Climate Variability: Integration of Renewable Energy into Present and Future Energy Systems in Designing Residential Buildings

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Abstarct— *As far as the reduction of fossil fuel reserves and environmental degradation in building houses are concerned, contemporary architects use other energy sources to create thermal comfort. Passive system is the most efficient way in which the needs of buildings thermal heat, without using the fossil energy, mechanical force and renewable energy sources like solar and wind energy, are met. Compatibility with environment, using context and area potentials to reduce fossil energy consumption and environmental destructive effects are the main advantages of these systems. Considering the temperature principles used in different elements of Iranian architecture this article reviews the operation of architectural elements which were compatible with the context in traditional Iranian architecture by focusing on the role of architect in environmental health and conservation. This study further offers solutions for creating thermal comfort by using descriptive content analysis in order to describe passive system principles associated with each of the above elements. Additionally, this research illustrates traditional architectural elements in terms of form and fabric in correspondence with modern elements as a method for mitigating climate changes.*

Key words— Climate change – Sustainable architecture-Renewable energy- Passive systems.

I. INTRODUCTION

To define the relationship between compatible architecture with climate and its adaptation to the current climate change, building and nature are considered as two elements which have inevitably mutual connection at the level of coexistence. This issue is analyzed from two aspects;the first aspect is about the Field-oriented architecture. Field -oriented architecture has a wholistic look to the context and building.Actually this method introduces the ancient Iranian architecture blueprints as a process in which form follows performance. The second aspect relies on the necessityof constructive interaction between buildings, people and environment in context-oriented architecture.

The purpose of this article is to present the principles of architecture in climate change erawith considerationof climate variability by considering Iranian architectural prancipals. This issue is important since the rate of global warming has been increased andit is scientifically proved that man and his activities have a significant role in increasing atmospheric density of greenhouse gases which cause global warming.

Today contemporary architecture is inevitable of establishing interaction with the environment. This approach affected architecture not only in terms of physical appearance but also in functionality and performance.

Thus, this research seeks to recognize some ways for new buildings, developments, and major renovations to be carbon-neutral andconsideringclimate-compatible architecture as an applicant model reffering Iranian traditional architecting prancipals.This study is based on the qualitative research methods in analytical-descriptive way which are collected in bibliographic method to prove that how architects plan and design the built environment from here on out will determine whether climate change is manageable or catastrophic.

CLIMATE VARIABILITY

The earth's climate changes constantly with varying extremes of temperature, rainfall and air movement occurring naturally. Droughts, periods of unusual dryness, are therefore a natural climatic occurrence. They may be regarded as unusual in that they do not occur all the time or occur only rarely in some areas, but droughts are not abnormal.The first step in addressing the issue of global warming is to recognize that the warming pattern, if it continues, will probably not be uniform. The term "global warming" only tells part of the story; our attention should be focused on "global climate change". The real threat may not be the gradual rise in global temperature and sea level, but the redistribution of heat over the Earth's surface. Some spots will warm, while others will cool; these changes, and the accompanying shifts in rainfall patterns, could relocate agricultural regions across the planet.(Wassila M, et al., 2014)

Bellow diagram shows the consequences of climate variability on earth and its impacts on Economy, Society and Environment.

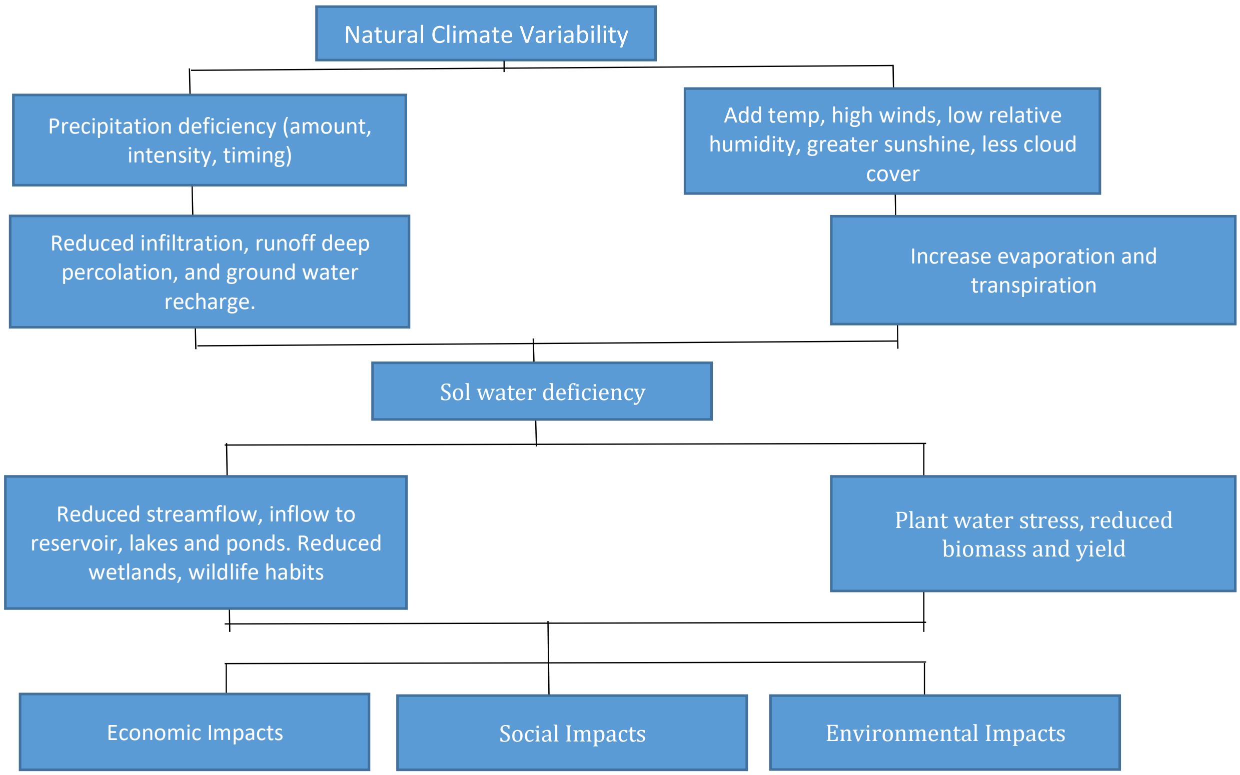


Chart (1), The impact of Climate Variability on Earth.

II. CLIMATE CHANGE

The atmosphereis the most unstable and rapidly changingpart of the climate system (The Climate System, E. Ahlonsou, Y. Ding, D. Schimel). Obviously, there have always been slight variations in local weathers, but usually changes have taken place so slowly that animals (including humans), plants and other forms of life have had time to adapt or migrate. However, since the onset of the Industrial Revolution, the pace of these variations has been dramatically speeding up: humans have changed the chemistry of the atmosphere through the combustion of fossil fuels and living matter, bringing about the prospect of global alterations and shifts in the whole terrestrial climate system. The threat of global warming brought about by the build-up of heat-trapping gases in the atmosphere has nowadays become common knowledge.In order to respond to these threats and meet the needs imposed by a sustainable development, a new approach to building design and construction is mandatory, one which simultaneously addresses the complex requirements of the environment with its finite resources and the needs of contemporary societies and economies (Shayannejad M. et al. 2015, Shayannejad M. et al. 2016, Shayannejad M. et al. 2017).

Nevertheless, human activities of the last two centuries - primarily the burning of fossil fuels and the clearing of forests, have greatly intensified this natural greenhouse effect, initiating a chain of events which, as we are now starting to realise, can lead to drastic climate change (Sayedipour M. et al. 2015, Raeisi-Vanani H. et al. 2015, Soltani-Toudeshki A.R. et al. 2015, Eskandari S. et al. 2017, Raeisi-Vanani H. et al. 2017, Shojaei N. et al. 2017, Bahmanpour H. et al. 2017).

According IPCC fifth assignment, if emissions continue on their present trajectory, without either technological or regulatory abatement, then the best estimate is that global average temperature will warm a further 2.6 to 4.8 °C (4.7 to 8.6 °F) by the end of the century (IPCC, AR5).

2.1. Energy and GHG emissions from buildings

Greenhouse gas (GHG) emissions from the residential building sector have more than doubled since 1970 to reach 9.18 GtCO2eq in 2010 (IEA, 2012a). In 2010 buildings accounted for 32 % (24 % for residential) of total global final energy use or 32.4 PW, being one of the largest end-use sectors worldwide. Space heating represented 32 – 34 % of the global final energy consumption in both the residential and the commercial building sub-sectors in 2010 (IEA, 2013).

Most of GHG (Greenhouse gas) emissions (6.02 Gt) are indirect CO2 emissions from electricity use in buildings, and these have shown dynamic growth in the studied period in contrast to direct emissions, which have roughly stagnated during few last decades (IEA, 2012a; JRC / PBL, 2013).

The knowledge gap that exists with respect to how emissions from built environments can be mitigated and, simultaneously, how buildings and their occupants can adapt to shifts in global and local climate must be filled, involving integration of established knowledge, advanced design strategies, application of innovative technologies and multidisciplinary research. Although the evidence of climate change is supported by large consensus, the amount of data and predictions currently available often results in ambiguous information for climate non-specialists. Starting from a review of the Fourth Assessment Report published by the IPCC, the paper examines the interactions between human systems and dynamic environmental forces, trying to underline the causes and consequences of the evident alteration in the climatic equilibrium of the planet and exploring how built environments can contribute to mitigate and adapt to these changing conditions.

Currently, IPCC refers to stabilisation targets for CO2 between 445 and 710 ppm by 2030 (IPCC 2007c), with a general agreement at 550 ppm, double the pre-industrial level. However, it is relevant to say that, considering the projected growth in emissions from developing countries, the limited targets of Kyoto are little more than irrelevant towards this target, since cuts of around 70% by the next decades would be needed to keep the atmospheric greenhouse gases concentration at double the pre-industrial levels. Yet, meeting this objective would still represent a serious challenge for human economies!

III. MITIGATION AND ADAPTATION IN THE BUILT ENVIRONMENT

The United Nations Framework Convention on Climate Change (UNFCCC) uses two significant terms: mitigation, which is aimed at reducing emissions to minimize global warming or 'avoiding the unmanageable, and adaptation, which is managing the unavoidable (GTZ/PIK, 2009).

While neither mitigation nor adaptation measures on their own can prevent significant climate change impacts, taken together they can significantly reduce risks. (Parry et al and Klein et al. 2007).

While mitigation efforts are clearly important in terms of slowing the rate of climate change, given the climate system has already changed, and will continue to do so irrespective of mitigation efforts, at least in the short to medium term, investment in climate change adaptation is a prudent course of action. An adaptation approach acknowledges that there will be a need to adjust to unavoidable climate change to minimize building and infrastructure upkeep costs and maintain healthy ecosystems and loveable urban areas.

As we live challenging times, therefore, it is possible to make reasonably confident predictions on the repercussions that climate change will have on most aspects of life on Earth, and consider their consequences on the future of human activities (Ostad-Ali-Askari K. et al. 2015, Ostad-Ali-Askari K. et al. 2016, Ostad-Ali-Askari K. et al. 2017).

In pursuit of solutions, an important lesson can be derived by looking at adaptive natural systems. In Nature, almost all living organisms develop, through evolution, responsive mechanisms to endure changing conditions without depleting their resources and altering the equilibrium of their ecosystem. Considering the global climate alterations, we are now facing and the speed and momentum of these shifts, an 'adaptive' attitude in the way built environments are conceived and inhabited can provide the conceptual basis for the building design of the future.

There are multiple mitigation pathways that are likely to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero emissions of carbon dioxide and other long-lived greenhouse gases by the end of the century. Implementing such reductions poses substantial technological, economic, social, and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges, but on different timescales.

To effectively mitigate long-term impacts and adapt in the short-term to inevitable climate alterations, the challenge is thus to identify and effectively put in place the design methodologies by which sustainable technologies can be integrated with current building models in order to guarantee the continuous social and economic growth of human developments, whilst limiting emissions and effectively responding to the consequences of climate alterations which are expected in the next few decades(Altomonte,2008).

IV. THE CONTRIBUTION OF BUILDINGS TO CLIMATE CHANGE

Today, buildings are responsible for more than 40 percent of global energy used, and as much as one third of global greenhouse gas emissions, both in developed and developing countries.In absolute terms, the Fourth Assessment Report of the IPCC estimated building-related GHG emissions to be around 8.6 million metric tons CO2 (Levine et al, 2007).

What particularly worrying is the rate of growth of emissions whichunder the IPCC's high growth scenario, this rate could almost double by 2030 to reach 15.6 billion metric tons CO2 eqv. (Levine et al, 2007).

The good news is that the Building Sector (residential buildings) has the largest potential for significantly reducing greenhouse gas emissions compared to other major emitting sectors. This potential is relatively independent of the cost per ton of CO2 equ. achieved (IPCC, 2007). Figure 3, from the IPCC's Fourth Assessment Report, shows that the potential for greenhouse gas reductions from buildings is common to both developed and developing countries. What this means is that with proven and commercially available technologies, the energy consumption in both new and existing buildings can be cut by an estimated 30 to 80 percent with potential net profit during the building life-span.

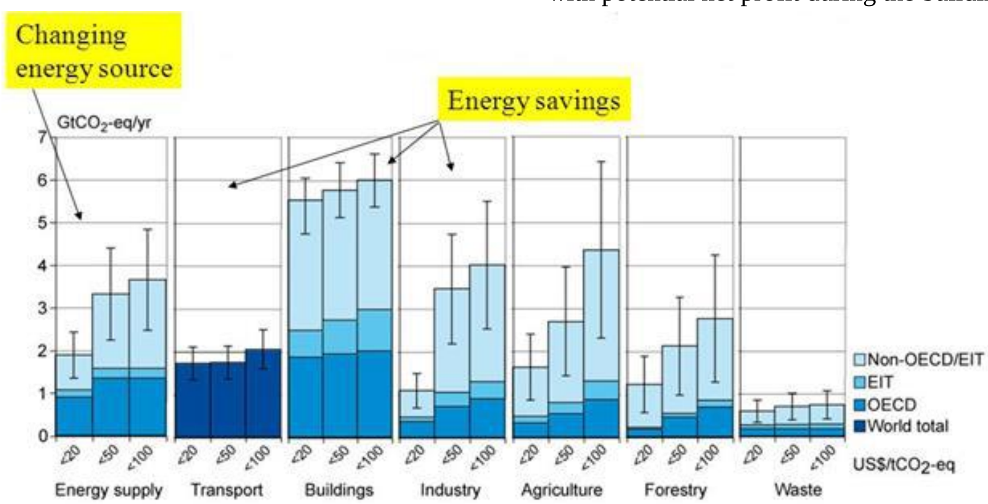


Fig.1: Estimated economic mitigation potential by sector and region using technologies and practices expected to be available in 2030. The potentials do not include non-technical options such as lifestyle changes. Source: IPCC, 2007a.

Therefore,buildings could represent a critical piece of a low-carbon future and a global challenge for integration with sustainable development. Buildings offer immediately available, highly cost-effective opportunities to reduce (growth in) energy demand, while contributing to meeting other key sustainable development goals including poverty alleviation, energy security, and improved employment. This potential is more fully represented in sectoral models than in many integrated models (Shayannejad M. et al. 2017, Dehghan Sh. et al. 2017, Eslamian S. et al. 2017, Ostad-Ali-Askari K. et al. 2017, Godarzi A. et al. 2016).

V. INTEGRATED BUILDING DESIGN

As per the conclusions of the IPCC Fourth Assessment Report, amongst the key sectorial mitigation technologies and practices which are suggested to be applied within the design of built environments before 2030, an essential role is to be played by "integrated design" of buildings, which should be exploiting advances in technology and implement both passive and active techniques in order to provide comfort for their users and reduce their energy requirements (IPCC, 2007c).

In terms of climate, the basis for the formation of the residential environment is human thermal comfort and providing a suitable environment for better living conditions. Environmental conditions within the buildings must be balanced in such a way that brings physical and psychological comfort for residents. Physical comfort means to Supply thermal comfort conditions (heating and cooling) and visual comfort conditions (for light) which required consuming the energy. Depending on the type of energy used in a building to provide comfort conditions, four general methods can be named as the following table.

Table.1: Methods to create thermal comfort, Source: Author

Ways of creating comfort	Energy Sources	Solution	Architect Role
Dynamin	The majority is renewable energy plus small amount of non-renewable energy	Solar collectors Photovoltaic systems	Architecture's role is, coordinate system layout and its incorporation into body building
Super Dynamic	non-renewable energy	Radiators, fan coils and coolers	Locating equipment and route system components
Static	The majority is non-renewable energy plus small amount of renewable energy	Trombe wall, cooling roof, greenhouse space	Harmonious design and architectural elements of the building
Super Static	renewable energy	Orientation, proportion, form, , window size and sunshade	Special role of architectural decision in features and architectural solutions

5.1 Sustainable Design Framework

Besides pure investment, decision makers need to address in order to significantly upscale the contribution of the different kinds of renewables:

- Bio energy: proper design and monitoring of sustainability to minimize negative impacts
- Solar energy: regulatory and institutional barriers, integration and transmission issues
- Geothermal energy: prove that enhanced geothermal systems can be deployed
- Hydropower: sustainable assessments tools, regional and multi-party collaboration
- Ocean energy: testing centres, policies that encourage early deployment
- Wind energy: develop solutions to transmission constraints, increase public acceptance

So, if the aim of the residential Building Sector is to become carbon neutral in the medium to long run, then renewable energies will have to play a much bigger role in meeting energy needs in buildings. This can be achieved through two avenues: first, by substituting fossil fuels with renewable energy sources at the point of electricity generation; and second, through the use of renewable energy technologies at the point of consumption, i.e. off-grid applications of renewable energy. Clearly, both approaches must be followed simultaneously.

5.1.1 Energy intensity of new high-performance buildings

Cooling energy use is growing rapidly in many regions where, with proper attention to useful components of vernacular design combined with modern passive design principles, mechanical air conditioning would not be needed. This use includes regions that have a strong diurnal temperature variation (where a combination of external insulation, exposed interior thermal mass, and night ventilation can maintain comfortable conditions), or a strong seasonal temperature variation (so that the ground can be used to cool incoming ventilation air) or which are dry, thereby permitting evaporative cooling or hybrid evaporative / mechanical cooling strategies to be implemented (Eslamian S. et al. 2009, Fakhri M. et al. 2013, Eslamian S. et al. 2012, Eslamian S. et al. 2013, Chavoshi S. et al. 1999, Eslamian S. et al. 2010, Eslamian S. et al. 2008).

5.1.2 Monitoring and commissioning of new and existing buildings

Commissioning is the process of systematically checking that all components of building HVAC (Heating, Ventilation and Air Conditioning) and lighting systems have been installed properly and operate correctly. It often identifies problems that, unless corrected, increase energy uses by 20% or more, but is often not done (Piette et al., 2001). Advanced building control systems are a key to obtaining very low energy intensities. It routinely takes over one year or more to adjust the control systems so that they deliver the expected savings (Jacobson et al. 2011) through detailed monitoring of energy use once the building is occupied.(Wagner et al. 2007) give an example where monitoring of a naturally ventilated and passively cooled bank building in Frankfurt, Germany lead to a reduction in primary energy intensity from about 200 kWh / m2 / yr during the first year of operation to 150 kWh / m2 / yr during the third year (with a predicted improvement to 110 kWh / m2 / yr during the fourth year). Post-construction evaluation also provides opportunities for improving the design and construction of subsequent buildings (Wingfield et al., 2011).

5.1.3 Zero energy / carbon and energy plus buildings

Net zero energy buildings (NZEBs) refer to buildings with on-site renewable energy systems (such as PV, wind turbines, or solar thermal) that, over the year, generate as much energy as is consumed by the building. NZEBs have varying definitions around the world, but these typically refer to a net balance of on-site energy, or in terms of a net balance of primary energy associated with fuels used by the building and avoided through the net export of electricity to the power grid (Marszal et al, 2011). Space heating and service hot water has been supplied in NZEBs either through heat pumps (supplemented with electric resistance heating on rare occasions), biomass boilers, or fossil fuel-powered boilers, furnaces, or cogeneration. (Musall et al. 2010) identify almost 300 net zero or almost net zero energy residential buildings constructed worldwide.

5.2 Substituting fossil fuels with renewable energies Methods in Iranian Traditional Architecting

We can see many residential buildings which were built based on vernacular architecture in Iran, which consider contextand climate. Therefore, this caused the architects to benefit from geographic and climatic features; all these considerations refer to field oriented and sustainable architecture.

Table.2: The principles of passive systems to field-oriented architecture, source: Author

Passive systems Principles According to accommodation with climate	Solution	Tools	Target
	Using traditional principles of Iranian architecture According to accommodation with climate	use of thermal mass and natural energy	Reduce heat loss in buildings
		Natural ventilation	Reduce the impact of wind on the building heat loss
		The proper orientation	Taking advantage of solar energy for heating
		Considering Materials, roofs, terraces and facades types	Building protect against hot air
		Considering Space Layout	Taking advantage of the daily fluctuations in air temperature
		Design appropriate form consistent with the climate	Reduce the impact of dust winds on buildings
	use of solar energy and solar design	Eaves and sunshades	Meet the needs of building heating and cooling
		Windows	
		thermal mass	
		Insulation	
		Proper Orientation	
	use of plants and vegetation in the highlands	On Roof	Sensing the change of seasons
			Vertical yard instead of the central courtyard
			Psychological comfort and better climate
		On Terrace	Creating the appropriate Micro climate in the region
			Use of plants humidity for cooling the region
			Air purification and reducing CO_2
		On facade	Dealing with high temperatures in facade
			Improving the landscape around the building
			Intensity modulated sounds to building

In fact, Iranian traditional buildings have been developed horizontallywhile today architecture is growing vertically, so it is important to find the ways to integrate these traditional principals in other direction. As an example, vertical yards play a big role in both Iranian traditional architecture and following that its physical and mental impacts and also in todays sustainable high rise buildings. (Figur2).Now we can find these type of buildings as Yard scraper instead of sky scraper.

Fig.2: Natural elements, Court Yard.

VI. POLICY OPTIONS FOR REDUCING EMISSIONS FROM BUILDINGS

To select the most appropriate policies for the "carbon emissions" scenario of the Building Sector of the countries, architects as a part of society should consider what policy objective they wish to target. Broadly speaking, the five major policy objectives, or targets, for reducing greenhouse gas emissions from buildings are:

Target 1: Increase the energy efficiency of new & existing buildings (both the physical envelope, and the operational aspects such as energy systems for heating, ventilation and other appliances);

Target 2: Increase the energy efficiency of appliances

Target 3: Encourage energy and distribution companies to support emission reductions in the Building Sector;

Target 4: Change attitudes and behavior;

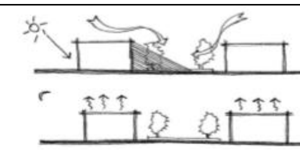
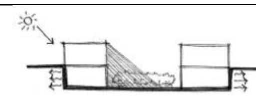
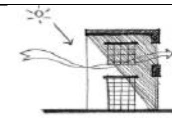
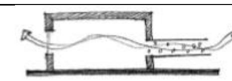
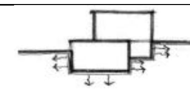
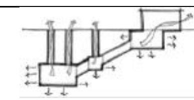
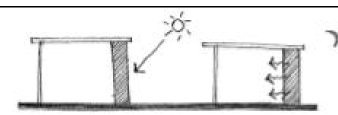
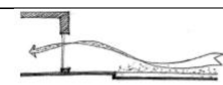
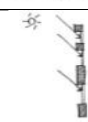
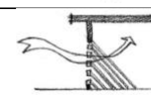
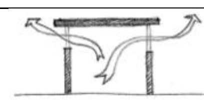
Target 5: Substitute fossil fuels with renewable energies.

In which all mentioned targets can be placed under environmental architecting sector and the first and last targets are more efficient among them and the architects have a big role on it and in this article these two targets have been discussed.Studying Iranian vernacular architecture, we can find many architectural elements which have been the inseparable parts of old residential buildings that prepare thermal comfort without using fossil energy. Tabatabi's house is an example of Iranian vernacular architecture (Figure 4).

Fig.4: Tabtabaei house, source: Flavorverse.com

Iranian architectural elements which have been used more than 500 years ago based on using renewable energy instead on fossil fuel for natural ways of cooling, ventilating and preparing light and each element has been described by its static system principles.Some of these traditional elements in terms of performance and architectural forms, corresponding to some passive systems today.

Table.3: A static cooling principles in Iranian architectural elements, Source: Author

Architectural Elements	Static System Principles	Images
Windward	Corresponding system of solar chimney	
Central courtyard	Air flew and Ventilation through the chimney in combination with the adjacent body of water hub sunshade and cold trap	
garden pit	Cooling with Mass Effect	
Porch	Air flew and Ventilation through the chimney	
Spring house	The corresponding system evaporative coolers (open loop systems)	
Bedchamber	Seasonal storage of heat	
Shvadan	Seasonal storage of heat	
Materials with high thermal capacity	Delays in time-temperature heating applications for direct absorption , The corresponding system(Trombe wall)	
Building bodies nearby water	Exposure to natural elements and use the stylized air	
Nodulation wood and plaster window	The corresponding system frame sunshades Horizontal and vertical awnings	
Grille brick or tile	Cooling through ventilation (air flow) The corresponding system, the traditional facades	
Windows under the roof	Air flew and Ventilation through the chimney	

In summary, it is very likely that the portfolio of technologies and know-how needed to make built environments minimize their impact on the ecosystem and adapt to shifting climatic conditions is already with us, as long as integrated design and behavioural strategies are put in place for their implementation. Making the most of ancient, existing and forthcoming knowledge (also featuring hybridisations between seemingly distant disciplinary fields), the design of buildings has to progress in response to environmental and users demand, re-establishing the fundamental connection between humans and the natural system that has sustained us so far, cradling and nourishing us, making all of our (sometimes insane) actions possible.

VII. CONCLUSION

The buildings are so compatible with the outside conditions that the indoor comfort is available without the energy devices. This compatibility was created by the geographical location of the building, roofs, the reduction of the outer sides of the building which are against the sun, the appropriate sunshades, wind towers, basements and cellars, central courtyards, shadow creating defilade, sunny windows, appropriate materials and etc. It can be concluded that by believing the principles of sustainable architecture and the intelligent compliance with the new concepts of ecological sustainability, we can reach the functional and sustainable patterns. Therefore, conducting research on the patterns of sustainability in Iranian architecture is necessary in order to renew the old sustainable architecture. (Unregard and farzian, 1387)

It is evident from ongoing developments in the regulatory and insurance spheres that climate change adaptation (CCA) will be an increasingly important consideration for architects. This is regardless of weather one holds to precautionary principle or other views about the environment.

Architects who develop skills to retrofit and design buildings that offer reduced liabilities to extreme weather impacts that extend beyond jurisdictional building controls and land-use planning will position themselves well in the marketplace.

Building flexibility into design to allow for the unexpected makes investment decisions robust to most possible changes in climate conditions. This may include no-regret strategies that bring benefits even in the absence of future climate change.

Since each building has always been in the vicinity of objects and various natural factors, can affect reaction against climatic factors. In fact, Micro-climate is a weather conditions around the building. Site study and using different elements for is the first important step in building design in order to establishing micro-climate conditions around the building.

The factors such as favorable microclimate conditions, static heating, cooling and lighting, using renewable energy and meanwhile creativity, paying attention to Materials, structures, protection and improvement of natural elements and looking at the architecture as a living organism are the factors which have been considered in Iran traditional architecture. Recommended solutions for creating comfort zone compatible with the environment by using renewable energy are as bellow:

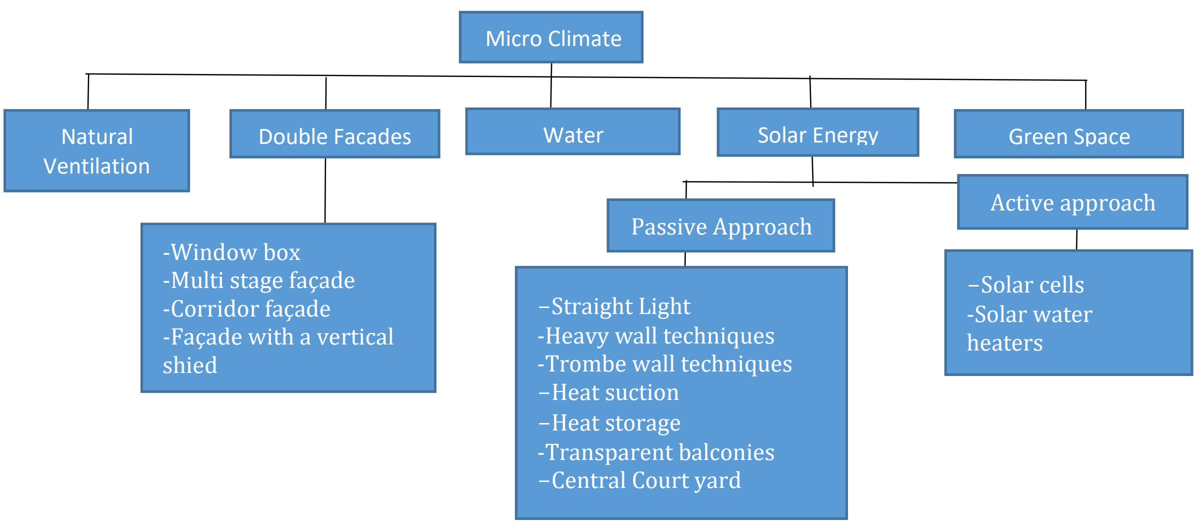


Chart (2), Micro climate subsets, source: Author

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