International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

Study of Site's Potential for Residential Buildings with Physical-Environmental Approach, using Site Selection Model – A Case Study

Ar. Smita Mane[1], Dr. Madhav Kumthekar[2]

[1]P.G. Student, S.P.S.M.B.H'S College of Architecture, Kolhapur, Maharashtra, India.
[2]Professor and Head, Department of Civil Engineering, Government Engineering College, Karad, Maharashtra, India.

Abstract – *The selection of a site in terms of social, economic, and environmental factors is critical to the success of the project. Appropriate site selection contributes to long-term sustainability. One of the most important decisions made by the project planning team during the preliminary phase of construction projects is site selection. The primary goal of this paper is to develop a decision-support model that will allow a medium-sized construction company to optimize the site selection decision for one of its residences. Whatever the complexity of a project's planning stage, the proposed AHP rating model organizes and structures a variety of tangible and intangible variables such that leaders can make the best choice for the firms and clients' gain. In this study, three potential residential construction sites in Kolhapur city were ranked. To obtain rankings based on physical, environmental, access to city and site value, an AHP Rating model was used. The model was taught that by using the applicable model, firm was able to secure long-term consumer benefits and achieve a major competitive advantage with environmental protection. As a result, using this model during the early stages of a project could provide a major competitive advantage to residential project operators.*

Key Words: Green rating system, environmental impact, sustainable development, single family residential buildings, GRIHA, IGBC.

1. INTRODUCTION

One of the most important needs of humans is to have a place to live. The availability of natural resources such as water, fertile land, and other factors affected the positioning of early civilization settlements. In the river valley, where there was fertile soil in floodplains and river water for irrigation and transportation, five major ancient civilizations flourished. The Indus valley civilization, which evolved along the Indus river, is India's oldest civilization. From the ancient Indus Valley civilization to modern India, there has been a significant shift in housing site selection. The demand on natural resources is increasing as the world's population grows. Rapid urbanisation is wreaking havoc on the climate, society, and economy. According to the 2011 Census, the urban population is 31.8%, up from 27.81% in 2001. Maharashtra ranks first in terms of the absolute number of people living in cities. Maharashtra accounts for 13.5% of India's overall urban population, or 50.8 million people. Housing projects in the construction industry are growing in parallel with the pace of urbanisation. However, poor site selection for residential projects can result in disasters like the landslide in Malin, Pune. This haphazard development has a negative impact on not only human well-being but also the environment. To resolve this situation, a sustainable housing site selection is needed.

The influx of people from nearby villages into Kolhapur city has resulted in significant changes in the city's land use. Between 1989 and 2000, land used for agriculture and water bodies decreased by 50%, while land used for residential purposes increased by more than twofold. Population growth has resulted in the misuse of marginal land and the over-exploitation of land with high potential. Creating a balance between rapid urbanization and the carrying capacity of land, as well as land resource management, has become a major problem. Technical, socioeconomic, and environmental factors all play an important role in site selection. The capacity of land for residential development is determined by the site selection process.

2. METHODOLOGY

The Food and Agriculture Organization (FAO) Framework's theory is that each land use type's requirements should correspond to available land resources. FAO's (1976) framework for land assessment has been updated to suit land usage for residential purposes. Modifications are made due to the study area's land use type, local socioeconomic, and environmental conditions. Modifications are based on expert experience and the context of residential construction within the study area's boundaries. A precise calculation is used to classify the study area according to its quality and characteristics in order to determine its possible suitability for residential land use. The overall land suitability for residential use is calculated by assessing the 'Analytical Hierarchy Process-AHP' for selected qualities and characteristics of land. The Analytic Hierarchy Process (AHP) is a math and psychology-based approach for organising and evaluating complex decisions. By quantifying its parameters and possible alternatives, and linking those elements to the ultimate objective, AHP offers a logical basis for a required decision. In the form of a flow map, Figure 1 illustrates the methodology. Three sites in Kolhapur were chosen and assessed based on physical and environmental parameters.

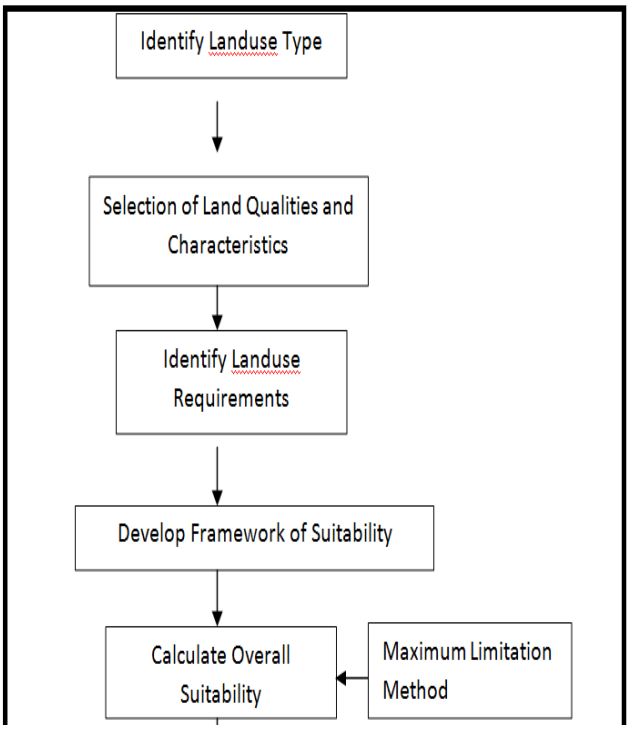

Fig -1: Flow Chart Of Methodology

3. THE CONTEXT OF THE STUDY AREA

Kolhapur is one of the most economically developed cities in Maharashtra, due to fertile soil, the Panchganga river and its tributaries, good modes of communication, co-operative and banking networks. It can be reached by road, rail, and air. The Chatrapati Shahu Maharaj railway station is 10 kilometers from the city centre and connects to cities such as Pune, Mumbai, Tirupati, and Bengaluru. It is situated on the NH 4 Highway (Mumbai-Bengaluru). Kolhapur is located at 16.7000 N latitude and 74.2333 E longitude, has an elevation of 545.6 m, and has a total area of 66.82 square kilometers. Kolhapur has elevations ranging from 0.00 meters to 1300.7 meters. The city's slope runs north to south, towards the Panchganga river. Kolhapur has a moderate climate. Kolhapur's decadal population data in 1951 was 136835, and according to the 2011 Census survey, it was 5.5 lakhs. Kolhapur ranked 7th in Maharashtra in terms of nominal gross district value added (at current prices) per capita in 2017-18, with 1, 79,170 Rs. According to a survey conducted by the Kolhapur Municipal Corporation's health department, there are 1,28211 households within the city limits. In 2014, 36-39 percent of land was used for residential purposes, according to the UDRPFI norm. 17 villages on the outskirts of the city will be integrated into the city for growth and extension. The total area of the city will be 18926 hectors after the city limits are expanded, nearly three times the current city area. It is overseen by the Kolhapur Development Authority.

4. CASE STUDY WITH THREE ALTERNATIVES

In Kolhapur, three sites have been chosen for single-family residential development. Table 1 provides a description of the site.

Table -1: Location and area of selected sites

Site No.	Location	Area (sqm)
1	LIC Society, E Ward, Old Pune-Bangalore Hignway, Kawala Naka, Shahupuri, Kolhapur.	415
2	A Ward, Kanerkar Nagar, Ring Road, Kolhapur.	500
3	E Ward, Near New Place, Kasaba Bawada, Kolhapur.	460

Fig -2: Location of site 1

Fig -3: Location of site 2

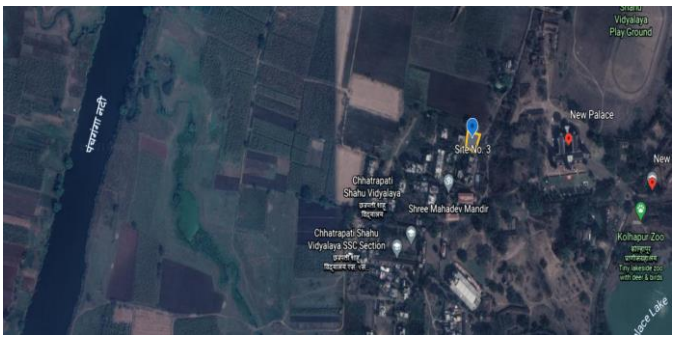

Fig -4: Location of site 3

5. PHYSICAL- ENVIRONMENTAL CRITERIA FOR SITE SELECTION

Slope and topography, infrastructure services, and construction feasibility are all part of the physical requirements. Sub-criteria such as environmental pollutant and natural hazards are included in environmental criteria. The next criterion is the site's location within the area. Form, proportion, site value, and neighborhood land use consistency are the final site value parameters. Table 2 summarizes all of the criteria and sub-criteria. Table 3 shows scale of relative importance. The goal is to determine which site is best.

Table -2: Criteria and sub-criteria

Criteria		Sub-Criteria	
A	Physical	A1	Slope and Topography
		A2	Infrastructure Services
		A3	Construction Feasibility
B	Environmental	B1	Avoid Environmental pollutants
		B2	No Natural Hazards
C	Location in the city	_	_
D	Site Value	D1	Form, Proportion and Site Value
		D2	Site View
		D3	Neighborhood and Use Consistency

Table -3: Scale of relative importance

Score	**Scale of relative importance**
1	Equal important
3	Moderate important
5	Strong important
7	Very strong important
9	Extreme important
2, 4, 6, 8	Between the two

Table 4 shows how the criteria were rated against each other. Looking at the top row, Physical scored a "5" above Location and a "7" above Site value, while Environment scored a "9" above Physical. This gives Physical is 23% of the criteria priority, with the most important criteria being Environmental, at 68%.

Table -4: Criteria weights with respect to goal

Goal	A	B	C	D	Product	4th root of product	Priorities = 4th root of product/ 5.83
A	1	1/9	9	9	9	1.73	0.23
B	9	1	9	9	7.29	5.19	0.68
C	1/9	1/9	1	5	0.061	0.50	0.06
D	1/9	1/9	1/5	1	0.002	0.22	0.03
Tot.	-	-	-	-	-	7.65	-

The next tables demonstrates the weights of each alternative against the criteria A,B,C,D. Here, site A is with highest score to physical, Environmental, Location, Site value, while site 3 is the lowest.

Table -5: Rating for criteria A1

Slope and Topography A1	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	5	9	45	15	0.977789
Site 2	0.2	1	5	1	0.33333333	0.021729
Site 3	0.111111	0.2	1	0.022222	0.00740741	0.000483
					15.3407407	1

Table -6: Rating for criteria A2

Infrastructure Services A2	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	5	9	45	15	0.977789
Site 2	0.2	1	5	1	0.33333333	0.021729
Site 3	0.111111	0.2	1	0.022222	0.00740741	0.000483
					15.3407407	1

Table -7: Rating for criteria A3

Construction Feasibility A3	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	0.142857	5	0.714286	0.23809524	0.015621
Site 2	7	1	0.11111111	0.777778	0.25925926	0.984131
Site 3	0.2	9	1	1.8	0.6	0.000248
					1.0973545	1

Table -8: Rating for criteria B1

Avoid Environmental pollutants B1	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	3	5	15	5	0.93361
Site 2	0.333333	1	0.2	0.066667	0.02222222	0.004149
Site 3	0.2	5	1	1	0.33333333	0.062241
					5.35555556	1

Table -9: Rating for criteria B2

No Natural Hazards B2	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	0.2	7	1.4	0.46666667	0.030162
Site 2	5	1	9	45	15	0.969496
Site 3	0.142857	0.111111	1	0.015873	0.00529101	0.000342
					15.4719577	1

Table -10: Rating for criteria C

Location in the city C	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	7	9	63	21	0.984131
Site 2	0.142857	1	7	1	0.33333333	0.015621
Site 3	0.111111	0.142857	1	0.015873	0.00529101	0.000248
					21.3386243	1

Table -11: Rating for criteria D1

Form, Proportion and Site Value D1	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	7	9	63	21	0.992664
Site 2	0.142857	1	3	0.428571	0.14285714	0.006753
Site 3	0.111111	0.333333	1	0.037037	0.01234568	0.000584
					21.1552028	1

Table -12: Rating for criteria D2

Site View D2	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	7	7	49	16.3333333	0.990375
Site 2	0.142857	1	0.33333333	0.047619	0.01587302	0.000962
Site 3	0.142857	3	1	0.428571	0.14285714	0.008662
					16.4920635	1

Table -13: Rating for criteria D3

Neighborhood and Use Consistency D3	Site 1	Site 2	Site 3	Product	3rd root of product	Priorities
Site 1	1	9	7	63	21	0.992664
Site 2	0.111111	1	0.33333333	0.037037	0.01234568	0.000584
Site 3	0.142857	3	1	0.428571	0.14285714	0.006753
					21.1552028	1

Table -14: Local and global priorities for A

Criteria	A		
	0.23		
Sub-Criteria	A1	A2	A3
	0.000685	0.499657	0.499657
S1	0.977789	0.977789	0.015621
S2	0.021729	0.021729	0.984131
S3	0.000483	0.000483	0.000248

Table -15: Local and global priorities for B

Criteria	B	
	0.68	
Sub-Criteria	B1	B2
	0.5	0.5
S1	0.93361	0.030162
S2	0.004149	0.969496
S3	0.062241	0.000342

Table -16: Local and global priorities for C

Criteria	C
	0.07
Sub-Criteria	-
S1	0.984131
S2	0.015621
S3	0.000248

Table -17: Local and global priorities for D

Criteria	D		
	0.03		
Sub-Criteria	D1	D2	D3
	0.000685	0.499657	0.499657
S1	0.992664	0.990375	0.992664
S2	0.006753	0.000962	0.000584
S3	0.000584	0.008662	0.006753

Table -18: Weights and Ranks of alternatives

Site Alternatives	Final Weight	Rank
S1	0.540635059	1st
S2	0.447754054	2nd
S3	0.021610742	3rd
S1	1.009999855	

6. CONCLUSION

Site selection through land evaluation for residential purpose significantly impacts the environment and socio-economic development of urban area. It accelerates the sustainable development of city. This paper highlights the selection of site suitable for residential development from three alternatives based on four criteria and eight sub-criteria. These four criteria are Physical, environmental, access to city and site value. For calculating overall suitability with the help of AHP model suitability degree is calculated. Results shows among three sites first site is highly suitable for residential purpose with 54% weightage , second site is moderately suitable with45% weightage, and third site is marginally suitable with 2% weightage. The process was successfully analyzed for determining the optimum land suitability for residential purposes.

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