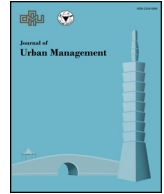




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Review of environment responsiveness of building regulations in Jaipur



M.F. Jawaid^a, Satish Pipralia^{b,*}, Ashwani Kumar^b

^a Department of Architecture & Planning, I K Gujral Punjab Technical University, Jalandhar, Punjab, India

^b Department of Architecture & Planning, Malaviya National Institute of Technology Jaipur, India

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ABSTRACT

India is a country of diverse culture, traditions, and customs at the same time it is also a land of diverse geographical and climate zones with almost all type of climate, geographical conditions and ecosystems of the globes found in different parts of the country. These factors also affect the design, development and quality of the urban form and urban landscape i.e. urban built and unbuilt environment. The admixtures of geo-climatic conditions, socioeconomic conditions and resource availability form a set of unique urban ecosystem require a specific set of building regulations and development guidelines for the sustainable urban development of any city or urban area. The analysis of the urban planning system in India highlights a general prototypic practice of developing building codes and guidelines in the country. This paper attempts at analyzing the building regulations in India for environmental sustainability with special reference to by-laws and building codes applicable to Jaipur city and try to address the case-specific regulatory intervention.

1. Introduction

The advent of urbanization, especially after the industrial revolution in European countries, has evolved into a global phenomenon experienced currently by almost all the countries. It has become an integral part of modern economic growth and contributes to protecting people from more local environment burdens, but the large scale and rapid urbanization in India have led to a situation of chaos in the absence of adequate urban planning and management guidelines and regulations (Jawaid & Khan, 2015). The development of the building and construction sector to accommodate growing urban population has also developed as significant sector contributing to the employment and revenue generation, but at the same time, it is also a major contributor of greenhouse gas emission and an intensive consumer of energy. Building accounts for 40% of total energy consumption and contributes over 30% of CO₂ emission (Iwaro & Mwashya, 2010; Murphy, 2012; Pan & Garmston, 2012; Tulsyan, Dhaka, Mathur, & Yadav, 2013; Chandel, Sharma, & Marwaha, 2016) hence the process of urbanization itself is sometimes blamed for contributing to climate change and other global environmental burdens (Jawaid & Khan, 2015).

The life cycle assessment of the buildings also point out the use of energy-intensive building materials which produce a significant amount of CO₂ and greenhouse gasses and the operational phase alone contributes more than 50% to greenhouse gasses (GHG) emissions and is highest energy consumer (80–85%) (Sharma, Saxena, Sethi, Shree, & Varun, 2011). The building sector's energy use in India is rising continuously with the growing population and urbanization and has doubled since 2000 with residential buildings in

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* Corresponding author.

E-mail address: pipralia@gmail.com (S. Pipralia).

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urban area accounts for a major chunk of consumption and residential energy consumption also slated to change dramatically from 10% in 2013 to 41% by 2040 due to rising incomes, appliance ownership and demand for cooling (IEA, 2015). The energy production and power generation in India is largely dependent on fossil fuels, and coal accounts for over 70% of energy generation (IEA, 2015) which also produce a significant amount of CO₂ and other greenhouse gasses which has emerged as a major environmental concern.

The level of urbanization in India is projected to increase from 31.2% in 2011 (*census of India, 2011*) to more than 50% by 2050 (Jawaid & Khan, 2015) with an estimated addition of 404 million urban dwellers between 2014 and 2050 (United Nations, 2014). As per the current trend, the growth of urban population in the country is not only explosive but also highly skewed (Jawaid & Khan, 2015). The Class I Cities (population above 1 lakh or 0.1 million) which accounts for 70.20% of urban population in 2011 and out of this Million plus (population above 10 lakh) Metro cities alone accounting for more than 40% of total urban population (*Census of India, 2011*), and are still set dominate the urban scenario. The obstinate increase in urban population is liable to create demand for the building stock for residential as well as non-residential purposes which is yet to be constructed under various schemes by the government agencies, market-driven private developers or individuals, etc. and the major chunk of development will be residential to cater to the urban housing demand which is still inadequate.

The study of building regulations for environmental protection in India is limited largely to energy and energy performance or regulation and the built form as discussed in the subsequent sections. The building regulations specifically in relation to the residential built environment have not been dealt in detail, its nature and relations have not been thoroughly explored. It is very important to investigate the impact of building regulations on urban environment in the multi-cultural communities, particularly Metropolitans, where the large-scale and rapid urbanization have led to a situation of chaos in the absence of adequate urban planning and management guidelines and regulations. It is valuable to examine the role of building regulations (specifically the aspect of urban environmental quality and its environmental responsiveness) in the design of built form and urban landscape, and its application to Jaipur city in particular and the country as a whole. The present study highlights the analysis of building regulations applicable to Jaipur city in India (as a case study) for environmental responsiveness and environmental sustainability, in order to highlight the case-specific regulatory intervention required to enhance the urban environmental quality and to achieve the goal of urban development of Jaipur city.

The subsequent sections first discuss the urban environmental scenario, environmental policies and legislations, and building regulations, codes and guidelines at the national level, since the local building regulation in one way or the other regulated and guided by the national regulations. It is followed by a brief description of the Jaipur city, its planning, historical trajectory, the urbanization and environment trend. The penultimate section is focused on the discussion and analysis of environmental considerations in the building regulations applicable to Jaipur city and the paper finally concludes in highlighting the immediate area of interventions for enhancement of existing building regulations and their implementation to make them environmentally responsive and sustainable.

2. Urban environmental policy and building regulations in India

The densely populated metropolitan areas of the world especially in developing countries like India are ecologically most sensitive and fragile due to limited land for urbanization, huge population and population growth coupled with high population density. The rapid rate of urbanization, depleting vegetation and water resources, excess pollution and waste generation resulting in ecological imbalance and climate change have added to the misery of the urban environment in these cities due to lack of efficient planning and absence of effective building regulations (Grosso, 1998; Kumar & Pushplata, 2013). The unprecedented outward sprawling growths with a fast-growing urban population in metropolitan cities in India over last few decades resulted in tremendous pressure and demand for urban land in the periphery resulting into consumptions of a vast stretch of fertile agricultural land for urban and residential developments. Some of the major factors attributed to sprawling development are a lack of apposite building regulations, planning policies and land management mechanism to regulate the intensity of the development within and around the urban centres (Ahmed & Dinye, 2011).

The serious challenges to environment-conscious urban planning have been posed by decrease of land available for building, already existing housing shortage and backlogs together with deterioration of ancient building stock, especially when the economic profitability of land use and maximum built-to-ground exploitation, are far highest priorities for urban developers rather than environmental protection, solar and wind access, quality of built spaces, etc. (Grosso, 1998), resulting in problems of unplanned growth, illegal squatters and settlements which pose a big challenge to the quality of urban environment. This is despite the fact that India is among the few countries in the world to incorporate the concern for the environment in its constitution (Article 21, 38, 48A, 49, 51, DPSP, etc.). The special provisions were made in the constitution for safeguarding the environment and natural resources through 42nd Constitutional Amendment Act (CAA) of 1976 (Khan, 2015). In addition to this a number of other legal steps have also been introduced to protect the urban environment in the country by all levels of government – Central, State and Local from time to time (Bhutani & Mazumdar, 1998; Khan, 2015). Some significant legislations for environment protection are as follows:

- The Wildlife Protection Act, 1972
- The Water (Prevention and Control of Pollution) Act, 1974
- The Forest Conservation Act, 1980
- The Air (Prevention and Control of Pollution) Act, 1981
- The Environment Protection Act, 1986
- Public Liability Insurance Act, 1991

- The Bio-diversity Act, 2002
- The National Green Tribunal Act, 2010
- Coastal Regulation Zone Notification, 2011
- The Hazardous Waste Management Regulations, etc.

The urban change as the impact of human behaviour affecting urban ecosystems has gained more attention over the last decade (Deal & Schunk, 2004; Sudhira, Ramachandra, & Jagadish, 2004). These accentuate the need to control human conduct and activities vis-à-vis environment (in monitoring the quality of life through environmental regulation and management) and to rectify the situation through legal structure and regulations. Thus the role of building regulations is being reconceptualised as a tool to improve the quality of life of the current population and bequeath to future generations a less carbon-intensive and sustainable housing stock (Murphy, 2012). The improvement and conservation of environmental quality are one of the aims of development regulations and building codes, but the environmental considerations, sustainability and energy performance and saving has recently gained priorities in India with the revision of Urban and Regional Development Plans Formulations and Implementation Guidelines (URDPFI) in 2014, the National Building Codes (NBC) and Model building Byelaws (MBBL) in 2016 as discussed in subsequent sub-section.

2.1. National level building codes & guidelines

The *National Building Code (NBC)* is first unified guideline prepared in 1970 for guiding municipalities and development authorities, urban improvement trusts and other urban development agencies for preparing performance oriented bylaws and local regulations for regulating construction practices in the country (BIS, 2005). This code was revised and published in 1983, 2005 and 2016. The initial revisions were focused on updating and incorporating the change in norms for plantation and green belts, building services, fire and earthquake safety, energy conservation etc. with additional focus on special area planning, building energy performance and certification, natural calamities, etc. in 2005 edition (BIS, 2016). The latest revised and amended version of NBC (i.e. SP-7:2016) has dedicated 'Part 11' based on an approach to sustainability besides enhanced safety and technological advancements. The Part 11 demonstrated a holistic and integrated approach for various components of built and unbuilt environment starting from the site selection, design process and building element design, construction practices, energy optimization techniques and methods for orientation of building, envelope design, material specifications, to building services, operation, maintenance and building performance tracking, renewable energy integration, etc.

The *Model Building Byelaws* were at first published by Ministry of Urban Development (MoUD) in 2004 to provide a regulatory framework at national level for emphasizing the provision for structural and fire safety, rainwater harvesting, waste recycling, solar assisted heating, barrier free public buildings, etc. (TCPO, 2016). These byelaws have been extensively revised as model Building Byelaws 2016 to incorporate the growing environmental concerns for sustainability and green buildings, increased safety and security, incorporate the technological developments, norms for low income housing and high rise buildings, provision of flexible FAR (floor area ratio) among other (TCPO, 2016). The model building byelaws have also been formulated by various state governments including state of Rajasthan. The model building byelaws are advisory in nature hence some provisions and suggestions could not find place into the Building byelaws prepared by urban local bodies/development authorities at city level. An attempt has been made by Rajasthan government in this regard by implementing new revised 'Unified Building Byelaws 2017' applicable to all the cities and urban centres in the state.

2.2. The green rating systems & building energy performance measures

Some agencies/organizations have also been formed by the government over the last decade to regulate the building sector and promote the energy efficient, eco-friendly and green building practices; through national and international collaboration of various ministries with different agencies.

The *Green Rating for Integrated Habitat Assessment (GRIHA)*, *Indian Green Building Council (IGBC) rating system* are sets of rating tool that assesses the performance of the building holistically to reduce the environmental impacts over its entire lifecycle. They are an amalgamation of a host of sustainable practices and solutions based on accepted energy and environmental principles that evaluate the environmental performance of a building against certain nationally acceptable benchmarks (GRIHA, 2016; IGBC, 2016).

The *ECBC* is based on life cycle approach incorporating building features and components of different climatic zones in which building would be constructed giving specifications for different building components to improve building energy performance and occupants comfort (Tulsyani, et al., 2013).

3. The case of Jaipur

Jaipur is tenth largest metropolitan city Jaipur located at 26°55' N 75°49' E coordinates at an average elevation of 432 m. It was founded in 1727 as the capital of erstwhile Dhoondhar kingdom to serve and accommodate the needs of exploding population and solve scarcity of water of hill city of Amber. It is a significant multi-functional urban centre in the north-western region and also the capital of the largest Indian state of Rajasthan. The walled city still continues to serve as the central business district of the city and hosts a dense concentration of tourism attractions and trade, and harbours 60% of the city's commercial activity (MacDonald, 2015). The gridiron planning of the walled city of Jaipur has wide and hierarchical street system with intricately designed characters still catering to the demands of the present day vehicular traffic (Jawaid, Pipralia, & Kumar, 2016) which most of the historical Indian



Fig. 2. Market Streets: (Top) - Wide rectilinear street with covered pathways in Johari Bazaar (old city) & (Bottom) - Narrow and encroached street at Adarsh Market, Barkat Nagar (Latter Development).

complete loss of Mansagar Lake, which once used to be the source of portable water supply for the city, and depletion and shrinkage of the seasonal river – Amanishah Nala (also called as Dravyawati river) flowing across the city. The unregulated development in and around urban forest and eco-sensitive zones has led to incidents of wild animals like leopard crossing over into the urban residential areas.

The major reason attributed to this is inappropriate planning and regulations (the aspect of regulating the intensity and location of development), and weak and ineffective implementation and regulatory framework. This has also resulted in increase in unplanned transition of land uses mainly through conversion of agricultural and barren land surrounding the city into urban areas and development of slums, squatters and illegal encroachments and constructions throughout the city, which may also have an impact on existing planning policies for the development of the city (Dadhich & Hanaoka, 2011). Some attempts in the form of segregating the urban areas and eco-sensitive zones and planning for the same has been attempted in current master development plan 2025 but it is still in its nascent stage and demands a support of scientifically devised and environmentally responsive regulatory mechanism and process for its implementation to retrieve the excessive pressure on peripheral and rural lands and restore the environmental quality.

4. Environmental responsiveness in Jaipur building regulations

The changes in the form and structure of residences and residential use affects the overall morphology and environment of urban area the most, on account of constituting a significant proportion (nearly 2/3 in the case of Jaipur) of the urban built form by virtue of being the fundamental need of people. The construction of the residences to meet the housing demand is largely catered by the private developers in the form of individual houses to large group housings, apartments, and townships. These developments are primarily focused on the profit motive and hardly care for the environmental repercussions. At the same time large number of housing schemes are also developed, controlled and regulated by the public authorities such as Rajasthan Housing Board (RHB), Jaipur Development Authority (JDA), and earlier Urban Improvement Trust (UIT), etc. but also lack micro-climatic performance parameters like illumination, ventilation, orientation and positioning, overall energy performance, walkability, safety, buffer zones,



Fig. 3. Street Facade Characteristics: (Top) – Continuous & Complementary (walled city) & (Bottom) – Fragmented & Contrasting, at Tonk Road (Latter Development).

etc. due to lack of integrated and clear-cut frameworks, guidelines and regulations. The Building byelaws for residential development as prescribed in the building regulation (Table 1) is as follows:

4.1. Provisions for environmental protection

The building regulatory measures for the conservation of the environment in Jaipur are limited to the rainwater harvesting at large with some provisions for solar energy in the buildings that too for large projects, but the nature and extent of the provision and its implementation and incorporation into the buildings still need to be thoroughly studied and analyzed. The provisions of groundwater recharge, water recycle and reuse are almost absent. The byelaws applicable to walled city has a dedicated section regulating the health, sanitation, design of drains and other provisions which affect the quality of life, environment and human wellbeing. The regulation also lacks any consideration for the natural topography and for the developments near hills and ridges and catchment areas of the surface water bodies. The environmental and energy efficiency aspects in NBC have been enhanced to include climatic factors, the wind and solar orientation, humidity, landscape design, envelope optimization techniques, water and waste management, etc. but their incorporation into the building regulation and design is a matter of great concern as NBC lacks proper framework and guidelines for implementation.

4.2. Open spaces & greening provisions

In addition to this, the regulations for nature and intensity of open spaces and onsite greening, the proportion of soft surfaces for water catchment and absorption, other environmental considerations such site drainage, natural drainage channels, etc. at the level of the residential building and community/neighbourhood are largely absent. The climatic design considerations, treatment of open spaces and site vegetations are not considered a part of the building regulations, though the provision for 15% landscaping has also been mandated for plots larger than 1000 sqm. but the nature and character of landscaping has not been specified. The plantation of tree for every 100 sqm. of area has been mandated for larger housing, commercial, institutional but it does not have any relation to the nature and character of foliage and spatial extent of each tree and area to be dedicated for plantation.

Table 1

Building Bylaws/Guidelines for Residential Scheme/ Non-scheme areas and independent residential Developments. Source: Table 1 – Jaipur Building Regulations, 2010.

S. No.	Type of Use and plot size (sq. m)	Maximum Covered Area	Minimum setbacks (Metres)				Maximum Height	Standard FAR
			Front	Side	Side	Rear		
(A)(1)	Up to 50	Within setbacks	1.5	–	–	–	8	Whatever available (Max. 1 unit per floor)
(2)	50 to 75 (for LIG)	Within setbacks	1.5				8	Whatever available (Max. 1 unit per floor)
(3)	75 to 100	Within setbacks	3.0					
(3)	100 to 162	Within setbacks	3.0			2	12 (maximum ground + 2 Floor)	Whatever available (Max. 3 units on entire plot)
(4)	162 to 225	Within setbacks	4.5			2.5	12 (maximum ground + 2 Floor)	Whatever available (Max. 5 units on entire plot)
(5)	225 to 350	Within setbacks	4.5	3.0		3.0	12 (maximum ground + 2 Floor)	Whatever available (Max. 6 units on entire plot)
(6)	350 to 500	Within setbacks	6.0	3.0		3.0	14 (maximum ground + 2 Floor)	Whatever available (Max. 12 units on entire plot)
(7)	500 to 750	Within setbacks	7.5	3.0	3.0	3.0	14	1.2
(8)	750 to 1500	Within setbacks	9.0	4.5	4.5	4.5	14	1.2
(9)	1500 to 2500	Within setbacks	12.0	6.0	6.0	6.0	14	1.2
(10)	2500 to 4000	40% ^a	12.0	9.0	9.0	9.0	14	1.2
(11)	4000 to 10000(1 ha)	35% ^a	15.0	9.0	9.0	9.0	14	1.2
(12)	More than 1 ha to 10 ha	35% ^a	18.0	9.0	9.0	9.0	14	1.2
(B)	Farm House (minimum area 2500 sq. m.)	10% of plot or 500 sq. m whichever is less	15.0	10.0	10.0	10.0	8	–

^a Maximum covered area can additionally be permitted up to 5% if the applicant possesses TDR (Transferable Developmental Right) on proposed Plot.

4.3. Architectural character and built form

The emphasis has been laid on regulating the nature and character of built form especially in the byelaws of walled city and the building regulations of the Vidyadhar Nagar through regulation of various design parameters and architectural controls. The building regulation applicable to other parts of city still lacks any guidelines for nature and character of developments in terms of mass and volumes or bulk of development, the ratio of mass and void; surface area and volumes, which are important factors affecting the energy performance of the buildings. The urban form and street s-facade has been regulated through provision in the byelaws and regulations applicable to walled city and Vidyadhar Nagar but are largely absent in other part of the city. The development regulations in India deal only with the regulation of the spatial dimensions of land or 2-dimensional spaces rather than in volumetric terms in 3-dimensional form, hence there is still a lack of direct relationship between the urban form and the regulations governing them.

4.4. FAR, ground coverage, setbacks and building height

The Building Regulations of Jaipur city lacks any direct relation to the control parameters like FAR, setbacks, coverage, the footprint of buildings, etc. to nature and character of built form which shall take into account the fenestration properties, the wall-window ratio as per the orientation of the buildings. It does not have any direct guidelines for natural ventilation and lighting, or mutual shading of the buildings based on distances between them. The prescribed parameters are largely related to the area of the plots where it again is not in any defined proportion or ration hence resulting into unorganized built form. Further there is no direct relation to the width of the road hence the level of service provisions with area the plot, front setback, rear setback, building height and number of residential units permissible on a plot which results in fragmentation of road width for different control parameters as shown in Table 2 below.

4.5. Socio economic considerations and institutional arrangements

The socio-economic condition prevailing in the society affects the choice of materials and technologies which in turn affect the energy performance of buildings, but these have not been given due weightage. Further, the location and intensity of development based on the carrying capacity of the area have not been worked out or stated in the building regulations thereby creating the mismatch in the supply and demand of the infrastructure provisions and services. In addition to this, the national, regional and local regulations also lack evidence-based instruments in building forms that can measure the performances of dwellings, buildings, neighbourhoods, districts, cities or a whole region. Some of the major problems also lie in the multiplicity of agencies with variable jurisdictions in implementation and administrative framework having many issues in the compliances (Jawaid et al., 2017).

Table 2
Front setback, heights & no. of residential units in relation to road width. Source: Prepared by author based on Jaipur Building Regulations 2010.

S. No.	Road Width (Metres)	Front Setback (Metres)	Maximum Permissible Heights (Metres)	Remarks
1	Less than 9	Not specified	height not more than width of abutting road	
2	Less than 12	3	12 (15 with stilt floor)	1 RU/floor (G+2) for 162–225 sqm on road 9 m & above
3	12 – 18	3	Equal to width of road	2 RU/floor (G+2) & 3 RU/ floor (Stilt + 3) for area 225–500 sqm & 500–750 sqm respectively on road of 12 m & above; stilt for parking mandatory
4	Less than 18	As above		Only standard FAR permissible for 5000sqm & more
5	18 - 24	4.5		3 RU/ floor (Stilt + 4 floor) for area 500–750 sqm on road of 18 m & above; stilt for parking mandatory
6	18 - 30	–	1.5 times width of road	Multistorey & group housing permissible on road above 18 m width & plot area above 1000 sqm & 5000 sqm respectively
7	More than 24	6		
8	More than 30	As above	1.5 times width of road & front setback	

RU – Residential Unit; m- metres; sqm – square metres.

5. Conclusion and recommendations

Many attempts have been made by many researchers and government agencies from time to time to analyse the problems of the built environment resulting from building regulations, codes and guidelines and improvise upon them through regular updates/amendments and revision of same but the codes and regulations but still lack a holistic and integrated approach and framework for implementation. Many parameters like illumination, ventilation, orientation and positioning, overall energy performance of buildings, walkability and safety in neighbourhoods, buffer zones between buildings, etc. have been studied by many researchers and also been discussed to an extent in NBC, MBBL, ECBC, etc. yet fail to find place in the building regulations of Jaipur city. One of the major reasons is that these guidelines (NBC, MBBL, etc.) are advisory in nature and not statutory hence their incorporation into the Building regulations/by-laws is often overlooked.

The study of informal sector which forms a major section of societies in India is almost absent in the study of the urban environment and regulations. Almost 90% of the residential built stock is free of the requirement of regulations and governance since there is no mandate for building permission up to the plot size of 350 sqm. The informal building practices and lack of resources have led to the low prioritization of regulations against meeting the demands for shelter provision resulting from the problems of unplanned growth, illegal squatters, and settlements. These settlements are a huge threat to the quality of the urban environment and pose a big challenge for the government for implementation of planning policies and provision of all the basic amenities to residents. The building regulations must also address the problems of the informal sector and contraventions in the formal sector so as to achieve better urban forms through effective environment responsive development regulations.

There is an urgent need to study and assess the city's social and market characteristics and also to study the impact of performance-based rules and regulations associated with the time frame to incorporate the dynamism of urban growth and transformations resulting out of them. The Urban Arts Commissions have been constituted at some places like Delhi to look after the character and aesthetics of built form but the country is yet to benefit from it. There is a need for a synthesis between legislation and management so that the responsibilities of different agencies need to be spelt out for easy and effective implementation. There is a need for evolving a composite and well integrated legal system to protect the environment and built form, instead of creating a plethora of agencies under different Aegis to take care of varied jurisdiction with overlapping functional and territorial aspects, resulting in confusion, lack of coordination in decision making, plan and project implementations.

Khan (2015) stressed that we (Indians) have the potential to meet the environmental challenges confronting us today, by command and regulation, and public participation; but we need to concentrate fully on the protection of the physical environment and nature along with economic growth. Looking into the recent developments in this regards like revision or enhancement of major national level guidelines and regulations pertaining to urban development and building construction such as NBC 2016, MBBL 2016, Urban Development Promotions Formulation and Implementation Guidelines (URDPFI Guidelines 2014), etc. to cater to the environmental concerns and sustainability as a major aspect, highlights a promising future for the country as whole by providing opportunity to control the energy consumption, enhance and improve efficiency standard and regulate the environmental conditions through environmental responsive building regulations.

References

- Ahmed, A., & Dinye, R. D. (2011). Urbanisation and the challenges of development controls in Ghana: A case study of Wa Township. *Journal of Sustainable Development in Africa*, 13(7), 210–235.
- Bhutani, S., & Mazumdar, M. (1998). Urban environmental legislations in India: A macro study. *Urban India*, 18(2), 19–48.
- BIS (2005). "SP-7: National Building Code (NBC) 2005", BIS, New Delhi.
- BIS (2016). "SP-7: National Building Code (NBC) 2016", BIS, New Delhi.
- Census of India (2011). "Population Census-2011", Government of India, 2011. available: <<http://www.census2011.co.in&www.census.co.in>>.
- Chandel, S. S., Sharma, A., & Marwaha, B. M. (2016). Review of energy efficiency initiatives and regulations for residential buildings in India. *Renewable and Sustainable Energy Reviews*, 54, 1443–1458.
- Dadhich, P. N., & Hanaoka, S. (2011). Spatio-temporal urban growth modeling of Jaipur. *Journal of Urban Technology*, 18(3), 45–65.
- Deal, B., & Schunk, D. (2004). Spatial dynamic modeling and urban land use transformation: A simulation approach to assessing the costs of urban sprawl. *Ecological Economics*, 51(1), 79–95.
- Grosso, M. (1998). Urban form and renewable energy potential. *Renewable Energy*, 15(1–4), 331–336.
- GRIHA (2016). "GRIHA Rating System" Green Rating for Integrated Habitat Assessment Council, TERI-MNRE, New Delhi. Retrieved from <http://www.grihaindia.org/?T=Green_Rating_for_Integrated_Habitat_Assessment#&Green_Rating_for_Integrated_Habitat_Assessment> on 12th Aug.
- Government of Rajasthan (2010). "Jaipur Building Byelaws 2010", Jaipur Development Authority, Government of Rajasthan, Jaipur.
- IGBC (2016). "IGBC Rating System" Indian Green Building Council, Confederation of Indian Industries, New Delhi. Retrieved from <<https://igbc.in/igbc/redirectHtml.htm?RedVal=showratingSysnosign>> on 10th Aug.
- Iwaro, J., & Mwasha, A. (2010). A review of building energy regulation and policy for energy conservation in developing countries. *Energy Policy*, 38, 7744–7755.
- Jain, S. (2011). *Walking into the microcosms of Jaipur – concept paper*, Indian Heritage Cities Network. New Delhi: UNESCO.
- Jawaid, M. F., & Khan, S. A. (2015). Evaluating the need for smart cities in India. *International Journal of Advance Research In Science And Engineering*, 4(Special Issue (01)), 991–996.
- Jawaid, M. F., Pipralia, S., & Kumar, A. (2016). Exploring the imageability of walled city Jaipur. *Journal of Engineering Technology*, 4(1), 46–52 (August 2016).
- Jawaid, M. F., Sharma, M., Pipralia, S., & Kumar, A. (2017). Jaipur: a city profile. *Cities – The International Journal of Urban Policy and Planning*, 68, 63–81.
- Khan, F. A. (2015). Sustainable development: Environmental law with reference to town and country planning. *ITPI Journal*, 12(1), 28–52. <www.itpi.org.in>.
- Kumar, A., & Pushplata (2013). Building regulations for environmental protection in Indian hill towns. *International Journal of Sustainable Built Environment*, 2(2), 224–231.
- MacDonald, M. (2015). "Smart City proposal- Jaipur City" by Mott MacDonald, December 2015. Retrieved from Smart Cities Mission <<http://smartcities.gov.in/writereaddata/winningcity/SmartCityJaipur.pdf>>.
- Murphy, L. (2012). *Building regulations for energy conservation*. International Encyclopaedia of Housing and Home.
- Pan, W., & Garmston, H. (2012). Building regulations in energy efficiency: Compliance in England and Wales. *Energy Policy*, 45, 594–605.
- Roy, A. K. (1978). *History of the Jaipur City*. New Delhi: Manohar Publications 1978.

- Sachdev, V., & Tillotson, G. (2002). *Building Jaipur: Making of an Indian city*. London: Reaktion Books 2002.
- Sharma, A., Saxena, A., Sethi, M., Shree, V., & Varun (2011). Life cycle assessment of buildings: A review. *Renewable and Sustainable Energy Reviews*, 15, 871–875.
- Sudhira, H. S., Ramachandra, T. V., & Jagadish, K. S. (2004). Urban Sprawl: Metrics, dynamics and modelling using GIS. *International Journal of Applied Earth Observation and Geoinformation*, 5, 29–39.
- Tulsyan, A., Dhaka, S., Mathur, J., & Yadav, J. V. (2013). Potential of energy savings through implementation of Energy Conservation Building Code in Jaipur City, India. *Energy and Buildings*, 58, 123–130.
- United Nations (2014). “World Urbanization Prospects - Highlights” Department of Economic and Social Affairs, United Nations, 2014 Revision. Retrieved from <https://esa.un.org/unpd/wup/publications/files/wup2014-highlights.Pdf> on 8-h July 2017.