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Abstract - **In order to promote sustainability additional construction rights are provided to green buildings in Kolkata, India. The paper derived the green building costs from two cases presently under construction and determined that the existing policy is profitable to the builders only for high value properties in the city center. A life cycle analysis showed that there would be substantial financial and environmental benefits if properties in the outskirts are also converted to green. Concessions like tax reductions that are directed to the flat owners should be offered in addition to the present policy for promoting green buildings for all.**

Keywords - **Sustainability, Green building, Urban planning, life cycle analysis**

I. INTRODUCTION

The certification of buildings from sustainability considerations have become a popular feature in Indian real estate industry. The system was introduced in 2003 by the Indian Green Building Council (IGBC) with a license from the United States Green Building Council. It was christened as IGBC LEED (Leadership in Energy and Environmental Design). Other certification systems like GRIHA (Green Rating for Integrated Habitat Assessment), BEE (Bureau of Energy Efficiency) or LEED by USGBC (United States Green Building Council) are also operating in India. However, IGBC LEED is the most popular particularly among the private builders.

There are a number of items called credits in a certification system like IGBC LEED. The proposed buildings are evaluated in each of these credits and points are awarded depending upon the performance in that particular credit. The total score thus achieved would provide a designation like silver, gold, platinum etc. which measures the sustainability performance. In order to provide incentives the local authorities provide various benefits like additional right of constructions or allow property tax discounts for certified buildings. The city of Kolkata is allowing ten percent additional covered area for gold certified buildings.

In such a scenario, the builders would compare the cost for attaining certification with respect to the benefits earned by it. Certified buildings which were mostly a prescriptive requirement by the government for reducing greenhouse gases and improving the environment has thus become a part of the market force in real estate industry in India. This paper examines the impact of such commercialization of the building sustainability for the city of Kolkata, India.

II. PRESENT STATUS

The application of market forces in environmental control is not new. Friedman, a noble laureate economist argued as far back as in 1978 that polluting rights should be traded in the market places [1]. In 1997, the idea was applied to the Kyoto Protocol. It accepted the concept of emission trading in principle under which a country will be allowed to purchase the rights to emit greenhouse gases from other countries in certain cases [2].

In 2016, similar economic principle was applied in the building rules in India. The Model Building Bye Laws allowed additional buildable area for a price based on the carrying capacity of the plot [3]. Since certified buildings have smaller emission footprints more areas could be built in a given plot size. Local governments in India are now allowing more buildable areas ranging from five to ten percent in a given plot for certified buildings [4].

The downside of such principle is that sustainable building developments are skewed to high value properties. The construction costs for earning certified building credits is a function of resource inputs and is not dependent upon the plot location. However, the benefits that is the sale proceeds of additional constructions earned in certified buildings is dependent upon the location. Thus, the green certifications in peri-urban areas are often neglected because additional cost input for certifications may not be recoverable from the sale of added constructions. Neglecting construction of certified buildings in peri-urban areas would cause detrimental impact on the environment and defeating the prime purpose of certified building constructions.

There are several other ways of promoting green buildings as shown in Fig. 1. The chart is drawn based on a finding reported by US GBC [5].

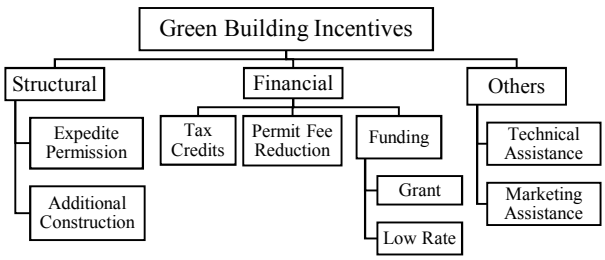


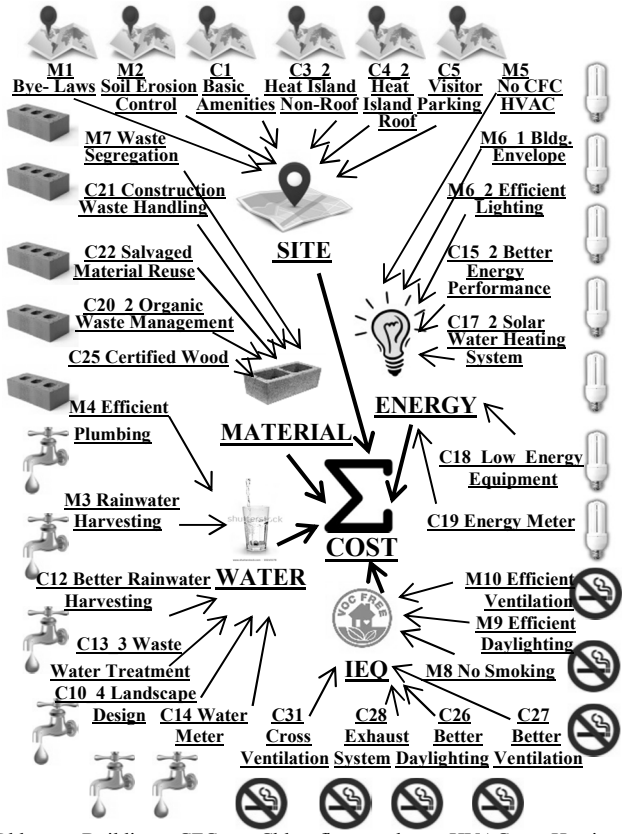
Fig. 1. Means of promoting certified buildings.

A mix of such processes shown in Fig. 1 may be used in lieu of only buildable rights presently in vogue in Indian scenario. A life cycle impact analysis for certified buildings may be also calculated before streamlining the policy for green buildings.

III. CERTIFICATION COSTS

Impact of the present rule of additional construction rights for certified buildings has been analyzed for two numbers projects currently under construction in Kolkata. Both the buildings are speculative residential multistoried apartments by the same builder and have been designed for IGBC gold certification. The project marked I is a multistoried residential development in Chowringhee Road, a posh locality in the central business district. The project marked II is a multistoried tower block in Tollygunge, a suburb in south of Kolkata.

Each of the provisions of IGBC credits has been evaluated for both the buildings. Credits were selected for obtaining different classes of ratings namely certified, silver, gold and platinum for both the buildings. The costs of each of the credits have been calculated. Since there could be a variations of costs three estimates of costs namely most likely, optimistic that is the lower end and pessimistic that is the higher end have been calculated. The cost data so arrived have been simulated by Monte Carlo's methods for obtaining mean and standard deviations. The scheme for simulation executed in GoldSim software is presented in Fig. 2 [6].



Bldg. = Building; CFC = Chlorofluorocarbon; HVAC = Heating Ventilation and Air Conditioning; M = Mandatory Points; C = Credit Points; IEQ = Indoor Environmental Quality

Fig. 2. Monte Carlo's simulation for costs

The principle of cost estimating is presented herein. The items that have to be included for obtaining an individual credit were first listed. The cost components for each of the items for that credit were tabled. The cost of each component was estimated based on the standard schedule of rates of the public works department of the government and or market rates in the locality. The optimistic, most likely and pessimistic costs of a credit reflect the market fluctuations, design variations and inflation in the economy. It was estimated based on the subjective judgment through discussions with the practicing specialists working in the area. The estimates so obtained were combined to obtain the cost data of a credit. Similarly, the cost data for all the thirty three credits were estimated.

The average unit costs of mandatory credits in Project I and II are presented in Table I. The distributions of costs are presented in Fig. 4. A review of the pie chart of mandatory items in Fig. 4 would show that items related to energy and water is the most important. They constitute more than seventy five percent of the cost.

The average unit costs of credits in Project I and II for an IGBC gold certification including the mandatory credits are presented in Table II. A review of the pie chart of the gold certification items in Fig. 4 would show that items related to energy and water are still the most important like the mandatory items. They constitute nearly fifty five percent of the total cost for obtaining a gold certification from IGBC. Therefore, items related to the energy and water would demand further analysis for any cost control exercise.

TABLE I
MANDATORY ITEM COSTS (INR*/m^2)

Credit Area	Optimistic	Most Likely	Pessimistic
Site	5.43	6.20	7.56
Energy	223.64	23.178	254.34
IEQ	78.7	87.38	99.89
Water	81.66	120.27	177.71
Material	12.71	16.04	19.06
Total	402.14	461.57	558.56

* INR = Indian Rupee

TABLE II
AVERAGE CREDIT COSTS FOR IGBC GOLD CERTIFICATION (INR*/m^2)

Credit Area	Optimistic	Most Likely	Pessimistic
Site	179.78	208.18	229.74
Energy	242.03	235.27	279.78
IEQ	84.08	93.95	107.75
Water	90.08	129.66	188.15
Material	17.46	21.12	24.46
Total	613.43	706.50	829.88

TABLE III
COST SIMULATION OF GREEN BUILDING CREDITS (INR*/m^2)

Credit Area	Project I		Project II	
	Mean	S.D.	Mean	S.D.
Certified	426.78	15.73	598.65	16.79
Silver	463.23	15.89	635.86	16.57
Gold	634.09	16.67	837.45	17.29
Platinum	7632.4	143.31	11177.00	288.24

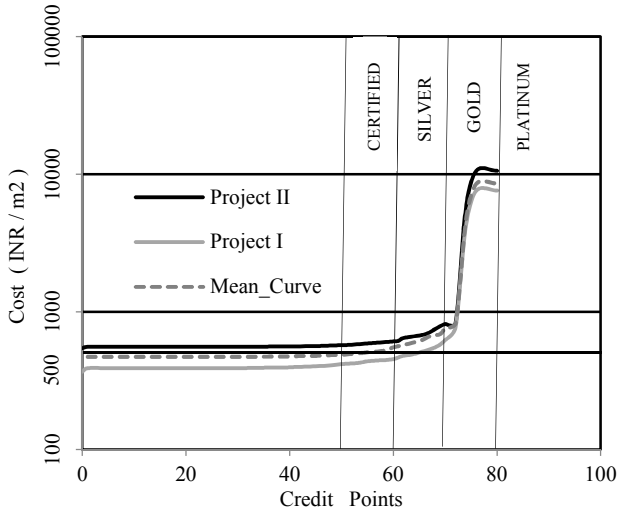


Fig. 3. Green Building Certification
Unit Cost v/s Credit Points

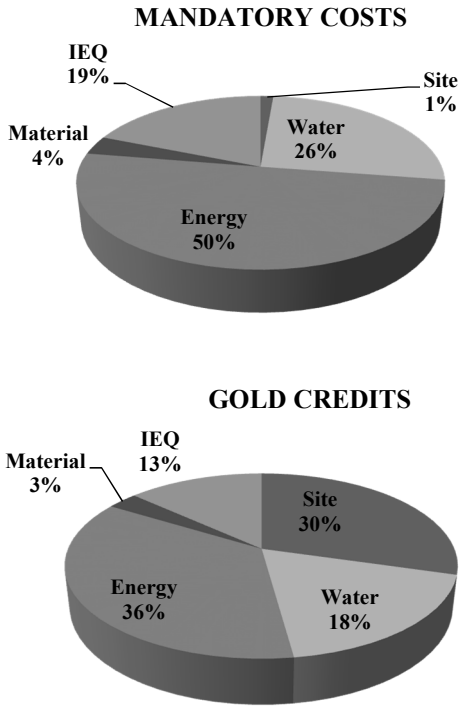


Fig. 4. Distribution of Costs

The cost statistics of IGBC Gold certification in Project I and II after simulation according to the scheme shown in Fig. 2 are presented in Table III.

The simulated mean costs for attaining credits for both the Project I and II are presented in Fig. 3. The mean of the two sites for a gold certification is INR 736 for each m^2 which is used for subsequent estimates. The mean of the two sites for different sustainability performance grading are also shown in Fig. 3. The simulated mean unit costs for attaining each of the credit for Project I is lower than that of Project II. The total covered areas for Project I and Project II sites are 61,914 m^2 and 32,235 m^2 respectively. Apparently, the smaller site is costlier in making provisions for green credits in unit rate basis.

The average most likely cost for obtaining the mandatory credits is INR 461 per m^2 as shown in Table I. The graphs in Fig. 3 therefore show that the cost for attaining green building would start from the range of about INR 500 per m^2. The Fig. 3 reveals that the cost curve for green building after mandatory provisions is flat. The difference of costs from a certified to a gold certified building is about INR 200 per m^2 only. After gold certification the cost curve is steep as shown in Fig. 3. The cost difference between a gold and platinum certification is about INR 10,000 per m^2 as shown in Fig. 3 and Table III.

IV. DEVELOPMENT IMPACT

The present building construction rules in the city allows ten percent additional right of constructions of the covered areas for a gold certified building but a platinum certification would not get any further advantage.

The cost estimates and profit margins of the projects in Project I and II areas are compared in Table IV. The construction cost in the city center that is the Project I area and the outskirts that is the Project II areas have remained the same as shown in Serial 6 of the Table IV. However, the land component value and the sale value has changed as shown in serial 7, 9 & 10 in the Table IV. The profit margin for city center that is Project I areas is reasonable even after including the INR 736 per m^2 as shown in serial 11 in Table IV whereas the profit margin has reduced to 1.11 percent in outskirts that is project II areas. In such scenario, builders would not be interested to increase the construction cost by INR 736 per m^2 unless the purchasers are willing to pay higher prices for sustainable building. Builders who are not opting for a sustainable building would have a profit advantage. In industrially advanced countries like in United States green office spaces does bring higher revenues [7]. However, apartment purchasers in peri-urban areas of Kolkata do not have the financial ability for spending more even if the benefits like lower energy and water bills in green buildings are recognized. As a result the market mechanisms may need to be augmented by mandates of the regulatory authorities for sustainable development of the city. There would be hardly any initiative for sustainable building construction on the part of the builder when the sale value is less than INR 54,000 per m^2

TABLE IV
PROFIT MARGINS OF UNIT AREAS IN PROJECT I AND II LOCALITY

Sl.	Description	Project I Areas	Project II Areas
1	Covered Area (m^2)	1.0	1.0
2	Extra for Gold Cert. (m^2)	10%	10%
3	Total Const. Area (m^2)	1.1	1.1
4	Unit cost for Gold (INR/m^2)	736	736
5	Unit const. cost (INR/m^2)	30,000	30,000
6	Total unit costs (4+5)	30,736	30,736
7	Land Component (m^2)	112,000	28,000
8	Develop. Unit cost (6+7)	142,736	58,736
9	Sale Value (INR/m^2)	150,000	54,000
10	Sale Amount(3x9)(INR/m^2)	165,000	59,400
11	Profit (10-8)/10 in (%)	13.49	1.11

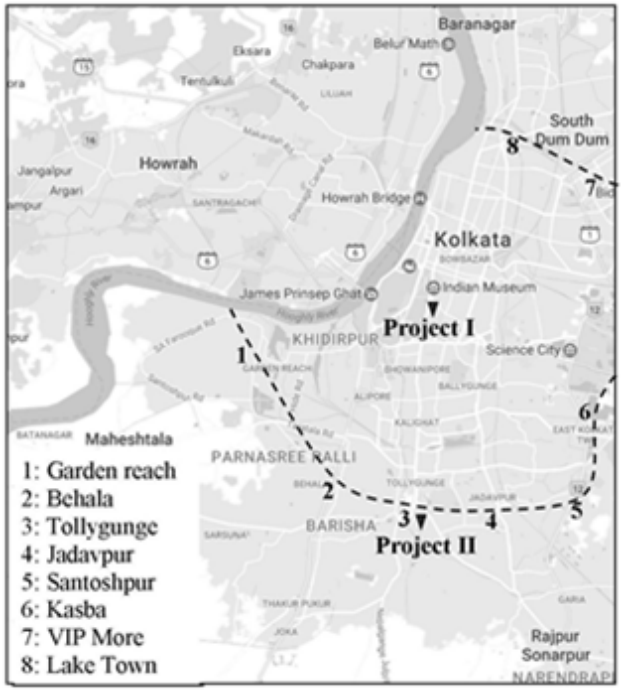


Fig. 5. Market Equilibrium Contour of Sustainable Buildings in Kolkata

Sale offers of apartments in Kolkata have been searched from established real estate sale portals [8] [9]. A contour where the sale value of residential apartments having a price of about INR 54,000 per m2 in the year 2017 is presented in Fig. 5. A Project located outside of the contour would not have the market viability for the builders as evidenced in Table IV.

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TABLE V
SAVINGS FROM WATER AND ELECTRICITY

Sl.	Description	Project I	Project II
1	Covered area (m^2)	61914	32235
2	Energy save (IGBC)	21%	21%
3	Annual cost (Report)	61.74Mil	39.78 Mil
4	Annual elec. saving (INR / m^2) (2x3)/1	402	134
5	Water save (IGBC)	35%	35%
6	Water use (Klpd)	63.390	136.000
7	Water saved (Klpd)	22.18	47.6
8	Annual water save. (INR / m^2) (6x365x12)/1	4.48	18.48
9	Total annual save for elec. & water (4+8)	407 INR	152 INR

Sl	Note
Sl 2	Submitted an application for IGBC Gold rating
Sl 3	Submitted application for microclimatic analysis to the State Pollution Control Board where energy simulation was conducted [10] [11]
Sl 5	Submitted an application for IGBC Gold rating
Sl 6	Submitted an application for IGBC Gold rating
Sl 8	Water charges in municipality INR 12/ Kilo Lit, https://www.kmcgov.in/KMCPortal/jsp/WaterSupplyFees.jsp, Last accessed on May 16 2017

V. LIFE CYCLE COST

In order to frame a sustainable policy for green building development a life cycle analysis approach is investigated. The provisions for energy and water would cost more than half the cost of making a gold rated green building in Kolkata as shown in the pie chart in Fig. 4. The monetary savings for these two items can be estimated relatively easily.

The annual energy and water savings for Project I and Project II are provided in Table V. Explanatory notes have been provided in Table V indicating the sources. Since the Project II location is in the borderline of market failure its data have been used for life cycle analysis. The total annual savings for Project II is INR 152 for each m^2 which has been used for estimating the total savings during the life time of these resource savings features.

Since the costs occur throughout the life span of the facility present value rules as presented in Equation 1 are applied.

$$Cp = \sum_{t=1}^{L} \frac{Ct(1+r)^t}{(1+i)^t} + \sum_{t=1}^{L} \frac{Ot(1+r)^t}{(1+i)^t} \qquad (1)$$

Where, C_p = Present value of cost in INR/ m^2 of covered area, i = Discount rate at year t, C_t = Acquisition costs of the energy and water saving facilities in Indian rupees (INR) incurred at year t, O_t = Maintenance costs in INR incurred at year t, L = Expected life of the facilities in years, i = Discount rate at year t and r = inflation rate at year t. The values of these factors shall not be the same over its lifetimes. Therefore, a range of values have been estimated after consulting various sources and presented in Table VI. These distributed values are simulated in

GoldSim software and the mean was found to be INR 3829 with a standard deviation of 1069. The initial investment was only INR 736 per m^2 as shown in Serial 4 in Table IV. The investment has returned five times over a period of twenty years. The internal rate of return (IRR) is estimated to be 34 percent. Obviously, such an high IRR should be considered as a good investment proposal even if the flat purchasers are unwilling to opt for it for want of information or capital. It would also reduce the energy and water use and thereby increasing the sustainability of the city. Therefore, these features should be included in the building plan sanction requirements for the city of Kolkata.

TABLE VI
COSTING FOR LIFE CYCLE ANALYSIS INPUTS (INR/m^2)

Sl.	Item	Optimistic	Most Likely	Pessimistic
1	C_t (INR)	128	152	407
2	i (%)	6	8	10
3	O_t (INR)	12	16	19
4	L (yr.)	15	20	25
5	r %	4	6	8

Notes	
Sl 1	Values based on findings in Table V
Sl 2	i and r are based on data of Reserve bank [12]
Sl 4	Based on advice of maintenance engineers

VI. DISCUSSIONS

The study shows that allowing additional construction rights for green buildings would help in increasing sustainable building footprints in the city center only in the areas as shown in Fig. 5. The area inside the contour in Fig. 5 is 1,10,000 m^2 which is about half of the total area of 2,05,000 m^2 of the Kolkata Municipal Corporation. The present policy of benefits extended to the builders alone would not be enough for making green buildings in the city outskirts and the peri-urban areas. Additional benefits like property tax discount would transfer the benefits to the apartment owners and might induce them to buy green buildings at a higher price which in turn would help the builders in proposing green buildings for economical housings. The sustainability measure of the city would thus increase considerably.

Alternative measures such as structuring the decision processes to align with tested behavioral science theories, like choice architecture can help in improving and influencing the decisions of the stake holders of similar projects. [13]

VII. CONCLUSION

The existing policy of providing additional construction rights for sustainable buildings is solely directed to the builders. It may not be sufficient for attracting enough investments for mass housing schemes. Tax credits and other means as shown in Fig. 1 may be combined with the existing scheme for developing a policy for growth of green buildings for all classes of housings in the metropolitan areas of Kolkata.

Future research may include formulation of policies which allow more tangible benefits being offered to the consumers, and re-structuring of the credit-point system and propagation of concept of green buildings through role models for the stakeholders and decision makers.

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