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Multi Criteria Decision Making Approach for Success Potential of Real Estate Project

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Abstract— ***The main purpose of this study is to develop a comprehensive success model for real estate projects considering both external and internal factors. In this respect, a wide range of success criteria are identified based on an extensive literature survey, and these criteria are classified into their respective sub criteria. In this context, a questionnaire was developed to facilitate systematic data collection in this study. In this survey, experts' opinion from professionals and academicians of civil engineering field is taken through questionnaire. Top level managers, Senior civil engineer and Professors were involved for data gathering and finalizing the project Success Criteria and their respective sub Criteria. Further attempt has been made to formulate a fuzzy set numbers and employing Fuzzy Multiple Criteria Decision Making technique with a view to determine success potential of real estate project. The two main objectives achieved from this study, first, to provide a success potential index for completed projects in order to compare them with each other and to establish for improvement in future projects. Real estate companies may benefit from the findings of the proposed model in assessing the performance of their projects and may take the necessary actions to achieve better success in their projects to make a reputation in market.***

Index Terms—Fuzzy logic, Multi Criteria, Project success, Real Estate, Success potential index.

I. INTRODUCTION

Success has always been the ultimate goal of every activity and a construction project is no exception. Due to the ambiguous definition of project success and the different perceptions of participants toward this concept, it may be difficult to tell whether a project is successful as there is a lack of consensus. Time, cost, and quality have long been the success criteria used to evaluate the performance of a construction project. However, such a list has been criticized as not being comprehensive. The modeling for determining success potential of Real estate project assumes greater complexity due to the involvement of human perception in the evolution of decision making process. The construction industry is project-based, the success of construction firms is determined by project success to a large extent. There are many aspects of construction project success, several evaluation methods, techniques, and frameworks have been proposed by researchers to measure the performance of projects and to describe the relationship between success and various criteria. This paper sets out to establish criteria for project success for a real estate project in construction, first by identifying relevant measures of project success for a construction project in past studies, with particular emphasis on real estate projects, and then by establishing a comprehensive assessment framework for project success for real estate projects.

Making decisions is a part of our daily lives. The major concern is that almost all decision problems have multiple, usually conflicting criteria. Multiple Criteria Decision Making (MCDM) is a structured (organized) approach to decision making. Values, beliefs and perceptions are the forces behind almost any decision-making activity. They are responsible for the perceived discrepancy between the present and a desirable state.

M. Medineckiene, E.K. Zavadskas and Z. Turskis [8] were described model of dwelling selection, using fuzzy game theory. Fuzzy games are applied for decision aiding. The problem solution result shows that fuzzy matrix games theory is appropriate for such purposes.

Chien-Chang Chou [1] was evaluated an integrated short-term and long-term multiple-criteria decision-making (MCDM) model for solving location selection problems. The advantages of the proposed integrated short-term and long-term MCDM model in this study are not only to evaluate the short-term investment environment, but also consider the long-term operation environment.

D. Singh and Robert L. K. Tiong [5] Gives the contractor selection process of selecting the most appropriate contractor to deliver the project as specified so that the achievement of the best value for money is ensured. They developed a fuzzy decision framework for contractor selection. The nation of Shapley value is used to determine the global value or relative importance of each criterion in accomplishing the overall objective of the decision making process.

Clarke [9] states that by targeting the main problems and issues using the key success factors as a focus could make a significant difference to the effectiveness of project management. In order to ensure that a project is completed successfully, project plans need to be updated regularly.

Cleland [9] suggested that "project success is meaningful only if considered from two vantage points: the degree to which the project's technical performance objective was attained on time and within budget; the contribution that the project made to the strategic mission of the enterprise."

Pinto & Slevin [9] Conclude that "project success" is something much more complex than simply meeting cost, schedule, and performance specifications. In fact client satisfaction with the final result has a great deal to do with the perceived success or failure of projects

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D. K. H. Chua, et al [2] The main factors which contribute to a project success are budget, schedule and quality, but there are other more specific objectives, such as safety consideration and market entry, depending on the nature of the project and company.

Lim and Mohamed [3] The project success should be viewed from different perspectives of the individual owner, developer, contractor, user, and the general public and so on.

Eric [6] The success of a building project is very important in a developing economy if we critically analyze the quantum of resources wasted and its negative impact to the Gross Domestic Product(GDP) of the nation's economy.

Christian Stoy and Hans-Rudolf Schalcher [11] Time and cost are considered to be substantial success factors of building construction projects.

Syed Zafar Shahid Tabish and Kumar Neeraj Jha [10] The human factors and management actions play a key role in making the project a success, as seen by the direct link between human factors and management actions– related success traits to project success.

Didem Erdem and Beliz Ozorhon [4] The project success depends on the characteristics of the project, external conditions, and stakeholder expectations. No single indicator is sufficient to define and measure project success.

II. RESEARCH METHODOLOGY

In this study, Real Estate Project Success potential Index (REPSPI) model has been developed using Fuzzy Multiple Criteria Decision Making technique. Fig. 1 shows overview of the fuzzy decision framework for Assessment of Project Success.

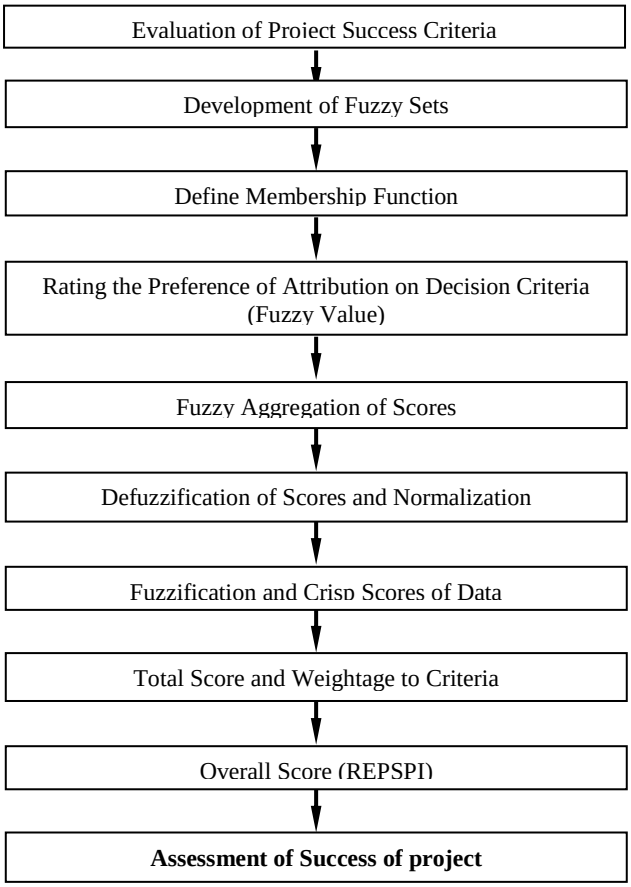

Fig. 1 Fuzzy decision framework for Assessment of Project Success

A. *Sets and fuzzy logic*

A fuzzy set can be defined mathematically by assigning, to each possible individual in the universe of discourse, a value representing its grade of membership in the fuzzy set. This grade represents the degree to which that individual is similar or compatible with the concept represented by the fuzzy set. Thus, an individual may belong in the fuzzy set to a greater or lesser degree as indicated by a larger or smaller membership grade. These membership grades are very often represented by real-number values ranging in the closed interval [0, 1]. As fuzzy logic deals with values between 0 and 1, it is also multi-valued logic. The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature (Klir and Yuan, 2003).

Linguistic Variables

The concept of a fuzzy number plays a fundamental role in formulating quantitative fuzzy variables. These are variables whose states are fuzzy numbers. When, in addition, the fuzzy numbers represent linguistic concepts, such as very good, good, fair, and so on, as interpreted in a particular context, the resulting constructs are usually called linguistic variables. Linguistic terms and there fuzzy numbers used for the study were: Very Important (VI) (0.777,0.888,1.000,1.000), Important (I) (0.555,0.666,0.777,0.888), Average (A) (0.333,0.444,0.555,0.666), Least Important (LI) (0.111,0.222,0.333,0.444) and Very Least Important (VLI) (0.000,0.000,0.111,0.222). Fig. 2 shows the graphical representation of fuzzy numbers for the linguistic terms.

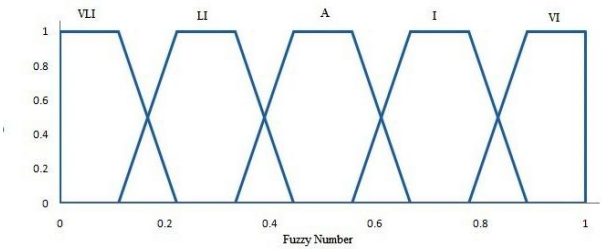

Fig. 2 Fuzzy sets for the linguistic terms

Experts' opinions are required to be taken from academicians and professionals, who are involved in the field of civil construction engineering, for sub criteria of Planning, Financial, Project management consultant, Sub contractor, Supplier, Client, Employee, Operational, Attractions, Health & Safety and Environmental Aspects. Then the importance weightage factors for these sub criteria can be calculated as follows.

B. *Average Fuzzy Number (AFN)*

The linguistic terms given by experts can be further simplified to calculate the Average Fuzzy Number (AFN). The linguistic terms as assigned by the experts for each sub criterion of Planning, Financial, Project management consultant, Sub contractor, Supplier, Client, Employee, Operational, Attractions, Health & Safety and Environmental Aspects can be converted to fuzzy numbers. Then AFN can be calculated by the equation no (1).

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$$A^p_{lm} = \left(\frac{1}{q}\right) \times \left(a^p_{l1} + a^p_{l2} + \ldots + a^p_{lp}\right) \text{ for } l = 1, 2, \ldots, n \text{ and } m = 1, 2, \ldots, q \quad (1)$$

Where,

a^P_{lm} = the fuzzy number assigned to a sub criterion,
q = the number of experts and
n = the number of fuzzy numbers.

C. Defuzzification & Normalized Weight

It is an operation that produces a nonfuzzy or crisp value that adequately represents the degree of satisfaction of the aggregated fuzzy number. In this study, trapezoidal fuzzy numbers were used to represent the experts' opinion. An importance of sub criterion was considered as a range value but not with specific value. So, only trapezoidal fuzzy sets were considered. Let a trapezoidal fuzzy number be parameterized by x1, x2, x3 and x4 as shown in the Figure then its defuzzified value (crisp score) 'e' for the sub criterion can be obtained by using the following (Kaufmann and Gupta, 1991).

$$e = (x1 + x2 + x3 + x4) / 4 \quad (2)$$

D. Fuzzy Decision Matrix

$$X_C = \begin{array}{c} \begin{array}{cccc} \mu_1 & \mu_2 & \mu_3 & \ldots\ \mu_n \end{array} \\ \left[\begin{array}{cccc} a_1, & a_2, & a_3, & \ldots\ a_n \\ b_1, & b_2, & b_3, & \ldots\ b_n \\ c_1, & c_2, & c_3, & \ldots\ c_n \end{array}\right] \end{array} \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \end{array}$$

Where a1, a2, a3... an, b1, b2, b3... bn and c1, c2, c3... cn are fuzzy values of Distance for Scheme S1, S2 and S3 respectively

E. The Crisp Scores

The next step is to determine crisp scores of the sub criterion for each building scheme.

F. Total Score

Using simple additive weighing method (Hwang and Yoon, 1981), overall score (OS) for the different schemes were calculated using equation no (3), with usual notations

$$TS_{rl} = \sum\left[X_{rp} \cdot W\left(C_{rp}\right)\right] \text{ for } p = 1, 2, \ldots n \quad (3)$$

Where,

TS_{rl} = Total score of the scheme i against the criterion m

X_{rp} = Crisp score of the scheme data against sub criterion k of the criterion m and

$W\left(C_{rp}\right)$ = Weight (importance value) of sub criterion k of the criterion m.

Now, Success potential importance weight $\left[W\left(C_{rl}\right)\right]$ of the criterion m for scheme i can be calculated as,

$$W\left(C_{rl}\right) = TS_{rl} \Big/ \sum TS_{rl} \quad (4)$$

G. Overall Score

Using simple additive weighing method (Hwang and Yoon, 1981), overall score (OS) for the different schemes were calculated using the equation no (5), with usual notations.

$$OS = \sum\left[TS_{rl} \cdot W\left(C_{rl}\right)\right] \text{for } l = 1, 2, \ldots n \quad (5)$$

Where,

TS_{rl} = Total score of criteria

$W\left(C_{rl}\right)$ = Normalized Weight of Criteria.

The next step is assessment of success of project, Table I can be referred for Real Estate Project Success Potential Index (REPSPI).

Table I : REPSPI Scale

Sr. No.	Scale	Linguistic Term
1.	0- 0.20	Higher Success
2.	0.21 - 0.40	Appropriate Success
3.	0.41 – 0.60	Moderate Success
4.	0.61 – 0.80	Lower Success
5.	0.81 – 1.00	Not Appropriate Success

III. CASE STUDY

The applications of REPSPI model were tested for three projects in the corporation area, to evaluate the Success rate and for comparison. The data were collected from the following schemes S_1, S_2 and S_3 of Reputed builders in the Pimpri Chinchwad, Pune, in the State of Maharashtra, India. For this model a set of Eleven criteria were considered such as Planning, Financial, Project management consultant, Sub contractor, Supplier, Client, Employee, Operational, Attractions, Health & Safety and Environmental Aspects. The following sub criteria of defined criteria are considered for the study:

Planning: Selection of proper location, Effectiveness of construction schedule, Effectiveness in delay cover management, Effectiveness of waste minimization, Pioneering status of innovative structure.

Financial: Adequacy of funding, Precise cost estimation considering cost of waste material, Precise cost estimation without considering cost of waste material, Efficacy of cost control, Efficacy of Marketability, Efficacy of financial resources, Regular Budget Update, Risk Assessment.

Project Management Consultant: Effectiveness of consultancy services, Competency of consultant's team, Consultant top management support's, Consultant's past record, Consultant's level of service, Level of compliance with government with laws and regulations

Sub-Contractor: Capability of contractor's key personnel, Competency of contractor's Team, Contractor team turnover rate, Contractor top management support, Contractor's past record, Contractor's level of service.

Supplier: Capability of supplier's key personnel, Competency of supplier's team, Supplier's top management support, Supplier's past record, Supplier's level of service.

Client: Client's willingness, Client's satisfaction, Attractiveness of project location, Increase value ability.

Employee: Level of satisfaction of project employees, Level of employee competency, Level of Salary satisfaction of employee

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Operational: Effectiveness of leadership, Efficiency of design, Efficiency of coordination among project Participants, Performance on technology use, Benefiting from past project experience, Timely Possession of Flats/Offices/Shops.

Attractions: Aesthetically Pleasing Building, Lift, Overall Maintenance Facility, Security facility, Intercom facility, Common toilet with Maintenance Facility, Parking, Internet Facility, Dry Balcony, Landscaping, Club House, Gymnasium, Swimming Pool, Pipe line Gas Connection.

Health & Safety: Adequacy of PPE, Medical facility, Provision of ELCB and MCB, Attainment in health and safety on site, Fire Fighting.

Environmental Aspects: Green and sustainable design, Compact module Sewage Treatment Plant, Reuse of treated wastewater, Rain Water Harvesting System, Solar Panels, Solid waste disposal, Reuse of solid waste in premises.(Refer APPENDIX)

IV. RESULTS AND DISSCUSSION

A. *Experts' Opinion*

Experts' opinion taken from academicians and professional were taken for the above mentioned sub criteria of defined criteria. Table II shows experts' opinion by academicians for sub criteria of Planning.

Table II: Experts' Opinion (Academician)

SUB CRITERIA	EXPERT OPINION ACADEMICIANS									
	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8	AE9	AE 10
Planning										
P1	I	I	I	VI	VI	VI	VI	VI	I	VI
P2	VI	I	A	I	I	I	I	VI	A	I
P3	I	I	I	VI	I	I	I	VI	A	I
P4	A	I	I	VI	I	A	I	VI	I	VI
P5	I	I	I	VI	I	A	I	VI	I	I

Then AFNs for Planning were calculated as follows:

B. *Average Fuzzy Numbers*

Average Fuzzy Matrix for criteria planning,

$$AFC_1 = \begin{bmatrix} 0.69 & 0.80 & 0.91 & 0.96 \\ 0.56 & 0.67 & 0.78 & 0.87 \\ 0.58 & 0.69 & 0.80 & 0.89 \\ 0.58 & 0.69 & 0.80 & 0.88 \\ 0.58 & 0.69 & 0.80 & 0.89 \end{bmatrix} \begin{matrix} P1 \\ P2 \\ P3 \\ P4 \\ P5 \end{matrix}$$

Average Fuzzy Numbers and crisp score respectively for sub criteria of Planning are as shown in Table III

Table III: Average Fuzzy Numbers

SUB CRITERIA	AFN1	AFN2	AFN3	AFN4	AVG(C_k)
Planning					
P1	0.688	0.799	0.911	0.955	0.838
P2	0.555	0.666	0.777	0.866	0.716
P3	0.577	0.688	0.799	0.888	0.738
P4	0.577	0.688	0.8	0.877	0.736
P5	0.577	0.688	0.799	0.888	0.738
Total Crisp Score					3.766

C. *Normalized Weight*

The normalized weight was calculated on the basis of total crisp score Table IV shows the normalized weight of sub criteria of Planning.

Table IV: Normalized Weight (Academician and Professional)

SUB CRITERIA	NORMALIZED WEIGHT	
	PROFESSIONALS	ACADEMICIANS
P1	0.223	0.223
P2	0.190	0.188
P3	0.196	0.198
P4	0.195	0.209
P5	0196	0.182

Similarly the normalized weight for other subcriteria was calculated.

D. *Total Score for schemes*

Using simple additive weighing method (Hwang and Yoon, 1981), the total score (TS), for each scheme, of Planning, Financial, Project management consultant, Sub contractor, Supplier, Client, Employee, Operational, Attractions, Health & Safety and Environmental Aspects criteria were calculated separately using the equation no (6), with usual notations.

$$TS_{rl} = \Sigma\left[X_{rp} \cdot W\left(C_{rp}\right)\right] \text{ for } p = 1, 2, \ldots n \quad (6)$$

Table V: Total Score (Academician and Professional)

Criteria	Expert	Total Scores		
		Scheme 1	Scheme 2	Scheme 3
Planning	Academician	0.048	0.322	0.329
	Professional	0.047	0.316	0.330
Financial	Academician	0.076	0.326	0.573
	Professional	0.076	0.327	0.571
QC/ PMC	Academician	0.206	0.335	0.464
	Professional	0.206	0.337	0.467
Sub Contractor	Academician	0.291	0.371	0.413
	Professional	0.285	0.370	0.409
Supplier	Academician	0.188	0.188	0.188
	Professional	0.190	0.190	0.190
Client	Academician	0.061	0.500	0.440
	Professional	0.062	0.500	0.435

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Employee	Academician	0.302	0.196	0.610
	Professional	0.302	0.195	0.611
Operational	Academician	0.108	0.303	0.442
	Professional	0.108	0.304	0.443
Attractions	Academician	0.018	0.586	0.499
	Professional	0.019	0.580	0.488
Health & Safety	Academician	0.094	0.367	0.330
	Professional	0.093	0.361	0.329
Environmental Aspects	Academician	0.277	0.339	0.636
	Professional	0.281	0.345	0.633

To determine the weight age for the criteria of **Planning, Financial, Project management consultant, Sub contractor, Supplier, Client, Employee, Operational, Attractions, Health & Safety and Environmental Aspects** (such that their summation was equal to 1), equation no (7) was used.

$$W(C_{rl}) = TS_{rl} / \sum TS_{rl} \qquad (7)$$

E. Real Estate Project Success Potential Index

Using simple additive weighing method (Hwang and Yoon, 1981), overall score (OS) for the different schemes were calculated using the equation no (8), with usual notations.

$$OS = \sum \left[TS_{rl} \cdot W(C_{rl}) \right] \text{ for } l = 1, 2, \ldots n \qquad (8)$$

Table VI: Overall Score (REPSPI)

	REPSPI		
	Scheme 1	**Scheme 2**	**Scheme 3**
Academicians	0.217	0.384	0.484
Professionals	0.217	0.383	0.482

From the normalized weightage method, following points were observed:

[1] The REPSPI of Scheme 1 is 0.217 & 0.217 in the range of 0.21 – 0.40 that is as per the scale scheme 1 has Appropriate Success.

[2] The REPSPI of Scheme 2 is 0.384 & 0.383 in the range of 0.21 – 0.40 that is as per the scale scheme 2 has Appropriate Success.

[3] The REPSPI of Scheme 3 is 0.484 & 0.482 in the range of 0.41 – 0.60 that is as per the scale scheme 3 has moderate Success.

V. CONCLUSIONS

The REPSPI model using Fuzzy Multiple Criteria Decision Making technique has been developed in the present study to evaluate REPSPI to decide Success Potential of Project.

The following are the conclusions on the basis of the analysis:

1) Application of fuzzy approach to determine the success potential index is found to be more appropriate compared to the current crisp approach.
2) When the comparison is made among the linguistic terms assignments by Academicians & Professionals the index value changes marginally
3) From results & discussion it is found out that the presence of all the Criteria & Sub Criteria have an equal importance, as if one or more of the criteria or sub criteria is not considered for the calculation, then results shows much variation in the overall score which affects the ranking order & potential index of the different schemes.

APPENDIX

Criteria	Notation	Sub Criteria
Planning	P1	Selection of proper location
	P2	Effectiveness of construction schedule
	P3	Effectiveness in delay cover management
	P4	Effectiveness of waste minimization
	P5	Pioneering status of innovative structure
Financial	F1	Adequacy of funding
	F2	Precise cost estimation considering cost of waste material
	F3	Precise cost estimation without considering cost of waste material
	F4	Efficacy of cost control
	F5	Efficacy of Marketability
	F6	Efficacy of financial resources
	F7	Regular Budget Update
	F8	Risk Assessment
Quality Control/ Project Management Consultancy	Q1	Effectiveness of consultancy services
	Q2	Competency of consultant's team
	Q3	Consultant top management support's
	Q4	Consultant's past record
	Q5	Consultant's level of service
	Q6	Level of compliance with government with laws and regulations
Sub contractor	SC1	Capability of contractor's key personnel
	SC2	Competency of contractor's Team
	SC3	Contractor team turnover rate
	SC4	Contractor top management support
	SC5	Contractor's past record
	SC6	Contractor's level of service
Supplier	S1	Competency of supplier's team
	S2	Supplier's top management support
	S3	Supplier's past record
	S4	Supplier's level of service
Client	C1	Client's willingness
	C2	Client's satisfaction
	C3	Attractiveness of project location
	C4	Increase value ability
Employee	E1	Level of satisfaction of project employees
	E2	Level of employee competency

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	E3	Level of Salary satisfaction of employee
Operational	O1	Effectiveness of leadership
	O2	Efficiency of design
	O3	Efficiency of coordination among project Participants
	O4	Performance on technology use
	O5	Benefiting from past project experience
	O6	Timely Possession of Flats/Offices/Shops
Attractions	A1	Aesthetically Pleasing Building
	A2	Lift
	A3	Overall Maintenance Facility
	A4	Security facility
	A5	Intercom facility
	A6	Common toilet with Maintenance Facility
	A7	Parking
	A8	Internet facility
	A9	Dry Balcony
	A10	Landscaping
	A11	Club House
	A12	Gymnasium
	A13	Swimming Pool
	A14	Pipe line Gas Connection
Health and Safety	HS1	Adequacy of PPE
	HS2	Medical facility
	HS3	Provision of ELCB and MCB
	HS4	Attainment in health and safety on site
	HS5	Fire Fighting
Environmental Aspects	EA 1	Green and sustainable design
	EA 2	Compact module Sewage Treatment Plant
	EA 3	Reuse of treated wastewater
	EA 4	Rain Water Harvesting System
	EA 5	Solar Panels
	EA 6	Solid waste disposal
	EA 7	Reuse of solid waste in premises

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Author of the following books:

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International Journals: 08; **International Conference:** 08 and **National Conference:** 07

Patents: Five patents have been published in Journal of Patent

Award: REC Topper Award at University Examination of M.E. Environmental Engineering, Regional College of Engineering (REC), Surat, Gujarat, India.

Research:

Environmental Engineering:

- Developed fertilizer from wasted material of Sugar Industry like Pressmud, Bagassee fly ash and Spentwash.
- Developed a methodology and software for ranking of different types of industries on the basis of environmental pollution potential and environmental acceptability of different types of industries in a region. This study is useful for Pollution Control Authorities.
- A treatment of water for drinking purpose using natural coagulants.

Ongoing Research:

Environmental Engineering:

- A fuzzy approach for Environmental Acceptability of Sewage Treatment Plant using natural coagulants.

Transportation Engineering:

- Use of Solid Waste (Fly ash with Coconut Shell Charcoal) for Construction of Road Pavement.
- Use of steel slag for sub-grade in road construction.

Testing and Consultancy:

- Actively involved in the Testing and Consultancy in the field of Highway, Geotechnical, Environmental Engineering and Concrete Technology since 2001.
- **Key tests conducted:** Compressive strength of concrete & Tensile strength of steel on Universal Testing Machine, CBR, Plate load, SPT, Marshall Stability, Bitumen Penetration, Bitumen Extraction and NDT.

Abroad Visits:

Visited countries like; South Korea, Greece, Thailand and Kazakhstan for presenting research papers in International Conference.