Towards a Climate Neutral Housing Strategy for Egypt – Performance based Living-Action Levels and Responsibilities

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Abstract. Egypt’s population has recently exceeded 100 Million inhabitants; a figure that is anticipated to double within the coming 20-30 years. At a current 2% annual growth rate, changing socio economics needs, and anticipated demographic change; more than ever, has housing provision become a challenging proposition. Residential construction in Egypt amounts to 21% of the total construction output by value in 2015 in Egypt (9.548 Billion LE) which is almost equivalent to the construction output by value of powerplants (EGP 9.67Billion LE). In addition, the construction and demolition waste accounts for 44% of the total solid waste of 94 Million tons produced in Egypt. Given the scarcity of resources, the resultant CO2 emissions and pollution, in addition to Egypt’s commitment to the World Sustainable Development Goals (SDGs); this paper, adopts a qualitative approach - literature review, to identify Egypt’s major housing challenges and potential solutions in light of SDG11. In this context, the concept of climate neutral design is investigated, different assessment tools are critically reviewed; and major components for strategy development are concluded in terms of levels and responsibilities. These are then used as a reference to reflect on Egypt housing strategies issued in 2016. This paper is exploratory in nature and is anticipated to furnish the ground for the following phase of the research to devise an action driven climate neutral housing strategy for Egypt.

Keywords: climate neutral design, Egypt, housing strategy, performance-based living

1. Housing in Egypt

Egypt historically, has always been solely dependent on agriculture along the river Nile, the main source for water in Egypt [1]. Thus, the population has been distributed along the Nile banks around 1,500 km in length [2]. Nevertheless, after the 1952 revolution, the country embarked on aggressive heavy industrial development in major urban cities, and particularly in Cairo. This has arguably resulted in surge of rural-urban migration for better job opportunities and improved quality of living [3]. Thus, experiencing increasing need for housing in urban areas. While the Government aimed to provide social housing as means for social justice at that time, it has not been able to meet the increasing demand since [4]. This has further exacerbated in the late 60s and in the 70s when war economy was assumed [3]. Since then, the informal housing has expanded throughout the years largely due it’s affordability in comparison to Government provided housing. In addition, inhabitants in Government provided housing embarked on informal adaptation to housing units to increase unit area and adapt it to their needs [5]; [6].
With a current population of 100 Mill inhabitants and around 2% annual growth rate [2]; around 900,000 units are arguably needed annually. This is further exacerbated by additional estimated accumulated gap of 2-4 million units [7]. Furthermore, the increase in housing demand exacerbated the challenge for the Government to accommodate not only in terms of quantity, but also quality, and affordability. In addition, the increasing informal housing that does not abide by any codes or regulations has also resulted in housing units that do not meet the changing needs of the population (social, economic, and demographics). Consequently, overburdening existing infrastructure and consequently negatively affecting the quality of living [8]. Thus, rendering these as socially, economically, and environmentally unsustainable.

Further to the environmental and economic aspect, the construction and demolition waste in Egypt represent around 44% of the total solid waste in Egypt exceeding both agricultural and industrial waste [9]. Given that construction output for public, private, and government projects by value in Egypt for residential sector and Powerplants is by far the largest in comparison to other sectors [10]; it may be argued that residential sector is contributing to the majority of construction and demolition waste in Egypt. Thus, making the construction sector in general and the housing sector in particular inefficient and consequently unsustainable. Therefore, there is a pressing need for sustainable solutions to the housing sector in Egypt.

2. Sustainable development indicators
According to Brundtland report [11], sustainable development arguably implies limitations governed by the present state of technology and social organization on environmental resources and the ability of the biosphere to absorb the effects of human activities. In this context, technology and social organization can arguably be further managed and improved to allow for economic growth.

Building on Daly’s ends-means spectrum which illustrates the relation between human economy and earth for a steady economic state [12]; Meadows [13] suggested a framework for sustainable development indicators (Figure 1). In this context, the three main measures of sustainable development have been suggested to include: a) sufficiency (through which ultimate ends are realized), b) the efficiency (through which ultimate means are translated into ultimate ends), and c) the sustainability (i.e use of ultimate means). The ultimate means are those means out of which all life and economic transactions are built and sustained. Thus, considered the natural capital such as the sun’s energy, the biogeochemical cycles, the ecosystems and the genetic information they bear, and the human being as an organism. These ultimate means are arguably not created, rather are considered the heritage that humans are born into, and out of them. These are then transformed using technology as intermediate means. These are e.g. tools, machines, factories, skilled labour, processed material and energy (i.e built and human capital and raw material). These are also referred to as inputs to the economy. While intermediate means are considered necessary but are arguably not sufficient to accomplish all higher purposes.

The intermediate ends are considered e.g. the goals that governments promise, and subsequently economies are expected to deliver in the form of e.g. consumer goods, health, wealth, knowledge, leisure, communication, transportation), also referred to as ‘outputs’. It was further noted that intermediate ends should not be considered as ends in themselves, rather are instruments to achieve something higher. Hence, the translation of intermediate ends to ultimate ends depends on e.g. an effective ethic, religion, or philosophy. At the top of the triangle of sustainability; the ultimate end has been located, thus; is desired for itself. Therefore, should not be considered as the means to the achievement of any other end. The definition or measurement of the ultimate end is faced with challenges according to Huovilla [12]: “Our perception of the ultimate is always cloudy, but necessary nonetheless, for without a perception of the ultimate it would be impossible to order intermediate ends and to speak of priorities.”

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3. Climate neutral design
In line with Meadow’s framework for sustainable development indicators [13], a climate neutral building falls within the intermediate ends. A carbon neutral building is defined as one with significantly reduced energy consumption combined with the increased use of low carbon energy sources to meet the remaining demand [14]. In this context, buildings would arguably only need very little energy where the remaining energy needs will mainly be met by renewable energy sources [15].

To better manage carbon emissions, existing residential buildings are suggested to be subdivided into classes (e.g. single- and double-family houses (SDFH), small and medium-sized multi-family houses (SMH/MMH), and large multi-family houses (LMH)) [15]. It is further suggested that the building types be subdivided into age groups whose energetic characteristics in their originally built state differ significantly.

Whether the building exists or is in the development phase, and according to the United Nations economic commission for Europe, on how to make cities less energy and carbon intensive and more resilient to climatic challenges [16], the full life-cycle assessment including construction materials and end-of-service disposal or re-use should be considered; where, a climate neutral urban waste management should be implemented. Furthermore, it is advised that buildings to be maintained by well-developed maintenance industry. In addition, from a planning point of view, planning and development control should be in place to prevent sprawl; and ensure socio-spatial integration avoiding social segregation and social imbalances. This, however, require an evaluation/assessment mechanism to ensure cities and human settlements are inclusive, safe, resilient, and sustainable (SDG11).

Figure 1. Sustainable Development Indicators Framework (Meadow, 1998)

4. Assessment versus Certification criteria
To ensure energy efficiency in buildings and consequently a climate neutral built environment in general, several certification tools were developed and implemented. The very first certification tool developed was the British BREEAM in 1990, LEED in the US 1998, and the newest was DNGB in Germany 2009. The comparison carried out between the different certification systems [17] demonstrated different weighting criteria for the different components of sustainability, namely environmental, economic, and social quality. Only the DGNB system gave equal weights to the different sustainability components, whereas WELL has given the social quality the most emphasis. This further confirms that there is no consensus in terms of what is a sustainable building/built environment; and
consequently, raises concerns in terms of the purpose of building certification schemes, and which scheme should be applied, and why? Further questions arise in terms of the possibility of achieving different alternatives for the same goal, what is/are the determining factor(s), and who makes the decision? In this respect, a building certified under a particular certification scheme, may fail to get certified under another scheme [18]. To help compare between the different certification schemes; Guldager et al. [19] devised 13 aspects to guide the comparison of a selection of certification schemes. This has been further investigated to conclude a common definition for the different aspects of the certification schemes for ease cross-referencing the different schemes [20]. It was further concluded that the different certification schemes may not only differ in terms of their weighting criteria but may also differ in terms of the different aspects, and even principles [20]. Hence, raising the concern of the effectiveness of the different schemes; and thus, the call for investigating a more holistic approach that is flexible enough to allow responding and be tailored not only to the needs of the different people, communities, and countries; but also taking into account the changing national and global challenges. The following section attempts to explore such a holistic approach in residential buildings.

5. Performance-based living

The inability of housing to respond to the various inhabitants changing needs, further arguably affects the mental, social and physical health and wellbeing of the people who live in the homes [21]. Thus, jeopardizes people’s within their community. In this respect, there is a need to not consider housing as merely the provision of stock of houses, rather it should be considered as means to enable a healthy and productive community. In this context, Gibson [22] suggested the concept of ‘performance-based design (PBD), which calls for thinking and working considering ends rather than means [23]. This was in line with Vitruvius who referred to it as the art of building. Where the building should consider durability, convenience, and aesthetics [24]. This has been referred to in contemporary terms to identify user needs (UN) and performance requirements (PR) which are then to be translated into attributes for the different building sets and parts. These should have measurable impacts on health and wellbeing; and further relate to the building itself in terms of the fabric/envelope, the internal layout of the unit, systems, interface with the neighborhood, and strategy overall. The neighborhood should also enjoy certain characteristics to allow social interaction, exercise, access to nature, etc. so people would enjoy living in their community; and thus, would have a positive impact on their personal health and wellbeing [21].

The systemization of qualitative user expectations has arguably began in the US in 1970s as part of the framework of the Operation Breakthrough project [25] defining a list performance attributes. This list was later adapted and extended by different scholars to include:

- **Functionality** – which refer to spatial characteristics and accessibility, serviceability, operation and maintenance, and structural serviceability.
- **Safety** – refers to structural safety, fire safety, accident safety, body safety, and security.
- **Health and well-being** – this include indoor air quality, moisture and mould safety, indoor climate, acoustics, visual comfort, hygiene, water quality.
- **Sustainability** – refers to energy efficiency, durability, environmental impact

The stakeholders identified as most relevant to performance-based design PBD include users/inhabitants, guests, services personnel, the public; in addition to the regulator who is concerned with addressing the true needs and the building do not directly and/or indirectly affect the environment throughout the life span of the building. Furthermore, the design team is also an important stakeholder who is responsible for ensuring all pertinent PRs including the regulatory framework in the different areas are met. This further requires a coordinated design process and teamwork. The manufacturers are also important stakeholders of the building material who are responsible for using well established processes and quality control, e.g., in Europe they use the CE marking referring to the fitness for use [26]. In this context, PBD is argued to:

- encourage better apprehension and communication of client/user requirements
- allow considerable flexibility with regards to design proposals
- support innovation to cater for cost optimized solutions
- encourage international trade through integrating building codes

User requirements on the other hand are suggested to be grouped in a coherent fashion to define the performance categories, including:
- functional performance
- technical performance
- economic performance
- environmental performance
- social performance
- process performance

Factors varying from the quality of the internal air, how much space and light there is, in addition to the amount of storage space available, can arguably have measurable implications on health and wellbeing. Notwithstanding these issues, even the design of the neighbourhood is critical as it allows opportunities for social interaction, exercise, access to nature, local amenities and schools. Thus, define the extent to which residents will enjoy living in their community and further impact their own personal health and wellbeing [21].

The following ten steps are considered as the backbone for establishing a PBD process for any building occupancy and in every performance area:
- **Step-1**: define potential User-Activity groups and their UNs.
- **Step-2**: Specify all pertinent actions/conditions that may negatively affect building performance; and thus, hamper the achievement of the UNs
- **Step-3**: specify all related performance indicators for each UN.
- **Step-4**: for each performance indicator, identify the building related meaning of the term dissatisfaction or performance failure.
- **Step-5**: For every UN associated with every User-Activity, specify the accepted percentage of dissatisfaction or the accepted level of failure.
- **Step-6**: Specify the characteristic values of the generalized loads.
- **Step-7**: Specify the characteristic limit values of the performance indicators.
- **Step-8**: Determine safety/modification factors for transforming characteristic values into design values.
- **Step-9**: Establish reliable evaluation tools that help predict the consequences of exposing the suggested design solution to the relevant combinations of generalized load (e.g. simulations).
- **Step-10**: Establish methods for obtaining design values for all pertinent material or component properties.

In order to ensure that the 10 steps above are representing a real-life situation of people’s needs, and consequently a comprehensive response to these needs, a Sinus-Milieus Models i.e. target group segmentation may be needed [27]. The model should be continuously adapted to socio-cultural changes in the society. These illustrate the everyday reality of societies, people’s working and private lives, the changing family structures, the digitalisation of day-to-day living, and the growing polarisation of wealth. This is in line with Schäfers [28], who considered dwelling as part of most established cultural matters. In this respect, housing should not refer to the location where the basic needs are met, rather the spatial manifestation of individual needs, self-esteem, accomplishment, as well as the representation of cultural and civilization standards. Thus, promoting the identification and classification of living requirements (Wohnwünsche).

6. **Performance-based building and design evaluation**

Performance-based building is an approach concerned with building related processes, products and services that is predominantly targeting the required outcomes, the ends, and not necessarily how these outcomes are attained, i.e. the means. This contrasts with the traditional prescriptive approach, that tends to focus on specifying the method or solution for achieving the required outcomes [29]. It calls for better apprehension and communication of client/user requirements, thereby minimising opportunities for
disputes; and thus, ensure satisfied customers; allows considerable flexibility for building practitioners in terms of design solutions; encourages innovation, provides the opportunity for cost-optimised solutions; and further, supports international trade.

UNs and PRs convey the demand side of the building chain. Where the supply side provides design solutions as well as the final constructed facility. Nevertheless, design tools are needed to provide solutions. Furthermore, to ensure that supply meets demand, reliable assessment methods should be employed. It needs to be noted, however, that both the design tools and the assessment methods should be able to evaluate/simulate the behavior and response of the building to the generalized loads and anticipate the performance indicators specified in the performance criteria. Nevertheless, the tools required during design and for the final assessment of the integrated solution should not necessarily be the same. During the design phase, each professional is expected to seek answers for the set of given PRs under their responsibility. The process starts by identifying various conceptual solutions which should be first verified ‘superficially’ against other requirements. Those that clearly conflict with requirements are discarded. The architect, then, combines all remaining solutions into the most favourable combination or into several combinations of equivalent solutions. Each of the various members of the design team are then expected to elaborate the details in their area of specialization. It needs to be noted that every single decision made by any of the professionals may affect the performance in other areas that are not directly under his/her responsibility. Therefore, the final chosen combination should be re-assessed by the different design team members to ensure that it still responds to the entire set of requirements [29].

While assessment methods and tools employed by the different stakeholders may not necessarily be identical; those used by the authority having jurisdiction should, however, be specified in the regulatory documents. In addition, those used by the entrepreneur are suggested to be defined in the performance-based program and in the contracts. While there is little agreement in terms of which building performance evaluation criteria and methodologies should be best applied in the different situations; there is consensus, however, that performance-based approach ensures innovation, more open competition, allows transparent procurement, and ensures cost effective building [30]. In this context, there have been calls for evaluating the contribution of single buildings towards sustainable development. In this respect, the functional design, technical, economic, environmental, social, and process aspects should be considered simultaneously (Figure 2). Nevertheless, to achieve a sustainable development, the performance-based housing design approach should not be implemented by individual projects; rather a performance-based national housing strategy may be needed to guide the national housing development and build consensus among the different stakeholders.

| Performance Categories | Functional | Technical | Economic | Environmental | Social | Process |
|------------------------|------------|-----------|----------|---------------|--------|---------|
| user/inhabitants       |            |           |          |               |        |         |
| guests                 |            |           |          |               |        |         |
| services               |            |           |          |               |        |         |
| personnel              |            |           |          |               |        |         |
| public                 |            |           |          |               |        |         |
| regulator              |            |           |          |               |        |         |
| design team            |            |           |          |               |        |         |
| manufacturers          |            |           |          |               |        |         |

**Figure 2.** Performance-based building design action levels and responsibility matrix
7. **Strategy development**

A strategy may be defined as “a unified, comprehensive, and integrated plan that relates to the strategic advantages …… to the challenges of the environment. It is designed to ensure that the basic objectives …… are achieved through proper execution ……” [31].

Strategy formulation is arguably contextually based as it may be understood as a flow of events, values, and actions running through a context. Part of the context is the location of strategy in time. In this context, yesterday's strategies eventually provide some of the pathways to today’s strategies; and today's strategies would bear a concept for the future. Eight different strategies have been identified [32], namely planned, entrepreneurial, ideological, umbrella, process, unconnected, consensus and imposed.

Rao (2010) identified different forms of strategies, namely deliberate, emergent, and realised. A planned strategy takes the form of formal plans, with clear intentions identified by the leadership and supported by formal controls to ensure seamless implementation in controllable or predictable environment. It is further argued that a strategy can best be seen as the product of the political, cognitive, and cultural fabric of an ‘organisation’.

In order to agree on the strategy, comprehensive answers to the following questions should be determined: a) where are we now? B) what do we think will happen in the future? C) where do we want to go? This should be followed by devising the actions needed to achieve the strategies; and thus, conclude an action plan followed by a budgeting plan and measures of success.

8. **Egypt’s Housing Strategy**

Housing challenges in Egypt emerged almost 70 years ago, several attempts to overcome these challenges throughout the years seemingly failed; thus, challenges have compounded. 1948 witnessed the first public housing project in Egypt. Housing initiatives in Egypt took several forms ranging from speculative finished apartment blocks, unfinished apartment blocks, to self-built housing in existing as well as in new cities. Nevertheless, failures were attributed to units being not affordable, small for an average Egyptian family size, requiring long commuting, in addition to failure to monitor self-built/incremental housing. All of which contributed to the informal adaptation of formal housing as well as the expansion of informal housing. In this context, Nadim [33], [8], [34], [35] explored the housing challenges and opportunities for sustainable smart solutions.

The current housing strategy was issued in 2020 [36]. Four major challenges identified in the strategy include a) existing urban development areas, b) existing housing stock and vacant units, c) low-income housing, d) dimensions of sustainable development. The strategy is arguably consistent with the sustainable development goals (SDG), The New Urban Agenda [37], the Arab Strategy for housing and Urban Development [38], and Egypt sustainable development strategy (Egypt vision 2030) [10]. This strategy is intended to inform the housing sector for the next 20 years. The strategy includes providing lands suitable for construction with the needed basic services, studying the social and economic aspects of the targeted populations by the housing programs, developing an integrated strategy for new urban communities, in addition to developing existing deteriorated low-income areas. Household income has been and is still considered the common factor for categorising housing to include low, middle, upper-middle. The strategy acknowledged the lack of information with regards to housing needs due to the lack of accurate data.

In terms of sustainability, the concept of ‘green building’ in the strategy is considered for new developments, with no reference being made to the existing stock which exceeds 40 million units. Thus, calling for revised building codes and established legislative framework to implement green and sustainable building practices. In addition to laws with binding standards to ensure sustainable and environmentally friendly buildings. Furthermore, to apply incentive schemes to motivate the private sector to invest in green and sustainable buildings. In terms of affordability, the strategy suggests ‘eased standards’ for affordable housing with alleviated procedures to support self-built housing, promoting the concept of mixed-use development. In terms of innovation, the strategy calls for energy efficient housing, employing cheaper building materials, and adopting more effective construction technology, (b) allowing diversity in social housing projects, achieving more dense plans for large
residential blocks to ensure social involvement, and maximizing access to public transport, and (c) stimulating innovation to achieve affordable housing. In addition, the strategy calls for housing provisions that takes into account the specificity of the different Egyptian societies.

9. **Discussion and Conclusion**

This paper attempts to pave the road for a climate neutral housing strategy for Egypt. This is of particular importance due to the increasing housing demand, the inability to respond to the changing socio-economic needs, and the expansion of informal housing to fill the demand-supply gap in terms of quantity but not necessarily quality. The paper further argued that this has resulted in the increasing construction and demolition waste.

Considering the above challenges, the paper investigated the different definitions for climate neutral design where socio-spatial integration should be maintained, and life-cycle assessment should be assumed to reduce waste by considering end-of-service disposal and/or re-use. This, however, require a solid assessment mechanism to achieve inclusive cities which are safe, resilient and sustainable according to SDG11.

The paper further questioned the reliability of the different existing assessment and certification systems, particularly as each system has a different approach to sustainability. While the paper acknowledges the need for different alternatives for the same goal, this however, should be based on the needs of the people and not be determined by a standard assessment/certification scheme. In this respect, the paper investigated the concept of performance-based living and performance-based buildings to translate the needs of the users which are mostly qualitative into measurable technical solutions. Thus, the paper argues that the different stakeholders need for any design should be first identified, followed by a translation of these into functional, technical, economic, environmental, social and process performance to conclude the optimum solution for achieving the different needs of the different stakeholders.

From a sustainability perspective in terms of ensuing performance-based buildings and cities in general, the papers highlighted the different types of strategies; arguing that a planned strategy would be most suitable for the complex housing context in Egypt.

The paper finally explored the current housing strategy of Egypt issued in 2020. The strategy is understandably mainly concerned with the provision of affordable housing in terms of provision of adequate financing schemes. Nevertheless, while acknowledging the SDG goals and the provision of green concepts to the housing sector, no clear definition of what ‘green’ means, in addition these will be dependent on issuing a binding law and incentives to encourage the implementation thereof. Furthermore, the strategy promotes mixed-use and self-built housing schemes, and did not refer to the means to avoid previous failures in similar past schemes [8], [33]. Sustainability and innovative solutions are generally very broad which may bear different interpretations, which would make it real difficult to assess the efficiency of the proposed solutions. It is therefore expected that the concept of performance-based housing, may help achieve a holistic approach for sustainable climate neutral housing in Egypt by defining the ultimate needs and attempt to achieve them starting from the ultimate means. This however and overcome require the careful identification of the different stakeholders to help achieve the ultimate ends and avoid failures of previous initiatives.

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