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Application of Sustainability Measures to Vernacular Architecture in Jordan

A comparative study

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ABSTRACT:

This research is intended to investigate sustainability aspects in Jordanian vernacular architecture in Jordan, its efficiency, and its correspondence with typical sustainability measures according to modern concerns. Results are to be analyzed and to measure sustainability in modern buildings, then comparing both cases in order to arrive at a set of recommendations applicable to modern construction practices and architecture in Jordan.

A final discussion and recommendations will be included followed by a set of design guidelines applicable to developing countries with Jordan as case study.

Keywords: energy consumption, Jordan, modern architecture, sustainability, traditional architecture.

Conference Topic: Sustainable Architecture

1. INTRODUCTION:

Sustainability is not a new idea rather it is an old concept, since old times there were many sustainable practices in architecture, such practices were found in Greek, roman, and Islamic architecture.

Through the course of human history, the need to achieve harmony between the environment, economy and society, have been recognized, this final element sometimes being referred to as equity, thus formulating the so called three elements: environment, economy and equity.

For the sake of reaching profitable sustainability, it is important consider factors over a medium to long time scale and to take action on different levels of responsibility which are integrated to give a full picture that can reveal the full benefits.

Sustainable development focuses on improving the quality of life for all of the Earths citizens, keeping the right to use natural resources by future generations.

However, in recent times concerns have been raised regarding sustainability especially when the ozone depletion started to appear due to the large CO_2 emissions, and to environmental pollution as well as water pollution, apart from the depletion of natural resources, all the previous factors introduced to the development of sustainable culture which started to develop until our recent times.

Nowadays one can follow many definitions to the concept of sustainability and green culture, the following section will tackle the different definitions for sustainability.

Several scientific works has been done regarding green and sustainability issues, below some of the literature in this regard.

The process of materials selection, design, and construction used for a series of small residential buildings in southern France Whenever possible, materials were resourced in site in order to minimize the environmental impact of the new buildings.

Morel, Mesbah, Oggero, and walker (2001) studied the environmental impact of building houses using local building materials of both construction and operation of those houses, in which they tried to find an approach to reduce the negative effects on the environment by using local building materials. They described how to select local building materials, and the whole concept of the selection was based on nearest point of construction site, then they outlined the construction process, the new constructed houses were then compared to modern houses being constructed from concrete. They found that the new proposed solutions reduce energy in a noticeable way, for example the amount of energy used was decreased by 215%, the impact of transportation was reduced by 453%. (Morel, Mesbah, Oggero, and Walker, 2001)

wood and concrete designs of the wälludden building described by Börjesson et al. in terms of their embodied energy. employing an environmentally extended input –output frame work in a tiered hybrid life cycle assessment, and in a structural path analysis. we illustrate the complexity of the inter – industry supply chains underlying the upstream energy requirements for the building options, and demonstrate that higher-order inputs are difficult to capture in a conventional process analysis. our calculations show that Börjesson and Gustavsson's estimates of energy requirements and greenhouse gas emissions are underestimated by a factor of about 2, and that corresponding greenhouse gas balances are positive at about 30t C – eq . nevertheless Borjesson and Gustavssons general result –the concrete – framed building causing higher emissions – still holds (Lenzen, Treloar, 2002).

Total energy use during the life cycle of a building is growing research field. The embodied energy makes up a considerable part of the total energy use in low energy buildings. Recycling provides the opportunity to reduce the embodied energy by using recycled materials and reusable\ recyclable materials \ components. This paper presents values on embodied energy, energy needed for operation and the recycling potential of the most energy efficient apartment housing in Sweden (45 kWh\m^2). In a life span of 50 years, embodied energy accounted for 45% of the total energy need. The recycling potential was between 35% and 40% of the embodied energy (Thormak, 2002).

Also, Lenzen et al. (2004) calculated the energy requirements needed for households in Sydney, and they followed the structural path analysis and final consumption based approach to analyze energy requirements (Lenzen et al., 2004)

Despite rapid increases in the building industry contribution to resource depletion, waste generation and energy consumption, the creation of built environment remains vital to a country's economic development. This makes the building industry a prime candidate for sustainable development. Tools that help estimate the environmental suitability of building products can advance the cause of sustainable development.

Emmanuel (2004) estimated the environmental suitability for five of the most commonly used wall materials in Sri Lanka (brick, cement masonry unit, cabook, rubble and wattle and

daub). He developed An "Environmental Suitability Index" based on three parameters: embodied energy, life-cycle costs and re-usability. Emmanuel explored The possibility of using similar indices for other materials in Sri Lanka and elsewhere (Emmanuel, 2004).

2. Sustainabilty, definitions and measurement.

Sustainability as a concept has more than seventy definitions. The concept is generally defined as

'Development that meets the needs of the present without comprising the ability of future generations to meet their own needs" (cited in Kirby, 1995, p.1).

For the sake of achieving sustainable development, there are three main parameters identified by Pearce (1989) in which they may be summarized as foloow:

1. Environmental value: Sustainable development typically involves a substantially increased concentration on the real value of the natural, built and cultural environments

2. Futurity: Sustainable development involves a concern not only for the short to medium term time horizon, but also for a longer term, which will ultimately impact on future generations' quality of life.

3. Equity: Sustainable development places emphasis on providing for the needs of the least advantaged in society and on a fair treatment of future generation.

Sustainability relies upon the stronger relationship between economy and environment. First, it is necessary to define sustainability in both economic and ecological terms.

Zrasky (1990) described the main principles of sustainability and its measurement as follow:

1. Efficiency: projects implemented and production processes employed should be efficient and therefore should yield the greatest output per unit within the bounds of current technology.

For market-passed economies, inputs and output are measured by their monetary values.

2. Investment: The total resource base for production (comprising human, manufactured and natural resources) should not be diminished. Investment should be sufficient to at least replenish and preferably to expand the resource base. While there are short-term consumption gains from depleting the production stock, in the long term depletion destroys the capability for an economy generates an inventible surplus.

3. Diversification: Sources of inputs and range of outputs should be diversified as much as possible so that system as a whole is less vulnerable to internal or external risk.

4. External balance: The value of imports and exports should balance over the long term.

Ecological sustainability should be to contain humans interact with the biosphere whereas to consider that from important fundamentals for it. Where as can be described Ecological sustainability at some of the attributes, according to the definition of Zarsky (1990)**,** for ecological sustainability terms, for the sake of humans interact with the biosphere:

1. Biodiversity: all species of flora and fauna and their habitats should be conserved, maintaining the natural potential for species to evolve.

2. Ecosystem conservation: the natural stock of ecological resources such as soil, ground and surface water, land biomass, has regeneration limits. Ecosystem plays a vital life-support function and should be protected.

3. Interconnectedness: Improvement in environmental quality in one country should not be achieved at the expense of another.

4. Aversion to risk: The future is unpredictable and it is best to be cautionary and to make decisions based on avoidance of potentially bad consequences, even if this means that returns are not maximized in short term. This is particularly important given unknown thresholds where in incremental change.

5. Scale of impact: Humans should minimize their use of mass and energy flows relative to the total mass and energy flows of the relevant ecosystem.

In this research, the authors worked on a specific research problem, which is related mainly to the issue of vernacular construction being observed in the local regions of Jordan. And

therefore, some of the measures mentioned by Zarsky (1990) may be not applicable to our problem here, our work here is mainly concerned with energy consumption and resource depletion and materials recycling, and the related issues.

3. TRADITIONAL ARCHITECTURE AND MODERN ARCHITECTURE IN JORDAN

Traditional architecture in Jordan was born from the needs and from the available natural resources in close surroundings of the construction site, this was characterized by some main factors when viewed from the point of sustainable architecture, it seems that the resulting architecture was by its nature "sustainable architecture" a small comparison and analysis would show and prove that judgment.

First, local building materials were used in traditional architecture, and they were carried from close surrounding places, such materials were almost raw materials by their nature and there were no need for any further processes in order to produce manufactured building materials. This aspect was so important in studying sustainable building materials, no energy consumed in transportation, no energy consumed in manufacturing, and the material is fully recyclable after the end of its assumed operation period. Figure 1 shows such traditional materials.[1]

Structural systems in traditional architecture also show some sort of sustainability, the tree trunks used in traditional houses, either as supports or as beams, need, neither energy consumption in their production nor energy for transportation purposes, layers used in roofing and walls show the same sustainability aspects in traditional architecture in Jordan.

The other main aspect in analyzing traditional building materials is recyclable, this means that the manufacturing processes are almost absent before using such building materials, this made such materials recyclable when needed, because raw materials passed through none of any industrial processes that prevent

[1] Marino luigi, lodino michele, 1999, la casa tradizional nei villaggi della giordania, cierre edizioni, Italy.

recycling of the material itself, contrary to modern manufactured building materials.

Roofs consisted of tree trunks working as beams, earth as covering material, bamboo and hays; all of those layers are almost organic by their nature and therefore, they perform as ideal thermal insulators and have no negative effects in terms of any harmful emissions that a modern building material might have.

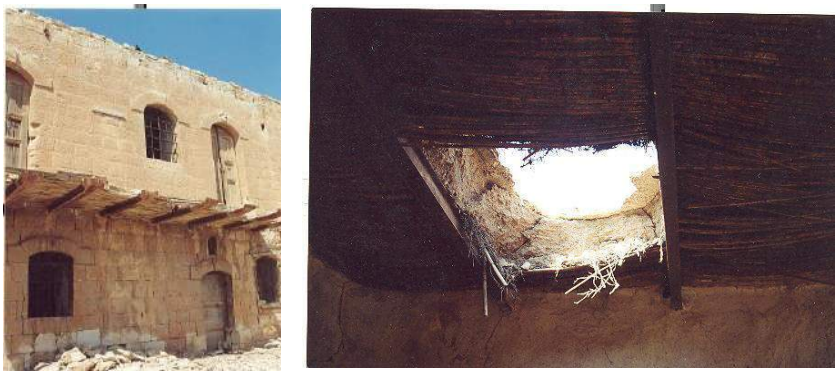


Fig. 1: traditional building materials used in walls and roofs. (Source: authors, 2010).

Modern architecture in Jordan, was and still is characterized in some aspects: the production of modern buildings required large quantities of fuel, importing raw materials from distant locations and resulting in high energy consumption needed for manufacturing, transportation, and construction.

Figure 2 shows an example of such modern building materials, natural dimensioned stone is taken as an example. Stone is extracted and manufactured in Jordan and figure 2 shows the whole process used in Jordan to produce stone.

It is obvious that modern materials have some negative effects on the environment, and this is apparent when trying to understand the degree of recycling for such materials, and the emissions to the environment during their manufacturing, an example for this is Granite which emits radon, a harmful emission to the human health, and the energy needed for its manufacturing. Another example of such materials is aluminum, it needs four times of energy as that needed for steel manufacturing and twelve times as that for wood, for example. (Letchner, 1990). Returning to figure 2 the whole processing stages are shown and it is clear how energy is needed to extract

a completely manufactured unit area of natural dimensioned stone (Alshboul & Alzoubi, 2008)

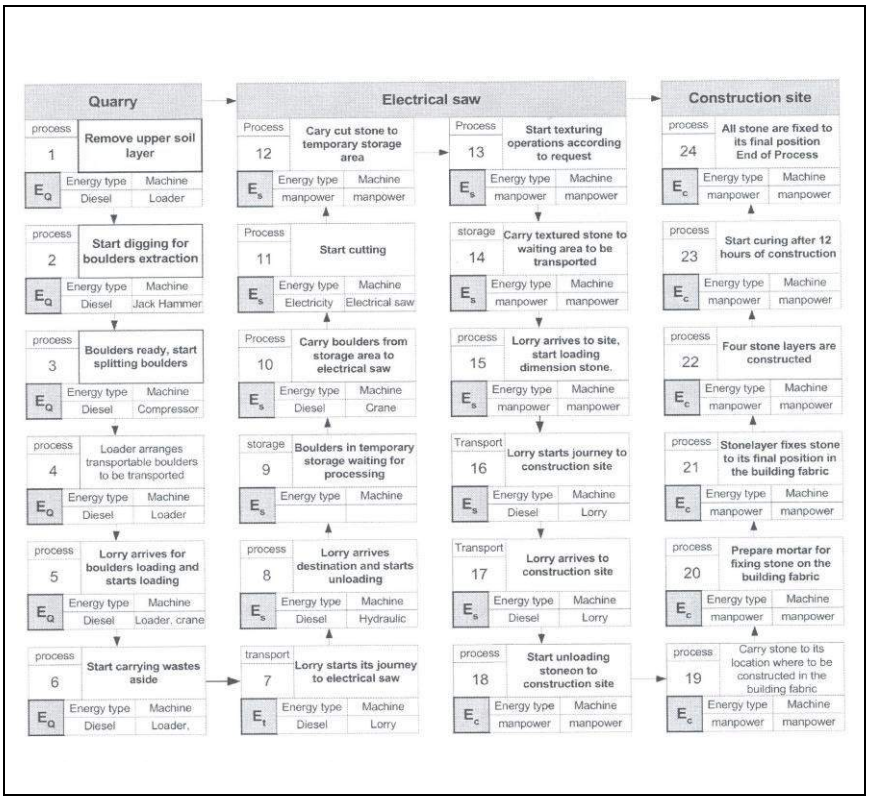


Fig. 2: an example of modern building materials, dimensioned stone high energy consumption, low recycling possibilities, and high emissions to the environment. Shown the process chart for manufacturing. (Source: Alshboul & Alzoubi, 2008).

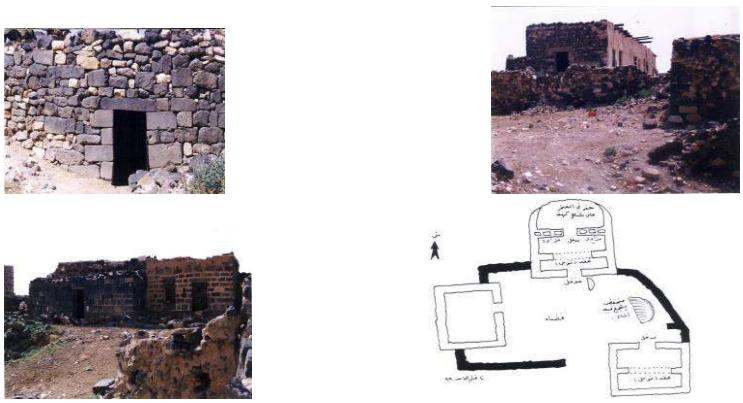


Fig 3. an example of vernacular architecture in Jordan, which could be considered as a base for developing sustainable architecture.

Raw materials are local "Basalt stone" existing in the surrounding sometimes gathered from land surface needing us dressing having good, even excellent, properties, "structural, thermal isolation, good loads materials." Little openings in face of strong sun, Good orientation in relation of climatic

conditions, Good social solution as an answer of human life practice after region, Courtyard and terrace solution respond strongly to climatic and social needs reducing to minimum the need to consume energy, natural sources are essential, biomass and ecosystem are essential in local tradition in architecture, Friendly solution related to nature they are interactive friendly solutions

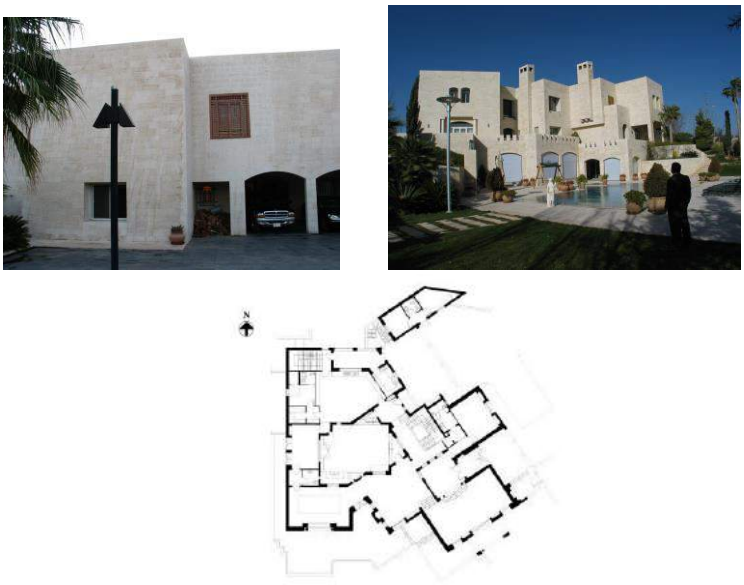


Fig. 4. Modern architecture in Jordan, building materials that needs large quantities of energy to be manufactured and constructed.

4. Discussion and conclusions

From the very beginning of the construction practices in Jordan that created the whole view of architecture in Jordan, when the first houses have been built and constructed, there were no high extreme energy flows that result in environmental deterioration and high energy costs.

As shown in figure 5, the main parameters reflect the need to follow a comprehensive scheme to achieve sustainable architecture, and perhaps this is due to the fact that industrialization took role in the construction industry, contrary to the processes were in the recent past.

Both images, present and past architecture in Jordan are easily comparable in regard to the concept of sustainability.

For vernacular architecture, local building materials were brought from near and close locations to the construction site,

less energy flows were needed to completely install a building material into the building fabric, and less pollution and negative emissions to the environment due to less manufacturing phases needed for a certain building material. After demolition, most of building materials in vernacular architecture are recyclable, just to mention earth, bamboo, natural stone, and tree trunks.

Furthermore, construction practices in vernacular architecture needed less energy, simpler construction operations which could be called sustainable construction.

On the other hand, modern construction practices show more complicated construction operations on different levels. First, building materials are very wide in their variety, some of them are locally manufactured and the other are imported from distant locations, and in both cases large energy flows are needed, please refer to figure 2, this complication in building materials manufacture creates many stresses upon the environment in terms of emissions, natural resources degradation and water consumption, not to forget pollution resulted from transportation to and from the construction site.

A short glance at just one simple modern building, we can notice how many building materials are used and how much embodied energy incorporated in those processes. Apart from energy and resources needed to operate the building.

After demolition, many of the building fabric, there are many harmful elements that could not be recycled which may create pressures upon the environment, and such materials will accumulate to the degree that problems begin to appear.

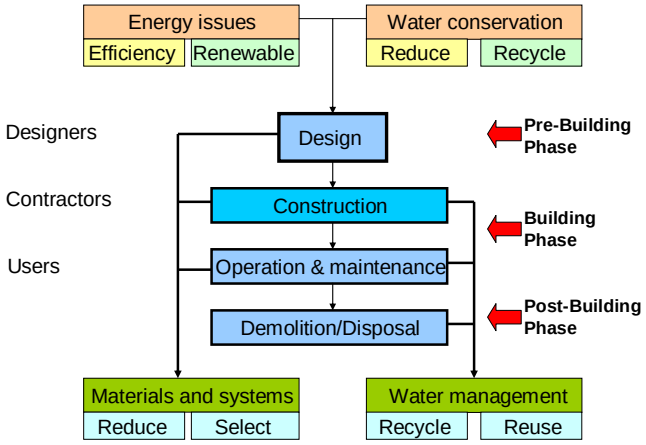
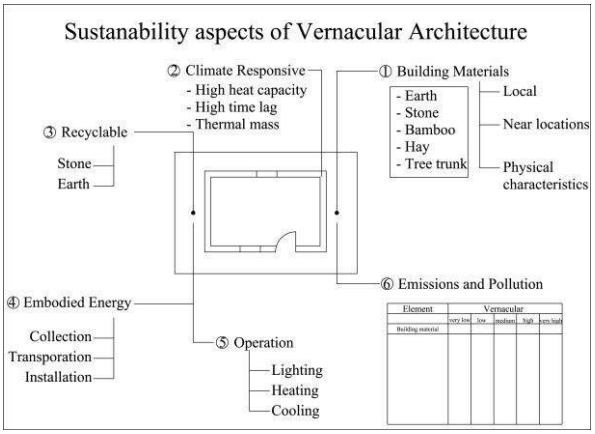


Fig. 5. The main parameters that influence the degree of sustainability, the chart demonstrates the parties, resources, and different variables presented in a comprehensive plan on a multi level approach. (Source: Authors, 2010).



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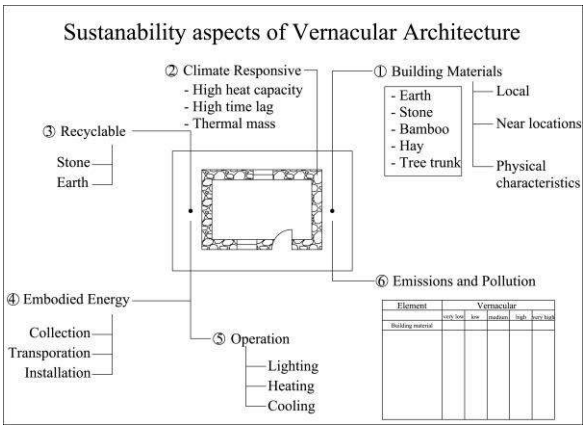

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Fig. 6. A: energy flows in a modern construction approach, this shows the potentials for high energy consumption and therefore high environmental impacts. B: energy flows in traditional construction approach, the nature of construction process and materials selections

reflects low energy flows and therefore less resource depletion and less environmental impacts. (figures by authors, 2010)

5. Recommendations:

From the previous discussion, it is clear that there is big difference between past construction practices and architecture and those modern ones, our work here concludes the following main recommendations:

First, the model of vernacular architecture in all of its aspects is considered an ideal sustainable architecture ever existed in the Jordanian architecture, and therefore, architects are requested to develop models based on past experiences in vernacular practices.

Second, as known by all experts in Jordan, building operations need extra energy flows to maintain the acceptable level of thermal comfort inside buildings, it is necessary that architects should develop climate responsive buildings in order to reduce energy demands, and this could be achieved by passive design techniques and solar passive systems. Experience showed that applying such systems will drastically reduce energy demands in both extreme situations either for cold weather or for hot season.

Third, architect must develop new wall structures that maintain thermal comfort inside buildings that could be achieved through minimum embodied energy and could be, in the same time, recyclable, with minimum negative effects upon the environment.

Fourth, national policies in this regards must be developed, and the government already started such programs through the development of national building codes that deals with the issue of green and sustainable architecture, just to mention: national building code for low energy buildings, national building code for green architecture.

Fifth, the issue of awareness is very important in this regard, the institutional body in Jordan is highly recommended to develop programs in order to enhance the concept of green and sustainable architecture through undergraduate courses and even on lower levels in schools, this will strengthen the behavioral aspects towards sustainability.

Sixth, it is strongly recommended to adopt and develop one of the green building rating systems, which could fit to Jordan considering the local conditions for Jordan and for different

climatic zones in Jordan. Because such systems consider mainly the issue of natural resources conservation and energy conservation which is very important, as Jordan is totally depends on imported oil.

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