

In analysis the systems, the model evaluates the impact and interface design eco-feedback performance. The model is applied within empirical roles for using a prototype eco-feedback interface with the significant inverse data to predict correlation between user engagement (i.e., measured as logins) and energy consumption. Utilizing this relationship as a performance basis, the spatial modeling is expanding analysis to evaluate five design components (i.e., biological, economics, sociology, environmental ethics and planning whilst) with eco-feedbacks. These eco-feedbacks are statistically corroborating to historical comparison incentives that drive design components in energy consumption within a higher level and for reduction coast of operations. This normative consumption and disaggregation elements are inconclusive for rewards and penalization aspect is necessary. This analysis type raises pertinent questions regarding the efficiency of various eco-feedback components in eliciting energy saving.

Another important property for improving energy efficiency is thermal inertia (or thermal mass), which represents the capacity of a material to store heat. In thermal inertia walls, it is not necessary to have a good insulation property for, providing better indoor comfort through reducing the impact of outdoor temperature for changing conditions of indoor environments. The thermal walls are constructed from dense and heavy materials to build a high thermal inertia and protect indoor zone from entering insides by storing thermal mass during the day and releasing it during the nighttime when the temperature cools down. It is widely accepted that the use of high thermal inertia walls, with excellent thermal insulation, in buildings would usually result in a reduction of energy requirements for both cooling and heating. If a building has the characteristics which are mentioned above, it will have a reduction in energy consumption. So, the model is investigated for the reduction of energy consumption due to multiple action scenarios with simulation outcomes. The comparison has referred the baseline reduction to the total energy use and assumes changes in their behavior upon learning the impact of their action on energy consumption. There is some adaptation in the required energy in terms of comfort for example, changing cooling set points will require users to accept that action for energy efficiency over their preferred choices of cooling set points.

C. Economic Sustainability Outcomes

In sustainability, the definition of economic sustainability means different things to different groups of people [126], the ecosystems of finite elements are designed for application quantitative model of spatial data. These economic outcomes are used for analysis of regional location, cities and neighborhoods. These approaches are invoking the conventional law and large numbers are united for such empirical settings. Apart from definitions such as maintaining economic factors into the future [120], [127], other viewpoints include providing financial resources for technical advance required solving environmental problems and overcoming a radical change in growth paradigm and resource technology. In the built environment this aspect can be achieved by actions such as involving local businesses in the construction ecology, providing regional marketing models by building feedback for minimizing waste. The spatial model uses quantitative economic models to evaluate urban environments such as infrastructure investments in land-use planning for decisions. The growing availability of economic data observed in spatial scales of tremendous potential new insights. However, the policy-makers rely on these data to support decisions for establishment the relevant features of the database for making counterfactual predictions [128], [129]. According to [128], the outcome performance measures for economic sustainability include employment and marketing. This model has improved upon the conventional continuum-of-individuals relation that perfectly performs pre-event data but produces predictions uncorrelated with the observed changes in spatial data flows.

D.Social Sustainability Outcomes

According to [126] and structured literature review [130], social outcomes refer to the spatial economic, environmental or urban community benefits that occur from the development of a construction asset. Social objectives for a construction project include conservation of local culture and heritage; and integration of the developed facility within the locality. The articulation of social sustainability has remained a challenge in literature. Reference [131] suggests that social sustainability is largely neglected because of difficult formulation performance criteria. According to [132], tangible social sustainability outcomes on construction projects include increased efficiency and reduced work time which could result in financial saving [133]. Outcomes are also exhibited as value created by considering social sustainability objectives [134]. The indicators for this value include a sense of community and neighborly behavior, reduced crime and press coverage.

E. Environmental Sustainability Outcomes

Environmental Sustainability Outcomes refer to the end result from the prudent use of natural resources, protection of ecosystems and biodiversity [126]. The environmental aspect is the most researched in literature. On a construction project, environmental sustainability objectives include minimizing use of resources, minimizing pollution and waste for protecting biodiversity and the environment. The success measures for environmental sustainability are easier to identify in literature since they can be benchmarked against conventional buildings. They include criteria such as decreased operating costs for the built facility 8-9% [123] and energy efficiency values compared to the conventional buildings [134]. Environmental sustainability also has ecological performance measures such as occupants' general satisfaction.

The literature that has been reviewed suggests that many researchers have made a link between sustainability realization of objectives and the procurement method used on sustainable buildings of construction projects [135], [136]. Despite its continued use on such projects, traditional procurement is rarely recommended. Reference [137] recommends other procurement strategies. However, no consensus has been reached on the most appropriate procurement strategy. The proposed partial data are defined in a systematic literature review of existing models to the most appropriate procurement strategy to meet and exceed sustainability goals on a project. Secondly, despite the link made between procurement delivery methods and favorable sustainability objectives, there is paucity in literature on the success criteria used for measuring sustainability favorable outcomes. Information is required from extant literature on the subject to identify sustainability success criteria.

Once the spatial independence in ecological data has been predicted, the spatial data are intended to define the relationship between others for obtaining the strategies of sustainability outcomes. The spatial data intended to define the relationship between others for obtaining the strategies of sustainability outcomes; the above model layers have specific keywords to be used for the literature search: procurement delivery, procurement strategy, procurement method, green building, high performance building, sustainable building, and construction ecology. The limitation of spatial models is related to databases objects as one–many or many–one which are specifically conduct the relations between the construction ecology and the urban environments. Due to the intensified interest in the subject of sustainability in academic research, open databases such as Google Scholar would have returned literature from large volumes of unpublished papers [139], [140].

TABLE I
ENVIRONMENTAL DIMENSIONS OF SPATIAL DATA [138]

Layer No.	Layers Name of Spatial Data	Model Consideration
1	Economic	Considers economic effects and benefits
2	Social	Considers human and societal interests
3	Ecological	Considers effect on nature and earth
4	Time	Considers long term effect
5	Values	Understands sustainability as a normative concept
6	Geographical	Considers both local and global effects
7	Performance	Considers failure and non-performance a waste of resources and energy
8	Participation	Considers including and participation of stakeholders
10	Waste Reduction	Considers reducing and prevention of waste
11	Transparency	Open and proactive sharing of information with decision maker
12	Accountability	Considers willing to be held accountable for decisions and actions
13	Cultural	Considers respecting differences in cultures and values
14	Risk reduction	Considers reducing and avoiding certain risks
15	Political	Considers recognizing differences in interest of decision maker
16	Reliability	Considers the failure in system
17	Maintainability	Considers the periodical response to failure in systems

V. CONCLUSION

This spatial modeling using finite element ecological model, along the industrial zone in the side of Suez Canal postulates forward a series of strategies for ecological improvement in the industrial areas, eco-feedbacks, eco-structure and eco-technology. Its purpose is not only to predict the common ecological problems in the industrial region, but also to analyze the larger regional climate and energy crisis. The topology integrated into construction ecology and sustainable outcomes in terms of energy and material. The eco-topologies have a significant impact in terms of urban environments as illustrated above in previous sections. The modification shields gap between the external forces that replaced by outcomes. As a result, a wide range of eco-feedbacks is captured in land use. The feedbacks model linked land use to transport, soil, market, climate and social systems. These systems are represented in landscape where the exploration of human behaviors is integrated sustainability dimensions of society, economy and environment. The feedback's inclusion in land influenced data collection and model coupling, as well as social context. As example, "LEED stands for Leadership in Energy and Environmental Design that has a green building rating system originally developed in 1998 by the U.S. Green Building Council (USGBC) to provide a recognized standard for the construction industry to assess the environmental sustainability of building designs. LEED for neighborhood development is developed in 2007 and last updated in 2019" [141]-[143].

REFERENCES

[1] Jaroslave Vrchota, Martin Pech, Ladislav Rolinek, and Jifi Bednaf, (2020) "Sustainability Outcomes of Green Processes in Relation to Industry 4.0 in Manufacturing: Systematic Review", Sustainability, Vol. 12(15): pp. 5968, 2020. https://doi.org/10.3390/su12155968.

[2] Rajput S P S, Datta S, (2020) "Sustainable and green manufacturing–A narrative literature review", Mater. Today Proc., 2020.

[3] Couckuyt D, Van Looy A, (2019) "Green BPM as a Business-Oriented Discipline: A Systematic Mapping Study and Research Agenda", Sustainability, Vol.11: pp. 4200, 2019.

[4] Kumar, R, Singh S P, Lamba K, (2018) "Sustainable robust layout using Big Data approach: A key towards industry 4.0", J. Clean Prod., Vol. 204: pp. 643–659, 2018.

[5] Lai K H, Wong C W Y, (2012) "Green logistics management and performance: Some empirical evidence from Chinese manufacturing exporters", Omega Vol. 40: pp. 267–282, 2012.

[6] Edwin H W Chan, Queena K Qian, Patrick T I Lam, (2009) "The market for green building in developed Asian cities- the perspectives of building designers", Energy Policy, Vol. 37: pp.3061-3070, 2009.

[7] Chinese National Standards (GB/T 50378-2006), "Evaluation Standard for Green Building", Beijing, China Building Industry Press, 2006.

[8] US global change research program, (2009) "Global climate change impacts in the United States", 2009.

[9] Wang W, Zmeureanua R, Rivard H, (2005) "Applying multi-objective genetic algorithms in green building design optimization. Building and Environment Vol. 40(11): pp.1512–25, 2005.

[10] Thormark C, (2006) "The effect of material choice on the total energy need and recycling potential of a building", Building and Environment, Vol. 41(8): pp. 1019–26, 2006.

[11] Carlucci S, Cattarn G, Causone F, and Pagliano L, (2015) "Multi-objective optimization of a nearly zero-energy building based on thermal and visual discomfort minimization using a non-dominated sorting genetic algorithm", Energy Build. Vol. 104: pp. 378–3940, 2015. doi: 10.1016/j.enbuild.2015.064.

[12] Aste N, Angelotti A, Buzzetti M, (2009) "The influence of the external thermal inertia on the energy performance of well insulated buildings", Energy Build, Vol. 41(11):1181–7, 2009.

[13] Sokolowski J A, Banks C M, (2009) "Principles of modeling and simulation", John Wiley & Son. p. 6, 2009. ISBN 978-0-470-28943-3.

[14] Zeigler, B P, Praehofer H, and Kim T G, (2000) "Theory of Modeling and Simulation: Integrating Discrete Event and Continuous Complex Dynamic Systems", Elsevier, Amsterdam, 2000.

[15] Naqi A, Jang J G, (2019) "Recent Progress in Green Cement Technology Utilizing Low-Carbon Emission Fuels and Raw Materials: A Review", Sustainability, Vol. 11: pp. 537, 2019.

[16] Tong H H, Yao Z Y, Lim J W, Mao L W, Zhang J X, Ge T S, Peng Y H, Wang C H, and Tong Y W, (2018) "Harvest green energy through energy recovery from waste: A technology review and an assessment of Singapore", Renew. Sust. Energ. Rev., Vol. 98: pp. 163–178, 2018.

[17] Ahn D G, (2016) "Direct Metal Additive Manufacturing Processes and Their Sustainable Applications for Green Technology: A Review", Int. J. Precis Eng Manuf-Green Technol. Vol. 3: pp. 381–395, 2016.

[18] Purohit D, and Malvi B, (2019) "Review on Green Technology for Sustainable Development", Am. J. Eng. Res. (AJER), Vol.8: pp. 296–300, 2019.

[19] Jeong Y J, Kang I, Choi S K, and Lee B H, (2018) "Network Analysis on Green Technology in National Research and Development Projects in Korea", Sustainability, Vol.10: pp. 1043, 2018

[20] Mukhtarova K, Trifilova A, and Zhidebekkyzy A, (2016) "Commercialization of Green Technologies: An Exploratory Literature Review", J. Int. Stud., Vol. 9: pp. 75–87, 2016.

[21] Matsebula F, Mnkandla E, (2016) "Information systems innovation adoption in higher education: Big data and analytics", In Proceedings of the 2016 International Conference on Advances in Computing and Communication Engineering (ICACCE); IEEE: Durban, South Africa, 2016; pp. 326–329, 2016.
[22] Patel D, Kellici S, and Saha B, (2014) "Green Process Engineering as the Key to Future Processes", Processes Vol. 2: pp. 311–332, 2014.
[23] Cheng C C J, Yang C, and Sheu C, (2014) "The link between eco-innovation and business performance: A Taiwanese industry context", J. Clean. Prod., Vol. 64: pp. 81–90, 2014.
[24] Wang L, Lu K, Liu P, Ranjan R, and Chen L, (2014) "IK-SVD: Dictionary Learning for Spatial Big Data via Incremental Atom Update", Comput. Sci. Eng, Vol. 16: pp. 41–52, 2014.
[25] Brown, Ronald, Higgins, Philip J, Sivera, and Rafael, (2011) "Nonabelian Algebraic Topology: Filtered Spaces, Crossed Complexes, Cubical Homotopy Groupoids, European Mathematical Society Tracts in Mathematics, Vol. 15, European Mathematical Society, ISBN 978-3-03719-083-8, archived from the original on 2009-06-04.
[26] Maunder C R F, (1970) "Algebraic Topology", London, Van Nostrand Reinhold, ISBN 0-486-69131-4.
[27] Tammo tom Dieck, (2008) "Algebraic Topology", EMS Textbooks in Mathematics, European Mathematical Society, ISBN 978-3-03719-048-7
[28] Beaverstock J V, (2002) "Transnational elites in global cities: British expatriates in Singapore's financial district", Geoforum Vol. 33: pp. 525 – 538, 2002.
[29] Castells M, (1996) "The Rise of the Network Society", (Blackwell, Oxford), 1996.
[30] Rimmer P J, (1998) "Transport and telecommunications among world cities", in Globalization and the World of Large Cities Eds F-C Lo, Y-m Yeung (United Nations University Press, Tokyo) pp. 433 – 470, 1998.
[31] Friedmann J, (1986) "The world city hypothesis", Development and Change, Vol. 17: pp.69 – 84, 1986.
[32] Matsumoto H, (2007) "International air network structures and air traffic density of world cities", Transportation Research Part E, Vol. 43, pp. 269 – 282, 2007.
[33] Erl T, (2005) "Service-Oriented Architecture: Concepts, Technology and Design", Prentice Hall, July 2005.
[34] Haldar Achintya, and Mahadevan Sankaran, (2000) "Reliability Assessment Using Stochastic Finite Element Analysis", John Wiley & Sons. ISBN 978-0471369615
[35] Tseng, Z Jack, (2021) "Rethinking the use of finite element simulations in comparative biomechanics research", PeerJ vol. 9 e11178. 7 Apr. 2021, doi:10.7717/peerj.11178
[36] Georg Jung, Tiziana Margaria, Ralf Nagel, Wolfgang Schubert, Bernhard Steffen, and Horst Voigt, (2007) "SCA and jABC: Bringing a Service-Oriented Paradigm to Web-Service", IEEE Computer, IEEE Press, November 2007.
[37] Dumont E R, Grosse I R and Slater G J, (2009) "Requirements for comparing the performance of finite element models of biological structures", J Theor Biol. 2009 Jan 7; Vol. 256(1):pp. 96-103.
[38] Vuong Q –H, (2021) "The semiconducting principle of monetary and environmental values exchange", Economics and Business Letters, Vol. 10 (3): pp. 284–290, 2021. doi:10.17811/ebl.10.3.2021.284-290.
[39] Bernardi E, Carlucci S, Cornaro C, Bohne R A, (2017) "An analysis of the most adopted rating systems for assessing the environmental impact of buildings", Sustainability. 2017 Jul 13; Vol. 9(7): pp.1226 Layer of flux modeling (from the previous paper)
[40] Ankur Gupta, Cristian Borcea, Achir Kalra, Quentin Jones, Liviu Iftode, (2009) "MobiSoC: a middleware for mobile social computing: Challenges, Design, and Early Experiences", Mobile Networking Applications, Springer, 2009.
[41] Bilandzic M, Foth M, and A de Luca, (2008) "CityFloks: Designing Social Navigation for Urban Mobile Information Systems", DIS 2008, ACM Press, February 2008.
[42] Hansen F A, and Gronbaek K, (2008) "Social Web Applications in the City: A Lightweight Infraestructure for Urban Computing", HT 2008, ACM Press, June 2008.
[43] Kjeldskov J, and Paay J, (2006) "Public Service Computing: Making the Invisible Visible", IEEE Computer, IEEE Press, September 2006.
[44] Daniel S, Tsoulfas G, Pappis C, and Rachaniotis N, (2004) "Aggregating and evaluating the results of different Environmental Impact Assessment methods", Ecological Indicators, Vol. 4 (2): pp. 125–138, 2004. doi:10.1016/j.ecolind.2004.01.003.
[45] Hitzschky K, and Silviera, J, (2009) "A proposed impact assessment method for genetically modified plants (As-GMP method)", Environmental Impact Assessment Review, Vol. 29 (6): pp. 348–368, 2009. doi:10.1016/j.eiar.2009.02.006.
[46] Peche R, and Rodriguez E, (2009) "Environmental impact Assessment procedure: A new approach based on Fuzzy logic", Environmental Impact Assessment review, Vol. 29: pp. 275–283, 2009.
[47] Cotton Roger, Emond D. Paul, and John Swaigen (ed.), (1981) "Environmental Impact Assessment", Environmental Rights in Canada. Toronto, Ontario: Butterworths, 1981.
[48] Singh, R, Kumar S, (2017) "Green Technologies and Environmental Sustainability", Springer, Berlin, Germany, 2017.
[49] Margaria T, Steffen B, Reitenspieß M, (2005) "Service-oriented design: The roots", In: Benatallah B, Casati F, Traverso, P (eds.) ICSOC 2005. LNCS, Vol. 3826: pp. 450–464. Springer, Heidelberg (2005).
[50] Yolande A A Strengers, (2011) "Designing eco-feedback systems for everyday life", Proceedings of the International Conference on Human Factors in Computing Systems, CHI 2011, Vancouver, BC, Canada, May 7-12, 2011
[51] Huang Jianhuan, Yang Xiaoguang, Cheng Gang, and Wang, "A comprehensive eco-feedback model and dynamics of regional eco-efficiency in China", Journal of Cleaner Production, Vol. 67: pp 228-238, March 15, 2014
[52] Qin Q, Zhu L, Li Z, Ghulam A, Nan P, "Satellite monitoring of spatio-temporal dynamics of China's coastal zone eco-efficiency environments: Preliminary analysis on the relationship between the environment, climate change and human behavior", Environmental Geology, Vol. 55(8): pp. 1687-1698, October 2008
[53] Ware I, Fitzpatrick C, Johnson M, Palkovacs E, Kinnison M, Mueller L, ... Bailey J, (2018) "Ecosystem effects of evolution: A synthesis of eco-evolutionary feedbacks across terrestrial and aquatic systems", Functional Ecology, 2018.
[54] terHorst C P, and Zee P C, (2016) "Eco -evolutionary dynamics in plant–soil feedbacks", Functional Ecology, Vol 30: pp.1062–1072, 2016.
[55] Van Nuland M E, Ware I M, Bailey J K, and Schweitzer J A, (2019) "Ecosystem feedbacks contribute to geographic variation in plant–soil eco-evolutionary dynamics across a fertility gradient", Functional Ecology, Vol. 33(1): pp. 95–106, 2019. https://doi.org/10.1111 /1365-2435.13259
[56] Van Nuland M E, Wooliver R C, Pfennigwerth A A, Read Q D, Ware, I M, Mueller L, ... Bailey J K,(2016) "Plant–soil feedbacks: Connecting ecosystem ecology and evolution", Functional Ecology, Vol. 30: pp. 1032–1042.
[57] Travis, J, Reznick, D, Bassar R D, López-Sepulcre A, Ferriere, R, and Coulson T,(2014) "Do eco -evo feedbacks help us understand na -ture? Answers from studies of the Trinidadian guppy", Advances in Ecological Research, Vol. 50: pp.1–40, 2014
[58] Smallegange I, Rhebergen F, Van Gorkum T, Vink D, and Egas M, (2018) "Around and around we go: Understanding eco-evolutionary dynamics by studying polymorphisms and closed feedback loops", Functional Ecology, 2018.
[59] Robertson, D S, (1991) "Feedback theory and darwinian evolution", J. Theor. Biol., Vol. 152: pp. 469-484, 1991.
[60] Roughgarden J, (1979)"Theory of Population Genetics and Evolutionary Ecology: An Introduction", Macmillan Publishing Co., Inc., 1979.
[61] Patel S, Cortez M H, and Schreiber S J, (2018) "Partitioning the effects of eco-evolutionary feedbacks on community stability", American Naturalist, Vol. 191: pp. 381–394, 2018.
[62] Tarek Rakha, Elena Echarri, Elizabeth Krietemeyer and Jason Dedrick, (2019) "Sustainable Urban Community Eco-Feedback through Simulation-enabled Performance Dashboards", Proceedings of the 16th IBPSA Conference Rome, Italy, Sept. 2-4, 2019. https://doi.org /10.26868/25222708.2019.210655
[63] Hairston N G, Ellner S P, Geber M A, Yoshida, T. & Fox, J.A. (2005) "Rapid evolution and the convergence of ecological and evolutionary time", Ecol. Lett. Vol. 8: pp.1114-1127, 2005
[64] Hendry A P, and Kinnison, M T, (1999) "The pace of modern life: measuring rates of contemporary micro evolution", Evolution Vol. 53: pp. 1637-1653, 1999.
[65] Hendry, A P, (2017) "Eco-evolutionary dynamics", Princeton University Press, Princeton, NJ, USA. Hendry, 2017.
[66] Hiltunen T, Hairston N G, Hooker G, Jones L E. and Ellner S P (2014) "A newly discovered role of evolution in previously published consumer-resource dynamics", Ecol. Lett., Vol. 17: pp. 915-923, 2014.

[67] Lynn Govaert, Emanuel A. Fronhofer, S_ebastien Lion, Christophe Eizaguirre, Dries Bonte, Martijn Egas, Andrew P. Hendry, Ayana De Brito Martins, Carlos J Melián, Joost A. M. Raeymaekers, Irja I. Ratikainen, Bernt-Erik Saether, Jennifer A. Schweitzer and Blake Matthews,(2018) "Eco-evolutionary feedbacks-theoretical models and perspectives", Function Ecology, Vol. 33(1): pp.13-33, 2018. https://doi.org/10.1111/1365-2435-13241.

[68] Aström K J, and Murray R M, (2008) "Feedback Systems: An Introduction for Scientists and Engineers", Princeton University Press: Princeton, NJ, USA, p. 1, 2008.

[69] Austin M P, (2002) "Spatial prediction of species distribution: an interface between ecological theory and statistical modeling", Ecological Modelling Vol.157: pp101-118, 2002.

[70] Beaumont, L J, Pitman A J, Paulsen M, and Hughes L, (2007) "Where will species go? Incorporating new advances in climate modeling into projections of species distributions", In G. C. Biology, editor, 2007. doi.10.1111/j.1365-2486.2007.01357.x.

[71] Monique R. Morgan, (January 2013) "The Eruption of Krakatoa (also known as Krakatau) in 1883", BRANCH: Britain, Representation and Nineteenth-Century History. Retrieved 5 February 2019.

[72] Forsyth, Mark, (2014) "The Elements of Eloquence", Berkley Publishing Group/Penguin Publishing. New York. ISBN 978-0-425-27618-1

[73] Quinn, and Edward, (1999) "A Dictionary of Literary and Thematic Terms", Checkmark Books, New York, 1999. ISBN 0-8160-4394-9

[74] Ross CF, (2005) "Finite element analysis in vertebrate biomechanics", Anat Rec A Discov Mol Cell Evol Biol. 2005 Apr; Vol. 283(2): pp.253-8, 2005.

[75] Rayfield E J. (2007) "Finite element analysis and understanding the biomechanics and evolution of living and fossil organisms", Annual Review of Earth and Planetary Sciences, 2007;Vol. 35(1): pp. 541–576, 2007. doi: 10.1146/annurev.earth.35.031306.140104.

[76] Jensen P D, (2011) "Reinterpreting Industrial Ecology", Journal of Industrial Ecology, Vol. 15 (5): pp. 680–692, 2011. doi:10.1111/j.1530-9290.2011.00377.x. S2CID 9188772.

[77] John Ehrenfeld, (2004), "Can Industrial Ecology be the Science of Sustainability?", Journal of Industrial Ecology, Vol. 8 (1–2): pp. 1–3, 2004.

[78] Azari R, and Kim Y W, (2015) "Integration evaluation framework for integrated design teams of green buildings: Development and validation", Journal of Management in Engineering. 2015 Dec 28; Vol. 32(3): pp. 04015053, 2015.

[79] Vincent Julian F V, Bogatyreva Olga A, Bogatyrev Nikolaj R, Bowyer Adrian and Pahl Anja-Karina, (21 August 2006) "Biomimetics: its practice and theory ", Journal of the Royal Society Interface, Vol. 3 (9): pp. 471–482, 2006. doi:10.1098/rsif.2006.0127. PMC 1664643. PMID 16849244.

[80] Anosh Nadeem Butt and Branka Dimitrijevic, (2022) "Multidisciplinary and Transdisciplinary Collaboration in Nature-Based Design of Sustainable Architecture and Urbanism", Sustainability 14(16):10339, 2022. doi: 10.3390/su141610339

[81] Mary McCarty, (2009) "Life of bionics founder a fine adventure", Dayton Daily News, 29 January 2009.

[82] Ganjidoost A, and Alkass S, (2012) "Environmental Life Cycle Analysis of Office Buildings in Canada", Int. J. Eng. Technol., Vol. 4(5): pp. 602–606, 2012.

[83] Zhang W, Tan S, Lei Y, and. Wang S, (2014) "Life cycle assessment of a single-family residential building in Canada: A case study", Build. Simul., Vol. 7 (4): pp. 429–438, 2014.

[84] Reza B, Sadiq R, and Hewage K, (2014) "Emergy-based life cycle assessment (Em-LCA) of multi-unit and single-family residential buildings in Canada", Int. J. Sustain. Built Environ. vol. 3, no. 2, pp. 207–224, Oct. 2014.

[85] I. O. for S. ISO 14040, "Environmental management: life cycle assessment. Principles and framework", 2006.

[86] I. O. for S. ISO 14041, (1998) "ISO 14041 Environmental management — Life cycle assessment — Goal and scope definition and inventory analysis", 1998.

[87] I. O. for S. ISO 14042, (2000) "ISO 14042 Environmental management - Life cycle assessment - Life cycle impact assessment", 2000.

[88] I. O. for S. ISO 14043, (2000) "ISO 14043 Environmental management — Life cycle assessment — Life cycle interpretation", 2000.

[89] I. O. for S. ISO 14044, (2006) "ISC 14044: Environmental Management — Life Cycle Assessment— Requirements and Guidelines", 2006.

[90] Hsu S L, (2010) "Life Cycle Assessment of Materials and Construction in Commercial Structures: Variability and Limitations", Massachusetts Institute of Technology. 2010.

[91] Li X, Yang F, Zhu Y, and Gao Y, (2014) "An assessment framework for analyzing the embodied carbon impacts of residential buildings in China", Energy Build., Vol. 85: pp. 400–409, Dec. 2014.

[92] Van Ooteghem K, and Xu L, (2012) "The life-cycle assessment of a single-story retail building in Canada", Build. Environ. Vol. 49: pp. 212–226, Mar. 2012.

[93] Wen T J, Siong H C, and Noor Z Z, (2014) "Assessment of Embodied Energy and Global Warming Potential of Building Construction using Life Cycle Analysis Approach: Case Studies of Residential Buildings in Iskandar Malaysia", Energy Build., Vol. 93: pp. 295–302, Dec. 2014.

[94] Asif M, Muneer T, and Kelley R, (2018) "Life cycle assessment: A case study of a dwelling home in Scotland", Build. Environ. Vol. 42(3): pp. 1391–1394, Mar. 2018.

[95] Valentine, Keri D.; Kopcha and Theodore J, (2016) "The embodiment of cases as alternative perspective in a mathematics hypermedia learing environment", Educational Technology Research and Development, Vol.64 (6): pp.1183-1206, Dec. 2016.

[96] Kostakos V et al, (2009) "Understanding and measuring the urban pervasive infrastructure", Personal and Ubiquitous Computing 13(5), Springer, 2009.

[97] Kostakos V., (2005) "A Design Framework for Pervasive Computing Systems", PhD thesis, University of Bath, 2005.

[98] Kostakos V., O`Neill E., Penn A., (2006) "Designing Urban Pervasive Systems", IEEE Computer, IEEE Press, September 2006.

[99] Wang Xin Jun, Hsu Po-Han, Zhou Rui, Su Hai-Long, "Activating eco-city in China: The system engineering for cities' green transition", 2011 5th International Association for China Planning Conference, 2012.

[100] Heinonen Jukka, Junnila, Seppo, Dimitrios Papastefanakis, Natassa Marini, "Implications of urban structure on carbon consumption in metropolitan areas", Environmental Research Letters, Vol 6 (1), 2011

[101] Zhang Yan, Yang, Zhifeng, Yu, Xiangyi, Berglund, Emily Zechman, "Measurement and evaluation of interactions in complex urban ecosystem", Ecological Modelling, Vol. 196 (1-2): pp. 77-89, July 10, 2006.

[102] Gard P T, (2001) "Fast and innovative delivery of high-performance building: Design-build delivers with less owner liability", Strategic planning for energy and the environment, 2004 Apr 1, Vol. 23(4): pp7-22, 2004.

[103] Martin H, Lewis T M, Petersen A, (2016) "Factors affecting the choice of construction project delivery in developing oil and gas economies", Architectural Engineering and Design Management, 2016 May 3, Vol. 12(3): pp.170-88, 2016.

[104] Naoum S, Egbu C, (2015) "Critical review of procurement method research in construction journals. Procedia Economics and Finance", 2015 Jan 1, Vol. 21: pp. 6-13, 2015.

[105] Prybyla A N, Tseng Z J, Flynn J J, (2018) "Biomechanical simulations of Leptarctus primus (Leptarctinae, Carnivora), and new evidence for a badger-like feeding capability", Journal of Vertebrate Paleontology, 2018; Vol. 38(6):e1531290. doi: 10.1080/02724634.2018.1531290.

[106] Pérez-Ramos A, Tseng ZJ, Grandal-D'Anglade A, Rabeder G, Pastor FJ, Figueirido B, (2020) "Biomechanical simulations reveal a trade-off between adaptation to glacial climate and dietary niche versatility in European cave bears" Sci Adv. 2020 Apr; Vol. 6(14):eaay9462, 2020.

[107] Tseng Z J, Su D F, Wang X, White S C, Ji X, (2017) "Feeding capability in the extinct giant Siamogale melilutra and comparative mandibular biomechanics of living Lutrinae", Sci Rep. 2017 Nov 9; Vol. 7(1):15225, 2017.

[108] Franz B W, Leicht R M, Riley D R, (2013) "Project impacts of specialty mechanical contractor design involvement in the health care industry: Comparative case study", Journal of Construction Engineering and Management. 2013 Aug 15, Vol. 139(9): pp.1091-7, 2013.

[109] Steiner Achim, (15 December 2020) "The Next Frontier: Human Development and the Anthropocene", UNDP. Retrieved 16 December 2020.

[110] Ehlers, Eckart, Moss C, Krafft Thomas, (2006) "Earth System Science in the Anthropocene: Emerging issues and problems", Springer Science Business Media. ISBN 9783540265900.

[111] Dixon Simon J, Viles Heather A, Garrett, Bradley L, (2018) "Ozymandias in the Anthropocene: The city as an emerging landform", Area. Vol. 50: pp. 117–125, 2018. doi:10.1111/area.12358. ISSN 1475-4762

[112] Masterman J, (2001) "An Introduction to Building Procurement Systems", Routledge; 2003 Sep 2.

[113] Robinson H, Symonds B, Gilbertson B, Ilozor B, editors. "Design Economics for the Built Environment: Impact of Sustainability on Project Evaluation", John Wiley & Sons; 2015 Jun 15.

[114] Buntaine M T, Parks B C, (2013) "When do environmentally focused assistance projects achieve their objectives? Evidence from World Bank post project evaluations", Global Environmental Politics. 2013 May; Vol 13(2): pp. 65- 88, 2013.

[115] Naoum SG, and Egbu C (2016) "Modern selection criteria for procurement methods in construction: A state-of-the-art literature review and a survey", International Journal of Managing Projects in Business. 2016 Apr 4; Vol. 9(2): pp309-36, 2016.

[116] Brelsford C, Lobo J, Hand J and Bettencourt L M A, (2017) "Heterogeneity and scale of sustainable development in cities", Proc. Natl. Acad. Sci. U.S.A. Vol. 114: pp. 8963–8968, 2017.

[117] Chan A P, Chan A P, (2004) "Key performance indicators for measuring construction success", Benchmarking: an international journal. 2004 Apr 1; Vol. 11(2): pp. 203-21, 2004.

[118] Liu AM, Walker A.(1988) "Evaluation of project outcomes", Construction Management & Economics, 1998 Mar 1; Vol. 16(2): pp, 209-19, 1988.

[119] Erik Cohen, David F. Aberle, Leopoldo J. Bartolomé, Lynton K. Caldwell, Aristide H. Esser, Donald L. Hardesty, Riaz Hassan, H. Dieter Heinen, Jiro Kawakita, Olga F. Linares, Partha Pratim Majumder, Albyn Knight Mark and Harald Tambs-Lyche, (March, 1976) "Environmental Orientations: A Multidimensional Approach to Social Ecology", Current Anthropology, Vol. 17 (1): pp. 49-70 (Mar., 1976), (22 pages), Published By: The University of Chicago Press.

[120] Christopher E Coletta and Alex Tolleson (2007) "Techniques for Modeling Muscle-induced Forces in Finite Element Models of Skeletal Structures", The Anatomical Record Advances in Integrative Anatomy and Evolutionary Biology, Vol. 290(9): pp.1069-88, 2007. DIO:10.1002/ar.20568

[121] Jones KE, Bielby J, Cardillo M, Fritz S A, O'Dell J, Orme C D L, Safi K, Sechrest W, Boakes E H, Carbone C, (2009) "PanTHERIA: a species-level database of life history, ecology, and geography of extant and recently extinct mammals: ecological archives E090-184", Ecology, Vol. 90(9):2648, 2009. DOI 10.1890/08-1494.1

[122] Volker Grimm and Steven F Railsback, (2012) "Pattern-oriented modelling: a 'multi-scope' for predictive systems ecology", 19 January 2012 https://doi.org/10.1098/rstb.2011.0180

[123] Bamgbade J A, Kamaruddeen A M, Nawi M N M, Adeleke A Q, and Maruf Gbadebo Salimon, (2019) "Analysis of some factors driving ecological sustainability in construction firms", Journal of Cleaner Production, Volume 208, 20 January 2019, Pages 1537-1545 https://doi.org/10.1016/j.jclepro.2018.10.229

[124] Satish Joshi, (1999) "Product Environmental Life-Cycle Assessment Using Input-Output Techniques", Journal of Industrial Ecology, Vol. 3(2-3):pp. 95 – 120, 1999. doi:10.1162/108819899569449

[125] Ghassan Zubi, (2011) "Technology mix alternatives with high shares of wind power and photovoltaics—case study for Spain", Energy Policy, Vol. 39, No. 12, pp. 8070-8077,2011.

[126] Williams K, and Dair C, (2007) "A framework for assessing the sustainability of brownfield developments" Journal of Environmental Planning and Management. 2007 Jan 1; Vol. 50(1): pp. 23-40, 2007.

[127] Snyder R E, Jaimes G Riley L W, Faerstein E and Corburn J, (2014) "A comparison of social and spatial determinants of health between formal and informal settlements in a large metropolitan setting in Brazil", J. Urban Health, Vol. 91: pp. 432–445, 2014.

[128] Frefer A A, Mahmoud M, Haleema H, and Almamlook R, (2018) "Overview Success Criteria and Critical Factors in Project Management", Ind Eng Manage., Vol. 7(244):2169-0316, 2018.

[129] Bryan Gharad, Edward Glaeser, and Nick Tsivanidis, (2019) "Cities in the Developing World", National Bureau of Economic Research Working Paper 26390, 2019.

[130] A Albert M, Balve P, and Spang K (2017) "Evaluation of project success: a structured literature review", International Journal of Managing Projects in Business. 2017 Sep 5; Vol. 10(4): pp.796-821, 2017.

[131] Hueskes M, Verhoest K, Block T, (2017) Governing public–private partnerships for sustainability: An analysis of procurement and governance practices of PPP infrastructure projects. International Journal of Project Management. 2017 Aug 1; Vol. 35(6): pp.1184-95, 2017.

[132] McCabe A, Parker R, and Brown K, (2011) "Social outcomes in the construction industry: the case of the Western Australian 'Percent for Art' policy", Construction Management and Economics, 2011 Sep 1; Vol. 29(9): pp. 929-41, 2011.

[133] B Burnett J, (2007) "Sustainability and sustainable buildings", HKIE Transactions. 2007 Jan 1; Vol. 14(3): pp.1-9, 2007.

[134] Lee H W, Tommelein I D, Ballard G, (2013) "Energy-related risk management in integrated project delivery", Journal of Construction Engineering and Management, 2013 Jun 13, Vol. 139(12): A4013001.

[135] Badi S. (2017) "Public sustainable-energy requirements and innovation in UK PFI school projects", Construction Management and Economics. 2017 Apr 3, Vol. 35(4): pp. 218-384, 2017.

[136] Sobin N, Molenaar K, and Gransberg D, (2010) "Sustainability by... A Synthesis of Procurement Approaches for High Performance Buildings", In Construction Research Congress 2010: Innovation for Reshaping Construction Practice, pp. 1366-13, 2010.

[137] Gultekin P, Mollaoglu-Korkmaz S, Riley D R, and Leicht R M, (2013) "Process indicators to track effectiveness of high-performance green building projects", Journal of Construction Engineering and Management", 2013Aug 6, Vol. 139(12): A4013005.

[138] Silvius A G, Schipper R, (2015) "A conceptual model for exploring the relationship between sustainability and project success", Procedia Computer Science. 2015 Jan 1; Vol. 64: pp. 334-42, 2015.

[139] Awadh O, (2017) "Sustainability and green building rating systems: LEED, BREEAM, GSAS and Estidama critical analysis", Journal of Building Engineering, 2017 May 31; Vol. 11: pp. 25-9

[140] Herazo B, Lizarralde G, (2015) "The influence of green building certifications in collaboration and innovation processes", Construction Management and Economics, 2015 Apr 3; Vol. 33(4): pp.279-98, 2015.

[141] El.Deeb S, AbelGalil R, and Sarhan A, (2011) "A Sustainability assessment framework for waterfront communities Egypt", Arab Academy for Science & Technology & Maritime Transport, 2011.

[142] van Mutis and Timo Hartmann, (2019) "Advances in Informatics and Computing in Civil and Construction Engineering",This proceedings volume chronicles the papers presented at the 35th CIB W78 2018 Conference: IT in Design, Construction, and Management, held in Chicago, IL, USA, in October 2018.

[143] Mollaoglu-Korkmaz S, Swarup L, Riley D, (2011) "Delivering sustainable, highperformance buildings: Influence of project delivery methods on integration and project outcomes", Journal of Management in Engineering. 2011 Dec 12;Vol. 29(1):pp. 71-8, 2011.