

RESILIENT RULES

Culture and computation in traditional built environments

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Abstract. This study explores the influence of the socio-cultural rules, based upon Islamic jurisprudence (fiqh), on the complexity of the traditional built environment. This system of rules organized the societal activities, including decisions and activities related to design and construction in the Arab-Islamic city. Considering the city as a complex system, the study will try to show how this rules system made the Arab-Islamic city resilient and adaptive. Complex Adaptive Systems (CAS) are non-linear, self-organizing systems that have the ability to adapt to changing conditions through changing the rules that organize the random autonomous interactions between agents in the environment. This adaptation takes place through gradual gained experience that is reflected in the behavior of agents. This study attempts to interrelate different bodies of literature (Complexity/Chaos theory and built environment studies) in a single framework that aims to show that the socio-cultural rules system based on fiqh was a major factor in the resilience of the traditional built environment. These interrelations are illustrated using a graph called Computational Rules Graph (CRG). The CRG relates the traditional rules system to attributes of complex systems in a graph that can be modeled computationally. Traditional rules (codes of conduct) are proscriptive (non-deterministic), defining what is prohibited, thereby producing autonomous environments where agents had control over their immediate environment. In comparison, contemporary rules of the built environment (building codes) are prescriptive (deterministic), subscribing definite actions that need to take place by the stake-holder (agent) neglecting user needs and preferences. The application of these traditional rules system increased the agent's autonomy and freedom of action. It also helped establish stronger social networks among agents, which resulted in a resilient environment.

1.Introduction

The science of planning responded to the problems of the city through two main paradigms. During the first half of the 20th century the city was viewed as a machine. Controlling the city changes through deterministic and top-down plans was the modernist planners' solution for the poor living conditions of the industrial cities of the 19th century. In the second half of the 20th century the city was dealt with as a system. The science of complexity can be the base for the third paradigm shift in city (Haghani, 2011).

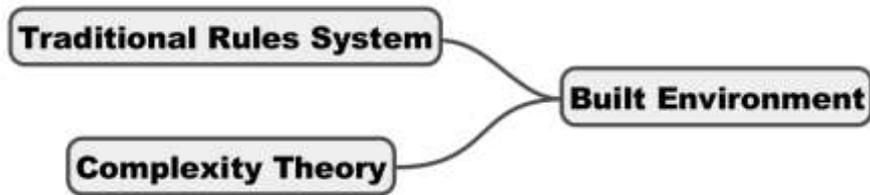


Figure 1. Bodies of literature Interrelated in the study

This study attempts to interrelate different bodies of literature (Complexity/Chaos Theory and built environment studies) in a single framework that aims to show that the socio-cultural rules system based on *fiqh* was a major factor in the resilience of the traditional built environment (Fig.1). If future research, interpreting this relation using computation models could constitute a rigorous method to analyze and learn from the traditional built environments. It can also explain the notion of self-organization in traditional Arab-Islamic cities in spite of their apparent disorder.

THE CITY AS A SYSTEM

The rise of dynamic systems theory in the 1960's motivated planners to revise traditional urban planning as popularized in various texts (Batty, 2007). This systemic approach replaced the rigid planning methods with more flexible planning policies. The city was considered as a system where numerous subsystems interact to create the whole. Accordingly planning a city is to define a systematic and hierarchical relation(s) among structural elements, by which any change in any element of the city is to correspond to the construction of the whole system. A system that would easily accommodate all the activities of a large number of people while having the flexibility to absorb growth and change. Thus, designing a city shifted from predicting the future of the city to predict a structure of the city.

One of the limitations of this approach is that it considered cities as systems in equilibrium and the planning role is to maintain this state.

Although it is more realistic than the mechanistic approach, a group of theoreticians still considered it deterministic in nature (Haghani, 2011). For this group, this approach clearly conflicted with aspects of democratic city life, which led to the paradigm of complexity theory (Batty, 2007).

THE CITY AS A COMPLEX SYSTEM

The two previous approaches did not deal with the notion of uncertainty and complexity of the city (Haghani, 2011)

“Cities should be identified, understood, and treated neither like simple mechanical systems nor like disorganized complex systems, but as organized complexity.”(Jacobs, 1961, p. 434)

Jacobs was one of the theorists who called for treating the city as an organized complexity rather than as a machine (Haghani, 2011). Organized complexity proved to be a constructive way of thinking about urban life letting the overall system reveals the details using the tools of feedback, neighbor interaction and pattern recognition that are the hallmark of all self-organizing systems (Johnson, 2001).

Since the 1980s, there has been a growing trend to consider the city as a complex system suggesting a radical shift from top-down, centralized management to more decentralized bottom-up structures (Haghani, 2011).

2.Theoretical background

2.1.COMPLEX SYSTEMS

A complex system consists of various independent elements that continuously interact and spontaneously organize themselves into a state of self-organization as a whole overtime. Complexity Theory is the study of the interactions among these local agents in transition from order and randomness (Haghani, 2011). Complexity or chaos theory as it is sometimes referred to, is concerned with structures that come into being through their self-organized nature and show emergent properties. Compared to holism, Chaos Theory does not overlook the notions of interaction and organization (Haghani, 2011). It can be defined as the study of ever-changing complex systems based on computational concepts of recursion. Fractal Theory is a subset of Chaos Theory as it is a geometric manifestation of complexity (Haghani, 2011). Cities are claimed to be complex systems for the chaotic behavior they show and their fractal emerging geometric patterns. In order to examine the credibility of this claim that a city can be observed as a self-organizing complex system, we need to go through the characteristics of Complexity/Chaos Theory. The list below shows main characteristics of complex systems that Haghani (2011) extracted from Complexity/ Chaos Theory literature:

- Variety
- Irreducibility
- Deterministic chaos (duality of determinism and randomness)
- Positive and negative feedback
- Sensitivity to initial condition
- Limited predictability
- Emergence
- Self-organization
- Adaptability
- Interconnectedness
- Hierarchy and levels of scale
- Self-similarity and fractal pattern

2.1.1. Complex Adaptive Systems (CAS)

Complex Adaptive Systems (CAS) are non-linear, self-organizing systems that have the ability to adapt to changing conditions through changing the rules that organize the random autonomous interactions between agents in the environment. This adaptation takes place through gradual gained experience that is reflected in the agent's behavior. Interacting agents that are described in terms of certain rules generate complex temporal patterns. In order to understand how CAS works, these patterns need to be studied (Holland, 1995). Holland (1995) states six main characteristics of CAS:

- Aggregation
- Non-Linearity
- Flows
- Self-organization
- Emergence
- Diversity

2.1.2. Computational models of CAS

The study in hand is concerned with computation as a tracer of non-linear complex emergent processes such as Conway games and Mandelbrot's sets. A core principle in computation is that global complex patterns emerge from local simple rules. Thus, computation can be a useful tool in exploring the influence of some very simple rules on the transformation of the city (Coates and Thum, 1995). Generative modeling using computers can be a mean to carry out endless experiments to explore key ideas in the design of built environments.

Several experiments have been conducted to interpret CAS and their emergent spatial properties such as multi-agent systems, cellular automata and genetic algorithms that adopt a bottom-up philosophy (Krämer and Kunze, 2005). These experiments fall under the computational paradigm in which computational models are used to describe social systems and natural phenomena (Hoekstra, Kroc, and Sloot, 2010).

2.2.RULES SYSTEM

Shari'a is a set of rules based on the revelation by God to the prophet Mohammad. Islamic jurisprudence (*fiqh*) was developed to interpret God's will from the available resources (Qur'an and prophet's sayings). It has been the principle objective of Islamic scholars to discover and develop the *Shari'a* as a concrete body of rules and principles. *Fiqh* has explained diversity as a result of its open, discursive nature which bridges the gap between divine abstract source and variety of human behaviors and contexts (Otto, 2010).

Listed below are some of the main socio-cultural rules discussed by Hakim (2008) and Akbar (1988a). This rules system that is based on *fiqh* organized the societal activities, including decisions and activities related to design and construction in Arab-Islamic city. Translations and transliteration used are according to (Al-Hathloul, 1981):

- *'Urf* العرف Customs
- *Tawrith* التوريث Inheritance
- *Shuf'ah* الشفعة Pre-emption
- *Ihyā* الإحياء Revivification
- *Asbaqiya* الأسبقية Right of precedence
- *Darar* الضرر Principle of damage
- *Irtifaq* الإرتفاق Servitude
- Right of appropriation of open spaces (Fina' فناء)

In the following some of the above mentioned principles are further explained and their impact on the Arab Islamic city is shown.

'Urf: Some scholars refer to the verse 7: 199 in the Qur'an as the basis for sanctioning the *'Urf*. It is what is customary to a people and which they follow in their sayings, acts and in what they reject (Hakim, 1994). Within traditional Arab built environments, Islamic law acknowledgment of *'Urf* was operational on a daily basis in the realm of houses and markets (Akbar, 1984). The smaller the scale the more evident the impact of the *'Urf* was on the built environment (Hakim, 1994).

Revivification: This principle was extracted from the prophet Mohammad (PBUH) saying "He who revives dead land will be rewarded by God (in the Day of Judgment)" (Akbar, 1984). Land is considered dead if there is no trace of building or cultivation; if it is not used by the neighboring locality as, for example, a burial ground, or as a source of wood or food for cattle. Streets network was greatly influenced by the principle of revivification (Akbar, 1984, p. 248).

Right of precedence: This is a principle that is concerned with the rights of the pre-existing buildings on a site as prevailing over buildings that are built later. Agreements were the basics of the right of precedence (Akbar,

1984). This principle may not result in an organized built environment in the common sense, but will produce an ordered environment were all decisions were each party realized its responsibility and rights in the physical environment (Akbar, 1984).

Neither *darar* nor *dirar*: According to the prophet saying "*There should be neither harming nor reciprocating harm*". This is one of five principles which jurisprudence is based upon (Akbar, 1984). This tradition implies moral control as well as the control of decisions affecting the built environment. It draws the broad limits of the party's action which suggests freedom of action as long as others aren't harmed (Akbar, 1984).

3.Computation and the built environment

This section mentions a few references that illustrate the potential impact of the previously mentioned computational tools/models on the design and planning of the built environments.

An example of computational models used to interpret the influence of applying the traditional rules system based on Islamic jurisprudence on the complexity of the built environment is discussed as shown in Figure1.

The Islamic city algorithm (Fig.2) is an algorithm designed by Paul Coates and a team from University of East London that produces a pattern similar to the dead end streets in a North African town. The algorithm depends on a gradual filling up process constrained by the following rule: You can build anywhere as long as you don't block out any existing building's access to the rest of the city. Hakim (1982) states a similar rule that were applied on dead-end streets in the traditional city; that is every resident is entitled to use the *cul de sac* from its entrance to his doorway. The process that this algorithm works is similar to the one shown in Figure 3 by Akbar (1989). First, there is a sprinkle of isolated houses, and then a recursive network emerges.

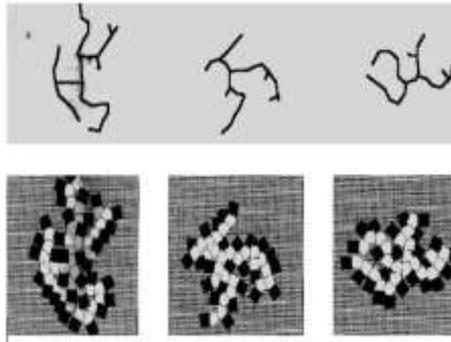


Figure 2. Islamic city algorithm

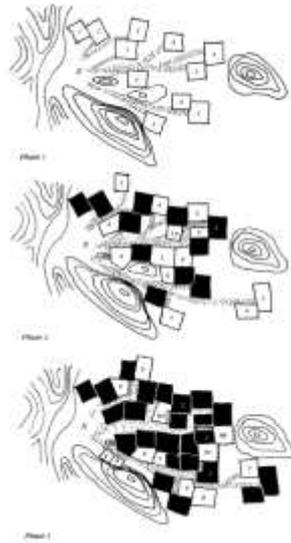


Figure 3. Emergent recursive network

‘City of slums’ is another example of modeling complexity in the built environment. This project combines the ideas generated by two simulating exercises: one is called the Favela Project (Sobreira, 2002) and the other is Peripherisation Project (Barros, 2002). These experiments aimed to model the spatial growth process of squatter settlements in Latin American cities using cellular automata to simulate the physical spatial patterns and agent-based modelling to simulate interactions and decision making process amongst stakeholders.

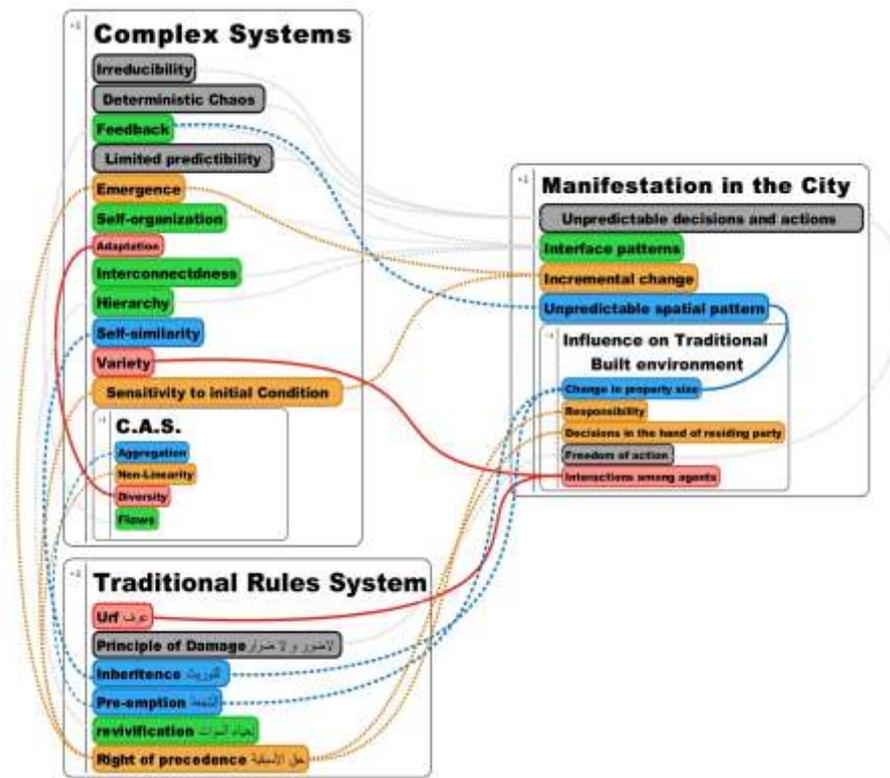


Figure 4 .Computational Rules Graph (CRG)

4. The Computational Rules Graph (CRG)

In this section, the study will try to establish a number of interrelations between different fields of literature to identify patterns that may reveal a theoretical framework. This is illustrated using a graph that connects attributes of these fields.

The Computational Rules Graph (CRG) showed in Figure 4 interrelates different bodies of literature (Complexity/Chaos theory and built environment studies) in a single framework that aims to show that the socio-cultural rules system based on Islamic jurisprudence (*fiqh*) had a self-regulating impact on activities in the traditional Arab-Islamic cities (Hakim, 2008) and was a major factor in the resilience of these built environment.

The CRG relates the traditional rules system to attributes of complex systems in a graph. Each of the previously mentioned sets is represented in the form of nodes cluster that are wired together to form a set of subgraphs. Each cluster represents a different body of literature to support these relations. Some important subgraphs that have been selected and highlighted in figure 4 using different colors are further explained below.

4.1.SUBGRAPH 01 (RED/ CONTINUOUS LINE)

Complex systems consist of a variety of subsystems or a large number of interacting elements. Holland argues that diversity exhibited in CAS is neither accidental nor random. Holland states that diversity in CAS is a dynamic pattern of interactions between agents. This pattern, when disturbed at any moment of time, has the ability to re-organize itself. That is why it is a main characteristic of resilient systems. In CAS, diversity is the result of progressive adaptations. Each new adaptation opens the possibility for new interactions (Holland, 1995).

Considering the traditional built environment as a complex system that includes a variety of interactions among agents, Hakim (1994) argues that '*urf* organized this diversity within the traditional city.

4.2.SUBGRAPH 02 (BLUE/ DASHED LINE)

Emergence is when a higher level pattern arises out of parallel complex interaction between local agents (Johnson, 2001, p.19). According to Johnson there are four core principles of Emergence: neighbor interaction, pattern recognition, feedback and indirect control.

Emergent systems are rule governed systems. Their capacity for learning and growth and experimentation derives from their adherence to low-level local rules (Johnson, 2001). Understanding emergence has always been about giving up control, letting systems govern themselves as much as possible, letting it learn from experience. (Johnson, 2001, p.234)

In the case of the city, global order and unpredictable spatial patterns emerge from the bottom-up and random actions of local neighborhoods. Emergent spatial patterns emerged within the traditional city in multiple ways. One can be due to change in property size, whether due to inheritance or pre-emption. The principle of inheritance led to the subdivision of property, and increased the complexity of the urban fabric and the fractal dimension of the city (Ben Hamouche, 2009). Pre-emption, where the priority is given to a co-owner or closet neighbor to get the share of the other partner in a property (Akbar 1988a, p.131) had an opposite impact that led to the aggregation of property. Jurists consider the street's process of evolution in resolving disputes related to dead-end streets (Akbar, 1984), which matches the fact that complex systems always has a history (Haghani, 2011).

4.3.SUBGRAPH 03 (ORANGE/ DOTTED LINE)

The principle of right of precedence is a principle that was applied in the traditional city where preceding actions may continue while every new action was questionable. Applying this rule resulted in an environment where all decisions were in the hand of the residing party. (Akbar, 1984)

Right of precedence can be related to a characteristic of complex

systems that is called sensitivity to initial condition, where infinitely small changes in the starting condition of a complex non-linear system will result in dramatically different output of the system (Haghani, 2011, p.105). Within the city, a series of cause-effect process of incremental change often start with small-scale actions that have an emergent potential (Hamdi, 2004, p.73-76). In the case of the traditional built environment this is also called “accretion of decisions” (Akbar, 1988b).

5. Discussion and future potential

The study aims to show that the resilience of the traditional built environment was strongly affected by the application of rules system based on *fiqh*. These principles can be considered as a flexible mechanism of interpreting *Shari'a* (Islamic law). It is worth noting that the existence of such socio-cultural rules system isn't unique to Islamic *fiqh*, but constitutes part of many other cultures.

The relation between the resilience of the built environment and applying rules system is investigated in the study through establishing a number of interrelations between different bodies of literature to identify patterns that may reveal a theoretical framework. This was illustrated using a graph that connects attributes of these fields of literature.

Traditional rules (codes of conduct) are proscriptive (non-deterministic), defining what is prohibited, thereby producing autonomous environments where agents had control over their immediate environment. In comparison, contemporary rules of the built environment (building codes) are prescriptive (deterministic), subscribing definite actions that need to take place by the stake-holder (agent) neglecting user needs and preferences. The application of this traditional rules system increased the agent's autonomy and freedom of action. It also helped establish stronger social networks among agents, which resulted in a more resilient environment.

It is worth noting that the subgraphs shown in Figure 4 still need further verification. This graph can be expanded through future research by adding other connections and subgraphs. A thorough network of relations and attributes of the built environment can be reached by tracing all possible connections. In addition to being a theoretical framework, the CRG can act as a framework to trace previous experiments conducted on the built environment using computation. This graph can also be a base flow chart for future algorithms designed for innovative applications in planning of the built environments.

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