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Sustainable Design Thinking: Adaptability, Resilience, and Productivity at the Core of Regionally Responsive Architecture

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Abstract This paper serves as an explorative overview of the state of architecture as it applies to mitigating social and global stress on the environment and natural systems. As well as a tool for students of architecture and design in Jordan. It will focus on emerging thinking within the field, on the light of regional case studies of interest. The growing social consciousness and understanding of the interconnected web of dependencies within the biogeochemical cycles (the carbon, water, nitrogen cycles to name a few) and our built environment; has created, the impetus to create social and architectural spaces that does not add more stress to these natural systems, but rather alleviates it. Recent academic focus has been driven by the immediate social needs of addressing the growing issues that have come about because of the global human migration into cities. This Article will focus on architecture both within and outside the city, considering the new sustainable development goals. The case studies presented in this paper will focus on productive and sustainable architecture design thought with the Middle East and North Africa (MENA) region in mind. As well as regionally responsive case studies in relation to creating smart, resilient, adaptive and productive architecture within Jordan. Future conflicts in the MENA region will involve the issue of city growth, and specifically water. This carries broader implications regionally and globally, as demands on limited resources only continues to grow. The following questions form the core of this paper. What role can productive and sustainable architecture design play in shaping resilient and adaptive buildings? How does sustainability intersect all aspects of human and social life including economic, political, cultural and environmental? Can sustainable design thinking when applied to the field of architecture, help create the socio-economic conditions conducive to promoting sustainability at all levels of society? Concluding with a case study of Jordan and a call for self evaluation in terms of sustainability. This paper will present emerging ideas surrounding the future of architecture and the role it can play in shaping social and environmental spaces. An example of a completed circle of sustainability for the city of Amman, Jordan. This would be the first of its kind, and is intend to highlight the lack of accessible information for the public.

Keywords Sustainability, Architectural paradigms, Social and environmental spaces, Amman, Jordan

1. Introduction

Critiques and scientist describe the era in which we live as the Anthropocene, the sixth extinction. The effect of the human ecological footprint on earth is such that at the current rate of resource consumption we would require 1.6 planet earths [1]. This understanding goes beyond the notion of environmental pollution as a cause of human activity or anthropogenic climate change to one in which the human population has reached a point of unsustainability.

Capitalism that emphasis mindless consumption has been distributed unevenly, as the most developed countries are consuming more than a fair share, often at the expense of those living in the developing world. By placing an emphasis on the impacts of human activity on our natural environment, data and knowledge can empower societies as well as individuals to act at the governmental and communal levels. Empowerment through knowledge remains the key starting point for any future endeavors to pursue architecture in light of socio-economic and environmental constraints. There has been both a practical and academic push to address the detrimental problems facing cities of the future.

It is important to note that there are theoretical gaps in terms of approaching the philosophy of architecture, specifically in terms of definition and nature of architecture. Academic discourses have limited the applicability of architecture to mitigate future environment and social risks by limiting the debate to aesthetics, utility, and form.

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The study of the relationships between architecture and values, can serve to help architects create the conditions conducive to sustainable, adaptive and resilient architecture. The changes in these relationships tell us about the ability of architecture to impact socio-economic political and environmental aspects of life for all the inhabitants of the earth. In studying the object of architecture, one must also understand the system of knowledge that produced it [2].

The study of architectural paradigms can serve as a tool by which to understand social behavior. These architectural snapshots in time highlight the scientific capabilities of societies, as well as the state at which values, operate within which a given society. These values transcend the basic skills of construction and are reflections of economic, political religious or ideological thoughts. On a philosophical level architecture, has been relatively ignored. Architecture as an art form, design medium, or object of function [3]. It can also be understood in terms of properties, as described by ancient romans in terms of integrity, beauty and utility [3].

For the purpose of this paper consciousness encompasses the social, economic, political, scientific, technological and environmental aspects of human life, as such when architecture is read as an embodiment of time, historical analysis serves as a useful tool when attempting to explore the question of embedded values.

History has shown that architecture and the build environment can shape social forces. Theoretical debates are stuck on whether or not humans should manipulate the build environment so as to shape society [3]. This paper, discusses the causality functions both ways. Society shapes Architecture and is simultaneously shaped by it.

This relationship can be characterized as a form of social systems, as well as urban and environmental sociology. Architecture or structures are thus understood as social systems that carry social functions. Urban sociology understands the city as a social space that simultaneously shapes and is shaped by the inhabitants. Environmental sociology expands this notion to the built environment, perceived as a tool for reproducing patterns of behavior or values. Exploring the relationships between utilitarianism, ethics and architecture a more humanist approach surfaces. One that rejects deontologist assumptions that the end result is what is important [3]. The means is just as important as the ends, humans cannot continue to inhabit the world in the manner that they do.

2. The Social Role of Architecture and the Architect

John Ruskin described architecture as an art form that contributes to the mental health, power, and pleasure of its consumer [4]. He drew connections, that resonate with environmentalist and sustainability movements of today. Louis Sullivan said that "form follows function". A product of his time, Sullivan emerged out of the Chicago school of thought, that emphasized simplicity in design [5].

The theoretical debates that have shaped the history of architecture, have revolved around questions of aesthetics, form or function, and utility. The focus ought to be on the role that architecture can play in reestablishing the relationship between humans and their environments, in order to make them more consciousness. Architecture goes beyond that functional aspect of visually pleasing aesthetics, but that it must be understood as a form of human science [6].

As such the role of the architect and architecture in society is a multifaceted one that encompasses the expression of values as well as value generation. Throughout history paradigm shifts in architecture have been shaped by scientific, technological, and critical thought advancements which forced the specialization of this profession and the departmentalization of the construction process itself.

3. From Modernism to Neomodernism

There is no doubt that industrialization has the most profound impact on the plant and human life, no other paradigm in history has impacted the natural environmental system, in terms of magnitude. Contemporary conceptualizations of architecture are often separated from the actual skill of construction, and focused on the art and technique of designing. This can be traced back to the era of industrialization which brought about the separation of engineering from architecture, due to mass production [7, 8].

Major architectural undertakings would often be attributed to one individual who assumed the role of both chief engineer and chief architect. Thus, with the advent of the new types of societies that industrialization brought with it, the role of the architect retreated to ornamental design and away from beauty within the form. This can also be attributed to the shift in social classes as the previous paradigm of renaissance architecture the focus was from and on the aristocratic class. The development in relationship to urbanization, must be based on a solid developing plan for the expansion of any city, based on a scientific analysis and approach. Moreover, modern needs such as the expansion accounted for the health of inhabitants by building central gardens and orienting the homes to maximize the sunlight should be a priority [9].

The rise of the modernist movement was a reaction to the empirical paradigm of empires and colonization, simply a reaction to the colonial city [10]. The master plans that would be imposed on colonized and later developing countries were rigid and often became outdated quickly. The modernist's concept plan was seen as flexible, as it was often based on policy instruments such as zoning and population density which would serve as a more useful tool for city planners, developers and the like.

The post-world war II reconstruction in Europe focused on creating a better socio-economic order based on the needs of middle class. This period also experienced the rise of industrial design as war time industries transformed to focus

on consumer commodities. Design was based on the qualities of materials used, for example steel allowed the rise of international style of skyscrapers. That period was characterized by building as apex of art, craft and technology. With a paradigm shift towards form and function rather than aesthetic ornament.

Many of the architectural innovations that were once deemed aesthetic signs of prosperity and progress began to crumble, often due to vacancies [10]. In 1972 when many of these modernist buildings began to be demolished, architect Charles Jencks declared the death of modern architecture [11].

Movements such as structuralism, post-structuralism, modernism, postmodernism, and even sub movements such as brutalism, expressionist, phenomenology, or organic architecture ought to be understood as paradigms that shift with time and context. Prior to the paradigm shift towards postmodernism and structuralism, the idea of organic architecture, emerged significantly and defined by the environment and purpose (Fig. 1).

Figure 1. Falling Water designed by Frank Lloyd Wright

In designed Falling Water, Frank Wright, centralized the question of man against nature, and emphasized the need for harmony between human habitation and natural world. Postmodernism saw the introduction of sub movements such as metaphoric, bio-morphism, and zoomorphic which focused on using nature as the inspiration for form and design. Often driven by anti-structuralism thought such as Martin Heidegger's application of phenomenology, which took a historical approach to the study of architecture, space and experience. Whereas modernism much like the political movements at the time took an anti-historical approach to modernization.

More recently, re-constructivism, saw the purpose of architecture to awaken the sense of the real, in a world were everything has been demonstrated to be an illusion. Architects can reawaken the sense of real environmental danger facing humans by designing buildings with this in mind. If future architecture is to serve a positive social and human purpose, the focus must be driven by environmental concerns.

4. Shifts in Architectural Paradigms

Within the critique of modernism and post-modernism architecture paradigm shift taken place is best understood as firstly, the good architecture is not a personal, philosophical, or aesthetic pursuit by individualists. Secondly, it must consider everyday needs of people and use technology to create livable environments. Finally, that the design process is informed by studies of behavioral, environmental, and social sciences. The following three paradigms are interesting to note for the purpose of understanding contemporary architecture.

Critical regionalism can be understood in terms of anti-globalization, as the main focus is to reintroduce the place and identity into buildings. Throughout this paper, the concept of regionally responsive architecture will be referred to in this sense. As critical regionalism, rejected both the lack of locality in the international style, as well as the individualism and return to ornamented style of postmodern architecture.

Deconstructive, ironically the birth of contemporary architecture in the sense of sustainability has taken place with this quasi-movement. For instance, the famous work of Frank Gehry, the Guggenheim Museum Bilbao in Spain, is hailed as one of the most admired works of contemporary architecture, even though it was completed in 1997 (Fig. 2).

Figure 2. Guggenheim Museum Bilbao, Spain

Neomodernism is important note as history has shown the shortcoming of modernization theory and modernism in architecture. The foundation of addressing human needs through the scientific method remains a vital tool. As a movement, it rejects the complexity of postmodernism and focus rather on simplicity, with focus on functionality (Fig. 3).

Prior to the financial crisis, the types of buildings built can be characterized as part of the height race. Who could build the tallest building? The intent was to demonstrate economic prosperity, and attract more investments. However, the sustainability of these types of buildings remains the main issue.

Figure 3. Burj Khalifa (Dubai) under construction

5. Post 2008 Financial Crisis

The 2008 financial crisis that consumed the economies of the world, can arguably be characterized as a failure of architecture. Debt and interest driven, housing sales, was powered by the age-old American value of home ownership, which lead to the collapse of the American economic machine and consequently the global economy. Following the global economic collapse, interest and investments grew in green technology. Driven by rising in fuel prices, peak oil, as well as issues with continued dependence on us dollar for exchange. This is the time to reimagine and redefine architecture and its social role, so that cities and societies can mitigate future risks.

Designing economies, or cities, that are dependent on a constant flow of natural resources and nonrenewable energy is unsustainable. Considering the facts following the 2008 crisis it is important to note that sustainability and renewable energy forces are now being driven from all parts of the world. China and India are two unique case studies offer great insights into what is to come, as both countries are pioneering and poring investments into alternative energy and focusing on smart sustainable growth. The 2008 financial crisis effectively pushed china as the world's growth engine.

The topic of development economics will be covered later on in this paper, but it is important to note that behind the scenes, much of the success associated with the Millennium Development Goals (MDGs) took place in India and China. Both countries lifted the most people out of poverty and this plays a major role today, in projecting them into the position of leading the world's economic growth and demand [12].

6. Globalization and the Sustainable Development Goals

Today more than ever, man made economic systems of extraction, production, distribution and consumption that have driven affluence and abundance are leading humanity towards environmental suicide. The International community has recognized the world is increasingly urbanized, and that more than 50% of the world's population live in cities. Development thinking has experienced a paradigm shift away from the rural focus of the Millennium development goals (MDGs) towards the city focused sustainable development goals (SDGs). In many ways, the SDGs grew out of the failures of the MDGs goals, targets, indicators and validation frameworks were very easily manipulated and the need to articulate indicators for success of programs.

To avoid further issues, participatory research established the need for more rigorous monitoring and articulate indicators to assess programs. Stepping away from technocratic expertise, information systems have to engage the local people, and increase participation in addressing their own problems and assessing impacts. The new SDGs have 17 goals along with 169 targets. This paper highlights the importance of Goal 11 of the SDGs, to make cities and human settlements inclusive, safe, resilient and sustainable. As well as the rights to the city movement, which takes a need based and bottom up approach to development.

The goals were created as confirmation of the global commitment to uphold international laws and while ensuring sustainable development socially, economically and environmentally [13]. Information systems have to engage the local people, and foster participation in addressing their own problems as well as assessing impacts and effects.

7. Smart Growth Cities

The concept of smart cities is ambiguous, as there are varying ways of describing and labeling a city smart. A notion, that attempts to integrate the use of information and communication technology (ICT) for the use of urban development. A smart city is one that is compact so as to limit urban sprawl. More importantly architecture needs to be responsive, on a regional and community needs basis as well as on an environmental level. In exploring the links between smart sustainable growth and development or underdevelopment, many interesting methods arise. Lack of data is one of the stumbling blocks that face the affective application of development projects and programs. However, what is equally fascinating is the quantity and rate at which the use of mobile devices has grown within emerging markets and regions. Although there is no formally collected and centralized, and often skewed, government certified data, individuals acting as a collective on an online network produce equally useful data. With applications that can vary from which regions lack infrastructure to how should we redevelop the inner-city roads to mitigate growing traffic. Public private partnerships between network providers, the government, and the communities can foster data production that can then be used to implement effective projects. There remains much research needed into the application of ICT.

However, by exploring the use of the ICT, the untapped potential for delivery better and more effective development assistance becomes apparent [14]. Innovative techniques and methods can allow for the achievement of the SDGs more efficiently. The entire country of Bhutan has surpassed the concept of carbon-neutrally, and is now the only carbon negative city in the world. The state's leadership hope to eventually create a zero-waste economy [15], with zero-net greenhouse gas emissions and 100% organic food dependent [16]. Currently the country is estimated to only create 1.5 million tons of carbon, while its forest absorbs six million annually.

8. Contemporary Architecture

Today's architecture is unique in that there is no dominant style, but what tends to be common, is the application of advanced technology and building materials. The advent of computer design programs has allowed for taller, stronger, and lighter buildings to be modeled tested and constructed faster with higher degrees of precision. The complexity of buildings has increased in terms of structural systems, services, energy, technological needs. The field of architecture has become multi-disciplinary with specializations often split between design and project architects. Drawing in teams of architects in order to maintain compliance with cost, durability, sustainability, laws and quality. Perspectives to take into account, such as metaphoric architecture, new classical architecture, and specifically new urbanism, are not new but rather they were marginalized with the advent of the automobile and wartime industry thinking. Today there is a need to return to responsive approaches that realize the social dimensions of architecture.

Sustainability: New Classical or New Urbanism?

The idea of sustainability is not new, although it may appear as a recent phenomenon in construction practices. Such as local laws that now adopt indicators and measures from Leadership in Energy and Environmental Design (LEED) certifications. But sustainability alone is not enough at a functional level. Several architects revolved around ecological design. They focused on efficiency and energy, as it pertained to the features, placement, and aspects of a building in terms of heating, cooling, powering, venting, lighting, feeding, watering, and sanitation. Today we understand these notions in terms of energy efficiency with a focus on carbon-neutral or even productively creating energy for self-sufficient use (autonomous buildings). The overarching focus is on positing architecture within a broader socio-cultural framework that takes into account the dependency relationships between humans and nature. New urbanism promotes a sustainable approach towards construction in terms of practices as well as a shift away from solitary estates that only increase suburban sprawl. With a focus on creating the spaces and conditions necessary to promote sense of community and ecological sustainability. Notions of sustainable growth such as transit-oriented development (TOD) and principles of intelligent urbanism (PIU) will be explored next, as the future of these theoretical perspectives in practices will be to promote and create smart cities. It is important to note, that the focus on the future of architecture, cannot be dominated by the sole notion of sustainability, and should incorporate notions of adaptability and resilience.

Recognizable Standards: Leadership in Energy and Environmental Design (LEED)

LEED, is one of the most used green building certifications globally (Fig. 4). Overall the savings from lower operational costs associated with LEED certified buildings mitigate additional costs of design and construction. However, it is important to note that LEED certified buildings alone cannot create sustainable conditions [17]. There is also a need to implement sustainable design thinking within the urban fabric. Critiques such as Jeff Speck emphasis the negatives of building-centric certifications [17]. That it promotes a culture of building practices, that tend to ignore external realities, such as location and placement, which could work against the whole point of building sustainably.

Figure 4. Art Center Greensburg, Kansas, USA, LEED Platinum

After a tornado destroy the town of Greensburg, Kansas (USA), the community decided to rebuild following LEED platinum environmental standards (Fig. 4). Featured is the town's new art center, collecting solar and wind energy for self-sufficiency [18, 19]. Recently, the International Living Future Institute, has developed its own certification which builds on much of the success of LEED. The living building challenge is considered to be more rigorous performance standard for buildings.

INTELLIGENT URBANISM

Principles of intelligent urbanism is a theory of urban planning that evolved out the of guidelines provided by the International Congress of Modern Architecture (CIAM). Described as a set of axioms, laying down a value-based framework, within which participatory planning can proceed [20]. The key take away is that effective technology application and engagement with the local communities during planning, leads to the fostering of collective intelligence as well as human capital [20]. Both of which are fundamental to creating the social conditions necessary for sustainable change.

Powered by a low carbon emitting tri generation power plant and featuring an internal water recycling plant, which filters rainwater from the roofs, ground water from drainage systems, sewage from the public sewer, and drinking water from the main water systems (Fig. 5). The building comprises its own shopping mall and other amenities to promote local walking culture [21].

Figure 5. One Central Park featuring hanging vertical gardens, Sydney

This is a great example of integrated urban water management philosophy [22], that applies the management of all forms of water, fresh, storm, waste or grey, into the flow of the water and sanitation supply [23]. Also, the featured hanging gardens, plays on to the concept of vertical farming [24]. One that applies the methods of hydro-culture and horticulture lighting and integrates the reuse of water [25], into creating features, that could potentially feed the inhabitants of the buildings.

The following selected six principles [20] are important to highlight, specifically in the case study of Amman, Jordan;

Principle One: A Balance with nature, emphasis the utilization, enhancement, and conservation of natural resources as opposed to exploiting them.

Principle Two: A Balance with tradition, emphasis value and respect for vernacular architecture, use of local resources, and precedents of patterns and styles.

Principle Three: Appropriate technology, goes beyond the appropriation of technologies, and emphasis the matching of interfaces. Finding the ideal balance between physical limits of urban services, administrative and electoral boundaries. As such to be in line with the local people in terms of absorption capacities, geo-climatic conditions and local resources.

Principle Four: Efficiency, emphasis the optimum sharing of energy, time and public amenities, to reduce individual household costs

Principle Five: Human scale, emphasis walkable, pedestrian oriented, urban arrangements, with a focus on accessibility.

Principle Six: Opportunity matrix builds on the emphasis of accessibility, by treating the city and urban arrangements as a vehicle for personal, social, and economic development. Bringing together opportunities for education, relaxation, health, safety, and employment.

Transit Oriented Development: TOD

TOD is a form of urban development that maximizes the economic, social, and political spaces within walking distance of public transit. Although the emphasis is on use of public transit, the greatest observable shift in transport habits, is from automobile use to walking [26]. The new habitable environment encourages regular exercise and an overall increase in health. This environmental shift in urban organization, offers the greatest return on public health, on the individual level, as well as on the health care system.

On an ecological level, overall energy emissions are reduced, and there is an observable decrease in air pollution from automobiles. This can offer many health benefits to a city such as Amman, Jordan. The major source of these emission is pollution caused from cars, and the burning of high sulfur diesel [27]. Although, industrial activities in relating parts of Amman such as Al-Zarqa does play a role [28]. Not to mention the geography and climate nature of Amman leads to large amounts of dust and sand from nearby deserts, and the topography of Amman, being a mountainous city the polluted air remains trapped (Fig. 6).

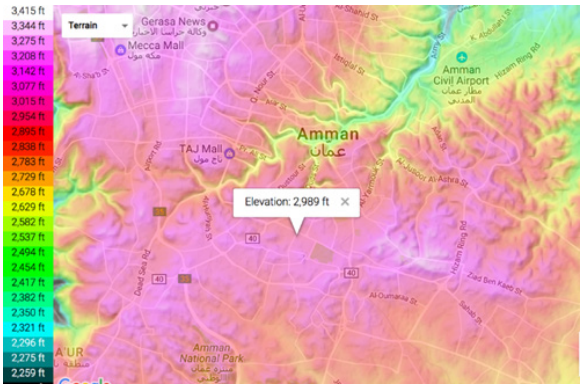

Figure 6. Topographic map of Amman, Jordan, elevations are shown in ft

Currently, air pollution in Jordan is three times the rates of the World Health Organization (WHO) air quality guidelines of recommend concentrations of $PM_{2.5}$ and PM_{10}. Measuring in at 36 um/m^3 $PM_{2.5}$ instead of 10, and 68 um/m^3 PM_{10} instead of 20. Short term symptoms result in upper respiratory infections such as bronchitis and pneumonia, and aggravate asthma. Long term symptoms effect lung cancer, cardiovascular disease, chronic respiratory illness, heart attacks and strokes. This is an issue that plagues Jordan, as there is an observed two-fold, increase in asthma rates over the past decade [29].

Taking the agenda of the sustainable development goals (SDGs), it is important to note that, air pollution has also been identified as a global health priority [30]. The WHO is responsible for the monitoring of air pollution related indicators for SDG goals 3, 7, and 11 in health, energy, and in cities [30]. It is also important to note that Amman is the only municipality in the region reporting to the WHO.

At the economic level, the improved mobility for non-drivers plays into another observable effect, that more money ends up circulating in the local economies. Overall,

the increased accessibility, supports an increase local property values along with household wealth. The city of Medellin in Colombia, has been at the fore front of increasing social cohesion and mobility by connecting the most disadvantaged to the city (Fig. 7).

Figure 7. Metro-Cables, Medellin, Colombia

This use of gondolas as metro-cable is the first of its kind in the South America, where many benefits observed, namely the decrease in crime in the poorer areas in which it was designed to connect. This application of public transport is a more cost and energy efficient option. It is mainly less invasive, as the construction process does not involve the intense digging, and rerouting of traffic, that goes into placing a subway or metro system. More importantly, for the case of Amman, Jordan, a mountainous city, this brings many benefits. This could also involve the private sector as the cable cars serve as an advertising and marketing medium.

9. Redefining Design Thinking

Streamlining sustainability is not enough, account for economic, political, cultural, ecological aspects of social life. Design thinking is a method for solution based problem solving. Although it is unique to the field of industrial design, it has been applied to urban planning and architecture, as well as any other field [31]. The difference between design thinking as a method or tool lies in iteration process. In other words, architecture will be driven by the consumer, this is how feedback works in design thinking.

Based on scientific findings from the Stanford design thinking research program [32], the following four principles are to serve as a guide for successful design thinking: *Human rule*: all design activity is ultimately social in nature; *ambiguity rule*: design thinkers must preserve ambiguity; *re-design rule*: all design is re-design and *tangibility rule*: making ideas tangible always facilitates communication.

Circular thinking: Cradle to Cradle

Cradle to cradle (C2C) also known as regenerative design, is a form of biomimicry that learns from natures design and manufacturing models [33]. It encompasses a holistic socio-economic and industrial paradigm that focus on waste-free systems (Fig. 8). The C2C model of circular thinking stems away from planned obsolesce which has plagued the landfills with waste. As opposed to the linear economy [34], a system that treats the inputs, as an end product. This model of manufacturing, fulfils the needs of the cycle of consumerism, often incorporating an expiry date into the product itself. The use of cheaper materials becomes the focus, usually non-biodegradable, since they were never designed to be recycled so that they breakdown, and the consumerism cycle can continue to thrive. China is one of the countries incorporating this form of design thinking, and principles, in the planning of future sustainable cities.

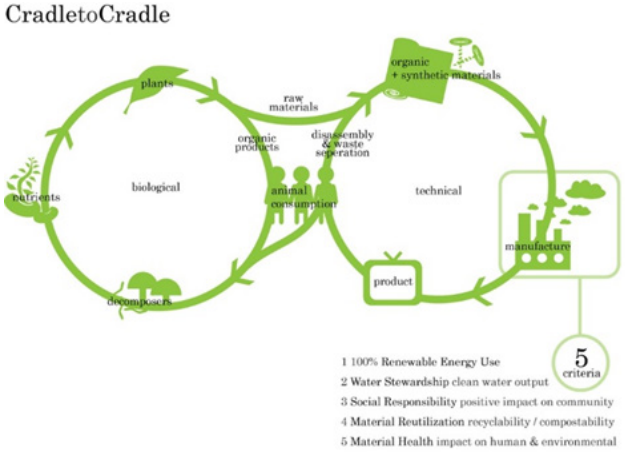

Figure 8. C2C life cycle

10. Megatrends and why Architecture is the Key

There is a paradigm shift towards the application of forward thinking technologies and design thinking such as, passive solar building design, greener roof designs, biodegradable materials, and energy-efficient landscapes. Creating buildings that can clean their own air, collect and filter their own water, cool and heat themselves is not only a possibility but a necessity.

The interconnected world whether through globalization, the internet, or social media, will allow architecture to be driven by people, so as to create comfortable spaces. Some architects indicated the power of architecture in shaping emotions, and the problem with feedback in designing and planning. Declaring that architecture is not about the math or zoning, but in the visceral feelings that it evokes [35]. The key to designing better architecture is to Make the best use of social media for real time feedback (for designers, planners and architects) from the people who will actually use the space. Moreover, the advent of crowd funding is driving a new form of bottom up development, people centric development. The plus pool (+POOL) project, in New York, was initially designed and proposed as a social experiment and managed to fund raise its own initial costs, for testing, through crowd funding [36].

Architecture shaping Social space

The learning Hub, also known as the Hive, attempts to apply the notion of form follows function [37]. The building is naturally ventilated and designed to enhance learning by creating an open, comfortable, collaborative space (Fig. 9). It draws its inspiration from nature, mimicking the design and look of bee hives. Demonstrating the power of architecture to drive innovation and to shape social space.

Figure 9. The Learning Hub "The Hive", Nanyang, Singapore

Nature's building blocks

Elora Hardy, founder of Ibuku, employed natural methods to protect bamboo from insects, paving the way for the use of this cheap grass for building [38]. Making use of the flexible properties of bamboo to create shapes that maximize air flow and cooling, simple ideas inspired by nature (Fig. 10).

Figure 10. Bamboo Architecture, Ibuku Green School, Bali

The carbon footprint resulting from the production and use of cement– and later concrete for roads, bridges, buildings– accounts for more than 5% of carbon dioxide (CO_2) emissions globally [39]. One ton of CO_2 is created form each one ton of cement, and it is the most widely consumed substance after water. A return to the use of wood in cities and in tall buildings, offers a more sustainable option for housing the global growing population. Many environmental benefits include the no waste by products created by the production of wood. As well as the natural ability to clean CO_2 and produce oxygen. Vernacular architecture such as the wooden pagodas built in Japan, an area that experiences seismic activity as well as fires and floods proves the tested solution of using wood.

The University of Cambridge in partnership with PLP Architecture, set a precedent and quasi-renaissance of using wood, timber, as a building material (Fig. 11). Such technology has allowed the use of wood in the construction of grander buildings while adhering to fire and legal codes. Much of the research is driven by the ability of wood to naturally absorb CO_2 in the atmosphere, creating buildings that clean the air in cities.

Figure 11. Renderings of proposed 300 m tall tower made of Timber, London, University of Cambridge

Digital Fabrications

Three-D printing has revolutionized the design process, by cutting down the time it takes to create prototypes and models. It can also help simplify previously complex architectural designs and shapes [40]. The advent of 3D printing, digital modeling, and the use of adaptable materials, will allow inspirations from nature to take shape (Fig. 12).

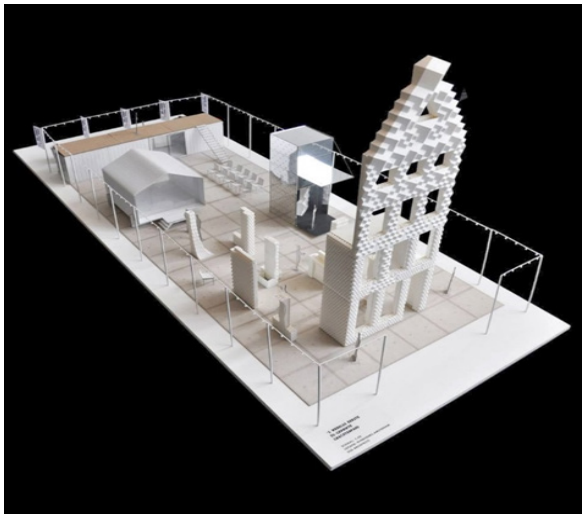

Figure 12. 3D Print Canal House, Dus Architects

Productive Architecture and the Energy Grid

Autonomous Buildings: Net-Positive Energy production

Although, complicated notions, sustainability and sustainable development, can both be simply defined in terms of meeting the demands of today, without

compromising the needs of tomorrow. As such, productive and sustainable architecture, can play a role in shaping resilient and adaptive buildings that transcend current needs and looks to the future. Autonomous buildings, are designed to operate independent of public infrastructure, meeting their own demands through passive and active techniques.

BedZED is a carbon-neutral eco-community, featuring solar panels and passive ventilation chimneys [41]. There is a growing focus on net-zero energy use buildings, which means the building creates the energy needed and can produces extra for the grid. Moreover, there is a growing focus on streamlining carbon neutrality in all aspects of buildings so as to reduce carbon and ecological footprints (Fig. 13).

Figure 13. Zero Energy Development, Beddington, UK

The K2 sustainable housing (Fig. 14) features passive solar design, recycled and sustainable materials, photovoltaic cells, wastewater treatment, rainwater collection and solar hot water [42].

Figure 14. K2 sustainable housing, Windsor, Victoria, Australia

The passivhaus standard combines a variety of techniques and technologies to achieve ultra-low energy use for heating or cooling. Designed to reduce a buildings ecological footprint [43]. Incorporating the basic building blocks of cities namely, water, energy and food, into self-sufficient thinking, shows positive potential for its inhabitants or users. The application of various techniques such as, net-positive/zero energy production, vertical farming, IUWM, and passive/active solar collection, must be at the core of the architectural design process (Fig. 15).

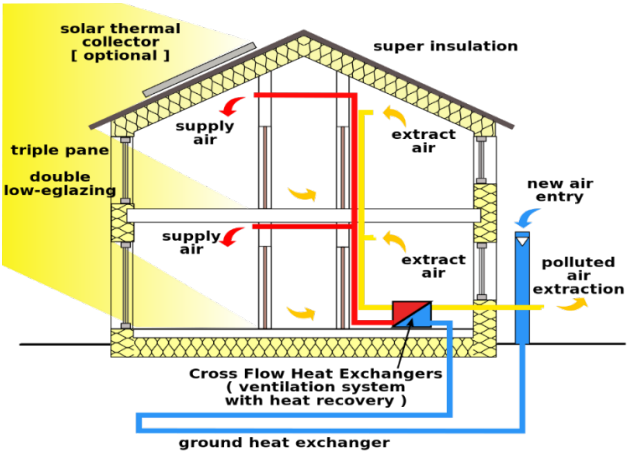

Figure 15. Diagram of the science behind the passive method

Resilient and Regionally Adaptive Architecture

In line with the thinking of resilience, architecture must be regionally responsive and adaptive. Although it is important to note that these are not all new ideas but rather revivals of previous applications of vernacular architecture. The featured BedZED housing with passive ventilation chimneys, draws its inspiration from ancient Persian architecture. This vernacular architecture, known as wind catchers, were used to both cool water storages as well as homes (Fig. 16).

Figure 16. BedZED featuring passive ventilation chimneys, UK

This ab anbar, meaning water reservoir, features four wind catchers, which create a pressure gradient that forces hot air out [44]. It does not actually allow cold air in, as such, the building itself was built underground (Fig. 17). Figure 18 demonstrates the application of two technologies, the wind tower and the qanat, demonstrating the air flow, and the process of this passive cooling technique [45].

Figure 17. Ab anbar, featuring 4 badghirs, wind towers, Yazd, Iran

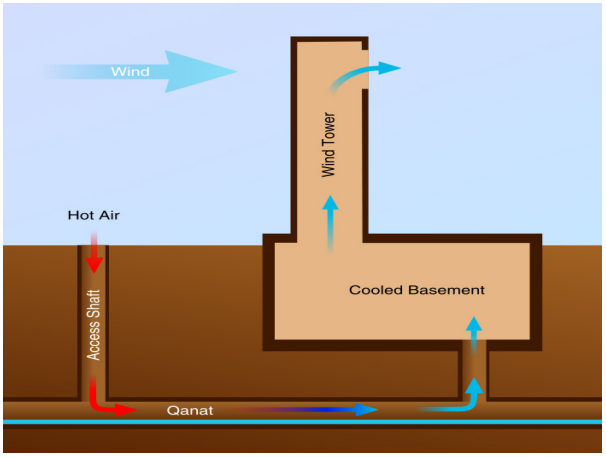

Figure 18. Diagram of qanat with wind tower

Responsive architecture, such as Al Bahar Towers, demonstrates how adaptive materials and forms can respond to their environments. This technique was inspired from the vernacular architecture of the region. Created using fiberglass rosettes, the shutters open and close in response to the outside temperature. The design is based on vernacular Islamic architecture known as the *mashrabiya*. Designed to allow constant air flow, this architectural feature, provides privacy for the inhabitants and shade for those walking in the street. From an architectural standpoint, it allows for an increase in the usable space inside a building without having to increase the physical plot size (Figs. 19 and 20).

Figure 19. Al Bahar Towers, Abu Dhabi, 2013, Flicker

Figure 20. Mashrabiya, Old Cairo, Egypt

Biomimicry: Nature Tested Approaches

Architects and scientist that pursue the field of biomimicry present the idea as an alternative to sustainable building. However, as mentioned earlier, the environment can inform design and architectural practices. Understanding the natural landscape allows architects to conserve heating costs or improve cooling within a building by simply accounting for proper placement. Biomimicry is the observation and application of systems and techniques employed throughout nature. This encompasses all living life forms, down to the nanostructures of plants that can inspire better structural design, all the way to the imitation of how nature as a system is holistic and does not create waste [46]. The argument for the study of nature to inform and inspire technologies, structures, and materials lies in the length of time that nature and living organisms have had to adapt and change [47].

Namibian Desert Beetle

Copying natures ideas to solve human problems is an emerging discipline and deeply adopted by non-profit organizations for the sharing and spreading of nature inspired ideas. For instance, the Namibian desert beetle, which collects water from fog and moisture on the little bumps on its back, which then trickle down to its mouth. These beetle lives in one of the driest deserts, it has hydrophilic (water attracting) tips and hydrophobic (water repelling) waxy sides (Fig. 21). This has been imitated by Yanko Design, and transformed into the Dew Bank Bottle, sold and used for personal water collection in developing countries. Moreover, the idea has been proposed for architectural applications, either as a method for collecting water as part of a large integrated water resources management system, or to clean the building itself. This is one of the simplest example of the scalability of design thinking and technology.

The study of the self-cleaning properties of plants such as the lotus and water lily, has inspired the LilyPad designed to be self-sustaining floating city (Fig. 22). A vernacular and natural way to design and deliver efficient and sustainable development. Even insets such as termites, usually characterized as building destroyers, can offer surprising insights into how they build their mounds with zero-waste, and unique techniques for cooling and temperate control [47].

Figure 21. Namibian Desert Beetle, featuring bumps on back

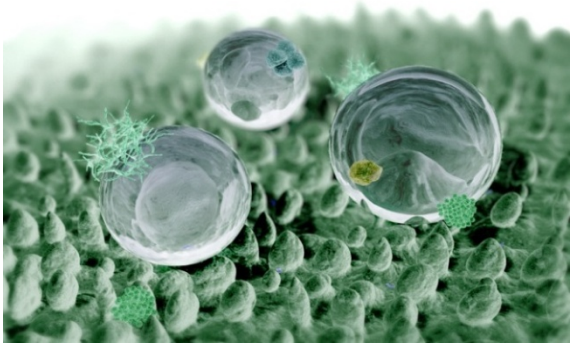

Figure 22. Lotus effect, rendering of hydrophobic bumps

This architectural paradigm is reminiscent of the ideological classical and renaissance era pursuit of the golden ratio (Fig. 23). In many ways, the relationship between biomimicry and architecture is based in the existing relationship between mathematics and nature. This epitomizes the debate between form, function, and aesthetics, as nature finds a balance between them. As humans, mathematics allows us to measure and implement this balance into our design systems, to solve the growing global problems.

Figure 23. Nautilus shell cutaway, often symbolized with the Golden Ratio

11. The Case for Jordan: The Ideal Testing Ground

Context and Challenges

Regionally Jordan remains one of the few safe states, and as a result, populations that have been displaced due to conflicts end up in Jordan. The issue, among other important issues, is that Jordan, as a nation is struggle to meet current population demands in terms of access to water, energy, and sustainable growth. Yet Jordan has much to offer to the field of architecture. Vast expanse of varying terrains, climates, elevations, ecosystems, and environments which allows for two things to take place. The opportunity to provide sustainable development as well as to test and improve, innovations in science, technology, and biomimicry.

The current study highlights in brief case studies the applications of sustainable design thinking, biomimicry, and productive architecture to respond to the serious problems this state faces in responding to water and waste management. Not to mention access to food and potable water, applications such as solar collection f or heating, wind collection for power and cooling, as well integrated water resource management for water preservation show great promise.

The urban congestions caused by the use of personal vehicles and population growth continues to increase the levels of air pollution in Amman. This is not only contributing to long term negative health effects, but as well as the visible dirtiness of buildings in Amman. Developing techniques to clean buildings or even designing self-cleaning buildings, is no longer fantasy. Science and technology, today, allows to ask these questions.

Latest Developments

In order to accommodate the growing demand and traffic moving through Jordan, the Queen Alia International Airport (Fig. 24), allows the building to expand at a rate of 6% each year for the next 25 years, increasing from three million to 12.8 million people per year by 2030 [48]. Each dome is its own modular unit, which allows for the expansion to take place easily, moreover the geometry pays homage to the vernacular architecture, just as the choice in building materials [48].

Figure 24. Queen Alia International airport, Amman, Jordan

In 2014, the newly renovated airport received two prestigious awards; Best Improvement by Region: Middle East and Best Airport by Region: Middle East. The awards were given by the Airport Council International, and was based on customer satisfaction in the global Airport Service Quality (ASQ) Survey. The airport was also awarded the gold recognition, for the world's top 40 Public-Private Partnerships (PPP), as Best Emerging Market Infrastructure Project for Europe, Central Asia, and the Middle East and North Africa. The government of Jordan has demonstrated its commitment to sustainable development as well as the local ability to absorb changes in environmental and economic directions.

Another great development, took place in 2015, the establishment of the Royal Academy for Nature Conservation as part of the broader Royal Society for the Conservation of Nature (RSCN). This center and type of work in ecological and biodiversity preservation is the first

of its kind in the region. It focuses on local and regional education as well as driving eco-tourism into the country. Most importantly it serves as a sign of the government's commitment to sustainable development.

12. Planning and Engagement

As of 2014, Jordan's Human Development Index (HDI) put the country in the high human development category ranking 80th out of 188 countries, with a value of 0.748 [49]. On the Social Progress Index, Jordan performs best on nutrition and basic medical care, on access to basic knowledge, and on personal freedom and choice. There remains much room for improvement in personal safety and personal rights, perhaps inclusive and sustainable architectural design can drive this change?

The focus on creating the future of sustainable cities, such as the case of Amman, must be on grounded in a bottom up and needs based approach. That focus on the people that will use these public spaces, while also highlights gender issues and community engagement. The progress that has taken place in Jordan is worth noting, and more importantly building on, as the public, private and state spheres have come together to improve the living standards of all individuals. These conditions are conducive to fostering the potential, imputes and drive necessary for sustainable and positive change.

Analytical Factors

The following key points have been synthesized from the best-known practices of sustainability, sustainable development principles [13], do no harm, rights to the city [50], participatory planning and engagement, from the ground up that is needs based, and most importantly, focuses on the issues facing Jordan. Cities and inhabitants can use the new urban agenda of the SDGs to mobilize local stakeholders in order to build cities more compactly. The goal is to create smart cities that are pedestrian friendly and aware of the geographic footprint they leave behind. This is important when considering the implications on energy consumption.

Information is key to sustainability, cities need to establish development indicators and data sources. This is required for baseline studies, a starting point required to evaluate progress against over time. Therefore, can relate to established targets and goals. Cities need to be able to collect this information through data, census or alternative ways, however top-down approaches are both cumbersome and expensive. Today new urban data can be collected through enumeration driven by locals and organized groups. As well as the application of GIS technology, participatory studies, or network infrastructure such as telecommunication towers. City authorities are encouraged to be engaged in data collection whether informal or formal.

The goal is to break complex targets into more than one indicator, that nature of which should be outcome focused. Both goals and targets need to be easily measurable, and not heavily policy driven from the outset. The data should drive and inform the policy, not the other way around. Goals articulated from a global point of view, must be coherent and universal. Governments and populations can adapt these goals to their regional contexts. However, they must remain motivational, operational and a challenge to governments, goals are to be measureable by targets.

Targets are simply things that can be quantified and measured. They must be operational with a clear definition of zero deprivation. SMART targets must also be sustainable, action orientated, applicable to all relevant stakeholders, and consistent with existing international and national frameworks.

Indicators, are a set of quantitative variables to measure progress at all levels local and national. Not all problems can be resolved locally, as such the measurement of progress allows the coordination at the state level to be more effective. However, these indicators must function both ways, as a tool for pressure on government and on local communities. Indicators must be managed by a designated group or organization to improve quality.

Management and monitoring tool must be used regularly, annually, and at several points throughout the implementation of projects. Who will capture the data is important to ensure accountability, the process should involve non-government organization (NGOs), external and local, as well as incorporate national statistics.

The final criteria for any measurement or project is that it should be straightforward and disaggregated. Account for characteristics of individuals and households such as; gender, age, income, disability, economic activity, spatial geographic dimensions. Success depends on outcome focused measurements and projects. The questions to ask are not how many schools did we build this year, but rather did the children attend school this year? Although this is not a fixed guideline, qualitative factors to take into consideration can focus on governance, policy, planning, and transparency. And quantitative factors can focus on physical structures, investment strategy, accountability, and decision making.

13. Call for Self-Evaluation

Below is an example of a completed circle of sustainability for the city of Amman, Jordan (Fig. 25). This would be the first of its kind, and is intend to highlight the lack of accessible information for the public. Although, this is not the only method of representing the issues that facing the city. This remains as a starting point which could be then peer reviewed by academics, architects, engineers and everyday citizens. In fact individuals and students are encouraged to adapt this thinking in their own way and find new ways of representing it. Intended more as a conversation starter about the issues of sustainability facing Amman and Jordan.

Figure 25. Jamal Abdul Nasser Circle, Amman, Jordan

14. Conclusions

They are an association of researchers, members of universities, and international organizations that apply the circle of social life approach. Circles of sustainability is a holistic method that seeks to consider sustainability across economic, ecological, political and cultural life. This tool supports cities, communities, and organization to collaboratively identify and decide on the critical issues at hand. The link to their website and profile tool, will be added in the references, as well as in herein [51]. The link provided urban sustainability in theory and Practice, which serves as a detailed discussion of how to use the tool. There is a total of 28 questions, seven per domain (economics, ecology, politics, and culture).

This paper has explored the current state of architecture design specifically, the notion of sustainability and productivity. The case for Jordan informed the types of examples used as, demonstrating not only the ability of Jordan as a society and country to absorb the change, but also the willingness and need for it. Sustainable development goals can only be met if the approach is holistic and city focused, one that requires the application of architectural design thinking. The benefits entailed intersect between the spheres of economic, environmental, social, political, cultural aspects of human needs and life. Cities, people, and buildings, the spaces they occupy, can play a transformative role in mitigating the future risks of a non-renewable resources dependent economy and society.

Is Amman a sustainable city?

http://www.circlesofsustainability.org/tools/urban-profile-process/

http://www.circlesofsustainability.org/wp-content/uploads/2014/10/Ch-07-Circles-Urban-Profile-2015.pdf

REFERENCES

[1] WWF., 2017, Living Planet Report 2016. Retrieved from wwf.panda.org:http://wwf.panda.org/about_our_earth/all_publications/lpr_2016/.

[2] Cohen, B., 2007, The Transatlantic Divide: Why are American and British IPE so Different? Review of International Political Economy, 14 (2), 197-219.

[3] Fisher, S., 2016, Philosophy of Architecture. E. N. Zalta, (Ed.). The Stanford Encyclopedia of Philosophy.

[4] Ruskin, J., 1906, The seven lamps of architecture. (G. Allen, Ed.). 266 pp.

[5] Sullivan, L., 1896, The tall office building artistically considered. Lippincott's Magazine, 57 (3), 406.

[6] Rondanini, N., 1981, Architecture and social change. Heresies II, 3 (3).

[7] Britannica, E., 2017a, Architecture. Encyclopedia Britannica.

[8] Britannica, E., 2017b, Aesthetics. Encyclopedia Britannica.

[9] Neuman, M., 2011, Centenary paper: Ildefons Cerdà and the future of spatial planning: The network urbanism of a city planning pioneer. Town Planning Review, 82 (2), 117-144.

[10] Marshall, S., 2009, Cities design and evolution. New York: Routledge, 343 pp.

[11] Jencks, C. A., 1978, The language of post-modern architecture, Publisher Rizzoli, 136 pp.

[12] James, H., 2011, International Order After the Financial Crisis. International Affairs, 87 (3), 525-537.

[13] Transforming Our World, 2015, The 2030 Agenda for Sustainable Development. https://sustainabledevelopment.un.org/

[14] Rashid, A., and Elder, L., 2009, Mobile phones and development: An analysis of IDRC-supported projects. The Electronic Journal of Information Systems in Developing Countries, 36, 1-16.

[15] Tobgay, 2016, Bhutan's Prime Minister's mission https://www.youtube.com/watch?v=7Lc_dlVrg5M. This country isn't just carbon neutral — it's carbon negative.

[16] Eco Watch., 2017, This country isn't just carbon neutral... It's carbon negative. Retrieved from http://www.ecowatch.com/this-country-isnt-just-carbon-neutral-its-carbon-negative-1882195367.html.

[17] Speck, J., 2013, Walkable city: How downtown can save America, one step at a time, North Point Press, 320 pp.

[18] Facility 5.4.7 Arts Center., 2017, Retrieved from 547artcenter.org/facility.

[19] White, S. S., 2010, Out of the rubble and towards a sustainable future: The "greening" of Greensburg, Kansas". Sustainability, 2 (7), 2302-2319.

[20] Benninger, C. C., 2002, Principles of intelligent urbanism: The case of the new capital plan for Bhutan. Ekistics, 60-80.

[21] Centralparksyndey.com., 2017, Retrieved from http://www.centralparksydney.com/explore/a-sustainable-habitat.

[22] World Bank., 2017, Water Security and IWRM. Retrieved from World Bank Group: http://water.worldbank.org/iuwm.

[23] Bahri, A., 2012, Integrated urban water management. Global Water Partnership, 16.

[24] The National, C. N., 2015, Urban Barns: Farming of the future.

[25] Despommier, D., 2013, Farming up the city: the rise of urban vertical farms. Trends in biotechnology, 31 (7), 388.

[26] Ohland, G., and Poticha, S., 2011, Street Smart: Streetcars and Cities in the Twenty First Century, 2nd. Retrieved from Reconnectingamerica.org: http://reconnectingamerica.org/resource-center/books-and-reports/2011/street-smart/.

[27] Alnawaiseh, N. A., Hashim, J. H., Isa, Z. M., and Salahat, S. J., 2014, Respiratory Symptoms from Particulate Air Pollution Related to Vehicle Traffic in Amman, Jordan. European Journal of Scientific Research, 120 (4), 550-563.

[28] Hamdi, M., Bdour, A. N., and Tarawneh, Z., 2008, Diesel Quality in Jordan: Impacts of Vehicular and Industrial Emissions on Urban Air Quality. Environmental Engineering Science, 25 (9), 1333-1343.

[29] Abu-Ekteish, F., Otoom, S., and Shehabi, I., 2009, Prevalence of asthma in Jordan: comparison between Bedouins and urban schoolchildren using the International Study of Asthma and Allergies in Childhood phase III protocol. Allergy and Asthma Proceedings, 30 (2), 181-185.

[30] World Health Organization, 2016, Ambient air pollution: A global assessment of exposure and burden of disease. http://www.who.int/gho/phe/outdoor_air_pollution/en/ For Full Report See: http://apps.who.int/iris/bitstream/10665/250141/1/9789241511353-eng.pdf.

[31] Buchanan, R., 1992, Wicked Problems in Design Thinking. Design Issues, Vol. 8, No. 2: 5-21.

[32] Plattner, H., Meinel, C., and Larry, L., 2011, Design thinking: understand, improve, apply. Understanding innovation, https://hpi.de/fileadmin/user_upload/fachgebiete/meinel/papers/Book_Chapters/Front_Matter_-_Design_Thinking_Understand__Improve__Apply.pdf.

[33] Braungart, M., McDonough, W., and Bollinger, A., 2007, Cradle-to-cradle design: creating healthy emissions-a strategy for eco-effective product and system design. Journal of cleaner production, 15 (13), 1337-1348.

[34] Andrews, D., 2015, The circular economy, design thinking and education for sustainability. Local Economy, 30 (3), 305-315.

[35] Marc Kushner: Ted Talks, 2015, Why the buildings of the future will be shaped by you.

[36] Wong, 2013, https://www.youtube.com/watch?v=ZVsZQ9at1Ww. Forget sustainable, productive architecture is the next big thing.

[37] Heatherwick Studio., 2017, Learning Hub (The Hive). Retrieved from http://www.heatherwick.com/learning-hub/.

[38] Hardy, 2015, https://www.youtube.com/watch?v=kK_UjBmHqQw. Magical houses, made of bamboo.

[39] Worrell, E. e., 2001, Carbon dioxide emissions from the global cement industry 1. Annual Review of Energy and the Environment, 26 (1), 303-329.

[40] Lipson, H., and Kurman, M., 2013, Fabricated: The new world of 3D printing, Wiley, 280 pp.

[41] Bedzed, 2017, Retrieved from zedfactory: www.zedfactor.com/bedzed, Beddington Zero Energy Development.

[42] Designinc., 2017, K2 Apartments by Designinc. Retrieved from Designinc.com.au: http://www.designinc.com.au/projects/k2-apartments.

[43] Passivhaus., 2017, The Passivehaud Standard. Retrieved fromPassivhaus.org.uk: http://www.passivhaus.org.uk/standard.jsp?id=122.

[44] Maleki, A., 2011, Traditional Sustainable Solutions in Iranian Desert Architecture to Solve the Energy Problem. International Journal on Technical and Physical Problems in Engineering, 3 (6), 84-91.

[45] Vefik, A., 1991, Vernacular Climate Control in Desert Architecture. Energy and Buildings, 15 (16), 809-815.

[46] Benyus, J., 1997, Biomimicry: Innovation inspired by Nature. New York: William Morrow, 320 pp.

[47] Pawlyn, M., 2011, Biomimicry in Architecture. Riba Publishing, 128 pp.

[48] Foster & Partners., 2017, Queen Alia International Airport Amman, Jordan 2005-2012. Retrieved from Foster & Partners: Projects: http://www.fosterandpartners.com/projects/queen-alia-international-airport/.

[49] UNDP., 2015, Human Development Report 2015. http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/JOR.pdf.

[50] Harvey, D., 2003, The right to the city. International journal of urban and regional research, 27 (4), 939-941.

[51] Circles of Sustainability, 2017, http://www.circlesofsustainability.org/tools/urban-profile-process/.