INTRODUCTION

Rapid urbanization, environmental pollution and resources scarcity greatly influence the ability of town planners to deliver sustainable housing to citizens in developing countries. This has resulted in development of housing colonies that is unsuitable for occupancy generating negative consequences to the surrounding communities and the environment in the long run (Moja and Mnguni, 2014; Poom et al., 2014; Dutta, 2012). Developing more resilient and sustainable settlements requires planners to anticipate and take account of changing socio-ecological and physical conditions (Fitzgerald et al., 2015). Understanding the complex interactions between dynamic environmental, technological, infrastructural and governance systems in relation to housing provisions forms the starting point for impact assessment within the framework of Environmental Impact Assessment (EIA). EIA is the process used to identify, predict, evaluate and mitigate the environmental, social, and other potential impacts and consequences of developmental projects prior to major decisions being taken and commitments made to recommend suitable mitigation measures and to decrease possible adverse impacts (International Association for Impact Assessment (IAIA), 1999; Kaya and Kahraman, 2011).

Human activities are both beneficial and harmful for environment such as biological, cultural, social, economic impacts and so on and they must be taken into consideration when the development projects or plans are evaluated (Puri et al., 2015; Deng, et al., 2014). The rapid growth in the population in urban areas has increased the demand of land and cost of living, and it has also increased the housing load and housing projects activities (Jiao, 2015). This high demand of urban land and housing is often in short supply and out of the economic reach of the majority of the urban households (Oladapo and Olotuah, 2007; Olotuah, 2010).

The urban areas in developing countries are crowded by a large mushrooming growth of settlements. These parts of the urban population needs special attention and is constrained with limited services, insufficient resources, crowded and squatter settlements and a generally poor environmental quality (McGranahan, 2015; Galbraith, 1968). These are the urban poor that are subjected to a life characterized by precarious conditions of housing, nutrition and health, little or poor material possessions (Walter et al., 2015; Mabogunje, 1975). In India, urbanization trend shows a dramatic shift. Total population has increased from 23.84 crores in 1901 to 102.7 crores in 2001, and number of town has grown from 1827 in 1901 to 7935 in 2011 (Census of India, 2011). The number of urban agglomerations has increased from 384 in 2001 to 475 in 2011, whereas the number of population living in urban areas has increased from 2.58 crores in 1901 to 28.53 crore in 2001.
1.1 EIA for Housing projects

EIA comes from Sec. 102 (2) of the National Environmental Policy Act (NEPA), 1969, USA. In many European countries, it came into trend with the introduction to the concept of sustainable development after the report of World Commission on Environment and Development (WCED) came in 1987. In India, EIA came into existence informally through isolated project assessment on environmental criteria around 1978-79, it was made a mandatory provision in 1994.

The vast majority of urban residents in India continue to live in sub-standard or informal housing, with few basic amenities (Tiwari and Hingorani, 2014). EIA is a planning and management tool that seeks to identify and assess the type, magnitude and probability of environmental and social changes likely to accrue from a proposed development or policy and to design the possible mitigation plans (Harvey, 1998; Momtaz, et al., 1998; Thomas, 1998). EIA is being used worldwide in order to reduce the harmful consequences of development. It is an illustration of the precautionary principle (Debbarma, 2012) because it focuses on prevention during the early stage of project development. The primary goal of EIA is ensuring environmental protection and management (Bailey, 1997; Morrison and Bailery, 1999). EIA is generally concerned with the prediction and identification of impacts at a pre-decision level focusing only on the steps before and up to the planning decision, but ignoring post development follow-up actions, such as post-project monitoring and auditing (Arts et al., 2001; Glasson, 1994; Petts and Eduljee, 1993). Moreover, the procedural emphasis of EIA upon the pre-decision investigation keeps it isolated from its final goal, i.e. environmental protection. In a major study on international EIA effectiveness (Sadler, 1996; Cashmore et al., 2004), it is found that there was a deficient or poor performance of follow-up activities in EIA. This is considered to be a major weakness of EIA internationally (Arts et al., 2001; Bisset and Tomlinson, 1988; Buckley, 1989; Dipper et al., 1998; Glasson et al., 1994; Ortolano and Shepherded, 1995; Sadler, 1996; Wood, 2003).

The living space becomes the centre and instrument for mankind’s socio-economic and moral well-being (Wang et al., 2015). Since living space affects the very foundation of an individual’s life, the house becomes an integral part of it. Besides it is fundamental to people’s physical, physiological, social and economic well-being (Kraatz et al., 2015). Housing is the physical structure that man uses for shelter. The quality of life of human beings can not be fulfilled without safe, secure and comfortable housing. But, in most of India’s towns and growing cities, people are not fortunate to have housing of their own which is safe, sustainable and comfortable. Housing is the biggest challenge associated with urbanization in India. In the absence of proper assessment of environmental significance of ongoing housing projects, the living standards of urban as well as rural area are deteriorating. Thus, the sustainable human settlement and construction of eco-cities or green housing can be achieved by implementing the policies of EIA in housing and construction projects (Kulkarni et al., 2014).
1.2 Application of RS and GIS in EIA

Geographical Information System (GIS) is a computer based system which can be used to store, integrate, analyze, and display spatial and non spatial data for undertaking an EIA study. The first GIS system was evolved in the late sixties, and by mid seventies, it was used for EIA. Overlay technique method is one of the main methods of analysis in GIS. In 1972, a computerized version of the GIS technique was used for siting of power lines and roads (Munn, 1975). First GIS (Canada GIS or CGIS) was used for EIA in the late 1970s for the preparation of an EIS for a dam on the river Thames. GIS processes are related to environment for considering the spatial properties of the housing projects. Most of the environmental issues can be handled properly with the use of GIS techniques (Schaller, 1990). Due to the evolution of computer technology, and their graphic capabilities, GIS’s have become more users friendly and powerful.

The availability and quality of digital spatial data sets have improved for routine analysis (Batty, 1993). The use of GIS in EIA process is common for scoping in terms of time and money relative to the time and budgets allocated for EIA preparation, and especially for scoping studies.

GIS is widely utilized in EIA of housing projects, however, its use is largely limited to the fundamental GIS functions such as map production, classic overlay or buffering (Joao, 1998). The key advantage of GIS for EIA is its ability to perform spatial analysis and modeling (Joao and Fonseca, 1996) for future urban growth projections in world’s developing and upcoming urban townships.

There are several advantages of RS and GIS techniques in EIA of housing projects which are outlined below:

1. Space management which is a major issue concerning the provision of limited space to meet housing goals, minimize operating costs, and promote an effective and productive environment. The ideal uses of space in successful manner decreases the building’s per capita functional costs. There are several cases where GIS is effectively used in the management of spaces for different housing projects.

2. The suitable site selection is the primary and essential part of eco-city/housing projects planning (Laprise et al., 2015). GIS can be utilized to visualize whether a particular site meets the predefined criteria or not. It helps to visualize the spatial interlinks or errors between various factors with that of chosen site for planning. GIS techniques help to generate several important functional maps for the master plan such as the location of the waste management sites, green space, parks and open areas etc.

3. Housing and construction industry is one of the major sources for Green House Gas (GHG) emission. Reducing the GHG emission from the construction activities is one of the critical challenging issues in construction industry. So, GIS technique helps in monitoring GHG emission from the construction activities (Fouquet et al.,
2015). The maps generated from several sources could be overlaid to prepare the emission scenario and its impact on settlements (Denga, 2014).

Many applications are enhanced by the use of 3-D spatial information, such as visualization of planning development proposals, flood predictions, modeling urban sprawl, tourist visit simulations and the design of transportation networks. Some GIS software also predicts the future growth with the help of modeling techniques.

1.3 SATELLITE DATA AND ANCILLIARY DATA

The satellite data is being used to observe land use/land cover changes, losses of water bodies and losses of flora / fauna by using Expert GPS, ARC VIEW GIS 3.3 and ARC GIS 9.2 software. While, ancillary data such as environmental clearance reports, analytical monitoring data, compliance reports etc can be collected from CPCB and SPCB, and Directorate of Environment as well as district Gazettes, the ancillary data helps in conflict analysis (comparing the compliance and non-compliance data) of the EIA system implemented in the housing projects.

1.4 Carrying Capacity and EIA

In an environment of the biological species the carrying capacity is the maximum population size of the species that the environment can sustain indefinitely, given the, habitat, water, food and other requirements available in the environment (Xilian, 2010). Thus, the carrying capacity is the number of biological species in an environment that can be supported without significant negative impacts to the given organism and its environment. The carrying capacity is directly or indirectly connected with EIA process which is used to determine the carrying capacity of the region due to any developmental projects like housing and construction projects.

1.5 Application of modeling techniques in EIA

FUZZY AHP (Analytical Hierarchy Process) which was developed by Saaty (1977, 1980), is a modeling technique based on multi-criteria decision making method. The method is specially used where different criteria sets are used in project evaluation and the criterion is found to be incapable of dealing with the problems of uncertainty in decision-making situation. Buckley (1985) applied the fuzzy set theory to depict the fuzziness of the decision-makers. This process comprises of both group decisions and fuzziness. Examples for the proper application of the fuzzy AHP are, amongst others, the assessment of water management plans (Sredjevic and Medeiros, 2008); decisions in new product development (Buyukozkam and Feyziog, 2004); flexible manufacturing systems (Chutima and Suwanfuji, 1998); safety management in production (Dag deviren and Yuksel, 2008); selection of enterprise resource planning systems (Cebeci, 2009); evaluation of success factors in e-commerce (Kong and Liu, 2005); personnel selection (Gungor et al., 2009); affordable housing (Bei et al., 2014) and weapon selection (Dag deviren et al., 2009). In a similar study, land capability of Shandiz urban region, northeast of Iran, was assessed for spatial development using multi-criteria evaluation framework.
(Afshari and Mafi, 2014). AHP and GIS was used to find the most important parameters that affected the spatial development in the study area.

AHP is a mathematical method for the determination of the priority of the process and criteria in the evaluation process and decision making. The main reason of applying AHP is that it helps decision makers to solve the complex problem into a hierarchical structure. The AHP analysis creates better and clear rationale for selecting the various options in a complex decision environment such as impact assessment for housing projects (Bei et al., 2014). Fuzzy models have many interesting features that make them ideal for such conceptual models (Wieland and Gutzler, 2014) in addition:

- Fuzzy models are represented as a set of fuzzy sets to describe outputs and a set of rules.
- Fuzzy models can easily be understood by experts.
- Fuzzy models can easily express complicated nonlinear relations.

1.6 Research Objectives

EIA has been used as a practical and effective tool in decision making process to identify environmental factors, and consequences for a proposed development project needed to arrive at socio-economic development. This study uses the EIA framework as a lens to evaluate current and future environmental impacts in developing housing projects by both public and private agencies and also evaluates the post-project conflicts through primary and secondary data. This research work quantitatively explores the spatio-temporal patterns of land use/land cover transformations in the core and along the city periphery of Lucknow city, the capital of India’s largest state, in addition to observing nature and form of urban expansion resulting in a complicated urban landscape. Conflict analysis is carried out to explore disagreements between urban suitability, enabling infrastructure and Master plan 2021 proposed by the land authorities using satellite imageries, Fuzzy AHP and sub-models within a framework of environmental assessment. The methodology provides a cost effective and rapid land evaluation framework for EIA which may help policy makers, urban and regional planners and researchers working in developing countries to understand the dynamics of urban growth and impacts of housing projects on the environment.

There are three main research objectives which are formulated as follows:-

- To assess the baseline and current environmental status (such as air, water, noise, and socio-economic parameters) for housing projects in Lucknow.
- To do a comparative study of the housing projects in the study area on different parameters using Leopold Matrix method.
- To review the effectiveness of EIA systems implemented in housing projects through conflict analysis and post-project monitoring using Fuzzy AHP models and GIS.

The study was used to observe the effectiveness of EIA for housing projects in Lucknow by studying and reviewing the Government of India EIA
notifications, with the help of spatial and non-spatial data, use of Fuzzy – AHP modelling techniques, Leopold interaction matrix, land use/cover change detection, and conflict analysis. The methodological framework is schematically outlined below in the figure 1.1.

Figure 1.1 Methodological framework adopted for the study
1.7 About the Study Area

Lucknow is located in the central region of Uttar Pradesh and is the capital of the largest populated state in India. The city is governed by Municipal Corporation which comes under Lucknow Metropolitan Region. Lucknow district administers 2,528 square kilometers of areas. In 2001 census, Lucknow had a population of 3.64 million with a density of 1816 people per sq. km which rose to 4.58 million in 2011 having a density of 1443 people per sq. km (Census of India, 2011). Floating population in the city is increasing every year, and with the growing infrastructure, the demand and expectation of quality housing has also gone up. The main urban areas of Lucknow are situated on both sides of the river Gomti which divides the city into two parts. Residential colonies like Gomti Nagar, Indira Nagar, Vikas Nagar, Jankipuram, Aliganj, Mahanagar, Rajajipuram and several integrated townships along the Faizabad Road are located trans-Gomti, while colonies like Aashiyana, Eldeco, South City, Vrindavan, Alambagh, Krishna Nagar etc. are situated in southern-western part of the city. Most of the colonies in these areas are developed with mixed land-use and commercial infrastructure, however, in some of the colonies in the far south and north, social and physical infrastructure is still developing. Three National Highways and other five Provincial Highways serve the region of Lucknow. During the last two decades, the city of Lucknow expanded rapidly and became less compact and more dispersed. However, the city grew faster and showed more sprawl between 2005-2014. The growth mainly spurred due to real estate markets becoming a popular investment avenue in India’s million plus cities. Good connectivity with the adjoining towns with the rest of the city also aided people to come and settle in different parts. The earlier work on Lucknow’s growth pattern and urbanization trends reveal that the growth in Lucknow city is not linear nor nodal, rather radial with minimal influence of transport infrastructure; change drivers are many and site-specific. Urbanization follows two physical processes, (i) envolvement (North, North-western, Southern sites): annexation of surrounding landscape and (ii) Attainment (North-eastern site): occupation of rural built-up clusters in landscape (Dutta, 2012).

A short description of high growth areas of Lucknow is provided below which are exhibiting rapid expansion of residential colonies:

(a) Northern site along Sitapur Road: It is located in Bakshi Ka Talab, a suburban town in Lucknow district, connected to Lucknow City via National Highway 25 which further leads to the neighbouring Sitapur City. The area has been primarily agriculture-intensive and has been experiencing significant urban development with increasing number of educational and research institutions coming up in the area. The peri-urban areas which had much lesser population and less explored by the real estate markets, are now becoming preferred destination for private developers.

(b) North-Eastern site along Faizabad Road: It is located in Chinhat Area situated along National Highway 28, around 15 km from Lucknow city connecting it to Faizabad city. The site is situated between the National Highway and River Gomti.
and has a railway route running through it. The area has been agriculture-intensive with very fertile croplands due to proximity to river Gomti and presence of canal network. Owing to its numerous industries, the area has is the industrial hub of city and has been experiencing significant development since a decade owing to establishment of new industries and some higher-education institutions.

(c) **Southern site located along Raebareli Road**: Raebareli road in the south is one of the six crucial roads of Lucknow which is currently expanding. The road starts from the Telibagh colony, just after the cantonment and extends up to the Mohanlalganj area. The area is in between Uterethia-Amausi situated 15 km from Lucknow city centre and is surrounded by National Highway 25 connecting to Kanpur city on one side and National Highway 24B connecting to Raibareli city on other side. It is a transportation hub due to the presence of Amausi international airport. The area has been historically marked by presence of numerous ponds/lakes, vast scrublands and numerous sporadic clusters of plantations. The area is currently experiencing rapid development due to several real-estate development plans under implementation. Many builders and buyers have shown interest in the area. Along this road, many renowned and city-based builders have started their housing projects and are offering a wide range of properties ranging from apartments in a group housing society to independent plots. The Amar Shaheed Path acts as a dividing line between the developed and the developing regions along the road. Areas within the Amar Shaheed Path or close to it are completely developed in terms of social and physical infrastructure. As one go away from the city in further south, an array of residential housing projects can be seen on both sides of the Raebareli road. Not only the private developers, the city’s Lucknow Development Authority (LDA) and UP Housing and Development Board has also acquired a good amount of land bank from the farmers in this region and coming with several housing projects.

(d) **South-Western site located along Kanpur Road**: Kanpur and Lucknow are separated by 80 kms. Land along the Lucknow-Kanpur road has become an area of intense interaction reflected by changes in land use and mushroomed development. Many interested investors are buying plots as they are relatively less expensive when compared to other areas of the city. Several buyers hope to construct homes after their retirement while investors wait for capital appreciation based on the infrastructure development in the future. It is one of the regions where future development is being aimed by both public and private developers.

(e) **Northwestern site located along Hardoi Road**: It is situated 12 km from the city centre and has two major roads and northern rail route passing through it. State Highway 40 connects Lucknow to Kannauj, finally leading to Agra and State Highway 25 connects Lucknow to Hardoi via Malihabad. The area though being dominated by agriculture has a significant amount of plantations on private lands which have been steadily increasing.
1.8 Significance of the Study

Better understanding of the overall dynamics and linkages of environmental parameters and their relative importance within and among housing and infrastructure sectors can guide more targeted and productive investment and policies for future to devise better and more holistic interventions. The outcome of this study revealed that EIA regulations were not adequately implemented in housing projects and there are conflicts with respect to post-project compliance. The study further reveals that zoning regulations and land-use suitability is not well considered in deciding housing projects. This land suitability addresses the question of how location and morpho-land use influences overall environmental impacts. The morpho-land use and location of settlements are considered one of the key determinants of the patterns of settlements and resource consumption, and their associated environmental load in future. The outcome of present study may be helpful as a tool for planners, decision makers, engineers and others to consider the impact of housing projects on environment for effective planning. The results of this research work would contribute in determining the effectiveness of EIA for housing projects in Lucknow, Uttar Pradesh which could be applied to other towns and cities. Urban transition is a major challenge in growing Indian cities. Disorderly urban sprawl creates war on cities’ dream to become engines of growth and threatens the future growth and vibrancy of cities’ economy. Urbanization in the Indian context should be looked at beyond mega-cities like Mumbai and Delhi with a holistic view to include second-tier towns and medium size agglomerations such as Lucknow which has not been studied in detail. This research work quantitatively explores the spatio-temporal patterns of land use/land cover transformations in the core and along the city periphery of Lucknow city, the capital of India’s largest state, in addition to observing nature and form of urban expansion resulting in a complicated urban landscape. Conflict analysis is carried out to explore disagreements between urban suitability, enabling infrastructure and Master plan 2021 proposed by the land authorities using satellite imageries, Fuzzy AHP and sub-models within a framework of environmental assessment. The methodology provides a cost effective and rapid land evaluation framework which may help policy makers, urban and regional planners and researchers working in developing countries to understand the dynamics of urban growth and implications of housing projects on the environment. The outcome can also help in better design of EIA studies, especially in the post-project monitoring and evaluation of housing projects.